

MINISTRY OF EDUCATION OF BELARUS

Polotsk State University

**EUROPEAN AND NATIONAL  
DIMENSION IN RESEARCH**

TECHNOLOGY

Electronic collected materials of IX Junior Researchers' Conference  
(Novopolotsk, April 26 – 27, 2017)

Обновляется 1 раз в год.

Novopolotsk  
2017

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EUROPEAN AND NATIONAL DIMENSION IN RESEARCH. TECHNOLOGY =  
ЕВРОПЕЙСКИЙ И НАЦИОНАЛЬНЫЙ КОНТЕКСТЫ В НАУЧНЫХ ИССЛЕДОВАНИЯХ :  
Electronic collected materials of IX Junior Researchers' Conference, Novopolotsk, April  
26–27, 2017 / Polotsk State University ; ed. D. Lazouski [et al.]. – Novopolotsk, 2017. –  
1 CD-ROM.

Издается с 2017 года (в печатном виде – с 2009 г.).

Сборник включен в Государственный регистр информационного ресурса. Регистрационное  
свидетельство № 3981711557 от 17.04.2017 г.

Первые два печатных издания вышли под заглавием «Материалы конференции молодых  
ученых», третье – «Национальный и европейский контексты в научных исследованиях» в 3 томах:  
«Гуманитарные науки», «Экономика» и «Технология».

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Техническое редактирование и компьютерная верстка *О. П. Михайловой*  
Компьютерный дизайн *М. С. Мухоморовой*

№ госрегистрации 3981711557.

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Издается с 2017 года (в печатном виде – с 2009 г.).

## ARCHITECTURE AND CIVIL ENGINEERING

UDC 726

### MODERN ARCHITECTURE OF DUBAI

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*Modern architecture has flourished in the Gulf, and the speed at which Dubai has grown has resulted in one of the most spectacular building booms of modern times – at one point in the mid-noughties it was estimated that, astonishingly, a quarter of all the world's construction cranes could be found in Dubai alone.*

**Building site.** The exploding real-estate market, ready supplies of apparently limitless finance and widespread availability of large plots of unused land all conspired to turn Dubai into an enormous building site, further heated by a general absence of the sort of zoning rules, planning permissions and conservation issues which so often haunt major new constructions in the West.

The wide open desert spaces of Dubai thus provided a kind of tabula rasa on which architects could doodle – and then see their doodles take shape with lightning speed. The results are inevitably mixed. Some of the modern architecture in the Gulf is spectacularly ugly, some is notable as much for its sheer quirkiness as for its ultimate success, although the region also boasts a clutch of undoubted modernist masterpieces, as well as some superb urban architectural ensembles, such as the teetering high-rises of Sheikh Zayed Road.

**Dubai's best buildings.** Almost all the region's finest modernist icons can be found in Dubai, a veritable encyclopedia of contemporary design ranging from the good through to the bad, the mad and the downright ugly. Some of Dubai's most memorable buildings are decidedly quirky in inspiration: the strange Dusit Thani hotel, for example, inspired by the traditional Thai *wai* greeting, with hands placed together in welcome (although it actually looks more like an enormous upside-down tuning fork), or the landmark Etisalat Building, topped by what looks like a vast golf ball (a design now copied in other Etisalat buildings in Dubai, Abu Dhabi and elsewhere).

Many of the city's finest buildings pay oblique homage to the emirate's former maritime traditions, with various sail-shaped architectural motifs, exemplified by the celebrated clubhouse of the Dubai Creek Golf Club (1993), a fascinating sculptural creation whose instantly recognizable outline (like a kind of Dubai remake of the Sydney Opera House) is inspired by the triangular shapes of the traditional *lateen* sail. The sail motif is invoked again in the superb National Bank of Dubai (designed by Carlos Ott, 1998), its towering Creek side facade comprising a single enormous "sail" surrounded by highly reflective aluminum cladding, mirroring boats on the waters below. Best of all, however, is the superlative Burj al Arab (Tom Wright, 1999), whose land-facing side provides Dubai with its largest and most magnificent architectural sail, memorably illuminated at night (and juxtaposed against the rollercoaster shape of the wonderful Jumeirah Beach Hotel next door, inspired by the shape of a breaking wave).

**Burj Khalifa, by Adrian Smith.** The tallest building in the world, at 829.8 meters (2722ft), the Burj Khalifa began its construction on 21 September 2004 and was completed on 1 October 2009. Previous to its inauguration on the 4 January 2010, the building was known as Burj Dubai. We're told all the steel used to build it would stretch from Dubai to Melbourne if end to end!

Adrian Smith, an American, is the chief architect of this construction. He is known for designing various skyscrapers all over the world, such as Jin Mao Tower and Trump International Hotel & Tower and is now involved in the construction of Kingdom Tower, an expensive (provisionally \$1.23 bn) and hugely high tower in Saudi Arabia.

It has notched up records including:

- Tallest building in the world;
- Tallest free-standing structure in the world;
- Highest number of storeys in the world;
- Highest outdoor observation deck in the world;
- Elevator with the longest travel distance in the world.

The Burj Khalifa receives an average of 4000 visitors daily to its viewing deck and houses the Armani Hotel, occupying a whopping 15 floors!

**Burj Al Arab, by Tom Wright.** Tom Wright, a British architect working for Atkins construction, designed the incredible Burj Al Arab, the fourth tallest hotel in the world at 321 meters.

The 5\* hotel is built on an artificial island and construction began in 1994, with the hotel opening to the public in December 1999.

Dubai's most iconic hotel, the Burj Al Arab soars skywards like a huge sail from its private island. If you're after glitz, bling and exceptional butler service, you won't be disappointed. Drink Champagne on the rooftop terrace, soaking in views of the cityscape; and dine on seafood at Al Mahara, where you'll take a simulated submarine ride into the magical aquarium restaurant.

The hotel offers 202 luxurious duplex suites, a decadent spa, nine world-class restaurants (six are award-winning) and complimentary access to Wild Wadi water park during your stay.

**Emirates Towers by Hazel W.S. Wong.** Emirates Towers were constructed in 2000 by Hazel Wong (Norr Group), a Chinese-Canadian architect known for her work in North America and the Middle-East.

The construction complex, located on the Sheik Zayed Road in Dubai, contains the Emirates Office Tower and the 5\* Jumeirah at Emirates Towers hotel. The first tower rises 355 meters and the second rises 309 meters, connected by a retail boulevard.

Jumeirah at Emirates Tower hotel is one of the most stunning architectural highlights on the Dubai skyline. It has 400 luxurious rooms and suites and offers extraordinary dining and nightlife venues, a luxurious spa and incredible service.

Dubai's skyline is filled with iconic landmarks, including the instantly recognizable sail of the Burj Al Arab, the wave-like Jumeirah Beach Hotel and the triangular tips of the Jumeirah Emirates Towers. Already home to the world's tallest building and the world's largest shopping mall, the city continues to astound with twisting towers, majestic mosques and lavish modern souks.

#### REFERENCES

1. Dubai Architecture [Electronic resource]. – Mode of access: <http://www.e-architect.co.uk/dubai/dubai-buildings.html>. – Data of access: 20.01.2017.
2. Architecture in Dubai [Electronic resource]. – Mode of access: <http://actionnewsnow.net/architecture-in-dubai.html>. – Data of access: 20.01.2017.

UDC 711.4

**THE CHURCH OF THE IMMACULATE CONCEPTION OF THE BLESSED VIRGIN MARY**

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*This article presents an analysis of historical and architectural aspects of the Church of the Immaculate Conception of the Blessed Virgin Mary, located in the town of Disna, Miory district, Vitebsk region. Highlights cultural value and uniqueness of the object. Particular attention is paid to history of the town, which makes clear the importance of the architectural object for the town. Along with the architectural design work it provides information about the current state of the church.*

Disna – the smallest city of the Republic of Belarus. The city has a population of 2 thousand people, and nevertheless the town is known not only in the country but also outside its borders. It is located in the northwest of the country, in Miory district, Vitebsk region, at the confluence of two rivers: The Disna and the Western Dvina [1].

For the first time in documents, the city was mentioned as far back as the 11th century under the name "Kopec-town" and has been an important subject in the way "from the Vikings to the Greeks." And in 1461 the town was mentioned under the present name Disna. However, the fortified settlement of Disna in the composition of the Polotsk province in the island at the confluence of two rivers known from later sources - according to the information of Polotsk "scribe books" for 1563.

It is said about the existence here Kopec, that is earthwork (from the word "копать"). At the same time in front of the fortified island on the left bank of the river Disna, "Disna village" has already existed. Thus, the rapid development and the strengthening of the city in the XVI century, due not only to favorable strategic and topographical situation, but "lived-in" of the land in the previous century [2].

Stefan Batory – his name is closely linked to the history of the city, he built fortifications on the banks of the Dvina. After the capture of Polotsk by Ivan the Terrible (1563), the Polish King Stefan Batory, trying to compensate for the loss, began to accelerate construction of the castle Disna. A new castle complex, stretching along the island (at the same time the southern channel of the river widens and deepens), absorbed old earthworks. The court builder S. BatoryGuinga from Urbino constructs Fortress of Disna. Kopec now became known as the Old Castle. In essence it was a single military fortress, is well known for wars XVI–XVIII centuries.

However, the castle, built by him and served as the basis for the formation of the city, could not resist and was destroyed, especially severe destruction it suffered in the 1812 war. To date, there are only ruins of the castle. Despite, in the city there are other interesting sights. Only the views that open from the lookout on the high banks of the Dvina dazzle the eyes of its power and beauty [3].

Franciscan Church of the Immaculate Conception of the Virgin Mary – is the main shrine and landmark in the city (fig. 1). This is one of the few historical and cultural heritage of the city of Disna preserved today. Stefan Batory built it to the same accelerated construction of the castle in 1553, but in the future it has been destroyed and in its place, in the 18th century, a new church was built. However, it could not resist and survive the Second World War.



Fig. 1. Church of the Immaculate Conception of the Blessed Virgin Mary

The Church of the Immaculate Conception of the Blessed Virgin Mary - is undoubtedly a unique monument of architecture of the late 18th century. Immaculate Conception of the Virgin Mary – Catholic dogma, which states that the Virgin Mary was conceived though ordinary parents – Joachim and Anna, but the original sin has not passed on her. Feast of the Immaculate Conception of the Virgin Mary is celebrated in the Catholic world on December 8 [1].

The church was built in 1773 in Baroque style. For a long time it was the main place of worship in this town and its surroundings. However, as it has already been mentioned, it was badly damaged during the Second World War. After its graduation, the Church has been neglected, and time has continued to destroy it.

In the last decade, the reconstruction of the building: Vitebsk diocese holds its examination and the conservation is started – forests are set, the area of the church is fenced, the work on the prevention of the building from further damage is begun. In spite of the fact, that virtually all of it is "dressed" in scaffolding, even through it, it is perfectly visible that the architecture is majestic (fig. 2) [4].



Fig. 2. Restoration of the church, 2016

Thus, based on the study, it should be noted that the Church has a great cultural value for the city. It is not well known, however, as one of the oldest surviving buildings of the city, the church became an important cultural and historical monument of the city of Disna.

#### REFERENCES

1. Миорский районный исполнительный комитет // Витебский район [Электронный ресурс]. – 2015. – Режим доступа: [http://miory.vitebsk-region.gov.by/ru/new\\_3/](http://miory.vitebsk-region.gov.by/ru/new_3/). – Дата доступа: 22.01.2017.
2. Дыбовский, А. История Дисны / А. Дыбовский // Дисна [Электронный ресурс]. – 2016. – Режим доступа: <http://globus.tut.by/disna/index.htm>. – Дата доступа: 22.01.2017.
3. Матвеева, Т. Дисна историческая / Т. Матвеева // Дисна – туризм [Электронный ресурс]. – 2016. – Режим доступа: <http://www.disna.by/ru/history>. – Дата доступа: 21.01.2017.
4. Дыбовский, А. Дисна, костел Непорочного Зачатия Девы Марии / А. Дыбовский // Витебская область, Миорский район [Электронный ресурс]. – 2015. – Режим доступа: <http://orda.of.by/.add/gallery.php?disna/kostel>. – Дата доступа: 22.01.2017.

UDC 711.4

**THE ARCHITECTURAL ENSEMBLE OF KIROV STREET IN VITEBSK**

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*The questions of the development of Kirov street in Vitebsk at the end of 18<sup>th</sup> – first half of 20<sup>th</sup> century on the basis of literary sources, analysis of archaeological excavations on the territory of Vitebsk, the photos are studied in the article. The features of architectural ensemble formation of Kirov Street and development are shown.*

Kirov Street is one of the main thoroughfares of Vitebsk. It runs from the railway station on Privokzalnaya Square to the Kirov Bridge. Kirov Street is the main entrance to the city and it connects the right Bank and left Bank parts.

The street was formed in the late 18<sup>th</sup> – early 19<sup>th</sup> century and was called Vokzalnaya. It acquired the name after the announcement of the railway in Vitebsk and building of the railway station. In 1867 the Dvina (nowadays Kirov) bridge over the Western Dvina River was built.

In the early 20<sup>th</sup> century on the street there were the railway station, the 2nd store of the consumers society, R. Ulrich pharmacy, military Assembly, and the most important single-track tram line, which was quite a rare phenomenon at that time [1, 2].

In 1930 – 1934 it was known as Karl Marx Street, and only in 1934 it was renamed in honor of revolutionary and political leader S. M. Kirov.

The great Patriotic war brought a lot of destruction to Vitebsk, some of the buildings of Lenin street survived, but the buildings of Kirov street were completely destroyed, including the Kirov bridge across the Western Dvina river (fig. 1), and required full restoration and reconstruction [3].

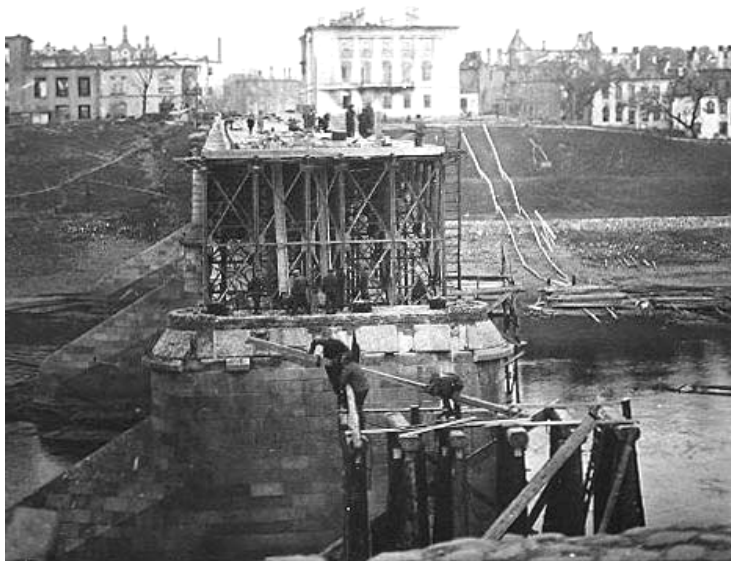


Fig. 1. Destroyed Kirov bridge. September 1941

Kirov Street's rebuilding started in 1947. According to architects' recollections, "it was not so easy to convince opponents in the need of 10-12 meter street widening to 66 meters." All architectural decisions were taken in Vitebsk. "The General project of planning, revival and reconstruction of Vitebsk" was developed in the Kharkov regional design Institute under the guidance of the architect Kasyanov and the plan was approved in 1946 [4].

During the street reconstruction a question of creating a coherent architectural ensemble of buildings was solved. The restoration lasted from 1948 to 1954. Street with the surrounding neighborhoods became the part of trunk diameter, crossing the city in the latitudinal direction and connected the Privokzalnaya square with town centre and Lenin Street, with its residential districts and public facilities (fig. 2) [5].

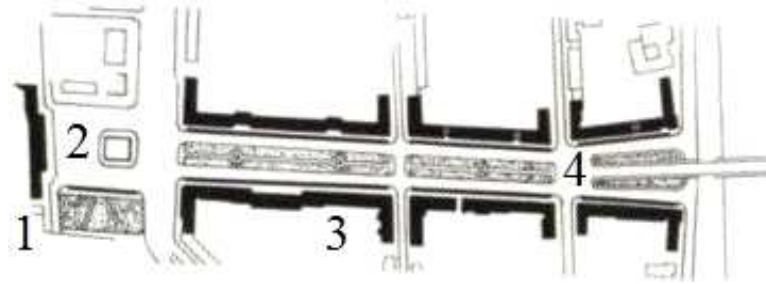


Fig. 2. Scheme of development of Kirov street:  
1 railway station; 2 – the Privokzalnaya square, 3 – civil building; 4 – pedestrian walkway

Honored architect Boris Mezentsev, co-author of one of the seven "Stalin's skyscrapers" in Moscow, designed the new building of the railway station. Built in 1954, it became the main dominant feature of Kirov Street. The station building has two stories, consists of three rectangular in plan, volumes: central and two lateral. On the main facade of the Central building there are three wide arched shaped windows. The facade is decorated with bas-reliefs, stucco niches and small columns of the Corinthian order. In the middle of the main facade clock is mounted. Marble and crafted stucco ceilings can be seen in the interior of the station. Heavy classical chandeliers are used for lighting.

Overall management of the design and control of a new street project, which was constructed on the site of the demolished old building blocks, was performed by the main architect V. I. Gusev who lived in Moscow. The authors of the project were A. Y. Danilova and V. A. Danilov who had just arrived in Vitebsk, immediately after graduating from Kiev Institute of civil engineering. In housing designing were used typical sections, designed in the national architectural institutions. Four-, five-floor buildings in the style of Stalin's Empire (the same as for the station) were designed as a single ensemble. The first floor was devoted to shopping and household enterprises. This ensemble was completed just before the Kirov Bridge with the two buildings with increased angular part in the form of towers – the hostel of electro-technical college connecting with the hotel "Dvina". Despite of some complicated forms of decoration (stucco details, massive cornices, pilasters with Corinthian capitals and others) the street building stand out to have a unique architectural and artistic qualities and completeness of the composition. In the middle of the street there was a Boulevard with Avenue of linden and chestnut trees (fig. 3) [2, 6].



Fig. 3. Kirov street in Vitebsk. The beginning of the 1960s

The concept of Kirov Street buildings ensemble is based on the unity of compositional and stylistic techniques, also the basic principles were creatively used: attractiveness of buildings with wide-open elegant first floor shops; the light colour of the facades, realistic architectural forms of the buildings, well thought-out proportions and silhouette completion. The completeness to the architectural solution gives the orientation on a single compositional center of the railway station building. Also the unity of the ensemble gives a close height, the



length of the buildings, the rhythm of facades articulation, formed by horizontal rods, cornices, window openings. Moreover, every building and street has its own peculiarity [5].

The length of Kirov Street is 650 meters that is not large. Architectural ensemble of the street is included in the "State list of historical and cultural heritage of Vitebsk". It is a perfect place for those who want to relax from the noise and to enjoy the Western Dvina River walking [6].

Thus, it can be noted that during three centuries of its history, Kirov Street has changed, but has not lost its purpose. Nothing is left from old buildings of the first stage of its formation. However, despite the loss of its historical buildings, modern buildings of Kirov Street are the bright example of complete expressive architectural ensemble. This is the main entrance to the city, the personification of austerity and the individuality of each building.

#### REFERENCES

1. Улица Кирова [Электронный ресурс] // Витебская энциклопедия. – Режим доступа: <http://evitebsk.com/wiki/Aliciau>. – Дата доступа: 25.12.2016.
2. Чарняўская, Т.І. Архітэктара Віцебска: 3 гісторыі планіроўкі і забудовы горада / Т.І. Чарняўская ; пад рэд. У.А. Чантурыя. – Мінск : Навука і тэхніка, 1980. – 112 с.
3. Витебск в годы Великой Отечественной войны [Электронный ресурс] // Live Journal. – Режим доступа: <http://belarus-travel.livejournal.com/253438.html>. – Дата доступа: 30.12.2016
4. Тузиков, П. Ансамбль улицы Кирова в Витебске: памятник градостроительства 1950-х годов [Электронный ресурс] / П. Тузиков // Белорусский союз архитекторов. – Режим доступа: <http://bsa.by/publikatsii/ansambl-ulitsyi-kirova-v-vitebske-pamyatnik-gradostroitelstva-1950-h-godov.html> – Дата доступа: 04.01.2017
5. Русецкий, А.В. Архитектура и градостроительство в художественной культуре Витебщины. С 1918 года и до наших дней : моногр. // А.В. Русецкий, Ю.А. Русецкий. – Витебск : Витеб. гос. ун-т им. П.М. Машерова, 2011. – 180 с.
6. Нестерович, С. Улица Кирова – парадный вход в Витебск [Электронный ресурс] / С. Нестерович // Vitebsk city : Информационно-туристический сайт города Витебска. – Режим доступа: [http://vitebskcity.by/article\\_view.php?idmenu=1&id=57](http://vitebskcity.by/article_view.php?idmenu=1&id=57). – Дата доступа: 17.01.2017.

**CHURCA OF SAINT JOHN THE BAPTIST IN KAMALA**

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*This article presents an analysis of the historical and cultural aspects of the origin and development of one of the monuments of the church of St. John the Baptist - Roman Catholic church in the agro Kamai Postavy district, Vitebsk region, one of the oldest Catholic churches in Belarus. The temple is unique in its architecture as well as the style and performance combines elements of Gothic, Renaissance and baroque. Name the creator of the temple is still unknown. This church served not only the house of God, but also a military fortress. Until now, the main decoration of the walls are thick core Swedish Northern War. The Swedes, who precipitated the temple, this small fortress and did not give up. Over the lifetime of the temple (about 400 years), it has never been closed.*

**Introduction.** The small village of Camay in Postavy district, Vitebsk region has preserved a unique temple of defensive type, was founded in 1603-1606 gg. Church of St. John the Baptist. This church - one of the few in the territory of Belarus, which has never been closed. This architectural structure was built on the site, which was originally for local residents prevail. This place was the center of the village, and then converged to form an intersection of five roads. In the old days, to the intersection has always been a special relationship. Even if one road flowed into another, at a location or set a stone, or put the cross - chapel. We know from history that initially at the crossroads was a huge boulder. From it not later than the XV century hewed cross, which stands in front of the church today. This cross is also a symbol of Kamaev.

**Researching part.** Catholic church of St. John the Baptist - Catholic church in agro Kamai (fig. 1), Belarus. It refers to the Postavy district, Vitebsk region. This monument of architecture, built in 1603-1606, respectively. It is one of the oldest Catholic churches in Belarus. The temple is included in the Cultural Properties of Belarus.



Fig. 1. St. John the Baptist Catholic church

The initiator of the construction of the Catholic church in the Kamai was the owner of the village Yang-Rudomino Dusyatsky, name of the architect is unknown.

Originally the temple had a longitudinally axial composition was nave, overlap naves with cross vaults and stellate. In 1643 the hospital was founded at the church. During the Russian-Polish war of 1654–1657 years the temple was burnt by Russian troops and vaults collapsed. When restoring the tower were dismantled, the temple became one nave, the main space was blocked with wooden mirrored vault. After the restoration of the church was re-consecrated in 1673.

During the Great Northern War (1700–1721) the temple was fired from the guns and the Swedes suffered serious damage. When restoring the church Swedish nuclei were imbedded in its wall. In the years 1726–1736,

and in the middle of the XIX century it was executed murals on the vaults in the form of bunches of plants and flowers.

In 1778, a temple on the south side was added in terms of a large rectangular chapel with a crypt, ceilings barrel vault. In 1861 the church was renovated and rebuilt slightly.

In 1915, a priest of the Church of St. John the Baptist in Kamai served Belarusian poet The priest Casimir Svoyak.

John the Baptist Catholic church - one of the few Catholic churches in Belarus, which is not closed since the founding (excluding periods of recovery and restoration).

In 2007, a hurricane one of the towers was damaged. In 2010–2011 he held the entire capital restoration of the temple.

The architecture of the Church of St. John the Baptist implemented methods and forms of defensive architecture, Gothic and Renaissance. Nave in terms close to the square, to adjoin the vast semi-circular apse and a small sacristy.

The main facade is flanked by two cylindrical towers with round portholes. Tower (height of 16 m, a diameter of more than 5 m), wall thickness (until 2 meters), as well as the overall monumental character of the entire structure, suggest that the temple served and defense purposes.

The appearance of the church is almost completely devoid of decorative elements. Decoration is only four arched niches, located at the top of the main facade.

The interior of the temple stands the main altar (2nd half of the XVIII century). Altar of the two-tier, it is based on four Corinthian columns, between them in the niches of the first tier are wooden statues of Saints Peter and Paul (the beginning of the XVIII century). In the center of the altar is an icon of the Mother of God the beginning of the XVII century (founded in 1610 in Krakow). The icon is venerated by believers miraculous. Previously, it was decorated with silver frame, but in 1995 it was stolen. On the second floor of the altar - the picturesque Epiphany image crowned altar carved image of the Lord of hosts.

When entering into the state list of historical and cultural values of the Republic of Belarus in the temple counted 118 objects of historical value. Among them are the icon of the Mother of God, the wooden altars statues of saints Peter and Paul, the end of the XVIII century organ, the painting "Jesus and the orphan» (XIX century) authorship Alfred Romer and many others. In the church are kept the relics of St. Casimir and St. Stanislaus. In the crypt are buried Oshmianny Marshal.

Next to the church is an ancient stone cross XV–XVI centuries, hewn from granite boulder. The height of the cross – 2.5 m, the beam width – 1.88 m. Middle cross – triangular niche for crucifixion.

**Conclusion.** Based on the study it can be noted that the historical, cultural and educational role of the church of St. John the Baptist is quite large. The history of the development of this architectural monument shows his durability and strength to the defensive side. He also is an example of a combination of various architectural styles.

#### REFERENCES

1. Костёл Иоанна Крестителя [Электронный ресурс] // Циклопедия. – Режим доступа: [http://cyclowiki.org/wiki/%D0%9A%D0%BE%D1%81%D1%82%D1%91%D0%BB\\_%D0%98%D0%BE%D0%B0%D0%BD%D0%BD%D0%B0\\_%D0%9A%D1%80%D0%B5%D1%81%D1%82%D0%B8%D1%82%D0%B5%D0%BB%D1%8F\\_\(%D0%9A%D0%B0%D0%BC%D0%B0%D0%B8\)](http://cyclowiki.org/wiki/%D0%9A%D0%BE%D1%81%D1%82%D1%91%D0%BB_%D0%98%D0%BE%D0%B0%D0%BD%D0%BD%D0%B0_%D0%9A%D1%80%D0%B5%D1%81%D1%82%D0%B8%D1%82%D0%B5%D0%BB%D1%8F_(%D0%9A%D0%B0%D0%BC%D0%B0%D0%B8)). – Дата доступа: 10.01.2017.
2. Костёл Иоанна Крестителя [Электронный ресурс] // Википедия. – Режим доступа: [https://ru.wikipedia.org/wiki/%D0%9A%D0%BE%D1%81%D1%82%D1%91%D0%BB\\_%D0%98%D0%BE%D0%B0%D0%BD%D0%BD%D0%B0\\_%D0%9A%D1%80%D0%B5%D1%81%D1%82%D0%B8%D1%82%D0%B5%D0%BB%D1%8F\\_\(%D0%9A%D0%B0%D0%BC%D0%B0%D0%B8\)](https://ru.wikipedia.org/wiki/%D0%9A%D0%BE%D1%81%D1%82%D1%91%D0%BB_%D0%98%D0%BE%D0%B0%D0%BD%D0%BD%D0%B0_%D0%9A%D1%80%D0%B5%D1%81%D1%82%D0%B8%D1%82%D0%B5%D0%BB%D1%8F_(%D0%9A%D0%B0%D0%BC%D0%B0%D0%B8)). – Дата доступа: 12.01.2017.
3. Костел Святого Иоанна Крестителя в деревне Камаи [Электронный ресурс] // Холидэйбай. – Режим доступа: <http://www.holiday.by/by/skarb/59-kostel-svjatogo-ioanna-krestitelja-v-derevne-kamai>. – Дата доступа: 13.01.2017.
4. Камайский костел Св. Иоанна Крестителя [Электронный ресурс] // Экскурсионное бюро «Вежа». – Режим доступа: <http://www.vezha.info/novosti/77-kamajskij-kostel.html>. – Дата доступа: 17.01.2017.
5. Камаи. Костел св. Иоанна Крестителя [Электронный ресурс] // Часопіс неабьякавага беларуса. – Режим доступа: <http://stanislav-05.livejournal.com/277262.html>. – Дата доступа: 17.01.2017.

## TYZENHAUS PALACE IN POSTAVY

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*This article presents an analysis of the historical, cultural, architectural and planning aspects of the creation and history of one of the most unique architectural monuments of Postavy town – Tizengauzen Palace, which building lasted from 1788 and all the 1 st half of the XIX century. This is one of the few fully extant monuments of history and culture in Postavy district.*

**Introduction.** Beautiful little town Postavy is situated 250 kilometres from Vitebsk on the river Myadelka. For a long time it belonged to different families, the most famous are Zenovich, Radziwill, Beganskaue. But, the true glory this place gets thanks to the old and well-known since the XII century Tizengauzen family, which owned this place since 1720. Antoni Tyzenhaus, tried to turn his family estate into the centre of the cultural and industrial transformation of the region, it was an aim of including Postavy in his property. Such a small place became a rather large settlement [1, 2].

**The research part.** Tyzenhaus Palace is a monument of classicism architecture (fig. 1). Building started in the second half of the XVIII century by Antoni Tyzenhaus – the owner of Postavy. His grandnephew Constantine Tizengauz finished construction. The palace is the U-shaped building, the facades are decorated with vertical blades, between which there are large windows.



Fig. 1. Tyzenhaus Palace today

Generic nest of Tizengauzen in Postavy was visited by Russian Emperor Nicholas II. Now here there is a Postavy central district hospital. In 2006, in front of the palace was installed the monument in honour of ornithologist Konstantin Tizengauzen. The scientist is shown in full length, on his right hand two birds are sitting, and near his right leg you can see an owl – a symbol of wisdom [3].

Pastavy – is a small cosy town, with amazing energy. The memoirist and writer Gabrielle Puzynina said: "If I were asked where on earth is happiness, I would have said that there is in Postavy".

Tizengauz was doing his best to turn the town on Myadelka into the industry and cultural centre. As Minister of Economy and Finance (from 1765 to 1780 years), Tizengauz realized economic, cultural and urban reforms. He opened 47 manufactures (and not only in Postavy), military, medical and artistic school. He invited Italian architects, and turned Postavy into one of the most beautiful villages of the province.

It is known that before Tizengauzen there were no any stone buildings in this place, there were only wooden constructions. The town was granted the status of the town in 1793, but real European outlook was formed thanks to Tizengauzen.

Antony began construction of the palace during his staying in the town. For this propose, in 1760 the Italian architect Giuseppe Sacco was invited. Active reformer Tizengauzen was very busy in the transformation of Grodno, so it was not possible to complete the construction work.

In 1814 Constantine Tizengauz came into possession of Postavy (1786–1853). He continued the project of his famous grandfather. He was able to breathe life into the deserted palace, by rebuilding it in the classical style. Beautiful and strict construction has become one of the cultural and scientific centres of the Belarusian land.

Constantine was a fan of ornithology (the study of birds), and here in his estate, he created one of the most beautiful and richest in Eastern Europe ornithological museum. The museum was a database of biological faculty of Vilnius University. For almost 40 years it has been collected huge even by today's standards, collection of 3000 stuffed birds of Belarus, the Ukraine and Lithuania. In addition, the scientist wrote a series of

works, in particular the famous "Catalogue of the birds and mammals of the Grand Duchy of Lithuania and Kingdom of Poland." In the palace library, in addition to books on ornithology, there were rare examples of Polish literature, valuable prints and family archives, starting from the XIII century. These values, as suggested, is now located somewhere in Russia, Poland and Lithuania.

The northern part of the Palace of Constantine is fully equipped for the arts and sciences. Here there are offices of zoology, mineralogy and ethnography. Constantine himself with his family – his wife, two daughters and the son – lived in the western, more modest part of the palace.

The scientist took a great interest in painting. By 1840 the palace had a magnificent art gallery, in which, according to contemporaries, there were about 600 exhibits. They say that in Postavy there were original paintings of such artists as Leonardo da Vinci, Rembrandt, Dürer, Rubens, Brueghel. In addition to paintings of Western European artists, some of the best paintings of Polish and Belarusian artists have been included in the collection.

Around the family nest Tizengauzen on the area of 10 acres was located the park with picturesque ponds, numerous ceremonial walkways, and garden of exotic plants. All this beauty and masterpieces of science and art attracted numerous famous and notable guests to palace in Postavy.

Nowadays appearance of the palace has not been changed – it is the one-storey U-shaped building with a mezzanine, the territory of the palace is decorated with sculptures of white marble of Italian artists.

Paintings and books from the family nest were taken to different places (even robbed) during the First and the Second World Wars [4].

Today the palace has been restored on the outside, but inside it is still housing the district hospital with medical facilities. Around the palace there is a park, which was founded in the XVIII century and it covers the area of about 10 acres. Park is a mixture of regular compositions with exotic plants in decorative groups, here also you can see the old linden alleys and canals [2].

This strict architectural monument of the XVIII century is under the state protection. There is a ten-year program to restore the family estate of Tizengauzen. On the restoration of the palace the grant of UNESCO is received [4].

**Conclusion.** Thus, based on the study, it should be noted that the historical role and the architectural value of the palace is inseparably connected with the history of the town and the building itself. In the architecture of the Grand Palace are clearly seen characteristics of classical features: six-column portico, U-shaped layout and decorated facades. Unfortunately, most of the interior has not been survived up to these days, and the internal layout has been completely redone.

Today it is more than ever important to preserve and support the historical monuments of the country, as they can serve as a worthy example for future generations. And they could revive in the hearts of people the desire for prosperity and better standards of life.

#### REFERENCES

1. Родовое гнездо Тизенгаузов в Поставах [Электронный ресурс] // Интерфакс. – Режим доступа: <http://www.interfax.by/article/50578>. – Дата доступа: 21.01.2017.
2. Дворец Тизенгаузов в Поставах [Электронный ресурс] // Холидэйбай. – Режим доступа: <http://www.holiday.by/by/skarb/439-dvorec-tyzengauza-v-postavah>. – Дата доступа: 21.01.2017.
3. Поставский дворец Тизенгауза [Электронный ресурс]. – Режим доступа: [http://www.ekskursii.by/?place=16396\\_\\_Postavskij\\_dvorec\\_Tizengauza](http://www.ekskursii.by/?place=16396__Postavskij_dvorec_Tizengauza). – Дата доступа: 21.01.2017.
4. Дворец Тизенгауза [Электронный ресурс]. – Режим доступа: <http://yan.vydra.com/vitebsk/vitebsk18/dvorec-tyzengauza/>. – Дата доступа: 21.01.2017.

UDC 691

## THE USE OF SEA CONTAINERS FOR PRIVATE COUNTRY HOUSE CONSTRUCTION

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*Working building materials for private house construction in Belarus are reviewed. The use of sea containers for private country house construction is analyzed. The example of a block-containers house built in Belarus is given.*

Nowadays more and more people want to be closer to nature and move away from the hustle and bustle of a city and as a result they move to live outside the city. Today bricks, gas silicate blocks and expanded clay concrete blocks are the most popular building materials in Belarus. The houses built of these materials require additional interior finishing.

There has been an increasing tendency to fall back on various types of original construction to reduce its cost. Sea containers construction is one of them.

Containers construction is a novelty in private houses construction, which is popular in Western countries. Today it is the best alternative to conventional construction in Belarus.

Container houses are as good as silicate block, brick or wood houses in quality and excel at constructional features on some occasions. Container houses building costs 20–50 % cheaper, needs a short period of construction along with no seasonal fluctuation. A container house is a full-fledged dwelling private house, warmed both inside and outside, with all the necessary facilities (heating, water, electricity, drainage, ventilation), along with any kind of interior and facade finishing, any planning and interior design, which can be put into practice at any customer's request. It is warm and comfortable all year round indoors [1].

A multi-roomed, multi-storied, comfortable dwelling private house or office building can be constructed of containers.

Only three 40-footed containers are necessary to get a 100 m<sup>2</sup>-120 m<sup>2</sup> area house (fig. 1). The construction of such a house will take from 3 to 4 months. Container house construction for private needs does not require any complicated technological processes. It is only necessary to purchase one or two blocks of containers, which are placed near or at an angle to each other (for example, like the letter "T"), or mounted on each other [2].



Fig. 1. Container construction

To make the facade more complicated and create an aesthetic appeal, you can slide two containers relative to each other or push the container push the container, erecting a spacious living room with maximum glazing in between.

Since containers are for maritime needs they are engineered to withstand bad weather conditions. Steel of such containers is galvanized and profiled, which provides reliable protection against corrosion, as well the area

is ready for finishing. The interior walls are made of lumber. Molded plywood is used as the main building material. Plywood is treated with various compositions to overcome the growth of mould or fungus.

Due to the fact that the weight of containers is only from 2.3 to 4.0 tons the load on the foundation is not so huge. Post footing fits well for container building. [3]

It is necessary to make weatherproofing if the living in the house is planned to be all year round. Weatherproofing can be made by any heat-insulating material (expanded polystyrene, mineral wool, basalt wool, etc.). However, the question arises: which side of the container should be insulated – outside or inside. Both outside and inside can be insulated, but to make the right and final choice, it is necessary to take into account some additional points due to the fact that metal is rather a specific material, fundamentally different from other materials for its high thermal conductivity, absence of porosity and high propensity to corrosion. If the house is used only in warmer months, it makes sense to insulate the outside part. If the house is used in all seasons, the best solution is to insulate it from the inside, avoiding thermal bridges.

If desired, the exterior walls are sheathed with siding. It also can simply be painted with metal paint in a juicy bright or discreet color with the help of spray or draw all over the facade [4].

This type of construction has long been popular in many countries of Europe and America, and is increasingly finding its application in Belarus. The example of such a house built in the Minsk region is shown in figure 2. The metal structure was used as a foundation. Then on it with the help of a crane were installed two block containers already insulated and sheathed with wood. Then with the help of a crane two block containers already insulated and sheathed with wood were fixed on it. The installation process took 2 days. Then the works on the communications connection (water, sewer, electricity) were carried out. The total area of the house is 32 m<sup>2</sup> [3].



Fig. 2. Container house built in Minsk region

**Conclusion.** In view of the foregoing considerations it is logical to assume that container private house construction is developing rapidly. Such a construction is gaining popularity due to such advantages as low cost, fast construction time and availability of materials. Private country houses are built increasingly of containers in Belarus today.

#### REFERENCES

1. Дома из контейнеров под ключ [Электронный ресурс] // Экскурсии. – Режим доступа: <http://profstroyka.by/>. – Дата доступа: 28.11.2016.
2. Дома из контейнеров [Электронный ресурс] // Строительство и ремонт своими руками. – Режим доступа: <http://nauchite.com/>. – Дата доступа: 22.12.2016.
3. Дом-контейнер: минчанин построил альтернативу обычной даче [Электронный ресурс] // Информационный портал Беларуси. – Режим доступа: <https://www.onliner.by/>. – Дата доступа: 22.12.2016.
4. Дома из контейнеров – разнообразие вариантов и особенности строительства [Электронный ресурс] // Обустройство загородного дома и участка. – Режим доступа: <http://greensector.ru/>. – Дата доступа: 22.12.2016.

**CONSTRUCTION MATERIALS, CONSTRUCTION METHODS  
IN THE BELARUSIAN DNEIPER REGION**

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*Traditional materials which were used for building of inhabited and economic constructions in the Dnieper region are considered. The analysis of the main receptions by means of which construction was carried out is given.*

**Introduction.** Wooden construction since ancient times was considered as one of the most important crafts. Existed many masters, experts capable build a log hut. But peasants most often counted only on the forces. To buy a ready blockhouse, to employ workers to construction it was expensive. Therefore preparation of materials for construction, even peasants carried out construction of the base, a blockhouse, overlapping and a covering. But usually involved experts to joiner's operation and a laying of furnaces. At construction of any construction it was very important to plan all construction process since together with it, in parallel, it was necessary to perform a set of agricultural works. In order that in short terms to perform large volume of works (and it concerned not only constructions), it was accepted to help with the Belarusian villages to all to someone to one. Women and teenagers took part in work even. They performed not really hard work: dug clay, prepared a moss.

Ready constructions differed in a big variety, everyone built in own way. And here works of experts usually differed from each other a little. But, despite it, building never was monotonous, and internal space identical. In each separate case the amount of works executed by experts and peasants was various, views and tastes differed. Places for construction always were different, unique, too.

**Choice and preparation of construction materials.** Wood was the most widespread construction material in the territory of Belarus. At the end of 17-18 centuries the territory of Belarus more than on a half was covered with the woods [1, p. 266]. In spite of the fact that constantly felled trees, woodiness of Belarus remained rather high.

Wood for a blockhouse was prepared in advance, in the winter when all wood juice departed in a root. At the same time chose those trees from which never took the resin. The material prepared in the winter had more resistant and hardy wood. Log huts from such wood could stay 100-150 years.

The wood at the age of more than 80 years was in the most great demand. Most often at construction used a fir-tree or a pine. Did a base, the lower wreaths of a blockhouse, and also separate elements of an oak: thresholds, window sills, etc. Oak wood very resistant and durable therefore was always in demand. But at the same time its massiveness and hardness demanded great efforts when processing. The log huts entirely constructed of an oak in the Dnieper region almost did not meet.

It was forbidden to use in construction the trees which are tumbled down by a storm: was considered that the log hut from such logs will be destroyed by sooner or later. Also it was impossible to build log huts of a dead wood. The dry tree was opposed green, and people believed that in such construction nothing live will get accustomed. But for building of economic constructions on the contrary recommended to use dry trees since there will be no mice, and hay will be protected from moisture. For the same reasons it was allowed to build barns and barns of trees to which the lightning got, but at construction of log huts and sheds it was not admissible. It was strictly forbidden to use in construction trees which grew at the cemetery, near church.

The aspen was considered as a bad tree therefore to build log huts and sheds of an aspen it was not recommended. This rule did not extend to buildings in which hay was stored. But, already at the end of 19 beginning of 20 centuries did not follow this rule any more. In inhabited and economic constructions the alder and an aspen was widely applied. Perhaps solid calculation and a practicality were more important.

Materials in construction used homogeneous (one breed of wood, at one time preparations, etc.). In important elements (rafters, support, beams) wood with defects was not used. Did not use a combination in designs of one type of different breeds of wood. For example, krokva of roofs did only of a fir-tree or only of a pine. Poles which pressed the top layer of a straw roof did only of young birches. An exception is the lower wreath of a blockhouse which carried out a base role. It was usually done of stronger wood, than a blockhouse, and often bigger diameter. Together with improvement of functional characteristics, it did a construction steady visually.

At construction of constructions tried to use a square form in planning. It helped to facilitate material preparation since for a blockhouse logs of one length were required.

**Construction receptions.** Joiner's skill united a set of receptions: trimming, split, cut, gouging, drilling, etc. Possession of these receptions and ability to apply them in different works defined not only skill of one person, but also the general level, local style.



Before beginning construction of any buildings, it was necessary to decide on the place of construction. Special attention was paid to the choice of the place for construction of housing. At the same time leaned as on purely rational reasons (character of soil, proximity of a reservoir, a surrounding landscape, the neighbourhood, etc.), and on centuries-old traditions. It was not allowed to construct the house on crossing roads, on the abandoned roads, on the place where there was a bath earlier. Preference was given to earlier made habitable tried places where already once there was a house in which life was peace and happy [2, p. 77].

Country estates were close, and it did not allow to carry out construction works directly in the yard. Therefore blockhouses cut somewhere on an empty seat, or directly in the wood. After the blockhouse was ready, each log was marked with certain signs, the blockhouse was sorted, transported on the site and anew collected. In transit logs of walls each log was marked with a notch. In each wreath from the lower log to top on one notch there was more. That is count was kept from below up. Notches did at end faces of logs, but tags and about a blockhouse corner met.

If there was a lot of place, free for construction, the blockhouse was cut from several parts – on 4-5 wreaths. It allowed to facilitate work since it was not necessary to lift logs on big height. After shrinkage blockhouses sorted and gathered already on the base. Despite uniformity of many elements, everyone was individual. Everyone was made only for that place on which was established. Therefore often elements adjusted already in installation time.

Designs of roofs adjusted not on the earth, and above, directly on the put-up walls. But farms and subrafter frames for big and high constructions collected on the earth. That is, while one builders put up walls, nearby collected a roof design, the sizes of the plan were already known. Then the design aimed, understood and rose upward. And already gathered on the put-up walls according to notches. It allowed to make work easier since designs had the considerable sizes and weight.

Separate elements and building constructions steadily fastened by means of a chisel and drills as iron nails were not used. The axe of different types was the main tool, everyone was adapted for these or those works. The ordinary axe, a splitting axe which split logs into flat boards, axewith the wide edge ground on the one hand for a hew of logs and others. The joiner's saw was known in the 14th century, but was especially widely applied from 19 century. Then even more often used also a longitudinal saw by means of which split logs and bars. Sawing of boards is frequent it was allocated in separate trade, and sawyers went from one settlement to another and offered the services. But in rich estates since 18 century there were already sawmills.

**Conclusion.** Thus, construction of housing was surrounded with various deep and steady traditions which helped to make a right choice of the place for construction, not to be mistaken with construction materials and time of work and since. They were formed throughout many generations, and bear with themselves centuries-old experience. But, at the same time, peasants were guided also by practical reasons. Strict calculation allowed to find the most optimum methods and ways of construction. Being imposed at each other traditional customs and a practicality allowed to build taking into account functional mission of rooms, their relationship in the general ensemble of domestic building, and also with the environment.

#### REFERENCES

1. Лакотка, А. І. Беларусь : у 8 т. / А. І. Лакотка ; рэдкал.: В. К. Бандарчык, М. Ф. Піліпенка, А. І. Лакотка. – Мінск : Тэхналогія, 1997. – Т. 2 : Дойлідства. – 391 с.
2. Цітоў, В. С. Этнаграфічная спадчына. Беларусь. Традыцыйна-бытавая культура : вучэб.-метад. дапам / В. С. Цітоў . – Мінск : Беларусь, 1997. – 207 с.

## STYLISTIC FEATURES AND TRENDS IN THE CONSTRUCTION OF CATHOLIC CHURCHES IN THE NORTH OF GRODNO REGION

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*Unique monuments of archeology, architecture and culture has been preserved in the North of Grodno region of Belarus. They represent the history of the formation of the Belarusian state. In the article the author has considered stylistic features and tendency in the construction of Catholic churches with their characteristic shape due to the rich cultural tradition of the region, based on mutual influence of Byzantine and Roman culture, local climate and level of construction equipment.*

Grodno region is located in the North-Western part of the country, it borders on Poland and Lithuania. The river Neman flows through the region, it stretches almost for one thousand kilometers across Belarus and Lithuania (Fig. 1).

The architectural and town-planning heritage of Grodno region is widely known. Here, on the banks of the Neman river as in no other region of Belarus, a great number of objects of monumental architecture has survived. Strengthenings of Grodno, Lida, Novogrudok and Krevo, together with other Belarusian, Lithuanian and Ukrainian castles formed a defensive system of national importance in the times of the Grand Duchy of Lithuania. Also it played a great role in fight against attacks of crusaders. Before the victory over the Teutonic order in the battle of Grunwald in 1410, fortresses and castles of the Grodno region were strongholds of defense.

Many cities, towns and villages of Grodno region in its Central parts have preserved the architectural features of past centuries, as well as dozens of works of architecture and culture. Many of them, fortunately, have not been touched by the urban transformations of recent centuries. Slonim and Novogrudok, Krevo and Golshany, Zhirovichi and Dyatlov are unique in its shape, and attractive for historical and architectural ensembles, noteworthy landscapes. But there are towns, which stand out by complex, multi-faceted beauty, that were born from the layers left by different eras and artistic styles. Grodno is a beautiful city [1]. Buildings of different ages coexist in the streets and squares, and it does not seem incompatible, and, on the contrary, makes surprising unity and appeal.



Fig. 1. – Map of the Grodno region

Many Catholic churches have been preserved in Belarus. Most of them belong to the historical and cultural heritage protected by the state [2]. Thanks to the support of government for the last few decades, many

Roman Catholic churches of Belarus recently have been restored or reconstructed, most of the churches are used by Roman Catholics nowadays.

Belarus has an exclusively rich natural, historical and cultural potential favourable for tourism. The relatively mild climate combined with landscapes: forested and open space, abundance of rivers and lakes, there are no extensive industrial areas. The Republic has the compact territory, a dense network of rural and urban (especially small and average) settlements, the developed infrastructure of road communications of various level. In urban and rural areas there are 1 834 archaeological monuments, 1597 – architectural, 1131 – historical, 122 – monuments of art, about 100 centers of folk arts and crafts, dozens of local areas of traditional weaving and embroidery, pottery, weaving, etc. In addition to natural reserves and sanctuaries, there are towns that represent complex reserves where historic environment coexists with the traditional and everyday way of life.

Tourism is one of the largest sectors of the world economy, which is developing dynamically, trying to take its proper place in the economy of our state. Numerous tourist routes of various subject and directions are currently developing.

Unique monuments of archeology, architecture and culture has been preserved in the North of Grodno region of Belarus. They represent the history of the formation of the Belarusian state. Monuments of architecture and history of Grodnenshchina occupy an important place in cultural heritage of Belarus. The most famous of them are the churches in the villages Mihalishki, Gervyaty, Doylidki, Kemelishki, Gudogay.

There is an old architectural ensemble of the 18th century in the village Vorniany. It consists of St. George Church, vicarage, apothecary's house, rustic residential architecture. Baruny village stands out in Oshmyany district, where preserved a magnificent church; and Catholic church and the ruins of the castle genus Sapieha have preserved in the town Golshany[3]. There are ruins of one of the oldest medieval castles on the territory of the Smorgon district in the Krevo village. The most important state events held in the castle in ancient times, and now Krevo castle is one of the most important architectural monuments of Belarus. And there is a beautiful Palace of Oginski in Zalesie (Smorgon district).

The cathedrals of the North of Grodno region are interesting for tourists, their rich internal and external decoration, the variety of forms, and, at the moment, good condition, serve as a good motivation to take a trip and visit the cathedrals of Belarus. Cultural and historical heritage and Roman Catholic churches of Grodno region attract many tourists.

Exactly cult constructions are the material certificate of rich history of the region. Churches and monasteries decorate historic centers of the cities and the rural settlements of Grodnenshchina. The formation of distinctive architecture took a long time, but if talking about the Northern patterns of the Grodno region, it is necessary to mention the usage of the types of monastic construction and organization of the space of the Church that was formed in the West. However, in Belarus there were churches and monasteries with their characteristic image due to the rich cultural tradition of the region, based on mutual influence of Byzantine and Roman culture, local climate, and level of construction equipment.

Short distance of the northern region of Grodno region from Vilnius (about 30 km) made the region surroundings of the capital and it had always been considered as Vilenshchina in the regional literature.

Regional and historical dependence on Vilnius affected the specificity of the architectural heritage of the region. At the end of the XIV century, this region, together with Vilnius, was baptized in the Catholic rite (1387), so all the surviving monuments of sacred Christian architecture are of Catholic origin.

Large parcels of land and many villages of the Northern region belonged to the Vilnius biskupstwo since ancient times. The first written information about most ancient cities and settlements of the region about the foundation in their Catholic parishes is connected with Historical events since the formation of the Grand Duchy of Lithuania and the expansion of Catholicism. The first churches, obviously, were constructed from traditional local construction material — wood, but, in view of its fragility, several times rebuilt, changed their shape and did not reach our time. More durable stone temples appeared only in the XVII century, its architecture clearly reflected the influence of the architecture and art of the Baroque style that prevailed at that time in the temple construction in Western and Central Europe, but the Belarusian architecture acquired its original features due to the strong local building traditions.

The middle of XVII century was noted by long-term war between the Commonwealth, on the one hand, and Russia and Sweden - on the other. The arena of this war, which received in history the name "blood flood", was the territory of the Grand Duchy of Lithuania. Almost all cities and towns were looted and burned, mostly wooden buildings and a few stone structures, especially Catholic churches. For example, the village Mikhlishki in Ostrovets region, located on important waterways, had strategic importance and also suffered during this war. Probably, the first stone church in honor of St. John Baptist was built at that time [4]. The Fund for the construction of a new Church was made after the armistice of the Commonwealth with Sweden, by the son of the first founder, - Ian Brzustowski in 1662. The author of the construction is considered the architect of Belgian origin Christoph Pence, which founded a whole dynasty of architects and decorators in the Grand Duchy of Lithuania.

During "the flood," in 1659, the first local treatise on architecture and construction in Commonwealth came in Krakow, which began with the preface "to have the opportunity" and urged them to build accordingly, "its sky and custom", it means according to their traditions, climate and lifestyle. Local traditionalism, patriotism, chivalry, reinforced by military events, are characteristics of the ideology of that time, which is called in science "Sarmatism". This phenomenon is genetically derived from the name of ancient free tribe of the Sarmatians, representatives of the local nobility were their descendants. The combination of ideology Sarmatism with the art of the European Baroque style, which was gradually extended in the Belarusian sacral architecture during XVII century, led to the formation of a distinctive movement of "Sarmatian" Baroque. The Church of Archangel Michael in the village Mikhalishki of Ostrovets district became the first work of this style in the history of Belarusian architecture.

The following architectural and artistic direction of the late Belarusian Baroque, called the "Vilensky baroque", is an original and significant phenomenon in the history of European art.

Many of the ancient shrines of the capital of the Grand Duchy of Lithuania suffered greatly during the fire of the city in 1737 and 1747. Their recovery required a lot of effort and money. At that time in Vilnius foreign and local architects, decorators, craftsmen of various building trades worked together, they rebuilt the city, gave to his shrines more modern European look. As a result of that activity in the middle of the 18th century distinctive architectural and artistic style developed, it was called in the history of art "Vilensky baroque". Two high tiered openwork towers on the main facade, which have a telescopic structure characterize the churches of the Vilensky baroque. The tiers of the tower gradually are decreasing upwards in size, which gives them a strong stereoscopic perspective and makes the visual more high and exalted. The openings of the towers had a complicated curved outline, were cross-cutting, it created a beautiful lace pattern on a background of the sky, made architectural structure easy and supposedly intangible. This illusion was strengthened by wavy outlines of the plans and facades of buildings, order decor, gorgeous altars, which created unclear boundaries between space and weight of building material, it was significantly different from the extent of the Sarmatian Baroque of early age.

The new direction of the late Belarusian baroque, called vilensky, soon spread throughout the country and, of course, did not pass the region closest to the capital. Stone Church of the Exaltation of the Holy Cross in the village Bystritsa was built in vilensky baroque style in 1760-1761. with help of donations of parishioners, at the same time the construction of a stone church in the village Vorniany was begun. The Church of St. George in Vorniany was built in the vilensky baroque style in 1760-1769 and was consecrated by Bishop of Vilna, Ziankovich [5]. The emphasis, according to its dominant role in the ensemble, is made on the main facade of the Church, which extends beyond the main volume and is defined by elegance and delicacy of the silhouette. The main attraction of the village Boruny of Oshmiany district is the Church of Saints Peter and Paul, which was built in 1757. This Church is striking embodiment of the architecture of the vilensky baroque style. This unique temple is located in the heart of the village.

In addition to stone religious buildings in the North of Grodno region several valuable monuments of wooden sacral architecture survived. It is obvious that all extant monuments of wooden religious architecture of Belarus have common features in the spatial composition and modest decorative decision. They were originally built in the Baroque style, then were rebuilt or restored on the old foundation and acquired new architectural and artistic styles, but firmly maintained local tradition of carpentry of the North-West of Belarus.

Residents of Grodno region since ancient times have treated God with great respect. Majestic artistic temples, numerous chapels are the evidence of that. They convey to us the long history of the folk, suffering fate of the nation, its commitment to the welfare, peace, religious respect and human ideals. The temples are shrines, which are carefully passed down from generation to generation. People guarded them from historical disasters to pass in the future in valuable spiritual treasure, unchangeable value, embodied in churches, - the soul of the nation.

#### REFERENCES

1. Харэўскі, С.В. Культывая архітэктара Заходняй Беларусі / С.В. Харэўскі // Искусство и культура. – 2012. – № 3(7). – 18 с.
2. Кулагін, А.М. Каталіцкія храмы Беларусі / А.М. Кулагін ; фатограф А.Л. Дыбоўскі. – Мінск : Беларусь. Энцыклапедыя імя П. Броўкі, 2008. – 488 с. : іл.
3. Збор помнікаў гісторыі і культуры Беларусі. Гродзенская вобласць / гал. рэд. С.В. Марцэлеў. – Мінск : Беларуская савецкая энцыклапедыя імя Петруся Броўкі, 1986. – 408 с. : іл.
4. Памяць : гіст.-дакум. хроніка Астравецкага раёна / рэд. кал.: Г.П. Пашкоў (гал. рэд.) [і інш.] ; маст. Э.Э. Жакевіч. – Мінск : БелЭн, 2004. – 632 с. : іл.
5. Гісторыя вёсак і мястэчак Астравеччыны [Электронны рэсурс]. – Рэжым доступу: <http://astraviec.org/cms/index.php?option=com>. – Дата доступу: 21.09.2016.

UDC 624.078.412

## BUTT JOINTS OF LONGITUDINAL REINFORCEMENT MONOLITHIC COLUMNS.

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*In this article the variants of jointing of the longitudinal reinforcement of columns in the designing of monolithic multistory buildings are discussed. There are made recommendations for the choice of method of jointing the reinforcement.*

In the construction industry in the formation of reinforcement cages regulations for the continuity of the rebar to the entire length of the structure are provided. As a rule, the maximum continuous length of rebar is limited as follows:

- The maximum length of rebar (from 11.7 m transportation conditions).
- Design considerations (for example, in the formation of columns installed rod length does not exceed the height of two floors).

To ensure continuity of reinforcement rods separate in-built conditions, the following methods are used:

- joints of reinforcing bars without welding lap joint (Fig. 1);
- splicing of reinforcement by welding;
- joints in reinforcing bars using special mechanical devices, for example, crimping or threaded couplings.



Fig. 1. Joints of valves without welding, The OVERLAP of rebar

The most common at the moment is the junction of the overlap, but it has a number of drawbacks, and its scope is rather limited. Among the disadvantages of this method should be noted: the consumption of rebar at the junction of the overlap in structures having sections where, due to the overlap of the reinforcement is doubled and there are difficulties with the concrete mixture.

Depending on conditions of valves and the number of joints in one section, overlap length leads to the loss of from 3.5 to 27% of rebar in its diameters and length of the abutting rods 6.0 m. The highest metal losses occur when matching rods of large diameters – accordingly to [1]. However, the problem is not limited to this. To guarantee the strength of such a connection requires a significant consumption of transverse reinforcement and minimum values of volumetric reinforcement should be, for example, not less than with concrete strength.

In addition, the use of lap joints for joining the armature of big diameters leads to restriction of the volume of concrete in the joint and the danger of reducing the actual strength of reinforced concrete element, which is especially dangerous in the columns and other compressed under the operation of reinforced concrete elements of relatively small cross-section.

For this reason, as shown practice, the cost of joining goes to the second plan.

The chief is the operational safety of the building. Therefore, in most countries, including the UK, USA, Germany, for splicing rebar diameter used mechanical connections, guaranteeing the reliability of the structure.

In our country is still generally accepted method of connection valves for installation welding: manual arc long seams, lap joint, and with linings, bath suture and layered seams on steel clamp-plate and arc in the cross.

For the splicing of reinforcing steel these types of arc welding can be applied almost without limit, but require significant energy consumption and labor costs, and strict systematic control.

An alternative to traditional methods of splicing reinforcement is received at the moment, a wide spread method of splicing rebar using threaded end connections. There are several concepts jointing fittings for couplings with cylindrical thread, crimp couplings and couplings with conical thread [2, 3].

The joints of the longitudinal reinforcement of the columns in monolithic multi-storey buildings are set in the top of the slab. The unit joints, due to the way the butt joint rods, and a set of design requirements.

In SNP 5. 03.01-02 it is not recommended to use lap bars with the diameter more than 25 mm, and the docking of lap bars with the diameter more than 36 mm are not allowed. Besides, the length of overlap in SNP 5. 03.01-02 reaches 40–50 diameters of the abutting rods ,which is about 40% of the height of the floor of a residential building. In this regard, the use of connecting rods of rebar overlap also becomes economically disadvantageous.

To reduce the consumption of steel and facilitate the concreting of the columns with the reinforcing bar diameter or more we should perform the splicing of rebar in the end through a bath of weld or crimp couplings [4]. When the diameter of the reinforcing bars is prior to and include the valves lapped it should be fit without welding.

Figure 2 shows a diagram of the intersection of the longitudinal bars of the column with reinforcement bars in top of slab with the same and different cross-section columns, lower and upper floors. In this case, the transfer of the rods from one floor to another column by limb releases with a slope not exceeding 1: 6. Part of the rods of the columns of the lower floor can be brought to the top of the ceiling and did not start at the top of the column, if the interrupted reinforcement by calculation is not needed in the column of the top floor [5].

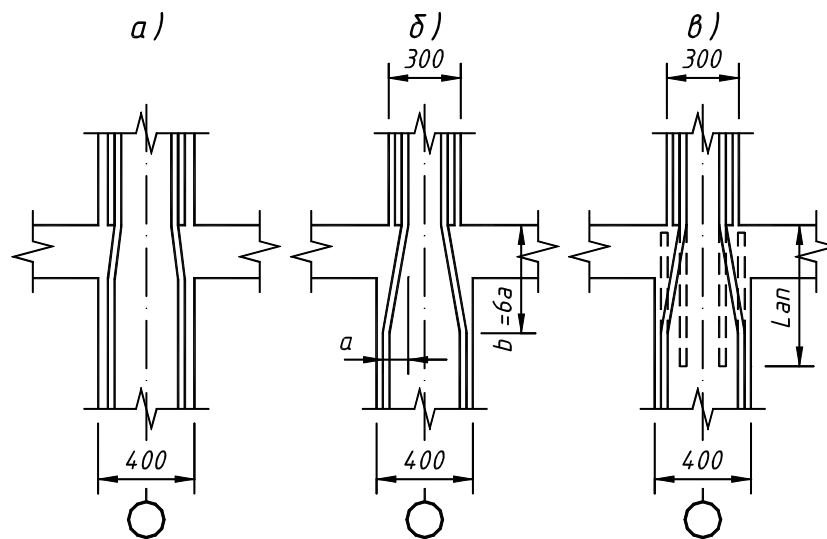


Fig. 2. Diagram of intersection of the longitudinal bars of the column with reinforcement bars in top of slab (transverse reinforcement of columns, reinforcement of the floor slab is not shown):

- a) with the same cross section of columns, lower and upper floors;
- б) at various cross-section columns, lower and upper floors;
- в) at various cross-section columns, floors and breakage of the longitudinal the bars of the lower column

In accordance with the recommendations given in [5], when constructing the longitudinal joint of rods of monolithic columns with reinforcement bars bar diameter is not limited to diameter  $d_s = 18$  mm, and to  $d_s > 28$  mm and to reduce the consumption of rebar at floor height or less 3,6 m when the joints of the longitudinal bars of the column are made through the floor.

The calculation of the required anchorage length shall take into account the type of reinforcing steel and properties of adhesion to cores is determined by the formula [6; 7, the formula (3.41)].

$$l_{bd} = \alpha_1 \alpha_2 \alpha_3 \alpha_4 \alpha_5 l_{b,rqd} \geq l_{b,\min} ,$$

Where  $\alpha_1, \alpha_2, \alpha_3, \alpha_4$  and  $\alpha_5$  shown in Table 8.2 [6] factors:

$\alpha_1$  – to account for the influence of the shape of rods with adequate protective layer;  
 $\alpha_2$  – to account for the effect of the minimum thickness of the protective layer of concrete;  
 $\alpha_3$  – to account for the effect of enhancing the transverse reinforcement;  
 $\alpha_4$  – to account for the influence of one or more cross-welded rods ( $\varnothing > 0,6\varnothing$ ) along the effective length of anchoring;  
 $\alpha_5$  – to account for the influence of transverse pressure to the plane of splitting along the design anchorage length.

$$l_{b,rqd} = \frac{\varnothing}{4} \cdot \frac{\sigma_{sd}}{f_{bd}} = \frac{\varnothing}{4} \cdot \frac{\sigma_{sd}}{2,25\eta_1\eta_2f_{ctd}},$$

the basic length of the anchoring, which in turn depends on the design resistance of the reinforcement  $f_{yd}$  to tension, the estimated resistance of concrete to tension  $f_{ctd}$ .

$\eta_1$  – the factor taking into account the quality of the grip conditions and position of bars during concreting:  
 $\eta_1 = 1,0$  – if achieved good adhesion and  
 $\eta_1 = 0,7$  – for all other cases and for structural elements that were made with the use of slip formers, unless it can be shown that provided good adhesion;  
 $\eta_2$  – the factor taking into account the diameter of the rod:  
 $\eta_2 = 1,0$  ( $\varnothing \leq 32$  mm);  
 $\eta_2 = (132 - \varnothing)/100$  ( $\varnothing > 32$  mm);  
 Piece  $\alpha_2\alpha_3\alpha_5 \geq 0,7$ ;  
 for anchorage in compression:

$$l_{b,min} \geq \max [0,6l_{b,rqd}; 10\varnothing; 100 \text{ mm}].$$

In any case, the actual length of embedment shall not be  $0,6 l_b$ , and equally and no less  $15\varnothing$ .

So when used for the erection of monolithic pillars of concrete C 20/25 and installation of rebar in the column, the base of Dean Embedment is:

$$l_{b,rqd} = \frac{\varnothing}{4} \cdot \frac{\sigma_{sd}}{f_{bd}} = \frac{18}{4} \cdot \frac{435}{1,82} = 1075 \text{ mm},$$

$$f_{bd} = \eta_1 \cdot \eta_2 \cdot f_{ctd} = 0,7 \cdot 1 \cdot 2,6 = 1,82 \text{ MPa}.$$

In the absence of stock on the valves and the compressive stress of the longitudinal bars of the column ( $\alpha = 0,9$ ), the length of the reinforcing editions is:

$$l_{bd} = \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5l_{b,rqd} \geq l_{b,min},$$

$$l_{bd} = 0,7 \cdot 1075 = 752,5 \geq 645.$$

Figure 3 shows an example of a device of the joint of reinforcing bars by using the reinforcement bars in top of slab. The length of the reinforcing editions of four rods in the corners of the column is the  $2 \times l_1 = 2 \times 550 = 1100$  mm. Length of the reinforcing releases for the rest of the rods of the column is thus 550 mm, the area of the longitudinal bars of the column, docked in one place, is 50%.

If the column is reinforced with four longitudinal bars, the joint bars without extension are arranged. The length of the reinforcing editions of leaves:

$$l_{bd} = \alpha \cdot l_b \cdot \frac{A_{s,req}}{A_{prov}} = 2 \cdot 785 \cdot 1 = 1570 \text{ mm}.$$

It should be noted that columns in the modern multi-store multi-use buildings are characterized by the emergence of considerable effort because of the increased cargo space of columns, number of storeys of buildings and loads. Therefore, the provisions of [4] allowed the increase of the reinforcement ratio of the columns (including the areas with lap joint rebar) before 10%.

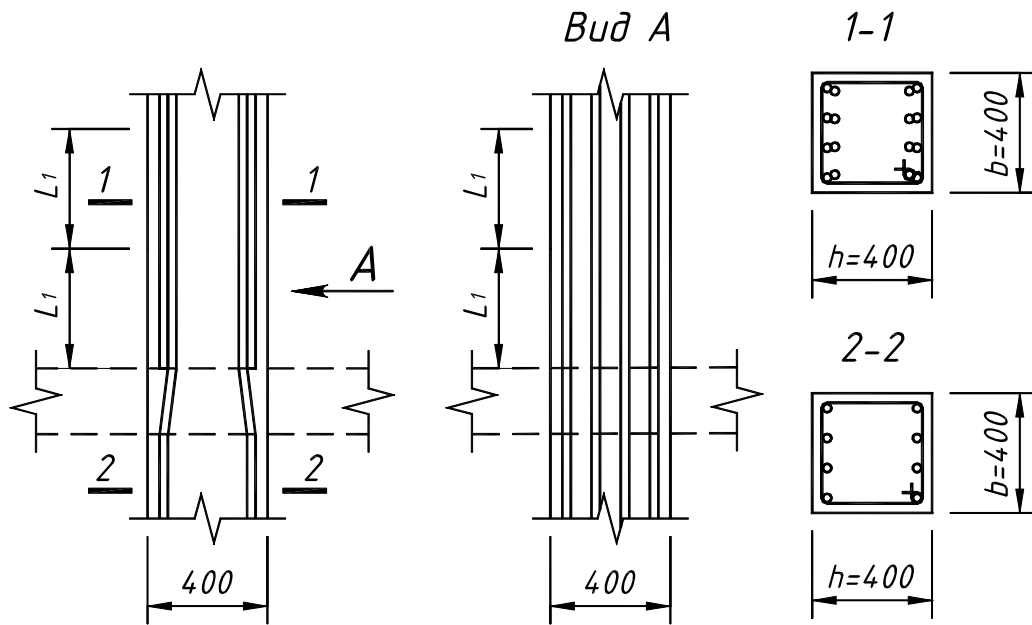


Fig. 3. An Example of a device of the joints of the reinforcing bars are spliced without welding

The reinforcement ratio may be reduced by the use of welded and mechanical joints of reinforcement due to the absence in these compounds the pen start, and accordingly the thickening of the valve.

Figure 4 a shows the design of the junction of the rods the longitudinal reinforcement of the column using a bath welding ( $d_H = 20 - 40$  mm,  $d_H / d_H' = 0,5 - 1$ , S500).

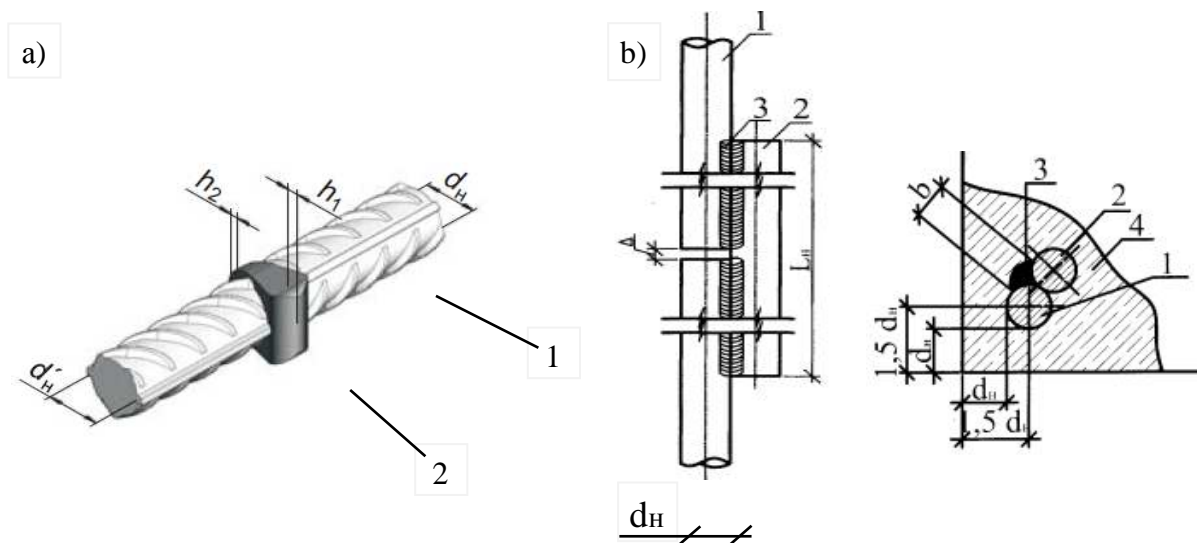


Fig. 4. The design of the junction of rods longitudinal reinforcement columns with the use of welding bath:

- a) no overlays: 1 – working-valves, 2 – weld;
- b) pick guard: 3 – panel, 4 – concrete columns

When connecting the valve with the use of welding bath in selection, design and dimensions of the joint shall be in accordance with the procedure outlined in [10].

The joint of rods of longitudinal reinforcement with the use of welding bath and overlays is shown in figure 3b ( $d_H = 20 - 32$  mm,  $d_H = d_p$ , S500) [11].

The design of the building, the choice of junction of the longitudinal bars of the columns by welding must be technically and economically feasible, as related to the technological capabilities of construction organiza-



tions in terms of the availability of equipment, qualified welders and the ability to organize the regulation of quality control of welding works.

The butt joint of the reinforcing rods can be provided without welding with couplings (crimp and screw).

Equipment for mechanical connections using crimp couplings represented in the domestic construction market hydraulic crimping presses SN-50/80, SN-90/80, PP-A80. Press and crimp couplings designed for joining of reinforcing bars of the same diameter  $\text{Ø}16\text{-}40\text{mm}$  and different diameters  $\text{Ø}36/\text{Ø}32$ ,  $\text{Ø}36/\text{Ø}28$ ,  $\text{Ø}32/\text{Ø}25$  mm classes A400, A500C, A600C [12, 13].

The advantage of the connection reinforcing bars using crimp couplings is saving of rebar compared to the butt lap joint, the simplicity of training and the relative speed of execution of the junction (10 min) in comparison with a welded joint. However, the size ( $650 \times 250 \times 160$  mm) and weight (35 kg) crimping tool can make it difficult to use crimp couplings for joining rods of the longitudinal reinforcement of monolithic columns in a specific building project.

Threaded couplers for splicing reinforcement in the construction market presents couplers Lenton Dutch ERICO. They are used for splicing reinforcing bars periodic profile with a diameter from 12 to 40mm of classes S400, A500C. The abutting members can be of the same diameter (standard coupler connection type A12) and different diameters (transition joints connection type R11). While one of the rods must rotate freely. Mechanical joint type A12 and R11 are manufactured on equipment of the company ERICO by cutting tapered threads on the ends of the reinforcing rods and their coupling through the coupling with the corresponding studs thread. Tapered thread couplers Lenton allows to reduce the size of the couplings, as well as to avoid stress concentrations in the joint. Splicing two reinforcing bars of large diameter is not more than 5–10 minutes. NIIJP issued technical conditions for the application of couplers Lenton [14].

If for the reinforcement of columns used screw reinforcement bars, in this case, the threading at the ends of the reinforcing bars is not required and splicing of rebars simplified [13, 15].

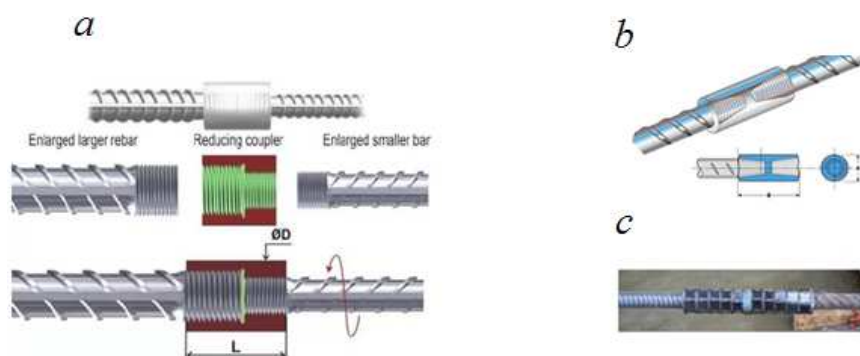


Fig. 5. The design of the junction of the rods the longitudinal reinforcement of the column with the use of special mechanical devices:

- a* – Coupler with parallel thread Bartec;
- b* – threaded couplers (couplers Lenton tapered thread);
- c* – cu compression (crimp) couplings

If for the reinforcement of columns used screw reinforcement bars, in this case, the threading at the ends of the reinforcing bars is not required and splicing of rebars simplified [15, 17].

The test results of the strength of the couplings on the thread, given in [16], provided a basis for recommending to perform the joints of the rods of the longitudinal reinforcement of the column extension. That is, the number joined in one cross-section of the column bars shall be not more than 50%. The distance between the closest edges of the coupling taken not less than  $0.5 \times l_{an}$  and at least 40% of the length of the coupling. At the junction it is necessary to provide additional transverse reinforcement.

**Conclusion:** It should be noted that inclusion in standards for designing reinforced concrete monolithic structures of buildings [4] recommendations for the splicing of rebar with screw and crimp couplings can be seen as a recognition of the connection method of reinforcement popular and economically viable.

## REFERENCES

- Mateljan, W. New materials and technologies for reinforcement works in-situ reinforced concrete / W. Mateljan // Technology of concrete. – No. 3-2006, V. 52–54.
- Kolchanov, I.E. Coupling periodic structure / A.A. Veselov, I.A. Kolchanov, E. Letko // Actual problems of modern construction : abstracts. 64th Int. Conf., Saint Petersburg, 05-07 Apr. 2011. – Saint-Petersburg, 2011. – Part II. – P. 131–134

3. STO SRO-60542960 00011-2012 "Requirements for mechanical connections of reinforcement of reinforced concrete structures, provided the documentation, at performance of works on construction, reconstruction and overhaul of nuclear facilities". – 60 p.
4. SP 52-103-2007. Reinforced concrete monolithic constructions of buildings – M., 2007, 18 p.
5. SP 52-101-2003. Concrete and reinforced concrete structures without prestressing. – M., 2005, 54 p.
6. SNP 5.03.01-2 "Concrete and reinforced Concrete structures", Rev. 1, 2, 3, 4, 5 the Ministry of architecture and construction of Republic of Belarus. – Minsk, 2003.
7. TKP EN 1992-1-1-2009 (02250) Eurocode 2. Design of concrete structures Part 1-1. General rules and rules for buildings. The Ministry of architecture and construction of Republic of Belarus. – Minsk, 2010.
8. A manual for design of concrete and reinforced concrete structures of heavy concrete without prestress reinforcement (SP 52-101-2003). – Moscow, 2005. – 214 p.
9. Manual design of concrete and reinforced concrete structures of heavy concrete (without prestress). – M., 1978.
10. GOST 14098-91. Welded joints of reinforcement and embedded items concrete structures. Styles, designs and sizes.
11. STO 02495307-001-2007. Weld reinforcing bars in monolithic reinforced concrete columns of buildings and structures.
12. RA-10-1-04. Recommendations for mechanical connection of reinforcing steel for concrete structures. – M., reinforced concrete Association, 2009.
13. Dyachkov, V.V. Mechanical rebar splice class A600C. – Concrete and reinforced concrete. – 2010. – No. 4. – P. 14–15.
14. TY 4842-196-46854090-2005. The connection of rebar mechanical "LENTON" manufactured by ERICO. Specifications.
15. Reinforcement of elements of monolithic reinforced concrete buildings. A manual for design. – M., NII ZHB, 2007.
16. Karpenko S. N., Chipizubov I. G., Shifrin K. S. On the results of testing the strength of couplings for fixtures to the thread by the diagram technique in Industrial and civil construction / S.N. Karpenko, I.G. Chipizubov, K.S. Shifrin. – 2008. – No. 11. – P. 44–46.
17. Malakhov, A.N. Reinforcement of reinforced concrete structures : textbook / A.N. Malakhov // M-of education and science Ross. Federation, Moscow. gos. stroit. un-t. – Moscow : MGSU, 2014. – 114 p.

UDC 624.012.45

**STUDIES OF THE STRESS-STRAIN STATE OF THE SUPPORT ZONES  
 OF REINFORCED CONCRETE BEAMS WITH CLIPPED BY THE FINITE ELEMENT METHOD**

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*This paper deals with the nonlinear finite element analysis of two shear-critical concrete dapped-end beams. Reinforced concrete dapped-end beams having nominal shear span to depth ratio values of 0.56 and 0.59, concrete strength 32 MPa and 34 MPa, and reinforcement ratio via yield strength 2.83 MPa and 7.39 MPa, that failed in shear have been analyzed using the 'ANSYS' program. The 'ANSYS' model accounts for the nonlinearity, such as, post cracking tensile stiffness of the concrete, stress transfer across the cracked blocks of concrete. The concrete is modeled using 'SOLID65'– eight-node brick element, which is capable of simulating the cracking and crushing behavior of brittle materials. The internal reinforcements have been modeled discretely using 'LINK8' – 3D spar element. A parametric study is also made to explain the effects of variation of some main parameters such as shear span to depth ratio, concrete compressive strength, and the parameter of main dapped-end reinforcement on the behavior of the beams. From the present modality the capability of the model to capture the critical crack regions, loads and deflections for various types of shear failures in reinforced concrete dapped-end beams have been illustrated. The parametric study shows that the beams shear strength is affected by the shear span to depth ratio, concrete compressive strength and the amount of main reinforcement.*

**Notations**

- $a$  – Shear span measured from the center of support to the center of hanger bars (mm)
- $d$  – Effective depth of the nib (mm)
- $A_s$  – Area of the main dapped-end Reinforcement (mm<sup>2</sup>)
- $f_c'$  – Compressive strength of the concrete cylinder (MPa)
- $f_t$  – Tensile strength of concrete (MPa)
- $f_y$  – Yield stress of the steel reinforcing bars. (MPa)
- $P_u$  – Failure load (kN)
- $V_d$  – Shear strength of dapped-end beam (kN)
- $V_{d, test}$  – Shear strength of the dapped-end beam measured in the test (kN)
- $\rho$  – Ratio of the main dapped reinforcement

**Introduction.** The dapped-end concrete beams enable the construction depth of a precast concrete floor or roof structure to be reduced, by recessing the supporting corbels into the depth of the beams supported [1]. They are mainly used in drop-in beams between corbels Fig. 1, *a*, as part of beam-to-beam connection Fig. 1, *b* and in suspended spans between cantilevers Fig. 1, *c*. The use of dapped-end beams facilitates the erection of a precast concrete structure, due to the greater lateral stability of an isolated dapped-end beam than that of an isolated beam supported at its bottom face [2].

A series of studies on dapped-end beams have investigated the influence of effective span to depth ratio and different main, anchorage, and web reinforcements on the behavior of reinforced concrete dapped-end beams [1– 4, 7–9].

Mattock and Chan, (1979) [1], tested eight dapped-end beams. Four beams being subjected to vertical load only and four to a combination of vertical and horizontal loads.

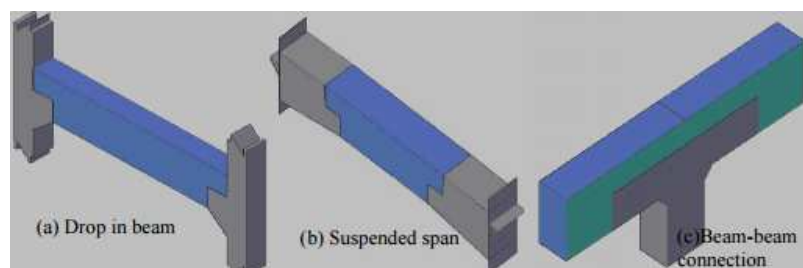


Fig. 1. Application of dapped-end beams

The dimensions of beams and amount of reinforcement in each specimen are listed in Table 1. From the test results the authors' inclusions were the followings:

1. The reduced depth part of the dapped end may be designed as if it were a corbel, using the design proposal of Mattock, providing the shear span ( $a$ ) used in design is taken equal to the distance from the center of action of vertical load to the center of the gravity of the hanger reinforcement.
2. The full depth part of the beam should be designed so as to satisfy moment and force component across inclined cracks, in addition to carrying out that the usual design of sections normal to the longitudinal axis of the beam for flexure, shear, and axial force.
3. As shown in Fig. 2.
4. The main nib reinforcement should be provided with a positive anchorage as close to the end face of the beam as possible.
5. A group of closed stirrups having yield strength not less than the nominal shear strength should be provided close to the end face of the full depth beam to resist the vertical component of the inclined compression force in the nib.
6. The horizontal (hoop) stirrups should be positively anchored near the face of the beam by wrapping around vertical bars in each corner. As shown in Fig. 2.

Table 1. – Specimen reinforcement details and concrete strength [1]

spec. no.	Main dapped-end reinforcement			Hoops horizontal reinforcement			Hanger reinforcement			Concrete strength	$a/d$	$\rho f_y$
	Bars	$A_s(mm^2)$	$f_y(MPa)$	Stir.	$A_h(mm^2)$	$f_y(MPa)$	Stir.	$A_{sh}(mm^2)$	$f_y(MPa)$	$f_c(MPa)$	$mm/mm$	$MP/a$
1A	2#3	141.9	476.4	1#2	64.5	461.9	3#3	425.8	451.6	33.6	0.59	1.89
1B	2#6	567.7	412.3	2#2	129.0	455.0	3#3	425.8	466.7	30.5	0.59	6.54
2A	3#3	212.9	478.5	2#2	129.0	461.9	2#3	283.8	462.6	32.9	0.59	2.85
2B	2#6	567.7	412.3	2#2	129.0	460.5	2#3	283.8	470.2	30.8	0.59	6.54
3A	3#3	212.9	476.4	2#2	129.0	448.1	2#3 +1#2	283.8 +64.5	470.2 448.1	37.0	0.59	2.83
3B	2#6	567.7	438.5	2#2	129.0	484.0	2#3 +1#2	283.8 +64.5	488.8 484.0	31.6	0.59	6.95
4A	3#3	212.9	476.4	2#2	129.0	435.7	2#3 +1#2	283.8 +64.5	488.8 484.0	31.6	0.59	2.83
4B	2#6	567.7	438.5	2#2	129.0	461.9	2#3 +1#2	283.8 +64.5	488.8 484.0	31.6	0.59	6.95

Stir. = Stirrups  $\rho$   
 $f_y = A_s / bd * f$

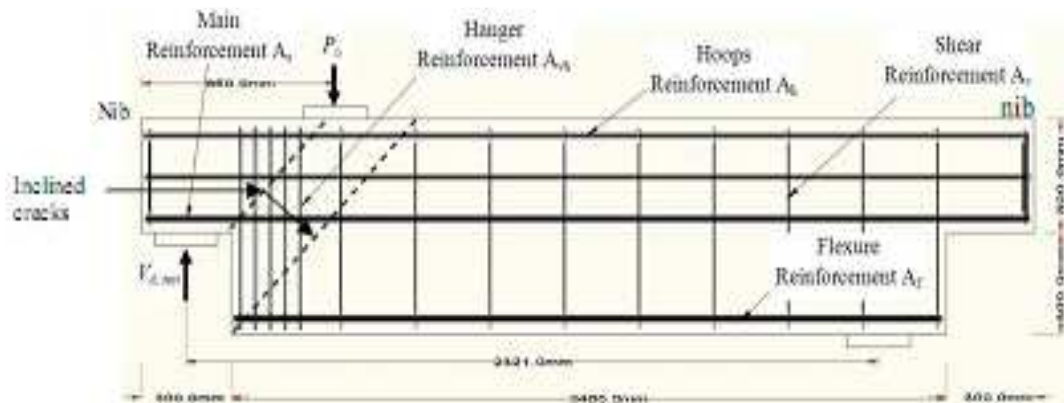


Fig. 2. Dimensions and reinforcement details of beam B56,  $a/d = 0.56$  [2]

Twelve high-strength concrete dapped-end beams were tested by Wen-Yao Lu, et al, (2003) [2], as listed in Table 2, to study the shear strength of dapped-end beams of the concrete strength, the amount of main dapped-end reinforcement, and the nominal shear span-to-depth ratio. The details of the tested specimens are listed in Table 2. The test results indicate that the shear strength of dapped-end beams increases with the increase of the concrete strength, the amount of main dapped-end reinforcement, and the decrease of nominal shear span-to-depth ratio.

Table 2. – Specimen reinforcement details and concrete strength [2]

spec no.	Main dapped-end reinforcement			Hoops horizontal reinforcement			Hanger reinforcement			Concrete strength	a/d	$\rho f_y$
	Bars	$A_s(mm^2)$	$f_y(MPa)$	Stir.	$A_h(mm^2)$	$f_y(MPa)$	Stir.	$A_{th}(mm^2)$	$f_y(MPa)$	$f_c(MPa)$	mm/mm	MPa
1	3#6	859.6	461.8	2#3	285.3	368	5#4	1266.8	430.14	34.0	0.56	7.39
2	3#6	859.6	461.8	2#3	285.3	368	6#4	1520.2	430.14	62.6	0.59	7.39
3	3#6	859.6	461.8	2#3	285.3	368	6#4	1520.2	430.14	69.2	0.59	7.39
4	3#6	859.6	461.8	2#3	285.3	368	6#3	856.0	416.14	34.0	0.89	7.39
5	3#6	859.6	461.8	2#3	285.3	368	4#4	1013.4	430.14	62.6	0.83	7.39
6	3#6	859.6	461.8	2#3	285.3	368	4#4	1013.4	430.14	69.2	0.81	7.39
7	2#6	573.0	461.8	2#3	285.3	368	4#4	1013.4	430.14	33.7	0.52	5.08
8	2#6	573.0	461.8	2#3	285.3	368	4#4	1013.4	430.14	62.6	0.54	5.08
9	2#6	573.0	461.8	2#3	285.3	368	4#4	1013.4	430.14	69.2	0.54	5.08
10	2#6	573.0	461.8	2#3	285.3	368	5#3	713.3	416.14	33.7	0.83	5.08
11	2#6	573.0	461.8	2#3	285.3	368	5#3	713.3	416.14	62.6	0.84	5.08
12	2#6	573.0	461.8	2#3	285.3	368	5#3	713.3	416.14	69.2	0.85	5.08

Stir. = Stirrups  
 $f_y = A_s / bd * f$

The comparison between test results and an analytical proposed model given by Lu, et al. [2] shows that it can predict the shear strength of reinforced concrete dapped-end beams more accurately than the approach of the PCI-Design Handbook [2].

Ronnie R.H. and et al, (2003) [3], are proposed compatibility-aided trut-and-tie model (CASTM), for predicting the diagonal crack widths at re-entrant corners of dapped ends of bridge girders and the ledges of inverted T bent caps. The validity of this model is supported by tests of seven full-scale specimens. From comparison CASTM with tests large diagonal cracks occur at the re-entrant corners of dapped ends of bridge girders and the ledges of inverted T bent caps. These diagonal crack widths can be predicted by the proposed CASTM, and the proposed CASTM is calibrated by large test specimens simulating bridge structures. They proposed that the calibrated gage length should be applicable to all concrete bridges.

**1. Research Objective.** The objective of this paper is to study the ultimate shear behavior of a reinforced concrete dapped-end beams using three-dimensional finite element analysis approach on the reinforced concrete dapped-end beams ultimate shear behavior. For this purpose, two reinforced concrete dapped-end beams with span to depth ratio (0.56, 0.59) were analysis in finite element solutions were obtained by using ANSYS program [10]. The experimental and finite element modeling results are compared numerically and graphically.

**2. Description of Analyzed Beams.** Two experimental reinforced dapped-end beams were analyzed in this study. The first beam has shear span to depth ratio  $a/d$  equal to 0.56, and the second beam with shear span to depth ratio  $a/d$  equal to 0.59, as illustrated below:

**2.1. Details of Dapped-End Beam B56.** The first was tested by Lu et al. [2] dapped-end beam had constant span and width of 3000mm and 200mm, respectively. The overall depth was 600mm, and the shear span to depth ratio was 0.56 (i.e.  $a = 150$  mm,  $d = 268$  mm). The beam sample B56 refer to beam with ( $a/d = 0.56$ ). The reinforcement of beam and properties are summarized in Table 2 and Fig. 2. The beam notation (1) denotes the beams from reference (2). The typical beam details and geometry is shown in Fig. 2 [2].

**2.2. Details of Dapped-End Beam B59.** The second beam was tested by Mattock and Chan [1] has constant span and width of 3000 mm and 127 mm, respectively. The overall depth was 610 mm, and the shear span to depth ratio of the beam is 0.59 (i.e.  $a = 165$  mm,  $d = 280$  mm), The beam sample B59 refer to beam with ( $a/d = 0.59$ ). The reinforcement of beam and properties are summarized in Table 2 and Fig. 3. The beam notation (4A) denotes the beams from reference (1). The typical beam details and geometry is shown is shown in Fig. 3 [1].

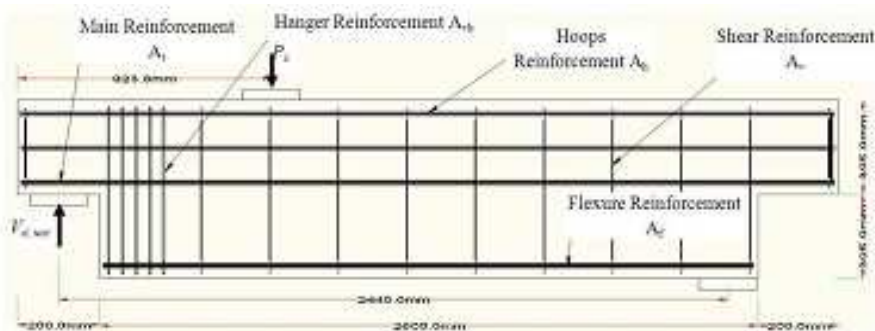


Fig. 3. Dimensions and reinforcement details of beam B59,  $a/d = 0.59$  [1]

**3. Finite Element Analysis and Nonlinear Solution Technique.** Finite element analysis has been performed in the present work using the ANSYS program [10] which is capable of handling dedicated numerical models for the nonlinear response of concrete under static and dynamic loading.

**3.1. Element Types.** The element type of concrete is eight-node solid brick element (SOLID 65) used for modelling the concrete. This element type includes a smeared crack analogy for cracking in tension zones and a plasticity algorithm to account for the possibility of concrete crushing in compression regions. It has eight corner nodes with three degrees of freedom for each: translations in x, y, and z directions. The eight-node solid element, SOLID 45, has been used for the steel plates, to represent the load plates and the beam supports. The element is also defined by eight nodes with three translational degrees of freedom for each node in x, y, and z directions, with plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. A reduced integration option with hourglass control is available. For Steel reinforcement the 3D spar element (LINK 8) which allows the elastic – perfectly plastic response of the reinforcing bars has been used. Two nodes are required for this element. Each node has three degrees of freedom: translations in the nodal x, y, and z directions.

Three material models have been adopted in the present study the; Material Model Number 1 refers to the SOLID 65 element for concrete. The SOLID 65 element requires linear isotropic and multi-linear isotropic material properties to properly model concrete. The multi-linear isotropic material uses the von Mises failure criterion along with the William and Warnke [12] model to define the failure of the concrete. EX is the modulus of elasticity of the concrete ( $E_c$ ), and PRXY is the Poisson's ratio ( $\nu$ ). The modulus of elasticity was based on Equation (1) [5]

$$E_c = 4730\sqrt{f'_c} \quad (f'_c \text{ MPa}). \quad (1)$$

A nonlinear elasticity model was adopted for concrete. The compressive uniaxial stress-strain relationship for the concrete model was obtained using the following equations to compute the multi-linear isotropic stress-strain curve for the concrete (MacGregor 1992) [14].

$$f = \frac{E_c \cdot \epsilon}{1 - \left(\frac{\epsilon}{\epsilon_0}\right)^2}, \quad \epsilon_0 = \frac{2f'_c}{E_c}, \quad E_c = \frac{f}{\epsilon} \quad (2)$$

where  $f$  = stress at any strain  $\epsilon$ , MPa;

$\epsilon$  = strain at stress  $f$ ;

$\epsilon_0$  = strain at stress  $f'_c$ .

For our concrete, the obtained stress–strain model is shown in Fig. 4.

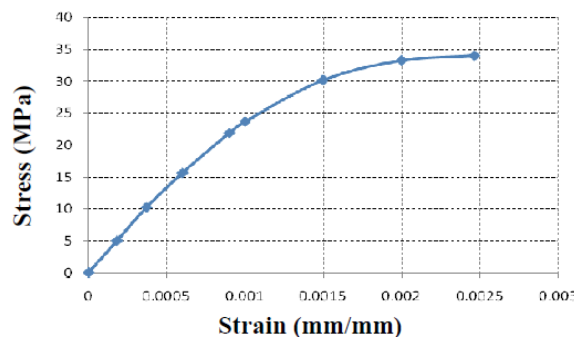


Fig. 4. Uni-axial stress-strain curve for concrete

The Poisson ratio is taken as 0.2. The ultimate uni-axial compressive strength of concrete is taken from the mean value of cylinder concrete compressive strength. The tensile strength of concrete is assumed to be equal to the value given below [12].

$$f_t = 0.62\sqrt{f'_c} \quad (f'_c \text{ MPa}). \quad (3)$$

The implemented multi-linear isotropic stress–strain relationship requires the first point of the curve to be defined by the user. It must satisfy Hooke's Law.

The shear transfer coefficient for open cracks,  $\beta_t$ , represents the conditions at the crack face. The value of  $\beta_t$  ranges from 0.0 to 1.0, with 0.0 representing a smooth crack (complete loss of shear transfer) and 1.0 representing a rough crack (no loss of shear transfer). Shear transfer coefficient of 0.3 is used to derive the theoretical load–displacement relationship for comparison with experimental results [12, 13].

During transition from elastic to plastic or elastic to brittle behavior, two numerical strategies were recommended [16]: proportional penetration, which subdivides proportional loading into an elastic and inelastic portion which governs the failure surface using integration, and normal penetration, which allows the elastic path to reach the yield surface at the intersection with the normal therefore solving a linear system of equations. Both these methods are feasible and give stress values that satisfy the constitutive constraint condition [16].

**3.2. Material Properties.** Steel reinforcement in the experimental beam was constructed with typical steel reinforcing bars as motion in Table 3. Elastic modulus and yield stress for the steel reinforcement used in tests were considered in the finite element modeling of reinforcement. A 50 mm thick steel plate modeled using SOLID45 elements, is added at the support location, and load applied position in order to avoid stress concentration problems. This provides a more even stress distribution over the support area and position of load. An elastic modulus equal to 200 GPa and Poisson's ratio equal to 0.3 are used to plate.

The steel for the finite element models is assumed to be an elastic–perfectly plastic material and identical in tension and compression. Poisson's ratio value of 0.3 is used for the steel reinforcement. Material properties for the concrete and steel reinforcement are summarized in Table 3.

Table 3. – Material properties of the tested beam [1, 2]

Beam No.	$E_c$ MPa	$A_s$ mm <sup>2</sup>	$f'_c$ MPa	$f_t$ MPa	$f_y$ MPa	$E_s$ MPa
B56	27,580	212.9	34.0	3.6	461.8	200,000
B59	26,757	859.6	31.6	3.4	476.4	200,000

**3.3. Modeling by ANSYS Code.** The dimension of the full-size beam B56 is 200\*600\*3000 mm. The span between the two supports was 2321 mm. As shown in Fig. 2 by taking the advantage of the symmetry of the beam, a half of the full beam was used for finite element modeling. The half of the entire model is shown in Fig. 5.

To obtain satisfactory results from the SOLID65 element, a square or rectangular mesh is recommended. Therefore, the mesh was setup such that square elements were created as shown in Fig. 6. Each concrete mesh element is a prism dimensions of 25 × 25 × 25 mm for specimen B56 [14]. The necessary element divisions are noted. The meshing of the reinforcement is a special case compared to the volumes to be omitted as it is a repetition.

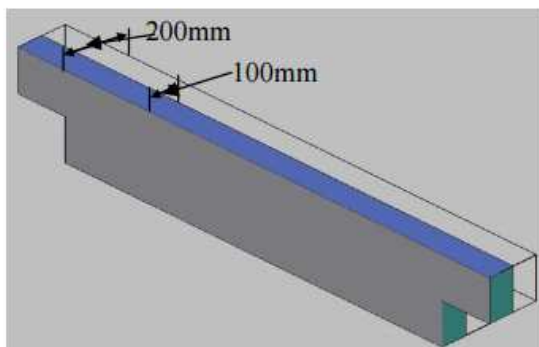


Fig. 5. The half of beam model B56

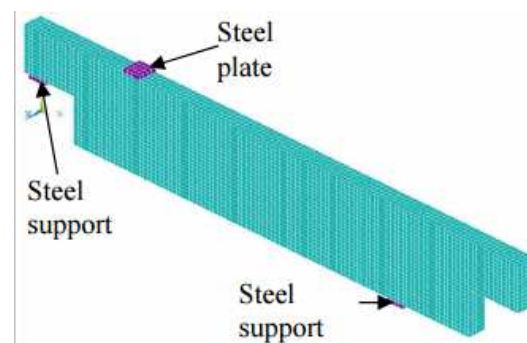


Fig. 6. Finite element mesh of the half beam B56

In nonlinear analysis, the total load applied to a finite element model is divided into a series of load increments called load steps [13]. At the completion of each incremental solution, the stiffness matrix of the model is adjusted to reflect nonlinear changes in structural stiffness before proceeding to the next load increment. The Newton–Raphson equilibrium iterations for updating the model stiffness were used in the nonlinear solutions. Prior to each solution, the Newton–Raphson approach assesses the out-of-balance load vector, which is the difference between there storing forces (the loads corresponding to the element stresses) and the applied loads [15] subsequently.

The program carries out a linear solution using the out-of-balance loads and checks for convergence. If convergence criteria are not satisfied, the out-of-balance load vector is re-evaluated, the stiffness matrix is updated, and a new solution is carried out. This iterative procedure continues until the results converge.

In this study, convergence criteria for the reinforced concrete SOLID elements were based on force and displacement, and the convergence tolerance limits were initially selected by analysis program. It was found that the convergence of solutions for the models was difficult to achieve due to the nonlinear behavior of reinforced concrete. Therefore, the convergence tolerance limits were increased to a maximum of five times the default tolerance limits 0.5% for force checking and 5% for displacement checking) in order to obtain the convergence of the solutions [11, 13].

**4. Comparison of experimental and analytical data.**

**4.1. Load-Deflection Relationship.** The load–deflection responses for the two reinforced concrete dapped-end beam B56, and B59 computed by the present finite element model are plotted in Fig. 7 based the corresponding relationships drawn from the previous experimental investigations [2], and [1], respectively.

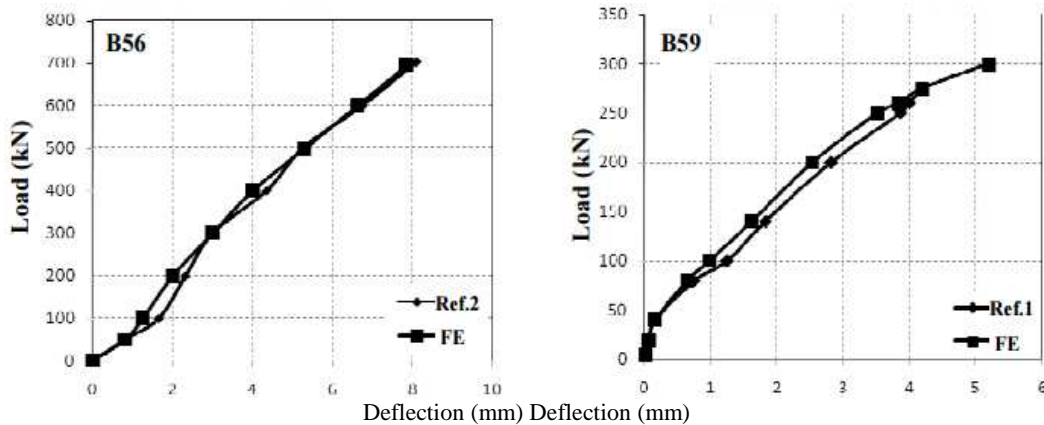


Fig. 7. Experimental [1, 2] and FEM load–deflection responses

For the dapped-end beam B56 the ultimate loads from the finite element and experimental models are 694 kN and 703 kN, respectively, and the ultimate deflection are 7.8 mm, and 8.1 mm, respectively. For dapped-end beam B59 the ultimate loads from the finite element and experimental models are calculated as 300 kN and 275 kN, respectively, and the ultimate deflection are 4.2 mm, and 5.21 mm, respectively. With reference to Table (4) and Fig. 7 deflections at beam soffits under bad positions given by the previous experimental tests of Ref. [2] and [1], and those computed by the present finite element model are very close to each other.

Table 4. – Comparison of test result [1, and 2], and FE solution

Beam Notation	Experimental Load (EXP) (kN)	FE Load (kN)	FE / EXP	EXP Ultimate Deflection (mm)	FE Ultimate Deflection (mm)
B56	703	694	0.98	8.1	7.8
B59	275	300	1.09	4.2	5.21

The ratio between the experimental and theoretical deflections at ultimate load are 0.99 and 1.09, for beams B56, and B59 are 1.09, respectively. On the other hand, the degree of correlation  $R^2$  is 0.99 for both the measured deflection and the applied load for both beams.

In general, the load–deflection plots for the beam from the present finite element analysis agree quite well with the previous experimental data of Ref. [1, and 2]. The finite element load–deflection curve is slightly different from the experimental curve. There are several effects that may cause this situation. First of all, microcracks are present in the concrete for the tested beam and could be produced by drying shrinkage in the concrete and/or handling of the beam. On the other hand, the finite element models do not include the microcracks. The other is that perfect bond between the concrete and steel reinforcing bars is assumed in the finite element analysis, this assumption would not be true for the tested beam. In ANSYS model, stresses and strains are calculated at the integration points of the concrete SOLID elements.

**4.2. Stress Distribution.** The behavior of beams B56 and B59 is considered satisfactory, both at service and ultimate loads. For all specimens the general process of cracking is similar. The first crack initiates at the re-entrant corner at about 12.4%, and 8.45% of ultimate load for beams B56 and B59, respectively. This crack propagated at approximately 45° to the horizontal. It extends to about 2/3 the height of the nib. At this time additional diagonal tension cracks take place in the nib and in the full depth of the beam. Maximum stresses for the last converging load step are shown for the beams in Fig. 8 and 9 where the maximum stress locations in the reinforced concrete dapped-end beams as determined by the present finite element model are shown.



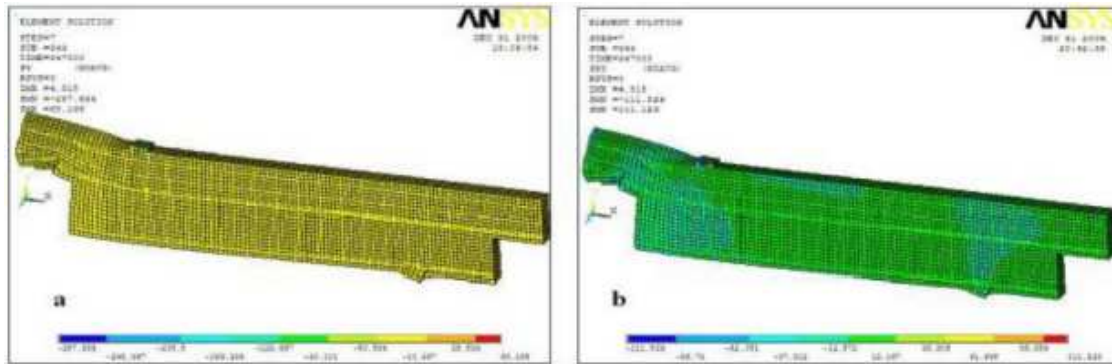


Fig. 8. Maximum stress distribution for beam B56 (MPa), given by the present finite element model: *a* – Maximum compressive and tensile stresses, *b* – Maximum shear stress

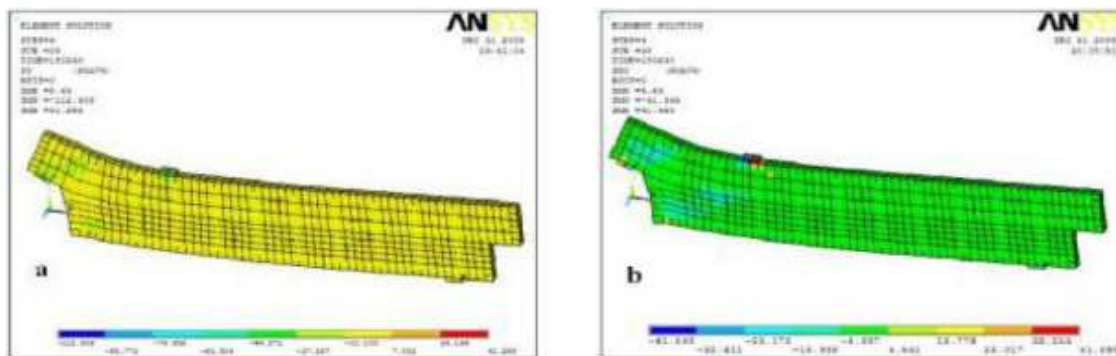


Fig. 9. Maximum stress distribution for beam B59 (MPa), given by the present finite element model: *a* – Maximum compressive and tensile stresses, *b* – Maximum shear stress

**4.3. Crack Patterns.** The crack patterns obtained from the present finite element analysis at the last converged load steps are shown in Fig. 10, *a* and *b*, from which it can be observed that that numerous cracks occur at midspan of the finite element model at four load levels, the cracks begin at the re-entrant corner of the dapped end beams at load values 56, and 35.5 kN for specimens B56 and B59, respectively.

As the load is further increased additional cracks form and existing cracks lengthen. The diagonal tension crack in the nib assumes a flatter trajectory on reaching the hanger reinforcement, propagating toward the loading plate. This is in agreement with the simulation of strut and ties modeling for deep beam, and corbel with struts (concrete) and ties (the tension steel bars with almost constant stress).

In all cases the main reinforcement yields before maximum load is reached. At that time, the cracks crossing this reinforcement widen noticeably. Shortly before failure, compression spalling and crushing the top face of the beam occurred adjacent to the loading plate. A side face of the half beam model is used to demonstrate cracking sign. As shown in Fig. 10, at the nib of the beam at bottom, cracking signs refer to development normal tensile stresses in the *x* (longitudinal) direction, and shear stresses in the *xz* plane. Consequently, the direction of tensile principal stresses becomes inclined from the horizontal.

Once the principal tensile stresses exceed the ultimate tensile strength of the concrete, tensile cracks perpendicular to the directions of the principal stresses appear at integration points of the concrete finite elements. These are referred as diagonal tensile cracks.

Principal tensile stresses occur mostly in the longitudinal direction. When the principal stresses exceed the ultimate tensile strength of the concrete, cracking signs appear perpendicular to the principal stresses in that direction. Therefore, the cracking signs shown in Fig. 10 appear as vertical straight lines occurring at the integration points of the concrete solid elements. These are referred as flexural cracks. For a concrete structure subjected to uni-axial compression, cracks propagate primarily parallel to the direction of the applied compressive load since the cracks resulting from the tensile strains developed due to Poisson's ratio effect [12, 16]. Similar behavior is seen in Fig. 10 based on the finite element analysis. Loads in the *z* direction result in tensile strains in the *y* direction by Poisson's effect. Thus, circles appear perpendicular to the principal tensile strains in the *y* direction at the integration points in the concrete elements near the loading location referring to as compressive fracture.

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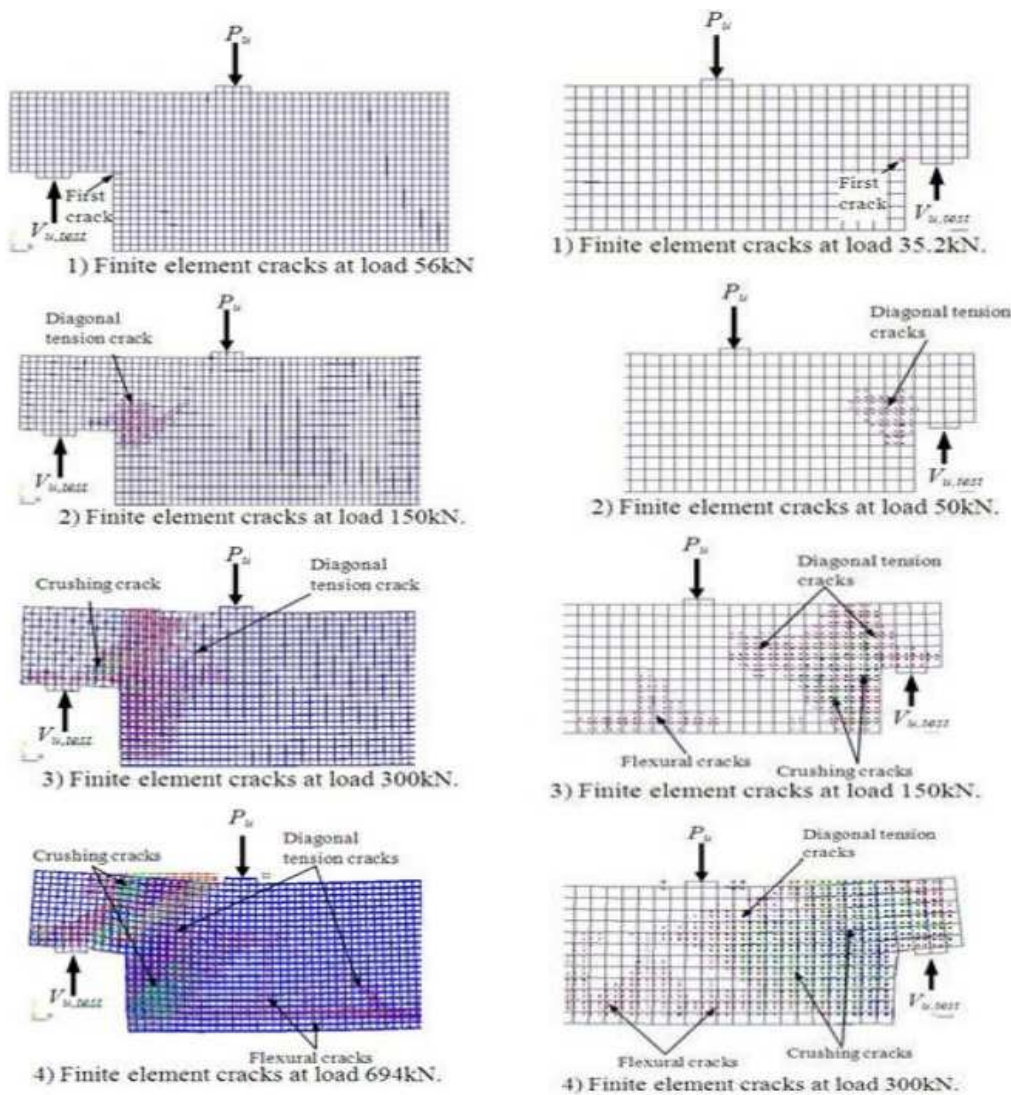


Fig. 10. Finite Element cracks at different load values:  
 a – For specimen B56, b – For specimen B59

Once the principal tensile stresses exceed the ultimate tensile strength of the concrete, tensile cracks perpendicular to the directions of the principal stresses appear at integration points of the concrete finite elements. These are referred as diagonal tensile cracks.

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**5. Parametric Study.** Using the developed the FE model that has been verified against the previous test results for reinforced concrete dapped end beam, a parametric study is conducted to beam B56 only, to evaluate the effects of shear span to depth ratio, compressive strength of concrete, and parameter of the main dapped end reinforcement. The details are described in Table 5.

Table 5. – Results summary of the parametric study

Parameter	Value	Ultimate load FEM (kN)
Shear span / depth ( $a/d$ )	0.78	650
	0.93	675
	1.12	725
Concrete strength ( $f'_c$ ) (MPa)	25	660
	30	632
	40	600
Parameter main dapped-end reinforcement ( $\rho_f$ ) (MPa)	7.39	694
	3	275
	5	570

**5.1. Effect of Nominal Shear Span to Depth Ratio.** Fig. 11 Shows effect of the nominal shear span to depth ratio  $a/d$  on the shear strength  $V_d$  for dapped-end beam. It is seen that the shear strength of the beam increases with decreasing the nominal shear span to depth ratio  $a/d$ . The shear strength  $V_d$  of beam B56 decreased from 482 kN for  $a/d = 0.56$ , to 383 kN for  $a/d = 1.12$ . This decrease in the shear strength is due to the cracks across depth of the nib of the beam, because when the shear span increases the flexural behavior becomes the controller instead of the shear failure, and cracks in the re-entrant corner of the beam develop. When the load further increases more cracks spread along depth of the nib and full depth of the beam, so that the beam should collapse at load level less than the beam with short shear span. Fig. 12 Shows the load-deflection relationship for B56 with different values of  $a/d$ . Also it can be seen that the shear strength decreases with increasing the nominal shear span to depth ratio  $a/d$ .

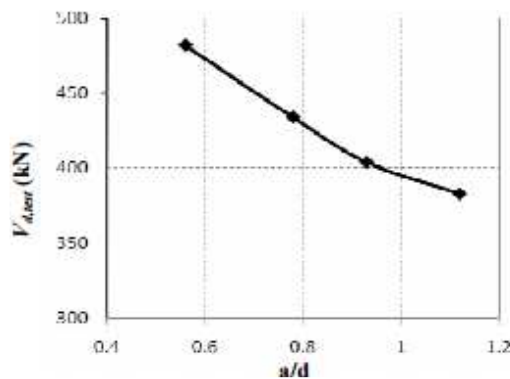


Fig. 11. – Effect of  $a/d$  ratio on the shear strength of beam B56

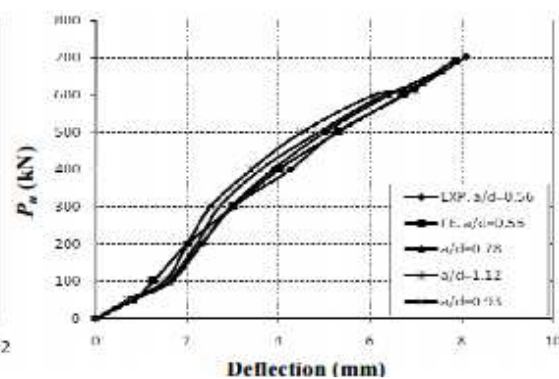


Fig. 12. – Load-deflection curves for beam B56 for different values of  $a/d$  ratio

**5.2. Effect of Compressive Strength.** A parametric study is conducted using the present FE model with various concrete compressive cylinder strength values of 25, 30, and 40 MPa. The other parameters are the same for beam B56. The effect of compressive strength on the shear strength of beam B56 is illustrated in Fig. 13. The shear strength of dapped-end beams increases with the increase of the concrete compressive strength. Shear strength  $V_d$  of the beam increases from 452 kN for  $f'_c = 25$  MPa, to 504 kN for  $f'_c = 40$  MPa. The amount of increase in shear strength is almost linearly proportional to compressive strength. The load-deflection behavior is illustrated in Fig. 14 for different values of concrete compressive strength. For all cases the initial values of deflection for the FE models are the same. Then when the load increases further differences is begin to be noticeable but less than the experimental values, expect for the case of  $f'_c = 40$  MPa. In general load–deflection curves of the finite element models are almost upper then the experimental curve.

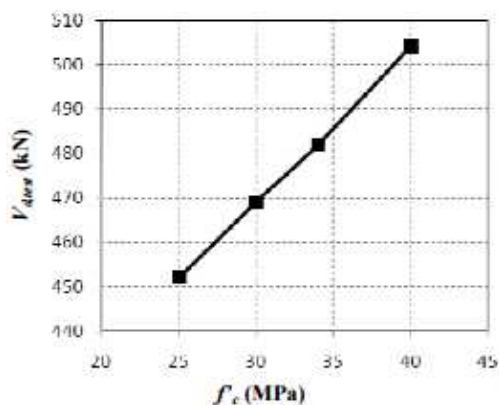


Fig. 13. – Effect of Concrete compressive strength on the shear strength of beam B56

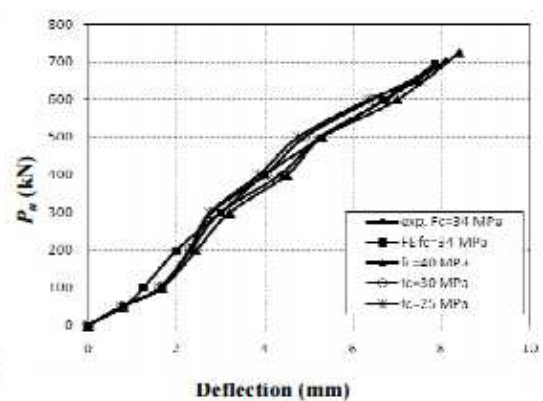


Fig. 14. – Load-deflection curves for beam B56 for different values of concrete compressive strength

**5.3. Effect of Main Dapped-End Reinforcement.** The parameter of main dapped-end reinforcement  $\rho f_y$  is one of the most significant factors effecting the shear strength of reinforced concrete dapped-end beams. The FE models with various  $\rho f_y$  values of 3, 5, and 7.39 MPa are illustrated in Fig. 15. Shear strength of the beam increases with the increase of the main dapped-end reinforcement. Higher shear strength values are predicted for larger  $\rho f_y$  values. The shear strength  $V_d$  of the beam increase from 313 kN for  $\rho f_y = 3$  MPa, to 482 kN for  $\rho f_y = 7.39$  MPa. The load-deflection relationship is shown in Fig. 16 for different values of  $\rho f_y$ , from which it is noticed that the shear strength values for the FE models are less than the experimental values.

On the other hand the deflection values in the earlier load applications are the same but when load increases further the difference begins to increase, especially for  $\rho f_y = 3$  MPa, due to the small amount of area of reinforcement in the beam. In general and for all cases the main dapped-end reinforcement yielded before reaching the maximum applied load. Thus the load–deflection curve for FE models is slightly different from the experimental curve.

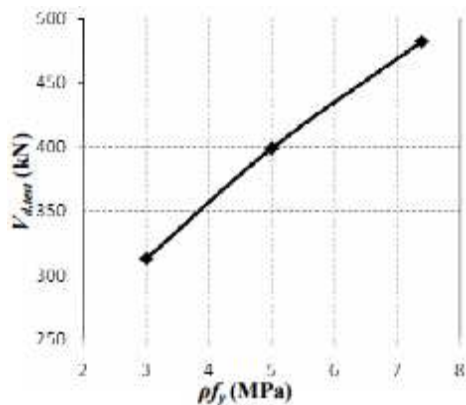


Fig. 15. – Effect of main dapped-end reinforcement on the shear strength of beam B56

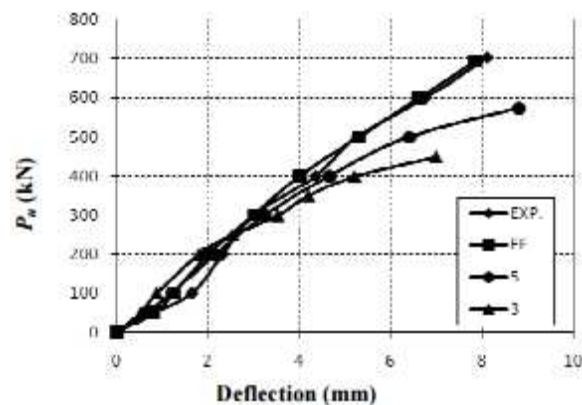


Fig. 16. – Load-deflection curves for beam B56 for different amount of main reinforcement

**Conclusions.** A Finite element model has been developed to simulate the load–displacement behavior of the reinforced concrete dapped-end beams under static monotonic loading. The model takes into account the linear and nonlinear material properties for concrete and steel reinforcement. The FE model compared well with the results of previous experimental studies.

Parametric studies using this model has been carried out to investigate the effects of shear span to depth ratio, concrete compressive strength, and the amount the main dapped-end reinforcement on the behavior of the reinforced concrete dapped-end beams. From that comparison, and the parametric studies, the Following conclusions are drawn.

- The predicted loads of the reinforced concrete dapped-end beams by the present FE models at various stages were found to be in good agreement with the previous test data.
- The failure mechanism of reinforced concrete dapped-end beams is modeled quite well using the present FE model, and the failure load predicted is very close to the failure load of previous experimental studies.
- Shear strength of the dapped-end beams increases with decreasing the nominal shear span to depth ratio ( $a/d$ ). The shear strength  $V_d$ , of beam B56 is 482 kN for  $a/d = 0.56$ , and decreases to be 383 kN for  $a/d = 1.12$ .
- Shear strength of the dapped-end beams linearly increases with the increase of the concrete strength for the studied beams.
- Shear strength of the dapped-end beams linearly increases with the increase of the main dapped-end Reinforcement for the studied beams.

#### REFERENCES

1. Mattock, A. H. Design and Behavior of Dapped-End Beams / A. H. Mattock, T. C. Chan // Journal of Structural Engineering, PCI Journal. 1979. – V. 24, No. 6. – P. 28–45.
2. Shear Strength of High-Strength Concrete Dapped-End Beams / W. Y. Lu [et al.] // Journal of the Chinese Institute of Engineers. – 2003. – V. 26, No. 5. – P. 671–680.
3. Crack Width Prediction Using Compatibility-Aided Strut-and-Tie Model / R. H. Ronnie // ACI Structural Journal. – 2003. – V. 100, No. – P. 413–421.

4. Foster, S. J. The Design of Nonflexural Members with Normal and High-Strength Concretes / S. J. Foster, R. I. Gilbert // *ACI Structural Journal*. – 1996. – V. 93, No. 1. – P. 3–10.
5. Building Code Requirements for Structural Concrete (ACI 318-2008) and Commentary (318R-2008) / American Concrete Institute. – Farmington Hills, Mich., 2008.
6. Marti, P. Basic Tools of Reinforced Concrete Beam Design / P. Marti // *ACI JOURNAL*, Proceedings. – 1985. – V. 82, No. 1. – P. 46–56.
7. Mirza, S. A. Strength Criteria for Concrete Inverted T-Girders / S. A. Mirza, R. W. Furlong // *Journal of Structural Engineering*, ASCE. – 1983. – V. 109, No. 8. – P. 1836–1853.
8. Mirza, S. A. Design of Reinforced and Prestressed Concrete Inverted T-Beams for Bridge Structures / S. A. Mirza, R. W. Furlong // *PCI Journal*. – 1985. – V. 30, No. 4. – P. 112–136.
9. Siao, W. B. Shear Strength of Short Reinforced Concrete Walls, Corbels, and Deep Beams / W. B. Siao // *ACI Structural Journal* – 1994. – V. 91, No. 2. – P. 123–132.
10. Swanson Analysis System / ANSYS. – US, 2003.
11. Schlaich, J. Towards a Consistent Design of Structural Concrete / J. Schlaich, K. Schafer, M. Jennewein // *PCI Journal*. – 1987. – V. 32, No. 3. – P. 74–150.
12. Willam, K.J. Constitutive model for triaxialbehaviour of concrete. In: Seminar on concrete structures subjected to triaxial stresses / K.J. Willam, E.P. Warnke // International association of bridge and structural engineering conference. – Bergamo, 1974. – P. 174.
13. Wolanski, A. J. Flexural Behavior of Reinforced and Prestressed Concrete Beams Using Finite Element Analysis / A. J. Wolanski // Master thesis, Marquette University. – Milwaukee, Wisconsin, 2004.
14. MacGregor, J.G. (1992) “Reinforced concrete mechanics and design” / J.G. MacGregor // Englewood Cliffs. – NJ : Prentice-Hall, Inc., 1992.
15. Job, T. Finite Element Analysis of Shear Critical Prestressed SFRC Beams / T. Job, R. Anath // *Computers and Concrete*. – 2006. – Vol. 3, No. 1. – P. 65–77.
16. Shah, S.P. Fracture mechanics of concrete / S.P. Shah, S.E. Swartz, C. Ouyang. – NY : John Wiley & Sons, Inc., 1995.

UDC 693.2

**SPECIFICATION OF CALCULATION OF THE JAMMING SUPPORT  
 TO CONSOLE BEAM IN BRICK LAYING**

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*One of the most widespread structures of plant and civil buildings is console beams. Beams are made of steel concrete or constructional steel. In civil buildings a console beam is the bearing design of balconies, peaks and other elements. In plant buildings a console beam is the bearing designs of cranes of small capacity, supports of various communications such as cables and pipelines. Console beams are often fixed in brick walls of . It is often observed in old buildings though it is also applied in modern structures.*

Jamming support calculation in the design of new buildings and structures or assessing the bearing capacity of existing ones is made without taking into account local stresses and deformations near the contact surfaces of the beam-wall. Meanwhile, the difference in strength and deformation characteristics of a reinforced concrete and steel beam is essential. Vertical movements and rotations of the support section occur due to local deformations of the compression of the brickwork. This phenomenon should be taken into account in the design of new buildings and is especially relevant at the present time when examining existing facilities to determine the bearing capacity and the necessity or non-necessity of reinforcement in case of further reconstruction. Due to the above reasons, your attention is invited to report on the research results on this issue.

The existing method of calculating the depth of seal of a console beam is based on the uniform distribution of contact stresses on the contact surfaces (Fig. 1)

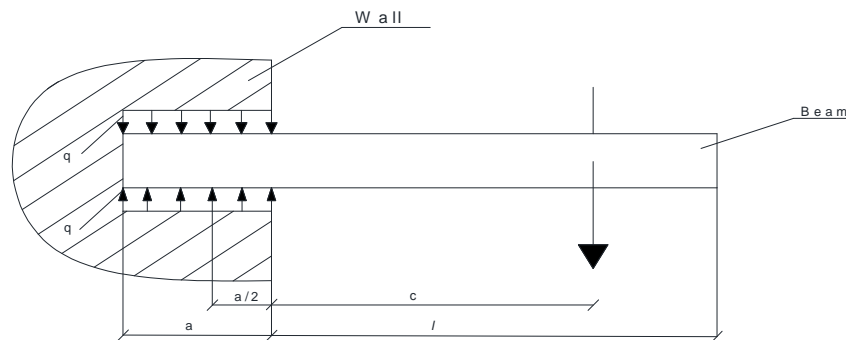
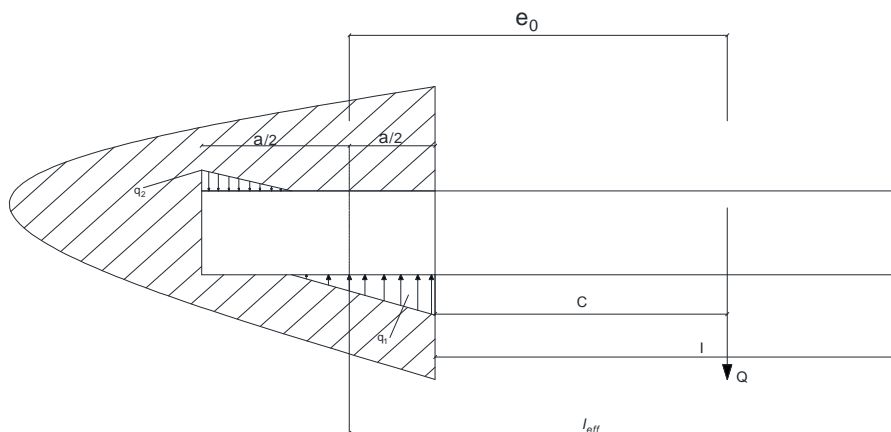


Fig. 1. Uniform distribution of contact tension in the jamming support

As follows from Fig. 1, in case of uniform distribution of contact tension the bricklaying is under conditions of central compression. However, the study of the supports jamming them indicates the presence of local movements (angles of rotation) due to deformations of the bricklaying , which leavy to redistribution of contact tension which is offered to be distributed under the linear law (Fig. 2).



Pic 2. The specified distribution of contact tension

Calculation on local compression of a laying in a zone of seal of consoles is made on the transformed formula for determination of tension at the non-central compression:

$$Q \leq \frac{R_c \cdot ab}{\frac{6e_0}{a} + 1}, \quad (1)$$

where  $Q$  – settlement loading from the beam weight and loadings attached to it;

$R_c$  – settlement crumpling resistance;

$e_0 = \frac{M}{Q}$ , where  $\langle M \rangle$  – the moment in seal concerning the seal center;

$a$  and  $b$  – respectively seal depth and the width of beam shelves.

The scheme of efforts in seal is provided (Fig. 2).

As follows from Fig. 2.

$$l_{eff} = l + \frac{a}{2}, \text{ a } e_0 = c + \frac{a}{2}.$$

Size  $\langle C \rangle$  for the majority of balconies changes in limits  $(0,2 \div 0,5)l_{eff}$ .

Size  $l_{eff}$  according to the National standard of Belarus and Eurokod lies in limits  $l$  and  $l + \frac{a}{2}$ .

At the same time from evenly distributed loading  $\langle q \rangle$  size  $e_0 = 0,5l_{eff}$  is accepted by a constant and it is entered into a formula (2), received from formula (1):

$$a = \frac{Q}{2R_c b} \sqrt{\frac{Q^2}{4R_c^2 b^2} + \frac{6Qe_0}{R_c b}}. \quad (2)$$

As the test equation when determining depth of seal expression can serve:

$$0,5l_{eff} = (0,2 \div 0,5)l_{eff} + 0,5a. \quad (3)$$

Thus, the method of calculating the depth of seal of a console beam in a bricklaying is offered.

1) We are given the value of  $l_{eff}$  (from materials of the project or from the results of the survey);

2) From formula (3) we obtain for a given value  $\langle C \rangle$  the value of  $e \langle a \rangle$ ;

3) From formula (2) we find the value of  $\langle a \rangle$  and we compare them;

4) We repeat with the new value  $\langle C \rangle$ .

The calculation ends when the process converges to this technical tolerance.

#### REFERENCES

1. TCP 45-5.02-82-2010. Stone and reinforced stone constructions. – Minsk : Ministry of architecture and construction of Republic of Belarus, 2010.
2. SNB 5.03.01-02. Concrete and reinforced concrete constructions. – Minsk. Ministry of architecture and construction of Republic of Belarus, 2003.

## PHYSICAL INTERACTION OF POINT DEFECTS WITH CRACKS IN THE SOLID

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*The problem of vacancy during healing of cracks in the metal is considered as part of the structural and diffusion mechanism of interaction between defects and cracks in the solid state. The dependence of the diffusion coefficient of defects on temperature is noted. It has been shown that the activation energy of the diffusion pores in the metal significantly affects the rate of healing of fractures. Spend a full time score heal at different temperatures.*

**Introduction.** Defects in solids, particular in metals, may be of various types and origins. The defect structure of solids forms at the stage of producing the material. In the manufacturing process of products and during the operation of finished products the defect structure can be transformed. This may change the number of the defects and may cause their reformation with the formation of new types of violations. The most typical defects in the crystal structure are [1]:

- point defects (vacancies, interstitial atoms);
- linear defects or dislocations which can exist both separately and combined into the loop, that leads to distortion of the crystal lattice;
- the surface defects (grain and twins boundaries, stacking faults);
- volume defects (voids and inclusions).

During the machining processing of the material such defects as cracks, voids, inclusions can be seen. The destruction process begins with the formation of cracks, their increasing and ends with the macroscopic destruction of the material into separate parts. In materials science of metals the surface state and the emergence of cracks in many ways determines the resistance to deformation and destruction of materials. Under certain conditions cracks in metals can heal (decrease its volume), which leads to improved performance characteristics of the material.

In this paper the possible outcome of cracks healing within the model of structure-diffusion mechanism is considered which was proposed by the authors [2].

**The model of pores and cracks interactions.** Cracks are sinks for point defects and micropores in the solid. The process of healing (overgrowing) is connected with the flow of the micropores (vacancies) from the crack (to the crack). It was established [2] that the vacancy concentration near the surface of small cracks (pores) higher than the vacancy concentration of large cracks, and therefore the flow of vacancies comes from small cracks to large cracks. There is the healing of small cracks. The flow of micropores on the surface of cracks of unit length is calculated by the formula [2]:

$$f = \frac{\gamma n_1}{R} \sqrt{\frac{D}{n_2}} \frac{K_1(z)}{K_0(z)},$$

where  $\gamma = \frac{2\alpha\Omega}{kT}$ ;

$$z = R\sqrt{\frac{n_2}{D}};$$

$R$  – radius of the crack;

$D$  – the effective diffusion coefficient for this type of defect;

$n_1, n_2$  – constants;  $\alpha$  – specific surface energy;

$\Omega$  – typical volume of micropores (defect);

$T$  – absolute temperature;

$K_i(z)$  – MacDonal'd's cylindrical functions of the  $i$ -th order.

Take into account that the temperature dependence of the diffusion coefficient of the defects can be described as well-known ratio:

$$D = D_0 e^{-\frac{E_a}{kT}},$$

where  $E_a$  – activation energy for diffusion of the defect;

$D_0$  – constant;

$k$  – Boltzmann constant.



In this way the flow of micropores is a complex function of many parameters: temperature, diffusion coefficient, surface energy, crack radius.

Consider the diffusion of micropores in volume adjacent to the open crack of cylindrical shape. Then the change of volume of crack  $\Delta V$  (length  $h$  in a time  $t$ ) is defined by the formula:

$$\Delta V = 2\pi R h f t \Omega .$$

In assessing crack healing process it's necessary to determine the relative change of crack volume (relative rate of crack healing):  $\varepsilon = \Delta V/V$ .

**Results, their discussion and perspectives.** Figure 1 shows the dependence of the relative change in the volume of crack on temperature for different values of activation energy of micropores diffusion. It is known [3, 4] that activation energy for the vacancies in metals is in the range 0,9–2,0 eV.

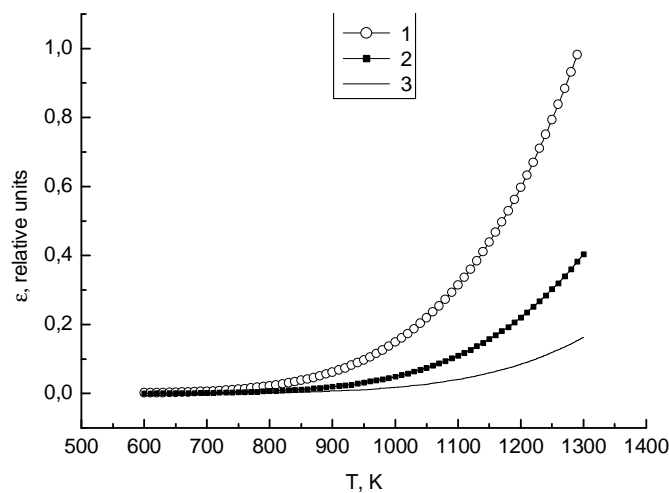


Fig. 1. The dependence of the relative change in the volume of crack on the temperature at different activation energies of pores, eV: 1 – 1; 2 – 1,13; 3 – 1,25;  $D_0 = 5 \cdot 10^{-6} \text{ m}^2/\text{s}$ ;  $t = 20 \text{ h}$

As we can see from the fig. 1 changes of activation energy of pores in a small range of 1–1,25 eV significantly affect the healing option. Additionally, the rate of healing process depends on the temperature. As the temperature rises the difference in the healing rate in the studied energy range sharply increases.

It is supposed that the flow of impurity atoms in healing process has to be an order less than the vacancy mechanism since the migration energy for impurities  $E_a$  lies in a wide range from 1 to 5 eV. In this way the main influence of pores on cracks healing connects with the low value of the activation energy of the diffusion pores. The surface energy of metal has a value on the value of pore flow (Fig. 2).

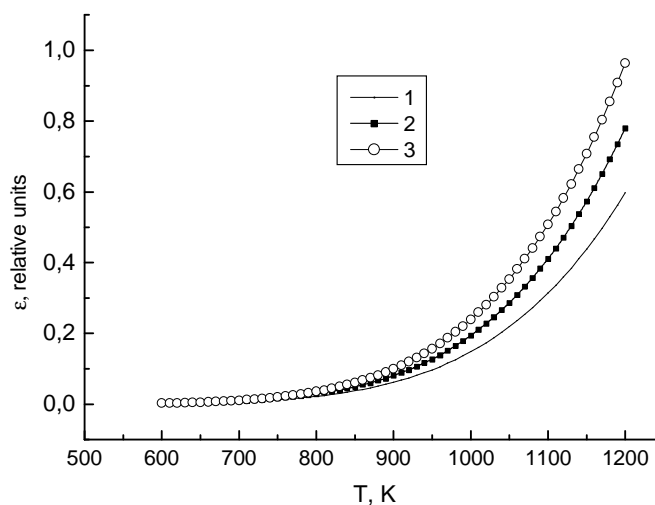


Fig. 2. Dependence of relative change of crack volume on the temperature at different values of surface energy,  $\text{J}/\text{m}^2$ : 1 – 1,3; 2 – 1,7; 3 – 2,1.  $D_0 = 5 \cdot 10^{-6} \text{ m}^2/\text{s}$ ;  $t = 20 \text{ h}$

Figure 3 shows the dependence of time of the total healing of cracks on the temperature. It can be seen, the shortest time of healing is typical for high temperatures 900–1000 K.

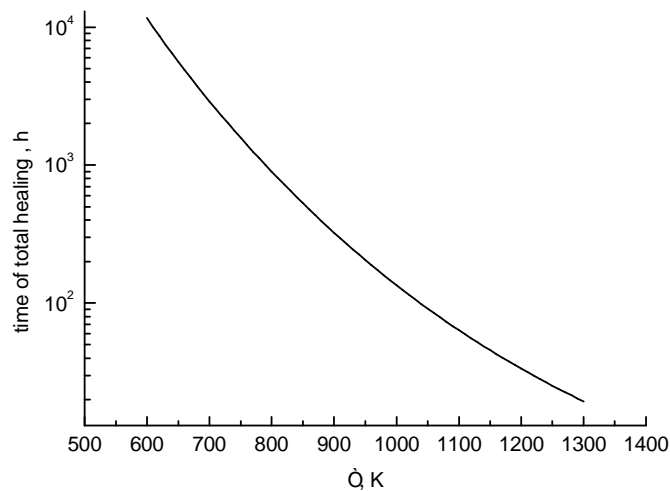


Fig. 3. The dependence of time of total healing of cracks on the temperature:  
 $E_a = 1 \text{ eV}; D_0 = 5 \cdot 10^{-6} \text{ m}^2/\text{s}$

**Conclusion.** Within the vacancy mechanism of cracks healing it was demonstrated that diffusion parameters of micropores significantly affect the rate of healing of cracks in the metal. 25% reduction in the diffusion coefficient leads to a 10-fold decrease in the rate of healing. The time of complete healing at temperatures of 900–1000 K is 100–200 hours.

#### REFERENCE

1. Завистовский, В.Э. Механика разрушения и прочность материалов с покрытиями / В.Э.Завистовский. – Новополоцк : Полоц. гос. ун-т, – 1999. – 144 с.
2. Zavistovskiy, V. On interaction between cracks and particles in coated materials / V. Zavistovskiy, E. Bogdanova, S. Zavistovskiy // Fracture mechanics and physics of construction materials and structures : Materials of II international symposium, Lviv-Dubliany, 7-10.11.1996. – P. 45–48.
3. Фистуль, В.И. Физика и химия твердого тела : учебник для вузов : в 2 т. / В.И. Фистуль. – М. : Металлургия, – 1995. – Т.1. – 486 с. ; Т. 2. – 325 с.
4. Верещагин, И.К. Физика твердого тела : учеб. пособие для вузов / И.К. Верещагин [и др.] – М. : Высш. шк., 2001. – 237 с.





and in this case the focal points of a truss aren't equal to zero. The emergence of the focal points will lead to the change of the longitudinal forces in the truss cores. The longitudinal force in this case will be equal in any core of a truss

$$N_k = \sum_{i=1}^n n_{ki} X_i + N_{kP} .$$

The change of the internal efforts in the cores of the truss will cause the emergence of the additional normal tension, the reason of which is the rigid connection of the cores in the knots of the truss.

Thus, the consideration of the longitudinal deformations when calculating trusses with rigid knots leads to change of parameters of the intense deformed state (VAT). Therefore, criterion of legitimacy of replacement of rigid knots of real trusses at their calculation on action of nodal loadings hinged is the possibility of not accounting of longitudinal deformations of cores of the truss when determining its VAT parameters.

We will carry out the numerical assessment of the influence of the longitudinal deformations on the VAT parameters of a truss on a private example. Let's consider a two-rod truss with the rigid connection in the knot under the influence of any nodal loading (Fig. 1)

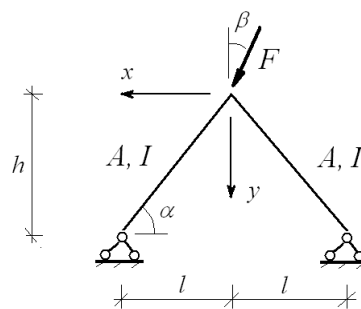


Fig. 1. The two-rod truss

The constructional material is considered uniform isotropic linearly elastic body which behavior is described by the module of elasticity of E identical at stretching and compression.

The calculation of the truss is performed by a method of forces. As the main system, the truss with hinged connection of cores in the knot undertakes (Fig. 2)

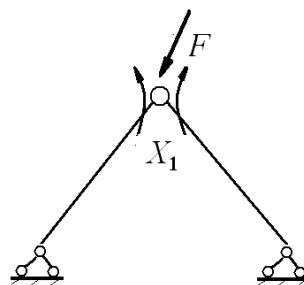


Fig. 2. The main system of a method of forces

The initial equation of a method of forces shows as

$$\delta_{11} X_1 + \Delta_{1P} = 0 . \tag{10}$$

The main unknown in the equation (10) is the bending moment arising in the knot owing to the rigid connection of the cores of the truss.

The entering (10) coefficient and the free member are calculated on Maxwell-Mora's formula which takes into account the influence of the flexural and longitudinal deformations as shown

$$\Delta_i = \sum_{k,l} \int \frac{m_i M}{EI_z} ds + \sum_{k,l} \int \frac{n_i N}{EA} ds .$$

The internal efforts of a single state connected with the calculation of the coefficient and the free member in a dimensionless form are shown as:

– the bending moments

$$m_1(x, l) = (1 - \frac{x}{l}); \quad m_2(x, l) = (1 - \frac{x}{l});$$

– longitudinal forces

$$n'_{11}(\alpha) = \cos \alpha; \quad n'_{21}(\alpha) = \cos \alpha,$$

where  $n'_{k1} = n_{k1}h$  ( $k = 1, 2$ ).

The longitudinal forces of a cargo state connected with calculation of the free member in a dimensionless form can be shown as

$$N'_{1P}(\alpha, \beta) = -0.5 \frac{\cos \beta}{\sin \alpha} (1 + \frac{\text{tg} \beta}{\text{tg} \alpha}); \quad N'_{2P}(\alpha, \beta) = 0.5 \frac{\cos \beta}{\sin \alpha} (\frac{\text{tg} \beta}{\text{tg} \alpha} - 1),$$

where  $N'_{1P} = \frac{N_{1P}}{F}$ ,  $N'_{2P} = \frac{N_{2P}}{F}$ .

The bending moments in both cores are identically equal in a cargo state to zero.

Taking into account the calculation of the coefficient and the free member, the bending moment arising in the rigid knot of a truss in a dimensionless form is shown as

$$X'_1(\alpha, \beta, \lambda) = 1.5 \frac{\cos \beta}{\cos^2 \alpha (3 + \lambda^2 \text{tg}^2 \alpha)},$$

where  $X'_1 = \frac{X_1}{Fl}$ ;

$\lambda = \frac{l_c}{i}$  – the parameter of the flexibility of a core of a truss depending on its length  $l_c$  and radius of inertia of cross section  $i$ .

The dependence of the size of the bending point received focal on truss parameters  $\alpha$ ,  $\beta$ ,  $\lambda$  it is presented on schedules Figure 3.

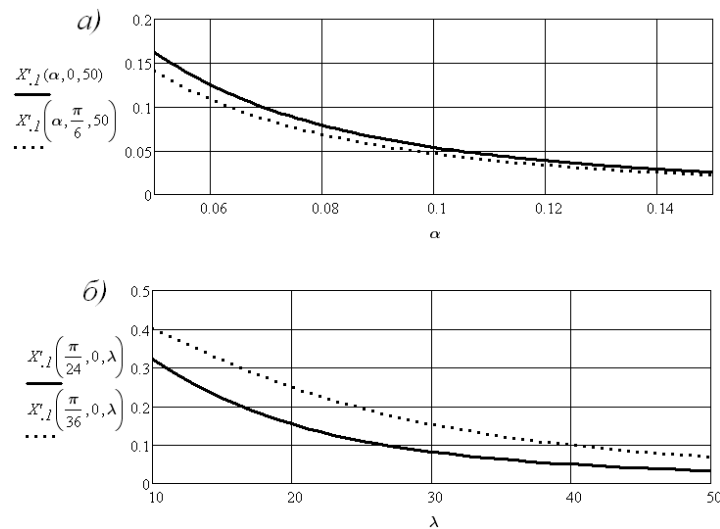


Fig. 3. The schedules of the dependence of the size of the focal bending point on the truss parameters

As follows from the schedules submitted in Figure 3, a) the size of the focal bending point increases with reduction of a corner  $\alpha$  and decreases with increase in a corner  $\beta$ , that is at emergence in the knot of a horizontal component of nodal loading. In a limit when values  $\alpha, \beta \rightarrow 0$ , the focal bending point comes to the value of

the frame the bending moment  $\frac{Fl}{2}$  arising in a beam with the size of flight and the scheme of loading identical with the considered truss. As it follows from the schedules submitted in Figure 3, *b* the size of the focal bending point increases with the reduction of the flexibility of the cores of a truss.

The dimensionless increments of longitudinal forces in the cores of a truss arising owing to emergence of the focal bending point are described by formulas

$$\Delta N_1(\alpha, \beta, \lambda) = 1 - k_1(\alpha, \beta, \lambda);$$

$$\Delta N_2(\alpha, \beta, \lambda) = 1 - k_2(\alpha, \beta, \lambda),$$

where  $k_1(\alpha, \beta, \lambda) = 1 - 1.5 \frac{\text{tg } \alpha}{(3 + \lambda^2 \text{tg}^2 \alpha)(\text{tg } \beta - \text{tg } \alpha)}$ ;

$$k_2(\alpha, \beta, \lambda) = 1 + 1.5 \frac{\text{tg } \alpha}{(3 + \lambda^2 \text{tg}^2 \alpha)(\text{tg } \beta - \text{tg } \alpha)}$$

the coefficients of the influence of the rigidity of a knot on the longitudinal forces in the truss cores.

The dependence of the increments of the longitudinal forces on the parameters of the truss  $\alpha, \beta, \lambda$  is presented on the schedules of Figure 4.

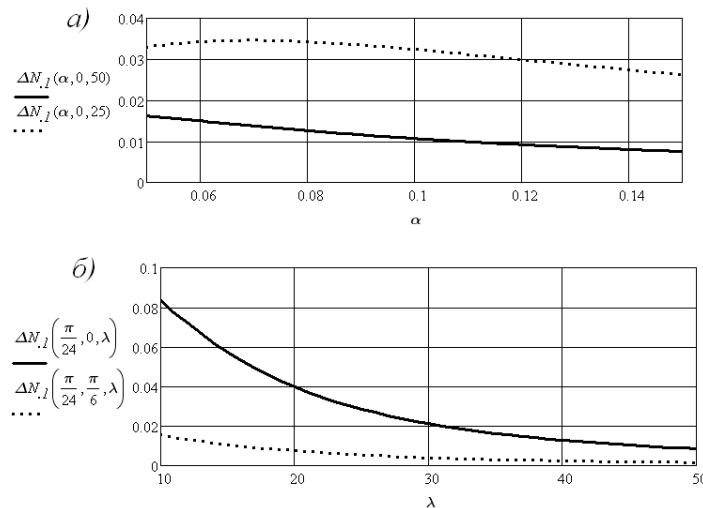


Fig. 4. The schedules of the dependence of the size of the increment of longitudinal forces on the truss parameters

As it follows from the schedules submitted in pic. 4 the size of the increments of the longitudinal forces increases with reduction of a corner  $\alpha$ , flexibility of cores of a truss  $\lambda$  and decreases at emergence in knot of a horizontal component of nodal loading. At the most adverse combination of parameters of a truss the size of an increment of longitudinal forces doesn't exceed 10% of values of the longitudinal forces according to the hinged scheme of the truss.

The dimensionless increments of the normal tension in the cores of a truss arising due to the emergence of the focal bending point and the changes of the longitudinal forces as described by the formulas

$$\Delta \sigma_1(\alpha, \beta, \lambda) = 1 - k_{1\sigma}(\alpha, \beta, \lambda);$$

$$\Delta \sigma_2(\alpha, \beta, \lambda) = 1 - k_{2\sigma}(\alpha, \beta, \lambda).$$

where  $k_{1\sigma}(\alpha, \beta, \lambda) = k_1(\alpha, \beta, \lambda) + \lambda \cos \alpha \frac{X'_1(\alpha, \beta, \lambda)}{N'_{1P}(\alpha, \beta)}$ ;

$$k_{2\sigma}(\alpha, \beta, \lambda) = k_2(\alpha, \beta, \lambda) + \lambda \cos \alpha \frac{X'_1(\alpha, \beta, \lambda)}{N'_{2P}(\alpha, \beta)}$$

coefficients of the influence of the rigidity of a knot on the normal tension in the truss cores. The dependence of the size of the increments of normal tension on parameters of the truss  $\alpha$ ,  $\beta$ ,  $\lambda$  is presented on schedules (Fig. 5).

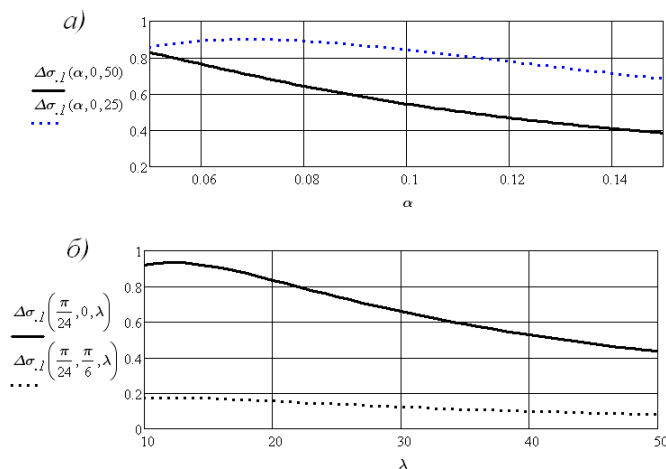


Fig. 5. The schedules of the dependence of the size of an increment of normal tension on the truss parameters

As it follows from the submitted schedules, the size of the increment of normal tension increases with the reduction of a corner  $\alpha$ , flexibility of cores  $\lambda$  and decreases at emergence in the knot of a horizontal component of nodal loading. In general it is possible to draw a conclusion at values  $\alpha < \frac{\pi}{6}$  and  $\lambda < 100$  the increment of normal tension makes more than 5% of normal tension in the truss cores according to the hinged scheme and at certain combinations and can reach the commensurable values.

#### REFERENCES

1. Патон, Е.О. Дополнительные напряжения мостовых ферм / Е.О. Патон. – М : Транспечать, 1930. – 98 с.
2. Даниловский, М.П. Влияние жесткости узлов на напряженное состояние железобетонных ферм / М.П. Даниловский // Труды Хабаров. ин-та ж.-д. транспорта. – Хабаовск, 1956. – Вып. 9. – С. 47–63.
3. Иванов, А.Н. Совершенствование конструкции и методики расчета пролетных строений мостов с несущими элементами из композиционных материалов : автореф. дис. ... канд. техн. наук / А.Н. Иванов ; Сибир. гос. ун-т путей сообщения. – Новосибирск, 2015. – 22 с.
4. Турищев Л.С. Строительная механика : учеб.-метод. комплекс / Л.С. Турищев. – Новополюк : Полоц. гос. ун-т. – 2010. – Ч.1 : Статически определимые системы. – 224 с.



UDC 681.326

**PRECONDITIONS OF CALCULATION SUPPORT ZONE OF PRESTRESSED CONCRETE  
BEAM WITH FLAT BENT-UP LONGITUDINAL COMPOSITE REINFORCEMENT  
UNDER THE EFFECT OF BENDS WITH TRANSVERS FORCE**

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*The article describes the preconditions for calculating the strength of the inclined sections of pre-stressed beams with a gentle contour reinforcement in the bending operation with a transverse force. Are presented assumptions and features of calculation of concrete structures with composite reinforcement. It noted the specificity of pre-stressing of curved composite rods.*

In construction practice special place is occupied beamed reinforced concrete elements with a contour of the work of the longitudinal reinforcement from the lower zone to the upper zone of the supports. The introduction of such structures with metal pre-stressing reinforcement is appropriate and justified, that is caused by economic and operational efficiency. However, it should be noted that there are certain obstacles to the widespread use of these structures, namely the insufficient knowledge about of resistance such elements bending with transverse force. Should also pay attention to the fact that existing methods of calculation require clarification [1]. Even less studied is the question, and the ability to use as a bent reinforcement composite, namely, fiberglass and basalt, which is a promising direction [2]. No studies on the cross-sectional area at the cut bent elements flat bent-up fiberglass reinforcement. Today, these types of reinforcement are the most widespread in the construction of composite materials, as well as some of the most advanced materials, thanks to their advantages over steel reinforcement [3].

To develop the methodology for calculating the strength of the support areas of concrete elements with flat bent-up composite reinforcement consider the existing methods for calculating the strength of such sections with pre-stressed steel reinforcement. The basis for calculating resistance sloping sections of concrete elements with a flat bent-up of the longitudinal reinforcement is more rational to use a modified compression field theory (MCFT) [4], based on models of varying the angle, and the general deformation method [5]. The advantages of these methods first and foremost due to the fact that the method of calculation of these models more fully take into account the stress strain state in a diagonal crack, and is the final step in calculating the strength of sections under the joint action of all internal and external forces. [6] In general, the resistance of the sloping sections of pre-stressed bending element can be written as

$$V_{Rd} = V_{cd} + V_{sw} + V_p = \sigma_1 \cdot b_w \cdot z \cdot \cot \theta + \frac{A_{sw} \cdot f_{ywd} \cdot z}{s} + V_p \geq V_{sd}, \quad (1)$$

where  $\sigma_1$  – average value of the major tensile stresses in the concrete, defined by the transformed strain diagram as a function of the relative principal tensile strain;

$z$  – a pair of shoulder internal forces, defined as the distance between the resultant force in the compressed concrete zone and stretched straight longitudinal reinforcement;

$\theta$  – the angle of diagonal stripes in a predetermined section;

$V_{sd}$  – transverse force caused by an external load;

$V_p$  – the vertical component of the lateral force perceived bent at an angle  $\alpha$  to the estimated reinforcement sections within the anchoring zone length is determined by the following equation:

$$V_p = \sigma_{pd,inc} \cdot A_{p,inc} \cdot \sin \alpha = \frac{l_x}{l_{bpd}} \cdot f_{pd,inc} \cdot A_{p,inc} \cdot \sin \alpha, \quad (2)$$

where  $l_x$  – the distance from the support to the section under consideration;

$l_{bpd}$  – the length of the anchoring zone.

For cross sections outside the anchoring zone  $\sigma_{pd,inc} = f_{pd,inc}$ .

Application of this technique to calculate the strength support zones bent elements with composite reinforcement requires consideration of the characteristics and assumptions in the design of such elements. Calcula-

tion of the elements should be performed for a simple flat sections based on strain compatibility equations. It is worth noting some of the basic assumptions for bent elements with composite reinforcement:

- hypothesis of plane sections;
- after the formation of cracks in the concrete inclined section extended area is not included in the resistance of the section;
- shear deformations can be ignored due to the small bending deformations;
- are used in the calculation of diagrams describing the relationship of stress and strain of concrete and reinforcement.

Also worth noting is the input of the concept of nominal state balanced deformations in sections of concrete elements reinforced composite rods. This condition is deemed to have occurred when a section of concrete reinforcement element relative deformation of stretching a polymer composite reaches its limiting value ( $\varepsilon_{fppu}$ ) and simultaneously compression deformation relative most compressed faces concrete section reaches its limiting value ( $\varepsilon_{cu} = 0.0035$ ). Upon the occurrence of such a state of the concrete element, reinforced composite reinforcement, insert decreases suddenly, without any visible strain, as this type of reinforcement is a brittle material and has no flow properties (absolutely linearly deformable material). Thus, the plastic and deformation properties in pre-stressed concrete elements with steel and composite reinforcement differ from each other. Under the influence of the load pre-stressed concrete beams with steel reinforcement are deformed elastically until the beginning of the destruction, and the time of occurrence of fracture strain begin to grow indefinitely because of the strength of steel. However, due to the linear deformability of the composite rods pre-stressed concrete elements well before the destruction of the deformed elastically, but with an increase in load current, such elements continue to deform elastically until failure occurring as a result of the exhaustion of its load-bearing capacity or stretched composite reinforcement or compressed concrete zone or at the same time as the tension reinforcement and concrete compressed zone.

It is also necessary to take into account the specifics of the pre-stressing of curved composite rods. Due to the fact that the composite rods are elastically deformable, when a decrease in their bending tensile strength. Thus, the voltage generated at the tension stage reinforcement in the composite rod with a flat bent-up (having a curvilinear outline in the longitudinal direction of the concrete element) must be reduced because it is necessary to consider the appearance of additional stresses in the curved portion of the rod. The level of stress achieved at a bend of the composite rod will depend on the radius of curvature at the inflection point of the rod, the elastic modulus and the cross section of the rod characteristics. Stress may be determined by the following equation [7]:

$$R_n = \frac{r^2}{2} \cdot \sqrt{\frac{E_{fpp} \cdot \pi}{P \cdot (1 - \cos \theta)}}, \quad (4)$$

where  $E_{fpp}$  – modulus of elasticity of the composite rod;

$y$  – the distance from the center of gravity to the verge of a stretched composite curved rod (the distance equal to the radius rod);

$R_{ch}$  – radius of curvature rod at the point of inflection.

It should also pay attention to the fact that the effectiveness of pre-stressing rods produced from a polymer composite is significantly reduced when the stresses in the composite rod as a result of bending, are deducted from the value of allowable stress generated in the composite reinforcement at the stage of its tension. The resulting tension in the web of a polymeric composite  $A_{fpp}$  area with a force of its tension  $P_j$  is given by:

$$\sigma_h = \frac{P_j}{A_{fpp}} + \frac{E_{fpp} \cdot y}{R_{ch}}. \quad (5)$$

It is worth paying attention to the fact that the value of the permissible voltage level rods of polymer composite reinforcement tension stage and transfer stage effort compression on concrete for concrete beams are limited to values much lower than with short-term tensile strength rods from polymer composite [8, 9]. For example, for polymer composites reinforced with glass fiber, the voltage on the reinforcement tension stage by pulling on the supports is 30% of the ultimate strength.

Thus, the use of methods of calculating strength support zones of pre-stressed concrete beams with a flat bent-up of the longitudinal reinforcement in composite action with the bending of the transverse force requires substantial consideration of all the characteristics and properties of composite reinforcement, as well as its work in the concrete.

## REFERENCES

1. Кривицкий, П.В. Влияние основных факторов на сопротивление преднапряженных железобетонных балок с канатной отогнутой арматурой изгибу с поперечной силой / П.В. Кривицкий, В.Н. Малиновский // Вестник БрГТУ. – 2016. – № 1 (97) : Строительство и архитектура. – С. 93–97.
2. Гиль, А.И. Перспективы применения пологоотгнутой стеклопластиковой арматуры в зоне среза изгибаемых армобетонных элементов / А.И. Гиль, Е.Д. Лазовский // Вестник Полоцкого государственного университета. Серия F, Строительство. Прикладные науки. – 2016. – № 8. – С. 61–65.
3. Гиль, А.И. Стеклопластиковая и углепластиковая арматура в строительстве: преимущества, недостатки, перспективы применения / А.И. Гиль, Е.Н. Бадалова, Е.Д. Лазовский // Вестник Полоцкого государственного университета. Серия F. Строительство. Прикладные науки. – 2015. – № 16. – С. 48–53.
4. Vecchio, F.J. The Modified Compression Field Theory for Reinforced Concrete Elements Subjected to Shear / F.J. Vecchio, M.P. Collins // ACI JOURNAL, Proceedings. – 1986. – V. 83, No. 2. – P. 219–231.
5. Бетонные и железобетонные конструкции : СНБ 5.03.01-02. – Введ. 20.06.2002. – Минск : М-во архитектуры и стр-ва Респ. Беларусь, 2003. – 143 с.
6. Малиновский, В.Н. Особенности расчета и конструирования приопорных зон преднапряженных железобетонных балок с пологим отгибом продольной стальной арматуры / В.Н. Малиновский, П.В. Кривицкий // Проблемы современного бетона и железобетона : сб. науч. тр. – 2015. – № 7. – С. 78–89.
7. Design Recommendations for Concrete Structures Prestressed with FRP Tendons : Final Report / University of Wyoming, Pennsylvania State University, University of Missouri-Rolla ; ed.: Dolan C.W. [et al.] – 2001. – FHWA – DTFH61-96-C-00019.
8. The Canadian Highway Bridge Design Code : CAN/CSA-S06-06. – Introduced November, 2006 – Ottawa, Ontario : Canadian Standards Association, 2006.
9. Design and Construction of Building components with Fibre Reinforced Polymers : CAN/CSA-S806-02. – Introduced May, 2004 – Ottawa, Ontario : Canadian Standards Association, 2004.

## COMPARISON OF HARMONY SEARCH METHOD AND PARTICLE SWARM OPTIMIZATION METHOD ALGORITHMS OF THE DESIGN OPTIMIZATION OF CELLULAR BEAMS

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*In the following research the problem of design optimization for the minimization of the cellular beam weight is solved using the optimum structural design algorithms that are based on stochastic search techniques which are quite effective in finding this solution to discrete programming problems.*

The design of a cellular beam requires the choice of an original rolled beam from which the cellular beam is to be produced, circular opening diameter and the spacing between the centers of these circular holes or the total number of holes in the beam. Hence, the sequence number of the rolled beam sections in the standard steel section tables, hole diameter and the total number of holes are taken as design variables in the optimum design problem considered.

In the research, the solution of the discrete non-composite cellular beam design problem given above is investigated using two meta-heuristic search techniques; namely harmony search algorithm and particle swarm optimizer.

The basic components of the harmony search algorithm can now be outlined in five steps as follows.

*Step 1. Initialization of a Parameter Set:* A harmony search optimization parameter sets are initialized first. These parameters consist of four entities called a harmony memory size (*hms*), a harmony memory considering rate (*hmcr*), a pitch adjusting rate (*par*) and a maximum search number ( $N_{cyc}$ ). It is worthwhile to mention that in the standard harmony search algorithm these parameters are treated as static quantities, suitable values are chosen within their recommended ranges of  $hmcr \in (0.70 \sim 0.95)$  and  $par \in (0.20 \sim 0.50)$ . It should be mentioned that the selection of these values is the problem dependent and it requires number of trials to identify the appropriate ones.

*Step 2. Initialization and Evaluation of Harmony Memory Matrix:* A harmony memory matrix *H* is generated and randomly initialized next. This matrix incorporates (*hms*) number of feasible solutions. Each solution (harmony vector,  $I^j$ ) consists of *nv* integer numbers between 1 to *ns* selected randomly each of which corresponds to sequence number of design variables in the design pool, and is represented in a separate row of the matrix; consequently the size of *H* is (*hms*  $\times$  *nv*).

$$H = \begin{bmatrix} I_1^1 & I_2^1 & \dots & I_{nv}^1 \\ I_1^2 & I_2^2 & \dots & I_{nv}^2 \\ \dots & \dots & \dots & \dots \\ I_1^{hms} & I_2^{hms} & \dots & I_{nv}^{hms} \end{bmatrix} \begin{matrix} f(I^1) \\ f(I^2) \\ \dots \\ f(I^{hms}) \end{matrix} \quad (1)$$

$I_i^j$  is the sequence number of the  $i^{\text{th}}$  design variable in the  $j^{\text{th}}$  randomly selected feasible solution. (*hms*) solutions shown in Eqn. 1 are then analyzed, and their objective function values are calculated.

*Step 3. Generating a New Harmony:* A new harmony solution vector  $I' = [I_1', I_2', \dots, I_{nv}']$  is improvised by selecting each design variable from either harmony memory or the entire discrete set. The probability that a design variable is selected from the harmony memory is controlled by a parameter called harmony memory considering rate (*hmcr*). To execute this probability, a random number  $r_i$  is generated between 0 and 1 for each variable  $I_i$ . If  $r_i$  is smaller than or equal to *hmcr*, the variable is chosen from harmony memory in which case it is assigned any value from the  $i$ -th column of the *H*, representing the value set of variable in *hms* solutions of the matrix Eqn. 2. Otherwise (if  $r_i > hmcr$ ), a random value is assigned to the variable from the entire discrete set.

$$I_i' = \begin{cases} I_i' \in \{I_i^1, I_i^2, \dots, I_i^{hms}\} & \text{if } r_i \leq hmcr \\ I_i' \in \{1, \dots, ns\} & \text{if } r_i > hmcr \end{cases} \quad (2)$$

*Step 4. Update of Harmony Matrix.*

*Step 5. Termination.*

The basic steps of the particle swarm optimization for a general discrete optimization problem can be outlined as follows:

Step 1. Swarm of particles is initialized randomly with sequence numbers  $I_0^i$  which corresponds positions  $I_0^i$  and initial velocities  $v_0^i$  that are randomly distributed throughout the design space. Here  $I_0^i$  represents the sequence number of values in the discrete set. These are obtained from the following expressions.

$$I_0^i = INT [I_{min} + r(I_{max} - I_{min})] \quad (3)$$

$$v_0^i = [I_{min} + r(I_{max} - I_{min}) / \Delta t] \quad (4)$$

Step 2. The objective function values  $f(x_k^i)$  are evaluated using the design space positions  $x_k^i$ .

Step 3. The optimum particle position  $p_k^i$  at the current iteration  $k$  and the global optimum particle position  $p_k^g$  are updated by equating  $p_k^i$  to  $f(x_k^i)$  and  $p_k^g$  to the best  $f(x_k^i)$ .

Step 4. The velocity vector of each particle is updated considering the particle's current velocity and position, the particle's best position and global best position, as follows:

$$v_{k+1}^i = wv_k^i + c_1r_1 \frac{(p_k^i - x_k^i)}{\Delta t} + c_2r_2 \frac{(p_k^g - x_k^i)}{\Delta t} \quad (5)$$

where  $r_1$  and  $r_2$  are random numbers between 0 and 1,  $p_k^i$  is the best position found by particle  $i$  so far, and  $p_k^g$  is the best position in the swarm at time  $k$ .  $w$  is the inertia of the particle which controls the exploration properties of the algorithm.  $c_1$  and  $c_2$  are trust parameters that indicate how much confidence the particle has in itself and in the swarm respectively.

Step 5. The sequence number for the position of each particle is updated from

$$I_{k+1}^i = INT (I_k^i + v_{k+1}^i \Delta t) \quad (6)$$

Where  $I_{k+1}^i$  is the sequence number in the discrete set for  $x_{k+1}^i$  which is the position of particle  $i$  at iteration  $k + 1$ ,  $v_{k+1}^i$  is the corresponding velocity vector and  $\Delta t$  is the time step value.

Step 6. Steps 2–5 are repeated until pre-determined maximum number of cycles is reached.

Harmony search method and particle swarm based optimum design algorithm presented above are used to design a cellular beam to compare which method is better while finding the optimum solution. For the hole diameters discrete set that has 421 values ranging from 180 mm to 600 mm with the increment of 1 mm is prepared. Another discrete set is arranged for the number of holes that contains numbers ranging from 2 to 40 with the increment of 1.

A simply supported beam shown in Figure 1 is selected as first design example to demonstrate the steps of optimum design algorithms developed for cellular beams that are based on harmony search and particle swarm methods. The beam has a span of 4 m and is subjected to 5 kN/m dead load including its own weight. A concentrated live load of 50 kN also acts at mid-span of the beam as shown in the same figure.

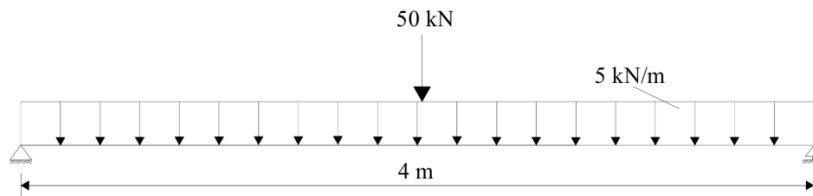


Fig. 1. Loading of 4-m simply supported beam

The maximum displacement of the beam under these point and distributed loads is restricted to 12 mm while other design constraints are implemented from BS5950. The modulus of elasticity is taken as 205 kN/mm<sup>2</sup> and Grade 50 steel is adopted for the beam which has the design strength of 355 MPa.

In the use of the harmony search method, the other parameters hmcr and par are taken as 0.8 and 0.35 respectively. It took 17 cycles for the harmony search method to fill the harmony memory matrix. This matrix is given in Table 1.

Table 1 – The initial feasible designs selected by PSO and HS algorithm

PSO Algorithm (Initial)					HS Algorithm (After 17 iterations)				
Particle No	Section (UB)	Number ofHoles	HoleDia. (mm)	Weight (kg)	Particle No	Section (UB)	Number ofHoles	HoleDia. (mm)	Weight (kg)
1	356×127×33	8	386	120,53	1	356×127×39	10	316	144,8
2	406×140×39	8	429	137,71	2	406×178×60	6	412	231,48
3	406×140×39	7	366	148,2	3	406×178×74	7	538	255,95
4	305×102×33	8	342	124,06	4	406×178×74	7	396	284,5
5	406×178×74	8	380	280,79	5	457×191×74	7	352	287,56
6	356×171×57	10	291	217,6	6	457×191×98	5	581	371,18
7	305×127×37	9	371	132,54	7	533×210×109	6	558	398,71
8	356×171×45	8	324	172,2	8	533×210×122	5	560	464,99
9	406×178×67	8	365	255,68	9	610×229×125	6	499	476,21
10	305×127×37	8	349	139,32	10	686×254×140	4	590	543,51

The new objective function value 163.44 kg is better than the worst harmony in the memory matrix 543.51 kg. Hence this new design is placed in the 2th row of the harmony memory matrix and the worst design with the largest objective function value is discarded from the harmony memory matrix. The new design does not affect the first row of the harmony memory matrix in this search. However later, when the harmony search algorithm continues to seek better designs another vector that is obtained in later cycles changes the harmony memory matrix.

Table 2 – Feasible designs obtained after 780 iterations by PSO and HS algorithms

PSO Algorithm (Initial)					HS Algorithm (After 17 iterations)				
Particle No	Section (UB)	Number ofHoles	HoleDia. (mm)	Weight (kg)	Particle No	Section (UB)	Number ofHoles	HoleDia. (mm)	Weight (kg)
1	305×102×25	9	374	86,27	1	305×102×25	9	402	82,19
2	305×102×25	10	365	83,19	2	305×102×25	10	345	82,5
3	254×146×4	10	336	157,78	3	305×102×25	10	342	82,8
4	305×102×25	9	351	89,1	4	305×102×25	10	315	82,9
5	305×102×25	10	348	85,81	5	305×102×25	10	312	83,11
6	305×102×25	11	334	84,15	6	305×102×25	9	335	83,52
7	305×102×25	11	330	84,8	7	305×102×25	10	305	83,72
8	254×146×37	12	303	133,65	8	305×102×25	9	328	83,82
9	305×102×25	11	333	84,32	9	305×102×25	9	313	84,33
10	305×102×25	10	368	82,71	10	305×102×25	9	310	84,43

The optimum result presented in Table 2 is obtained after 780 iterations. It is noticed that this design vector remained the same even though the design cycles are continued to reach 5000 which was the pre-selected maximum number of iterations.

Table 3 – Comparison of optimum designs for 4-m simply supported beam

Search Method	OptimumSection Designations (UB)	Diameterof Hole (mm)	TotalNumber ofHoles	Minimum Weight(kg)
HS Algorithm	305×102×25	402	9	82,19
PSO Algorithm	305×102×25	368	10	82,71

It is apparent from the Table 3 that the optimum design has the minimum weight of 82.19 kg. In the optimum design the harmony search algorithm selects 305×102×25 UB section for the root beam. Furthermore it decides that the cellular beam should have 9 circular holes each having 402mm diameter.

Similar to harmony search algorithm the particle swarm optimizer also starts initializing the parameters. The values  $c_1$  and  $c_2$  are selected as 1, 2 is adopted for  $w$  and the values of  $\Delta t$  and  $V_{max}$  are chosen as 2. The total number of particles is selected as 10. The initial set of feasible designs assigned to each particle is listed in Table 1. In this table, the first particle has the feasible design with minimum weight. This design has the minimum weight of 120.53 kg where the universal beam section of 356×127×33 UB is selected for the root beam. The beam should be produced such that it should have 8 circular holes each having 386mm diameter at this weight. Design cycles are started with these values of the particles and the positions and the objective function values of particles keep on changing iteration after iterations. The best among these positions is kept as the optimum design attained in the current iteration. If this one is better than the global one then it is assumed as the optimum design obtained up to the present iteration. Table 2 contains the designs obtained after 430 iterations. It is noticed that the optimum design obtained in this table does not improve even though the iterations are continued until 5000. Comparing to harmony search method, the optimum design is obtained after 430 iterations in particle swarm algorithm. It is apparent from Table 3 that the optimum design has the minimum weight of 82.71 kg which selects 305×102×25 UB section for the root beam, total of 10 holes in the beam each having 368mm diameter. In addition, the design history curve for both techniques is shown in Figure 2.

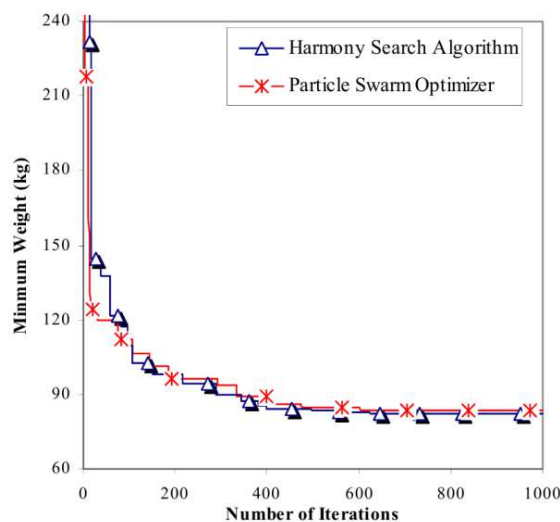


Fig. 2. The design history graph for 4-m cellular beam

**Conclusions.** In this particular problem, these results demonstrate that while both the strength and geometric constraints are dominant in HS algorithm, in PSO algorithm, only the strength constraints are severe. To sum up, the optimum result of harmony search technique is compared with particle swarm optimization method to show accuracy and performance of methods on cellular beams. Although the algorithms of HS and PSO are mathematically quite simple, they are quite robust in finding the solutions of combinatorial optimum design problems as it is demonstrated in the example considered. This result also demonstrates that harmony search algorithm is a very rapid and effective method for optimum design of small-scale problems that consist of a small number of decision variables. Consequently, the technique is recommended for its application to optimization of the three different cellular beam problems.

#### REFERENCES

1. Руководство по проектированию балок с перфорированной стенкой : утв. ЦНИИПСК 19.12.78. – М., 1978. – С. 28.
2. Steelwork design Guide to BS 5950 : Part 1, “Section Properties, Member Capacities”, Vol. 1, – Steel Construction Institute. – The 4th ed. – U.K., 1990.
3. Perez, R.E. Particle Swarm Approach for Structural Design Optimization / R.E. Perez, K. Behdinan // Computers and Structures, 85 (19-20), 1579-1588, 2007.
4. Saka, M.P. Optimum Design of Grillage Systems Using Harmony Search Algorithm / M.P. Saka // Journal of Structural and Multidisciplinary Optimization. – 2009. – Vol. 38 (1). – P. 25–41.

**INFLUENCE OF HETEROGENEITY OF THE REINFORCING BARS IN THE CROSS SECTION ON THE TESTIMONY OF PORTABLE HARDNESS****TAISIYA ERMOLAEVA, ALEXANDER KOLTUNOV****Polotsk State University, Belarus**

*It is considered one of the most important trends in the field of inspection and quality control of existing structures. The basic methods for determining the class of reinforcement in concrete examination of buildings and structures. The possibility of using portable hardness in practice. Attention is paid to methods for treating the side surface of reinforcement stem. Experimental data showing the unevenness of reinforcement strength readings across the section depending on the depth of cut. The conclusions about the need for additional testing.*

Today the development and improvement of methods and tools for monitoring the technical state of reinforced concrete structures of existing buildings and structures is one of the most important areas in the field of quality control of materials and products.

A detailed examination of reinforced concrete elements of buildings and structures a priority is to determine the parameters of the steel reinforcement. The most difficult and the most important in the performance of testing calculations is to establish a reinforcement belonging to a particular class, and thus assigning it specific strength qualities.

There is a fairly large number of methods of control parameters of the strength characteristics of reinforcement. However, not all of them allow you to reliably and accurately determine the required parameters. Some methods are hardly applicable because of the difficulties that accompany their use, while others are outdated.

The basic method of determining the strength of reinforcement is considered a test of samples in tension in accordance with GOST 12004. However, it has a major drawback: when it must extract using test samples, which necessitates partial structural failure, and hence to its weakening. Sampling the complexity is very high, as well as the complexity and carrier recovery element capability.

Actual and perspective are considered non-destructive methods to determine the strength of the steel through the dependence of the "strength-hardness". This method to date the subject of many research and experimental work. The fundamental relationship for steel is reflected in GOST 2276-77 "Metals and alloys. The method of measuring the Brinell portable hardness strength static action" and GOST 9013-59 "Metals. The method of measuring the hardness of Rockwell". To apply these methods, a large number of portable devices that allow you to determine the hardness of the steel in the field. The above measuring apparatus implemented by various methods such as:

- the dynamic series TEMPO units (Shore analog measurements) Ultrasound;
- series devices MET-U (Vickers) static;
- Equostat (Rockwell), and others [1].

In the dynamic method is defined indirect characteristic - the ratio of the velocity at impact and rebound of the indenter from the specimen surface. The measured parameter in the ultrasonic method is the oscillation frequency of the indenter during its introduction into the sample at a certain depth under the action of a constant force. In static indenter hardness measurement method slowly and continuously pressed into the surface of the test sample with a certain force.

When using these methods is not necessary to extract samples which greatly reduces the volume of work as compared with the method of reinforcement class by testing samples of the tensile and bearing capacity to restore the damaged element.

It should be noted that the use of any of the non-destructive testing methods requires compliance with a number of requirements to the measurement site, and its surface:

- measurement of the minimum area for the use of the dynamic method must be at least 10 mm and ultrasonic - not less than 5 mm;
- roughness of the surface to be measured with most methods of hardness measurement (both portable and fixed devices) must not exceed 0.32 mkm (Ra) [2].

To achieve the above requirements, you can perform with the help of processing rebar surface abrasive discs mounted on angle grinders (LBM). To get the desired size and area roughness is recommended to further refine the surface by appropriate nozzle angle grinders.



Also, do not ignore the fact that the properties and structure of the surface layer of steel can be changed during their processing. Generally, these changes are due to the influence of two factors: high temperature and hardening due to plastic deformation of the surface layer of the metal.

The same effect on the hardness readings provides the depth of cut surface, as the cross section of the reinforcing bar hardness is not uniformly distributed, close to a value above the sample surface, as compared with the other readings.

Thus, the use of portable devices with low penetration depth of the indenter (static, ultrasonic) can provide measurement results with significant differences from the truth. Therefore, to expand the scope of portable hardness testers on the side of the reinforcing bar is necessary to investigate the effect of treatments on the reinforcing steel and choose the optimum slice thickness.

In order to determine the depth of the cut affect the readings of portable hardness tester based on the Polotsk State University tests were conducted on samples of class S800 diameter 10, 12, 14 mm. It was selected for the six samples of each diameter.

Constant K5U instrument was used to determine the hardness of the metal. Hardness measurements were performed pre-polished samples on the lateral surface. To identify the hardness depending on the size of the cut, the samples were made thin sections of different depths. The thickness of the shear layer was administered – 1 mm, 2 mm, 3 mm diameter and 10.12 mm 1, 2 mm, 3 mm, 4 mm for diameter 14.

The averaged values of experimental results are shown in Table 1.

Table 1 – Average hardness readings static depending on the depth of cut

Class reinforcing steel	S800									
Diameter of the shaft	10			12			14			
Slice thickness	1 mm	2 mm	3 mm	1 mm	2 mm	3 mm	1 mm	2 mm	3 mm	4 mm
Results	38,54	44,5	42,91	29,42	40,58	33,88	44,05	42,69	41,94	37,75
	40,28	41,92	40,28	32,12	38,31	33,32	43,41	39,4	42,72	38,27
	46,03	39,95	46,03	36,29	44,6	40,22	43,04	38,68	41,82	39,72
	44,22	42,89	44,22	34,76	43,89	36,48	42,7	40,52	41,95	40,6
	41,5	42,35	41,5	32,01	36,45	39,56	44,19	41,23	38,31	39,28
	39,62	40,44	39,62	26,91	37,01	41,29	40,45	40,54	41,18	38,77
The averaged values	41,70	42,01	42,43	31,92	40,14	37,46	42,97	40,51	41,32	39,07

Here is a clear reflection of the change in hardness indices over the cross section of the reinforcing bar.

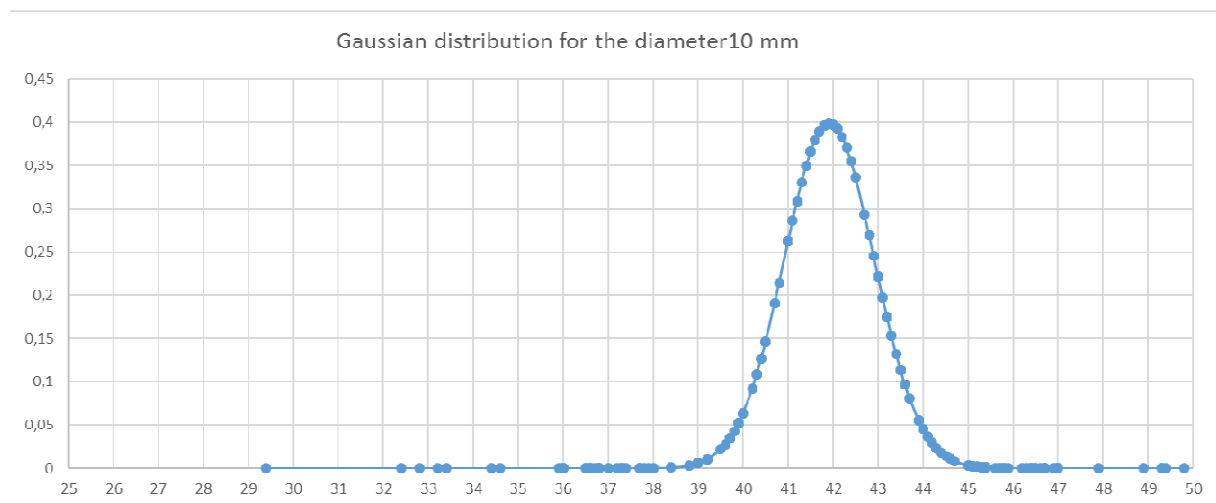


Fig. 1. Schedule changes in the indices of hardness class S800 of reinforcing bars diameter of 10 mm

From the data presented above it can be concluded that for the selected class scatter S800 durometer readings of samples in the cross section of the reinforcing rod is negligible. In this case, this phenomenon is related to the technology of manufacturing of reinforcing bars S800 class. Samples of reinforcing rods for Quality Certificate № 0037618 for diameter 10, № p 2146 for diameter 12 and № 1110 for diameter 14 are rental reinforcing thermo-hardened and comply with STB 1706-2006. The graphs show that the probability of falling hardness values of approximately 10 to 15%.

However, you must make an additional analysis based durometer readings on the depth of cut of the rod surface for of reinforcing bars produced by other technologies and to identify whether there is for them the optimum depth of cut.

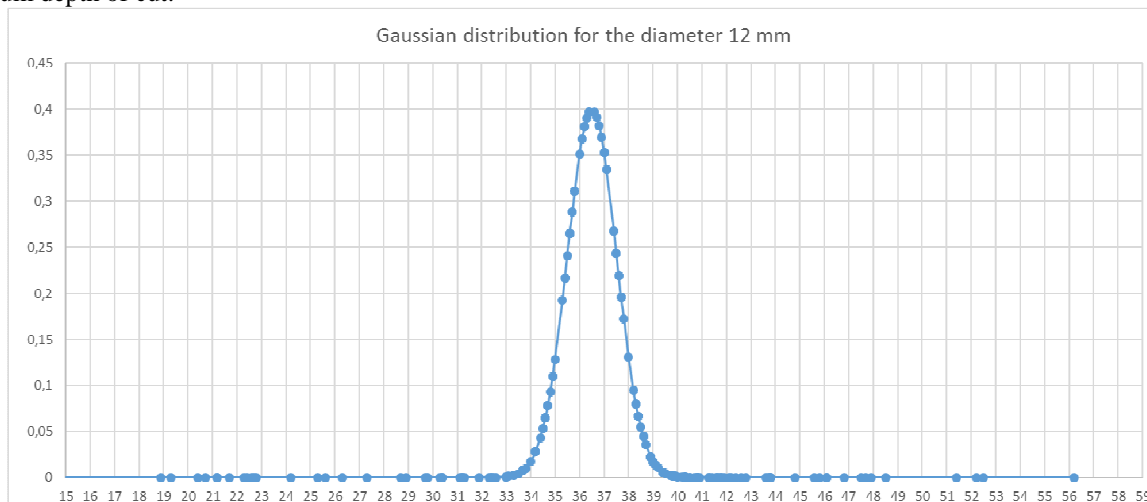


Fig. 2. Schedule changes in the indices of hardness class S800 of reinforcing bars diameter of 12 mm

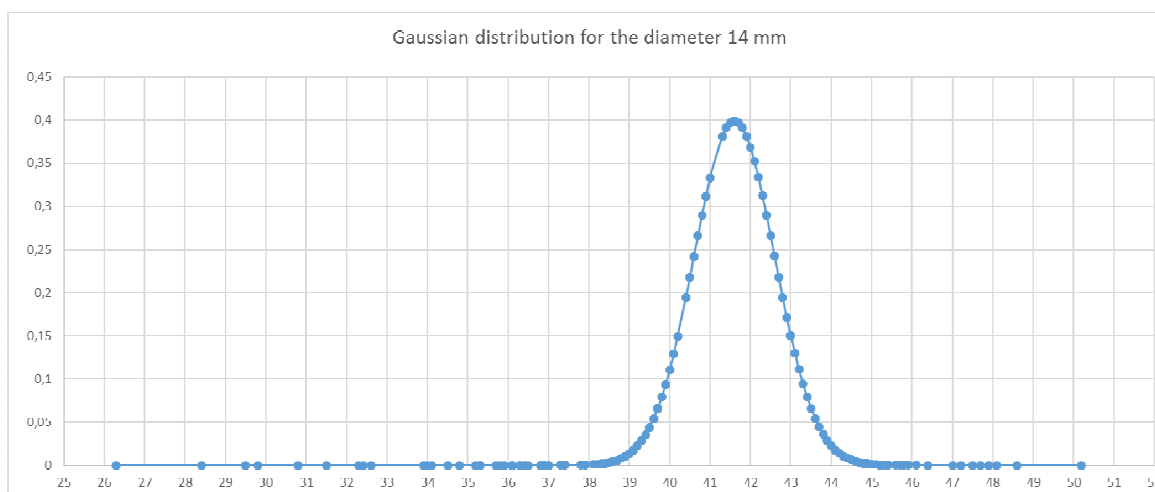


Fig. 3. Schedule changes in the indices of hardness class S800 of reinforcing bars diameter of 14 mm

Taking into account the wide variety of different grades of reinforcing bars, which are found during the examination of existing buildings and structures and their diameters, a more detailed study of the dependence of the depth of the sample cut and its diameter on hardness readings.

Most of the literature indicate dependence "hardness-strength steel", obtained in the study of rolled profiles (channels, I-beams, etc.), used for the construction elements [3]. Easy to use this dependence in the study of rolled sections is caused by a relatively narrow range of strength, a small variety of brands and simple way to improve thermal. All this can not be said of the reinforcing steel of various grades.

For a reliable assessment of the reliability of the proposed method is required to carry out additional experiments, obtained by different technological methods of reinforcement samples (hot-rolled, heat and thermo-hardened), in order to identify the hardness distribution in the cross section of the samples. When the relevant research and development of practical recommendations for the method can be used without sampling, on the surface of the rod directly at the opening portion.

#### REFERENCES

1. Улыбин, А.В. Применение зависимости «прочность-твердость» при обследовании стальных конструкций с помощью портативных твердомеров / А.В. Улыбин, П.А. Rogozin // Стройметалл. – 2011. – № 4 (23). – С. 25 – 27.

2. Металлы и сплавы. Метод измерения твердости по Бринеллю переносными твердомерами статического действия : ГОСТ 22761-77.
3. Хомич, В.М. Экспериментальное исследование взаимосвязи предела текучести и некоторых чисел твердости строительных сталей / В.М. Хомич, Д.Н. Логвинов // Известия вузов. Строительство. – 1999. – № 11. – С. 133–137.
4. Сталь арматурная термомеханически упрочненная для железобетонных конструкций. Технические условия : ГОСТ 10884.
5. Галкин, Д.С. Определение временного сопротивления стали эксплуатируемых строительных металлоконструкций методами твердомерии при обследовании / Д.С. Галкин, А.Н. Патраков // Вестник ПНИПУ. Строительство и архитектура. – 2010. – № 1. – С. 85–88.
6. Улыбин, А. В. Методы контроля параметров армирования железобетонных конструкций / А.В. Улыбин // Инженерно-строительный журнал. – 2011. – № 1 (27).
7. Металлы. Метод измерения твердости по Роквеллу : ГОСТ 9013-59.

**DETERMINATION OF THE ISSUE STRENGTH CHARACTERISTICS  
OF CONCRETE STRUCTURES IN SURVEY RECONSTRUCTED BUILDINGS**

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*At the moment the reconstruction is one of the priority areas in the construction. With reconstruction manage to solve many issues that arise in the real estate and land shortage. Occasionally, to obtain the required area, there is need for new construction. Suffice it during the reconstruction to add floor or make an addition. Reconstruction is also necessary if, without changing the appearance of the building, we have to completely change the interior layout. There are other methods to increase the usable area, connected with reconstruction.*

An important step in the reconstruction of buildings and structures is to determine the strength characteristics of reinforcement and concrete in structures. This step is an integral part in surveys of buildings and structures, the reconstruction of residential buildings, changing the industrial facility functionality. Evaluation of the bearing capacity of reinforced concrete structures in the survey of buildings and structures to determine the possibility of future use of the structure, its reliability and durability.

The basic method of determining the strength of the concrete is a test of samples (cores, cylinders) in compression. However, the reliability of such tests is influenced by many factors. These factors include the difference in size cores respect diameter to length, sample humidity, and the factors associated with the sampling portion, a design change relating to the preparation and laying of concrete technology and storage conditions at selected sites. Standard methods do not allow to determine the strength of the concrete in construction sites or, as in the survey of buildings and structures of these methods in specific structures and does not apply.

Consequently, although the strength of the cube and accepted as the benchmark of strength, it can be considered as a conditional response. To assess the strength of existing designs must take into account operating conditions data structures, their shape and dimensions.

Since the beginning of the 90s of the twentieth century is an active development and production of non-destructive testing instruments. With the passage of time there are more and more sophisticated instruments with electronics and microprocessor technology, developing and increasing their functionalities. However, during the determination of concrete strength using nondestructive inspection techniques must be borne in mind that all of these methods are indirect. Compliance with the test results of non-destructive methods of control values of strength of samples tested by conventional methods is achieved by the selection of calibration curves under certain test conditions. It should also be noted that the indirect parameters of non-destructive testing methods to varying degrees affected by changes in the physical and mechanical properties of a controlled concrete. Thus estimation of strength nondestructive methods depends not only on the strength of the concrete, but also on other factors: the modulus of elasticity of the structural concrete inhomogeneity category concrete surface, cement type cement composition, type of filler, hardening conditions, age of the concrete, humidity and the surface temperature, carbonation of the surface layer of concrete and a number of other less significant factors.

Also on the accuracy of the figures obtained by non-destructive methods of control, impact test method. There are several non-destructive methods of concrete strength:

- the method of separation with shear fracture;
- ultrasonic method;
- shock pulse method;
- the method of elastic rebound;
- plastic deformation method.

At the present time the territory of RepublicBelarus there are standards for the individual test methods GOST 17624-2012 and GOST 22690-88.

Non-destructive testing of concrete strength is produced, as a rule, high-performance devices after establishing correlation of indirect characteristics (basic dependencies) to the actual strength of the test concrete. For these purposes, percussion instruments, based on the methods of shock pulse (rebound, plastic deformation) and ultrasonic meters time (speed) of ultrasonic vibrations in the concrete.

Each of the non-destructive testing methods has its advantages and disadvantages. The use of a particular method is primarily determined by the required degree of accuracy readings, the technological capabilities of the application of one of the methods, material costs.

The only non-invasive method of monitoring resistance, for which there are calibration according to the regulations, is the method of separation with shear fracture. This method has a high accuracy in comparison with other methods of nondestructive testing, however, it should be noted a high volume of work during the test. Also

disadvantage of this method can be considered as inability to use this technique in high-density reinforcement and thin-walled constructions. In such cases, application of the method allowed separation steel discs, this method is also characterized by high accuracy and considered to be less time consuming in comparison with the method of separation with shear fracture. Disadvantages of the method is the necessity for bonding discs 3–24 hours prior to the test (depending on the adhesive used).

Shearing edges method is mainly used to control the linear elements (piles, columns, beams, girders, lintels). Unlike the separation methods and separation with shear fracture, it does not require preparatory work. However, when the protective layer is less than 20 mm and a damage protective layer the concrete method can not be used.

The most common method of controlling the strength of concrete is a shock pulse method. Instruments that use this method are characterized by low weight and compact design, and finding a concrete strength of a shock pulse method is a fairly simple procedure. Measurement results are provided in units of measurement of compressive strength. It should be noted that the application of this method can determine the class of the concrete, measure the strength at different angles to the surface of the concrete, moving the accumulated results to a computer. The classic model for testing devices according to this method is sclerometer Schmidt and his many counterparts. Rebound method, as well as plastic deformation methods based on the measurement of the surface hardness of the concrete. Rebound method is borrowed from the practice of determining the hardness of metal structures. For concrete testing devices are used, which are called sclerometry and are spring breakers with spherical stamps.

Plastic deformation method is based on measuring the size of the print, which remained on the concrete surface after the stress of her steel ball. Method outdated, but used so far due to the low cost of the equipment. More commonly used for such tests Kashkarova hammer. The operating principle is simple. The hammer is inserted a metal rod known strength, and then the device makes a blow to the concrete surface. With angular scale measure the size of prints left on the concrete surface and the rod. Concrete strength is determined from the ratio of print sizes (rod strength is known). Instruments used for the test method of plastic deformation, based on the indentation of the die in the concrete surface through impact or static pressure given force. Despite the relative ease and low cost of the application of this technique is limited to the degree of accuracy of the values is very high accuracy using this method of nondestructive testing of concrete strength, which suggests a lack of reliability of the results, and, as a consequence, inability to use this technique for critical buildings and structures.

The ultrasonic method is based on recording the speed of the ultrasonic waves. By testing technique emit ultrasound through ensounding (sensors have different angles with the test sample) and the surface ensounding (when sensors are located on one side). Sounding through ultrasonic method makes it possible, in contrast to other methods of nondestructive testing of strength, durability check not only in the surface layers of concrete, but also the structural strength of the concrete body. Ultrasonic devices are used not only to test the strength of the concrete, but also for inspection, quality control of concrete, the depth measurement.

The ultrasonic method makes it possible to carry out mass testing of products of any shape repeatedly conduct continuous monitoring of increase or decrease in strength. The disadvantage of this method is error during the transition from acoustic performance to the resistance. Also, ultrasonic devices can not be used for the quality control of high strength concrete, those range controlled strengths limited to 10 ... 40 MPa.

Control strength shock and ultrasonic methods carried out in the surface layers of concrete (except through ultrasonic sounding), and therefore the state of the surface layer has a significant effect on the control results. When exposed to concrete aggressive environments (chemical, thermal or atmospheric) it is necessary to identify the thickness of the surface layer with a modified structure. Also effect on the readings has experience performing the tests, we can not eliminate the human factor in assessing the reliability of the values obtained.

However, it should be noted that the strength of concrete is not the only factor affecting the strength and durability of the entire construction. Concrete should be regarded as a material with oscillating characteristics at random. To achieve the same concrete class may be used many different variations of the compositions of the concrete mix. Thus having a structure the same concrete class may vary in their structure. This involves the use of various technological approaches and material science. It includes the use of various grades of cement, different contents of mineral additives in cement, variations brands of concrete on workability, water-cement ratio, which changes are associated with different activity of cement, as well as with various modifiers the main factors affecting the concrete structure of the stone. Thus, within the same strength of available designs with different structures, increased water cement ratio increases the porosity and therefore the permeability, while the use of modifying agents allows to obtain concrete predetermined plasticity mixture with decreasing amount of water used, which leads to a denser structure of concrete blocks. With regard to the technological aspects, methods are important concrete mix compaction and curing conditions.

Based on the above it is a question from which concrete parameters is a start in determining the strength, reliability and durability of the entire structure. Structural features of the concrete can be taken as a basis for clarifying this issue. The heterogeneity of the structure and properties requires the use of a concrete assessment

of probabilistic and statistical methods, and should be taken into account in the design and organization of production of concrete and reinforced concrete structures. It is necessary to pay attention to the influence of non-homogeneous concrete structure on indirect indicators. A more detailed study of the question of choosing the most appropriate methods of control, as well as the study of the need to treat the surface of the test designs just before the tests.

## REFERENCES

1. Гольшев, А.Б. Железобетонные конструкции / А.Б. Гольшев, В.Я. Бачинский, В.П. Полищук. – Киев, 2001.
2. Бербеков Ж.В. Неразрушающие методы контроля прочности бетона / Ж.В. Бербеков // Молодой ученый. – 2012. – № 11. – С. 20–23.
3. Бетоны. Методы определения прочности по контрольным образцам : ГОСТ 10180-2012. – М. : 2013. – 35 с.
4. Бетоны. Ультразвуковой метод определения прочности : ГОСТ 17624-2012. – М., 2014 – 19 с.
5. Бетоны. Определение прочности механическими методами неразрушающего контроля : ГОСТ 22690-88. – Введ. 01.01.91. – М., 1991. – 22 с.
6. Снежков, Д.Ю. Анализ методик неразрушающих испытаний бетона конструкций по действующим государственным стандартам и нормам Евросоюза / Белорусский национальный технический университет ; Д.Ю. Снежков, С.Н. Леонович, А.В. Вознищик // Наука и техника. – 2013.
7. Улыбин, А.В. О выборе методов контроля прочности бетона построенных сооружений / А.В. Улыбин / Инженерно-строительный журнал. – 2011.

UDC 691.87

**METHOD OF MODELING AND PROTOTYPING TERMINAL CONNECTORS FOR TESTING  
AND OBTAINING PRESTRESSING FRP REINFORCEMENT**

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*The paper presents the possibility of using the technique of rapid prototyping, 3D printing method based on additive technologies. The resulting product, according to the three-dimensional construction of production technology, allows obtaining the characteristics of the stress and deformed state, as well as navigating to the characteristics of natural products, as model can be manufactured as a plastic or fiberglass one. The use of modeling method has become a characteristic feature of science. In view of this fact, it seems appropriate to consider the problem of the relationship of this method and various sciences in order to find the most adequate, objective and reliable foundation of scientific research. The paper presents the possibility of applying a fiberglass reinforcement in prestressed structures.*

Modern views on the use of non-metallic reinforcement have gained greater resonance, ie, used in conjunction with metal designs. However, physical and mechanical properties are much better. This fixture has a high corrosion resistance, in salts, chemical solutions, alkalis and acids. For fiberglass based on polyester resins, a number of general properties relating to their chemical resistance are determined based on the chemical structure of the resins being esters. To expand the applications of composite nonmetallic reinforcement and a detailed study of its joint work with concrete it is advisable to continue research and test various structures, the use of non-metallic reinforcement in prestressed concrete structures. Three ways of prestressing concrete structures with discrete fiberglass reinforcement are mainly used : tension at stops, tension on concrete, continuous winding.

The use of fiberglass reinforcement is expedient only in prestressed structures as fiberglass rods modulus are several times lower (4–5 times) than metal. In cases with fiberglass reinforcement often three basic methods of prestressing concrete structures are used:

1. Tension on abutments (Fig. 1).

This method involves pulling a cable to the desired value with the help of special devices, followed by concreting and concrete hydrothermal processing for faster curing.

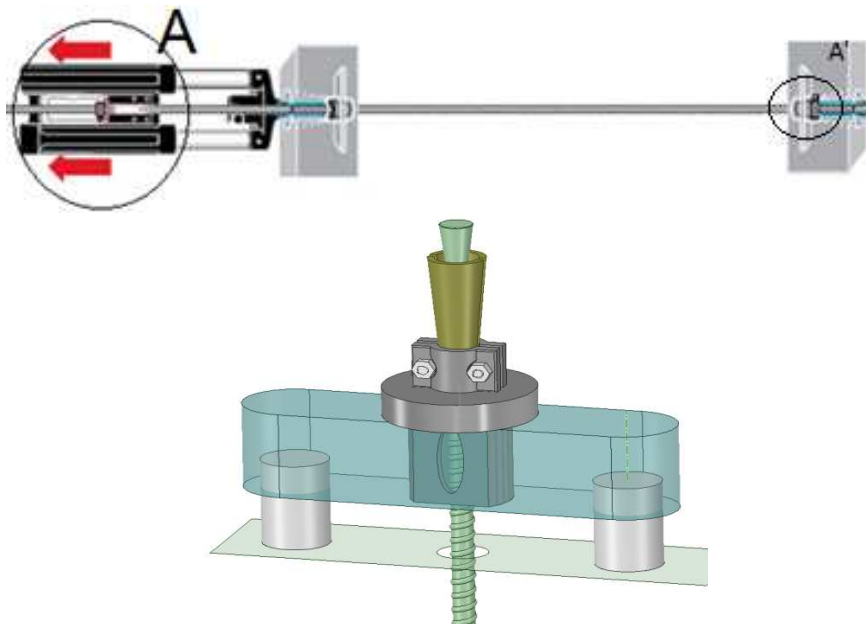


Fig. 1. The method of obtaining pre-stressing by means of hydraulic jacks

2. Tension on concrete.

When tensioning on concrete, channels are laid in it for laying the fiberglass reinforcement. The tension of the reinforcement in this case is made by means of hydraulic jacks, and petrolatum is injected into its systems to fix it.

3. Continuous winding.

This method, which, by the way, is not widely used in modern construction, is coiling on a concrete product of flexible rods or strips of fiberglass.

Developed device (Fig. 2) for testing of fiber reinforcement consists of worm jaws (1) mounted at the ends of fiber reinforcement (3) which is arranged within the support plates and gussets (2), corrugated reinforcement of glass fiber, eliminates the possibility of stress concentrators, the compressive force is controlled by loosening or tightening bolts. Feature constructive execution device is collapsible design elements that provides multiple use. The aim is to reduce the cost of the production of cement and concrete products, reinforced with glass fiber reinforcement periodic profile. The Use of this device enhances the reliability of the results obtained during the test because of lack of destruction in the clamp rod seats. Furthermore, the use of the developed device can create prestressing reinforcement FRP.

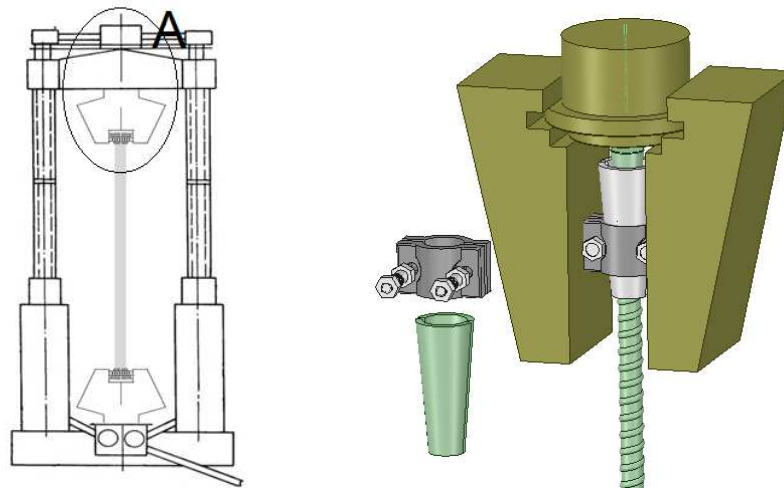


Fig. 2. The terminal clamp for testing and obtaining prestressing FRP reinforcement

In discussions related to the properties of FRP bars or tendons, the following points must be kept in mind. First, an FRP bar is anisotropic, with the longitudinal axis being the strong axis. Second, unlike steel, mechanical properties of FRP composites vary significantly from one product to another. Factors such as volume and type of fiber and resin, fiber orientation, dimensional effects, and quality control during manufacture, play a major role in establishing product characteristics. Furthermore, the mechanical properties of FRP composites, like all structural materials, are affected by such factors as loading history and duration, temperature, and moisture.

While standard tests have been established to determine the properties of traditional construction materials, such as steel and concrete, the same cannot be said for FRP materials. This is particularly true for civil engineering applications, where the use of FRP composites is in its stage of infancy. It is therefore required that exact loading conditions be determined in advance and that material characteristics corresponding to those conditions be obtained in consultation with the manufacturer.

Table 1. – Comparison of mechanical properties

	Steel reinforcing bar	GFRP tendon
Tensile strength, MPa (ksi)	483–690 70–100	165–2410 240–350
Yield strength, MPa (ksi)	276–414 40–60	Not applicable
Tensile elastic modulus, GPa (ksi)	200 29,000	152–165 22,000–24,000
Ultimate elongation, mm/mm	> 0.10	0.01–0.015
Compressive strength, MPa (ksi)	276–414 40–60	Not applicable
Specific gravity	7.9	1.5–1.6

Mechanical properties of composites are dependent on many factors including load duration and history, temperature, and moisture. These factors are interdependent and, consequently, it is difficult to determine the effect of each one in isolation while the others are held constant.



Tensile strength—FRP bars and tendons reach their ultimate tensile strength without exhibiting any material yielding. The comparison of the properties of FRP and steel reinforcing bars and tendons is shown in Table 1. The mechanical properties of FRP reported here are measured in the longitudinal (i.e. strong) direction. Values reported for FRP materials cover some of the more commonly available products.

Unlike steel, the tensile strength of FRP bars is a function of bar diameter. Due to shear lag, fibers located near the center of the bar cross section are not subjected to as much stress as those fibers that are near the outer surface of the bar. This phenomenon results in reduced strength and efficiency in larger diameter bars.

Compressive strength—FRP bars are weaker in compression than in tension. This is the result of difficulties in accurately testing unidirectional composites in compression, and is related to gripping and aligning procedures, and also to stability effects of fibers. However, the compressive strength of FRP composites is not a primary concern for most applications. The compressive strength also depends on whether the reinforcing bar is smooth or ribbed.

Creep and creep rupture—Fibers such as carbon and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of fibers have a significant influence on the creep performance of reinforcing bars and tendons. One study reports that for a high-quality GFRP reinforcing bar, the additional strain caused by creep was estimated to be only 3 percent of the initial elastic strain. Under loading and adverse environmental conditions, FRP reinforcing bars and tendons subjected to the action of a constant load may suddenly fail after a time, referred to as their endurance time. This phenomenon, known as creep rupture, exists for all structural materials including steel. For steel prestressing strands, however, this is not of concern. Steel can endure the typical tensile loads, which are about 75 percent of the ultimate strength, indefinitely without any loss of strength or fracture. As the ratio of the sustained tensile stress to the short-term strength of the FRP increases, endurance time decreases. The above limit on stress may be of little concern for most reinforced concrete structures since the sustained stress in the reinforcement is usually below 60 percent. It does, however, require special attention in applications of FRP composites as prestressing tendons. It must be noted that other factors, such as moisture, also impair creep performance and may result in shorter endurance time.

Test methods are important to evaluate the properties of resin, fiber, FRP composite, and structural components. The resin groups included are: polyester, vinyl ester, epoxy, and phenolic. The fibers included are: E-glass, S-2 glass, aramid, and carbon. FRP composites made of the combination of the above resins and fibers with different proportions are used for reinforcement of concrete members as bars, cables, and plates. Test methods are needed to determine properties of FRP products. Test results are used for quality control during production and for field use. Hence, test methods must be reproducible and reliable. Variation of test procedure and specimen geometry should be addressed to develop meaningful comparisons. Statistical methods of approval are needed to establish the properties of bars, plates, and cables. Other tests that take into consideration environmental changes such as temperature and moisture should be included in the evaluation of FRP products.

#### REFERENCES

1. State-of-the-Art Report on Fiber Reinforced Plastic (FRP) Reinforcement for Concrete Structures / ACI 440R-96 / Reported by ACI Committee 440.
2. Guide Examples for Design of Concrete Reinforced with FRP Bars / by W.K. Feeser and V.L. Brown SP-230—53.
3. Бетонные и железобетонные конструкции : СНиП 52-01-2003. – введ. РБ 01.03.04. – Минск : Белорус. гос. ин-т стандартизации и сертификации, 2004.
4. Полилов, А.Н. Критерии прочности полимерных волокнистых композитов, описывающие некоторые экспериментально наблюдаемые эффекты / А.Н. Полилов, Н.А. Татусь // Проблемы машиностроения и автоматизации. – 2008. – № 3. – С. 103–110.
5. Фролов, Н.П. Стеклопластиковая арматура и стеклопластбетонные конструкции / Н.П. Фролов. – М. : Стройиздат, 1980. – 104 с.
6. Арматура композитная полимерная для армирования бетонных конструкций. Методы определения характеристик долговечности : ГОСТ 32486-2013.
7. Питлюк, Д.А. Расчет строительных конструкций на основе моделирования / Д.А. Питлюк. – М. : Изд-во лит. по стр-ву, 1965. – 154 с.
8. Iyer, S. L. Testing and Evaluating Fiber Glass, Graphite and Steel Cables for Pretensioned Beams / S.L. Iyer, M. Anigol // Advanced Composite Materials in Civil Engineering Structures, Proceedings of the Specialty Conference, ASCE, Las Vegas. – 1991. – P. 44–56.
9. Budelmann, H. Creep Rupture Behavior of FRP Elements for Prestressed Concrete – Phenomenon, Results, and Forecast Models / H. Budelmann, F.S. Rostasy // *Proceedings*, ACI International Symposium on FRP Reinforcement for Concrete Structures, March, 1993. – Vancouver, 1993. – P. 87–100.

**THE QUESTION OF THE APPLICATION OF SLUDGE OF WATER TREATMENT**

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*The problem of negative impact of waste of a sludge collectors on the environment is considered. Sludge of water treatment use options as secondary raw materials, for production of construction materials are offered.*

One of important tasks of the industry of construction materials is ensuring a construction with effective, environmentally friendly materials which are made with the maximum use of raw materials from local production and waste of this production.

Waste of sludge of systems of water treatment of the entities of power is of considerable scientific and practical interest. The analysis of chemical and mineralogical composition of similar waste has shown a possibility of active use as a source of raw materials for receiving construction materials.

The enterprises of metallurgy, the mining and overworking complexes, large heat electro power station and others operate with large volumes of firm, liquid and gaseous components (including waste) create waste heaps of dead rock, a red mud disposal field and sludge collectors. Direct impact on the environment from sludge collectors is made by filtrational losses to the soil and ground waters, secondary dusting and evaporation of gaseous substances from their surface, losses of suspensions when transporting slimes, leading to pollution considerable on land area and transformation of a natural landscape. Sludge collectors are a serious source of hydrodynamic impact on the environment, causing change of level of underground waters that exerts negative impact on a residential zone. Subdump waters pollute superficial reservoirs, ground waters and soils toxic elements. Secondary dusting and gas emission from the surface of the sludge collector cause pollution by toxic connections not only the atmospheres around placement of the sludge collector, but also the soil around them. The working platforms including system of slurry pipelines for transportation of slimes to sludge collectors also demand withdrawal of certain land plots and, in turn pollute the soil and ground waters at damage of pipes and pumps [1].

Important stage is development of measures for the prevention, reduction, compensation and elimination of potential damage to the surrounding environment from the sludge collector.

It is most fully possible to solve this problem due to use of sludges as raw materials of the most material-intensive branch of the national economy of the construction industry. A variety of products of this industry allows to find the rational direction of utilization practically of each type of waste of this group [2].

In work [3] authors suggest to use high-iron sludge of water treatment of the Tomsk water intake for receiving a pigment for the painted composite construction materials. In the chemical composition of sludge of water treatment iron oxide (42 and 44%) on average prevails, shares of oxides of silicon (5,4 and 2,4%), calcium (4,2 and 2,8%) and magnesium (2,0 and 4,9%) are significantly lower.

In attempt of receiving a pigment from sludge of water treatment of the Tomsk water intake, it has been shown that heating of the dried-up sample in a crucible to 400 °C leads to uncontrollable increase in temperature in powder above 600 °C and to his agglomeration in the dense weight having black color. For an exception of agglomeration of powder the technique of receiving a pigment with use of the rotating furnace and with application of an automatic feeder has been offered. By this technique the pigment of coffee color has been received. Also easier way of receiving a pigment from high-iron sludge has been developed and experimentally checked: initial raw materials were dried up, crushed, burned in the muffle furnace at a temperature above 600°C. After cooling the deposit has gained saturated red color.

Authors studied a possibility of use of the received pigment in production of the painted construction composite materials.

Inorganic waste of heat electro power station can used as thinning agent additives in production of a ceramic brick on the basis of clay breeds. Inorganic waste as thinning agent additive, reduces plasticity of clay, connects water. As a result of a product are easier formed, product quality, in particular, frost resistance increases.

It is offered to use sludge of water treatment for production of a ceramic brick. In work [4] the composition of raw materials is developed for production of a brick ceramic by method of moist pressing with use of waste of heat electro power station according to requirements GOST 1160-99 «A brick and stones ceramic» and STB 1286-2001 «A ceramic brick». Clay raw materials of the Zapolye field are applied to production of a ceramic brick of moist pressing on JSC «Obolsky Ceramic Plant».

Inorganic waste of heat electro power stations on the chemical composition and technical characteristics is close to clay raw materials, their application in production of construction materials is one of the main directions on decrease in a material capacity of this large-tonnage production.

The brick made with additive of sludge of water treatment of a boiler room «Southern» JSC «Vityaz» of Vitebsk possesses high strength characteristics, high frost resistance, acid resistance. Due to use as a part of raw materials of waste the cost of such ceramic brick falls by 10–15%.

The analysis of modern experience has shown that use of sludges of chemical water treatment of heat electro power station is limited to their application as minor components at addition in mix of construction appointment. Considerably the smaller attention is paid to activization of these products and obtaining on their basis of the systems which independently have the binding properties. For these reasons as a result of these researches the technology of utilization of sludges of chemical water treatment of the heat electro power station with the maximum energy use stocked at a stage of their education in case of the minimum anthropogenous impact on the environment is developed [2].

Development of effective additives for cement mortars with use of secondary raw materials is an urgent task of construction materials science as allows to prove scientifically application of the construction materials received on the basis of industry by-products.

Technogenic sludges can be used as curing activators. Optimum amount of sludge in cement and sand solutions are 5–10% of weight binder. In this case stable increase in durability for 10–15% is provided. At introduction of carbonate sludge together with gypsiferous as well as for structures with carbonate sludge sharp increase in plastic durability of cement and sand solutions with the increased content of additives is noted.

Researches in work [5] have shown a possibility of use the gypsiferous and carbonate sludges for the purpose of regulation of process of initial structurization of cement and sand compositions. Increase in durability of samples of cement and sand solutions with additive of sludge makes, on average 20–25% and also increase with increase in his quantity in mix.

Some researches showing a possibility of use of sludge of water treatment as a part of gypseous binders as filler, and also efficiency of joint use of sludges with chemical additives modifiers of the properties knitting were conducted.

For the purpose of modification of physics and technology properties of the received gypseous binder during recovery sludge of water treatment additional studying of a possibility of use of sludge of water treatment as filler of the «KMK-OK» modifier representing the starch air exerting impact on a consistence the mortar of mixes, a thixotropy, resistance to a water separation, stickiness binder in the presence of chemical additive is carried out. «KMK-OK» supersoftener-modifier of production of CJSC «Politsel» in Vladimir on TU 6 – 55 – 221 – 1396 – 95 is used as a part of plasters, fillings, glues, as the technological additive reducing stickiness of solution mixes to the tool usually in a combination with cellulose air; let's combine with the majority of other additives for dry construction mixes.

In structure of the composition containing optimum amount of the prepared precleaning sludge in number of 14,7% at a subtlety of a grinding of 14,5% on the rest on a sieve No. 008, entered «KMK-OK» additive in a solid-phase state in number of 0,1–1%. The analysis of the obtained data [6] has shown that introduction of «KMK-OK» softener to structure of gypseous composition increases water requirement gypseous binder from 58% to 67% at introduction to 1% of additive. Acceleration of terms of a prehension of the gypseous test at introduction of additive in quantity to 0,5% is at the same time observed and delay of a prehension at further increase in number of the «KMK-OK» modifier.

In many cases chemical water treatment at heat electro power station is made with use of the cheapest components: coagulant (iron vitriol) and precipitator (slaked lime). Lime as the neutralized agent is applied quite widely, however still there are no corresponding standards regulating its structure and properties as a precipitator what brings in a case of use of usual construction lime to her big overexpenditure and affects phase composition of sludge.

The phase composition of sludge of Novogoryevsky heat electro power station is presented generally by a calcium carbonate, as impurity – compounds of magnesium and iron, plaster, silicon dioxide, organic chemistry.

As a result of researches [7] it is established that on functional purpose sludge of chemical water treatment of heat electro power station can be recommended as raw materials in case of production of the binding substances as contains in a large number of connection on the basis of calcium. For increase in reactionary ability of sludge before chemical neutralization it is recommended to carry out mechanical activation of a deposit by his grinding in a spherical mill. At mechanical activation there is a process of averaging of particles of sludge on grain structure. It allows to exclude a stage of separation of particles of sludge by the sizes as the kinetics and efficiency of reactions of neutralization depends on degree of dispersion.

The main rheological modifiers of cement mixes are chemical additives of surface-active action now. Entering of such additives promotes increase in their mobility, cuts a water consumption, saves binder and has a number of positive side effects depending on their composition, a type and amount of cement, the set parameters of concrete mix.

Special group of the mineral fillers which are functionally intended for regulation of sorption processes in the water binding suspensions and through them forming of a contact zone and superficial processes in composi-

tion «cement – filler», constitute sludges of water purification, water treatment and water softening of industrial enterprises.

Numerous technological experiments have shown that sludges as a part of cement compositions exert positive impact on rheological properties and sedimentation of firm particles on stages of processing of raw mixes at production of heavy, light and especially light concrete, masonry and plaster solutions.

Owing to high dispersion sludges increase number and the areas of phase contacts that increases superficial activity and interphase interactions between cement and filler, promotes decrease in fragility of a cement stone, increases the module of elasticity and durability at stretching and compression.

Effect of sludges on processes of structurization of cement compositions at various stages differs in complexity, however, it is possible to assume with confidence that the adsorptive and connected water – a positive factor for formation of mineral and sludge glue and increase in adhesive durability between binder and filler [8].

As a result it is possible to draw the following **conclusions**:

1) drawing into economic circulation of production wastes and consumption as secondary raw materials provides an effective solution of tasks of resource conservation and environmental protection;

2) because of a negative impact of waste of the sludge collector on the surrounding environment, the problem of their utilization is urgent at this stage of development of the industry of construction materials;

3) as show results of researches, sludge of water treatment perhaps actively to use as a source of raw materials for receiving construction materials.

#### REFERENCES

1. Касимов, А.М. Экологические и экономические инструменты сокращения ущерба окружающей среде со стороны накопителей промышленных отходов / А.М. Касимов, И.В. Гуренко, И.Н. Мацевитая // Экология и промышленность. – 2013. – № 1. – С. 79–83.
2. Николаева, Л.А. Ресурсосберегающая технология утилизации шлама водоподготовки на ТЭС / Л.А. Николаева, Е.Н. Бородай. – Казань : КГЭУ, 2012. – 110 с.
3. Композиционные материалы на основе высокожелезистого шлама водоподготовки / Н.Т. Усова [и др.] // Изв. Том. политехн. ун-та. – 2011. – Т. 319. – № 3. – С. 36–39.
4. Изготовление керамического кирпича с использованием промышленных отходов / А.П. Платонов [и др.] // Вестн. Витеб. гос. технол. ун-та. – 2015. – Вып. 28. – С. 128–134.
5. Тарасеева, Н.И. Структурообразование и твердение цементных материалов, модифицированных солевыми и шламовыми отходами предприятий энергетики : автореф. дис. ... канд. тех. наук : 05.23.05 / Н.И. Тарасеева ; Пензен. гос. ун-т архитектуры и стр-ва. – Пенза, 2005. – 24 с.
6. Валеев, Р.Ш. Способ применения шламовых отходов водоподготовки в строительных материалах с использованием суперпластификатора «КМК-ОК» / Р.Ш. Валеев, И.Г. Шайхиев // Вестн. Казан. технол. ун-та. – 2012. – Т. 15, № 12. – С. 74–75.
7. Дорожные строительные и лакокрасочные материалы / А.П. Платонов [и др.]. – Витебск : УО «ВГТУ», 2012. – 100с.
8. Фрактальное моделирование свойств шламовых отходов / С.Ф. Коренькова [и др.] // Башкир. хим. журн. – 2007. – Т. 14, № 4. – С. 114–119.

UDC 624.15

**METHODS OF ENSURING THE STRENGTH OF A CONTACT JOINT  
OF THE COMPOSITE CONCRETE STRUCTURES****KSENIYA KOSTURINA, VIKTORIYA KALITUHA, ELENA KREMNEVA**  
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*This article is devoted to the influence of material science, technological and engineering measures on the strength of contact joints. The necessity of all three aspects to achieve optimum adhesion of the concrete layers is determined. The expediency of actions from the point of view of labor and material costs is considered.*

Providing of collaboration of the layers of concrete and reinforced concrete in composite structures is an important issue not only in precast-monolithic and monolithic construction, but also in the reconstruction and modernization of buildings and structures. Quality adhesion of concrete is based on the unity of material science, technological and engineering measures to ensure the strength of the contact joint.

The impact on the joint of material science aspects is, first of all, in the structure of the materials itself and especially in the properties of the new concrete, and as it makes contact with the old one. Decisive role in this process is played by the type of binding agent. The concrete based on cement binding agents (Portland cement, slag Portland cement, portland pozzolan cement, aluminous cement) has unique properties and is used in load-bearing and enclosing structures, if they are not subject to special requirements. So during the study of adhesion of concrete with cement binding agents, it was found that the use of Portland cement gives the highest strength, the adhesion of alumina cement in comparison with Portland cement showed strength by 20-50% less [1].

The most important property for a binder is grinding fineness. With the increase of cement grinding fineness the rate of hydration and cement strength increase. The average specific surface area of the Portland cement is 2500–3000 cm<sup>2</sup>/g. The particles that comprise such cement react chemically with water only by a quarter of its volume. The remaining volume of the particles performs the function of an inert aggregate in the hardened cement mixture [2]. Modern technologies allow to produce special cement of much finer grinding. However, fine ground cement causes increased shrinkage that may adversely affect the strength of the contact joint.

Nowadays there is a wide use of special concretes, but at the same time their use doesn't always have a positive effect on the adhesion strength. Increased strength and durability under special conditions can greatly complicate the adhesion process, and that requires additional actions.

A water-cement ratio of concrete mixture plays an important role in strength of concrete adhesion. The use of low-slump concrete and stiff mixtures may adversely affect the joint performance, as even using concrete vibration it is difficult to achieve soundness of concrete adhesion. The use of flow concrete mixtures is also not recommended due to the significant difference between the shrinkage of concrete, which leads to disruption of adhesion bonds and the reduction of adhesion [3].

To increase the plasticity of the mixture with less water consumption it is recommended to use modifying additives. In modern construction modified concrete is widely used in practice. Of most interest is plasticizer: the super - and hyper plasticizers.

There are a great variety of plasticizers. Typical additives with pronounced plasticizing properties are additives on the basis of the waste and by-products of the pulp and paper industry (ССБ, СДБ, ЛСТ) and super plasticizers (C-3, 10-03, МФАС-100Р), etc. Plasticizers lead to the increase in the specific surface of cement, due to which the density of the cement paste increases and its viscosity decreases [4]. A lot of researches are devoted to the study of the influence of additives on the flocculation of cement grains, as on the basis of Polotsk State University the investigation of plasticizer C-3 was carried out and its positive effect was detected, figure 1 [4].

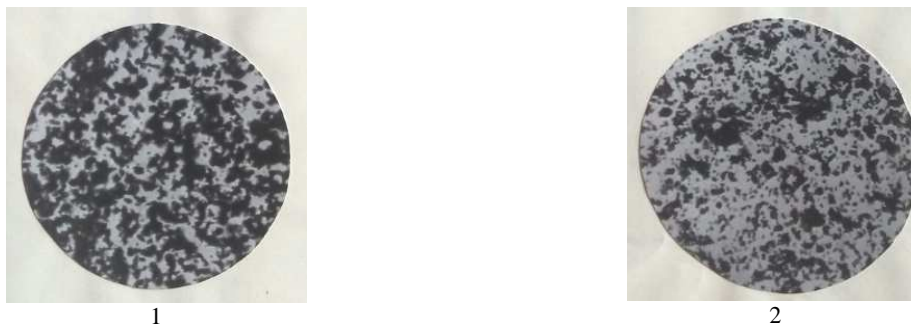


Fig. 1. Influence of additives on the flocculation of cement grains:  
1 – without additives; 2 – with the additive C-3

The rate of cement hydration in the presence of additives depends on the chemical composition of the additive and its concentration, it is not clear how different plasticizers will affect the strength of the contact joint.

In Vitebsk region the additives like C-3, CIIC, various modifiers of the Stakhem's company have found application. Table 1 shows the most common current plasticizers and the recommended dosages for them.

Table 1 – Modifying additives

Name	Recommended dosage in % from cement mass
Stakhement F super plasticizer	0,5–1,5
Stakhement 2000M hyper plasticizer	0,3–1,2
Stakhement hyper plasticizer	0,5–1,8
Stakhement 2010 hyper plasticizer	0,8–1,5
C-3 super plasticizer	0,9–2,5

A lot of researches done on the basis of Polotsk State University, Brest State Technical University, Kyyvi Rih National University are dedicated to the study of the concentration of a particular chemical additive in the concrete mixture [3, 5–7]. Modified concrete has been widely used in monolithic construction, but in precast-monolithic construction and renovation the question of the influence of modifying additives on the strength of the contact joint remains unstudied. So in the research [3] the use of C-3 was studied, and in the researches [5–7] the use of the additive CIIC and Stakhement-2000M. Table 2 shows experimental data obtained by the authors of these researches.

Table 2. – The change of shear strength of prefabricated samples depending on a concentration of chemical additive in new concrete

Name of used additive	Cone slump, sm	Test shearing resistance depending on additive ratio, MPa		
		0,4	0,7	1,0
Stakhementr-2000M	12	0,972	3,377	1,954
C-3	10	1,4	1,96	1,16
CIIC	12	1,04	1,27	1,06

From the above table it is seen that the optimal concentration for the studied additives can be considered as 0,7% [3, 5, 7].

However, for large volumes of work the use of modifying additives can be very costly and not advisable, as the cost of modified concrete is bigger than the cost of conventional concrete. In these cases it is possible to use layers or impregnations on the basis of modified cement systems. As the adhesive layer colloidal cement glue is used. But the adhesive layers and impregnations should be used carefully and only after appropriate studies. In the study conducted in [1] the glues made on the basis of cement, grinded until the specific surface of 5000–7000 cm<sup>2</sup>/g showed high strength of joints.

It is also worth noting that recently to improve the adhesion and to increase the strength of the joint of old concrete with new one various polymeric adhesives and composites have been applied. When choosing adhesives it's necessary to consider not only their strength, but also reliability and durability. Cohesive and adhesive properties of various adhesives and their physicochemical properties have been thoroughly studied. The recommendations for the use of the proposed chemicals for corresponding building structures have been developed. Epoxy adhesives have been widely spread. In Belarus today, there is a big variety of these materials, however their cost is quite high. That's why, the use of polymeric adhesives to connect concrete is suitable for minor areas of gluing, determined by technological and strength characteristics of the adhesive. However, polymer adhesives and compositions are increasingly used in construction and their properties are improved.

Technological activities depend mostly on the plasticity and formability of the concrete mix, the wetting of the surface of the old concrete and surface preparation method, and the actions on new and old concrete curing.

In Belarus and abroad there is some experience in the adhesion area treatment. There are several surface preparation methods. Their choice depends mainly on the volume and surface requirements for the job. These methods can be divided into four main groups: water and water-air treatment, dry mechanical, chemical and flame cleaning [8].

The most common and safe are water, water-air and dry mechanical treatment. A structural element subjected to flame cleaning can change its properties, which may affect its future work. Chemical treatment is based on the use of organic and inorganic removers and as a rule these removers are made from acidic chemical compounds. In the result of such process the concrete structure is broken and after that the remains of the concrete are simply washed off under the water pressure. The means for removal of concrete are flammable, some of

them emit harmful gases during the process and almost all compositions require extra individual protective measures. In addition, it is impossible to determine if chemical substances are fully washed away from the surface or have remained, and it is also unknown how the remnants of chemical agents will influence the strength of adhesion.

There are studies of the reliability of the adhesion of old concrete with new one in compliance with appropriate technology of laying of new concrete and surface preparation of old concrete [9, 10]. A special feature of the technology involves laying of the new concrete on clean, rough, wet surface, possibly by vibrating the concrete mix. However, in terms of reconstruction, during structural reinforcement it is impossible to use vibration because of tight working space or structure condition. So in the course of studying of the effect of the method and the nature of the surface treatment on the strength of the contact joint [11] the following conclusions have been made:

- cleaning of the surface to the filler with the help of cuts to the depth of 5 mm and with the pitch of not less than 40 mm increases the strength of contact joint by 1.5 times in comparison with the adhesion strength on a smooth surface. The difference values of the adhesion strength of the contact joint for samples having a smooth or intermediate between smooth and very smooth surface, not significant, therefore, during surface treatment in certain cases it may be enough just to remove cement milk;

- samples with layer-by-layer compaction of concrete by joint grouting with vibration give much higher results of the shear resistance of the composite structures than the samples with layer-by-layer compaction of concrete by joint grouting with ramming.

It should also be noted that differential of shrinkage of new and old concrete has adverse influence on the adhesion, that's why much attention is paid to the new concrete maturing and old concrete watering. It is necessary to lay the concrete on a damp but not wet surface, as excess of water reduces the strength of the adhesion. The adhesion strength is significantly higher during the hardening of the samples in wet conditions than under normal storage conditions [9]. During slow curing of new concrete ultimate strength of the joint has generally higher strength than during rapid solidification [12].

Structural measures include an increase in the actual area of contact joint, which can be reached through holes and slots, the anchor protrusions and curves, or by the device of keys of different shapes. However, such activities require high labour cost and are not always necessary. Their application depends on the requirements of the construction design and its overall condition.

According to the above mentioned information the following conclusions can be made:

- it is possible to achieve the required adhesion strength through a combination of material science, technological and engineering activities: 1) by increasing the actual contact area by stripping the surface roughness, to reduce labor costs it can be limited to a simple surface cleaning with the removal of cement milk; 2) through the use of modifying additives, in particular СПС, С-3, Stagement-2000M in the amount of 0.7% from the weight of cement; 3) and treatment of new and old concrete;

- the possibility of applying the impregnation or the layers with the use of modified cement systems requires detailed study, as perhaps a more cost-effective option for improving the strength of contact joint, in comparison with the use of modified concretes.

Today, on the basis of Polotsk State University a scientific study on the investigating of the possibility of applying of surface treatments or impregnations on the basis of modified cement systems is conducted.

#### REFERENCES

1. Торкатюк, В.И. Склеивание старого бетона с новым / Харьков. гос. акад. гор. хоз-ва ; В.И. Торкатюк, Н.М. Золотова // Коммунальное хозяйство городов : науч.-техн. сб. – 2002. – № 42.
2. Войтович, В.А. Нанонаука. Нанотехнология. Нанобетоны / В.А. Войтович // Н-Новгород : Нижегород. регион. центр nanoиндустрии, 2010.
3. Юкневечюте, Я.А. Предложения по расчету усилений изгибаемых и сжатых конструкций, находящихся под нагрузкой, для пособия по проектированию железобетонных конструкций при реконструкции / Я.А. Юкневечюте, В.А. Клевцов, В.М. Богачюнас. – НИИЖБИ, 1980.
4. Киреева, Ю.И. Исследование механизма действия химических добавок на свойства цементных систем / Ю.И. Киреева, Т.И. Ермолаева, К.А. Костюрина // Веснік Полацкага дзяржаўнага ўніверсітэта. Серыя Ф, Будаўніцтва. Прыкладныя навукі. – 2015.
5. Чикалина, О.П. Усиление железобетонных конструкций намоноличиванием с применением модифицированных бетонов : автореф. дис. ... магистра техн. наук : 05.23.01 / О.П. Чикалина ; Полоц. гос. ун-т. – Новополоцк, 2003.
6. Хаменок, Е.В. Особенности подготовки контактных швов в строительстве / Е.В. Хаменок, Е.Г. Кремнёва // Труды молодых специалистов Полоцкого государственного университета. Строительство. – 2007. – Вып. № 22.

7. Калитуха, В.В. Прочность контактного шва железобетонных составных конструкций : автореф. дис. ... маг. техн. наук / В.В. Калитуха; Полоц. гос. ун-т. – Новополоцк, 2017.
8. Баженов Ю.М. Технология бетона : учеб. пособие для технол. специальностей строит. вузов. / Ю.М. Баженов. – Изд. второе, перераб. – М. : Высш. шк., 1987.
9. Гвоздев, А.А. Изучение сцепления нового бетона со старым в стыках железобетонных конструкций и рабочих швах / А.А. Гвоздев, А.П. Васильев, С.А. Дмитриев. – М. : ОНТИ, 1936.
10. Бондаренко, С.В. Усиление железобетонных конструкций при реконструкции зданий / С.В. Бондаренко, Р.С. Санжаровский. — М. : Стройиздат, 1990.
11. Хаменок, Е.В. Контактные швы в железобетонных составных конструкциях / Е.В. Хаменок, Е.Г. Кремнева // Вестник Полоц. гос. ун-та. Серия F. – 2011.
12. Ремонт поврежденных поверхностей бетонных и железобетонных изделий / А. Г. Доля. – Донбасс : Донбас. нац. акад. стр-ва и архитектуры; ООО «ВП Мост»; ГП «Научно-исследовательский институт строительных конструкций», 2010.



UDC 697:921.22

**THE USING OF REGENERATIVE SUPPLY VENTILATION ELEMENTS TO ENSURE  
THE REQUIRED AIR EXCHANGE IN PREMISES BUILDINGS OF HIGH INTEGRITY**

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*In work questions of air supply ensuring of rooms in buildings of the increased tightness are considered. The description of a design, a way of installation and the principle of work of a recuperative affluent ventilating element are provided.*

When designing residential buildings the increased sealing of the external protecting designs is provided. External walls, windows and overlappings have the high resistance to a heat transfer, and also low coefficients of air permeability. At installation of windows with a plastic profile air exchange of rooms doesn't meet sanitary standards. If it isn't enough to warm the building and/or not to provide necessary amount of the ventilated air, then condensate of warm internal air is formed. It leads to development of fungus and mold on internal surfaces of the cold protecting designs. The premises of such buildings almost miss the outside air due to infiltration through leakages in building structures.

Now at household gas supply the gas equipment, combustion of gas in which is carried out in fire chambers of devices of various designs (coppers, water heaters, heat capacious furnaces, etc.), and also in gas stoves, is used. The usage of this or that method of burning depends on the thermal power of the gas device determining quantity of the allocated combustion products. In case of an open method of gas combustion its products due to natural ventilation are diluted to safe concentration. In case of the closed combustion chamber products of combustion are removed from rooms by means of special ventilating channels.

The importance for ensuring safe use of household gas appliances is ensuring giving of enough air on burning of gas and complete removal of products of combustion from rooms in the atmosphere.

Natural ventilation through open windows, doors, lattices and other provided designs depends on weather conditions – differences of temperatures of internal and external air, wind speed. Removal of air from rooms is possible in the presence of a difference of pressure:

$$\Delta P = g \cdot h \cdot (\rho_H - \rho_\epsilon) \quad (1)$$

where  $g$  – acceleration of gravity,  $m/c^2$ ;

$h$  – vertical distance from the center of an exhaust lattice to the mouth of the exhaust mine,  $m$ ;

$\rho_H$  – density of external air,  $kg/m^3$ ;

$\rho_\epsilon$  – density of internal air,  $kg/m^3$ .

The air for burning, necessary for gas combustion is desirable to be given artificially. For  $1 m^3$  of natural gas about  $10 m^3$  of air are required. There are systems with installation of fans in the served rooms. Mechanical ventilation can provide the required quantity, however it consumes energy.

In case of operation of the gas equipment there can be adverse conditions of a microclimate of rooms connected with the increase in concentration of products of combustion in air of rooms. As a result of the requirement of sanitary standards for separate components aren't carried out.

This situation is aggravated during the cold period of a year when airing of rooms is almost impossible. Low temperatures of outside air lead to the increased discharge in chimney channels which in turn influences the stability of a flame and a completeness of gas combustion in cameras of boilers and water heaters.

Thus, the organization of the forced and exhaust ventilation with air supply to rooms where the gas-using equipment is installed is an important question of design.

In residential buildings with gas stoves with 4 torches air exchange has to make not less than  $90 m^3/h$ . In case of infiltration, according to the payment under regulating documents, accomplishment of this requirement is observed only for the ground three floors of a ten-storied building.

There is a design of the ventilating block for supply of external air to rooms given in figure 1. The Recuperative Affluent Ventilating Element (RAVE) allows to provide necessary air exchange for an optimum microclimate. RAVE is made of concrete in the form of a parallelepiped  $100 \times 100 \times 300$  mm with the openings with a diameter of 1,5–5,0 mm [1]. The number of blocks, number and diameter of openings is selected according to ensuring the required air exchange of the room.

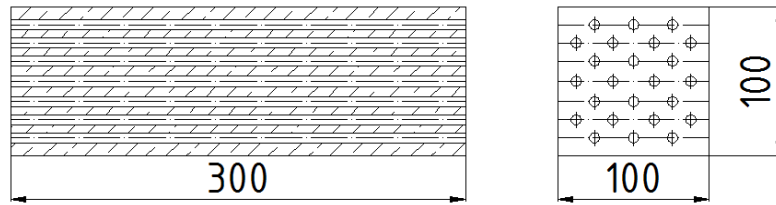


Fig. 1 – Design of a recuperative affluent ventilating element

The block is installed in an external wall under a windowsill plate and works as the heat exchanger (Fig. 2, *a*). The thermal stream moves in the direction to an opposite direction of the movement of external air. Longitudinal openings are the heat exchanging surfaces. External air gets in the room and at the same time there is its heating. Thus, observance of the required air exchange without considerable costs for heating of external affluent air is indoors provided. The process flow diagram of the RAVE counter flow heat exchanger and the schedule of change of temperature in it the heat exchanging environments along the surface of heating is provided on Fig. 2, *b*.

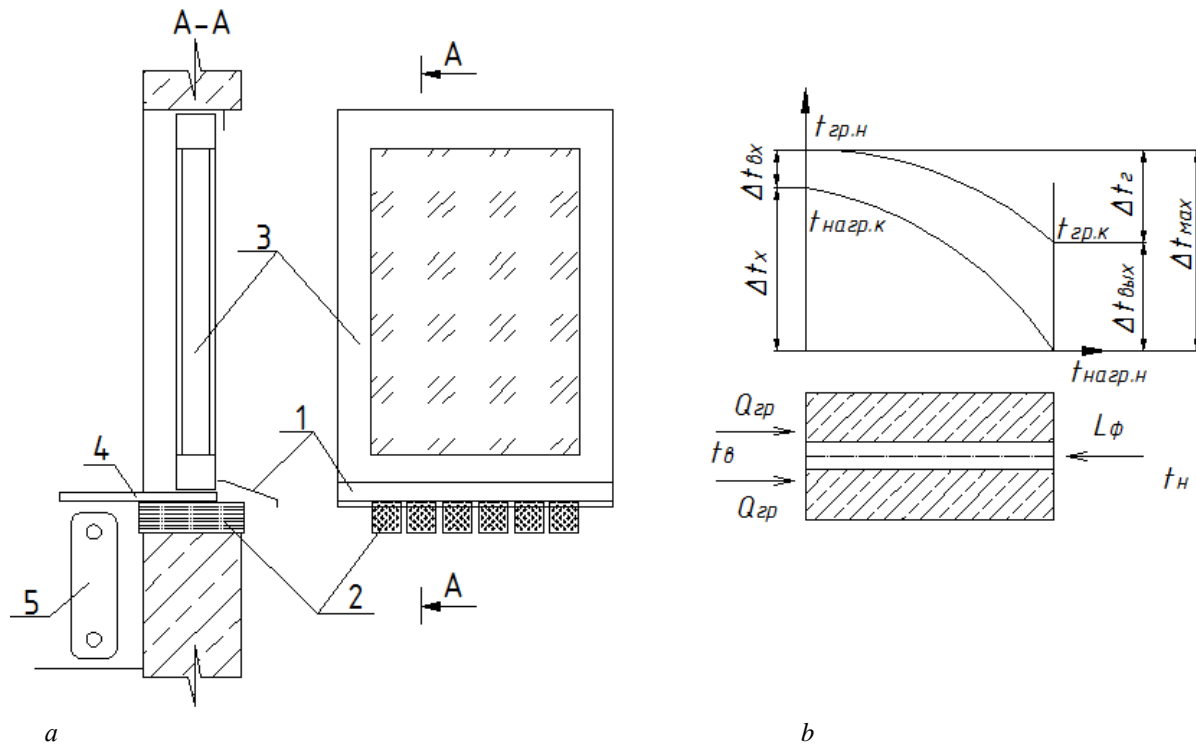


Fig. 2. The scheme of the RAVE installation on an external wall of the building and schedules of temperature changes in RAVE: 1 – window outflow, 2 – affluent ventilation block RAVE, 3 – window frame, 4 – windowsill plate, 5 – heating device.

The heatmass-exchanged processes proceeding in the recuperative affluent ventilating concrete block (RAVE) have a significant effect on formation of a microclimate of rooms. The directed filtration of cold external air in RAVE channels arising under the influence of the main thermal and additional wind pressures, intensifies heat exchange and causes the shift of the temperature field in comparison with a thermal condition of an external protection in the absence of filtration [2].

Considering the supply unit RAVE as the heat exchanger working according to the counter flow diagram in case of varying duties it is difficult to define an average difference of temperatures  $\Delta t_{cp}$  of the heat exchanging heat carriers since their temperatures  $t_{in}$  and  $t_{out}$  are unknown. For the solution of this task the method of calculation of heat exchange devices for dimensionless complexes is used [3].

The usage of RAVE blocks as air affluent devices provides a required consumption of affluent air to the ventilated rooms of the increased integrity and economy of energy resources due to recovery of transmission warmth, and also allows to reduce risk of emergence of the raised gas contamination of rooms with the gas-using equipment.

## REFERENCES

1. Рекуперативный приточный вентиляционный элемент : пат. 1С1 ВУ, МПК F 24F 13/08. / Липко В.И., Борвонов В.А. – Оpubл. 18.04.2002.
2. Липко, В.И. Вентиляция герметизированных зданий : в 2 т. / В.И. Липко. – Новополюцк : ПГУ, 2000. – Т. 1. – 300 с.
3. Липко, В.И. Теория исследования работы рекуперативных приточных вентиляционных элементов в инновационной технологии поддержания микроклимата герметизированных зданий / Липко В.И., Кундро Н.В. // Вестник науки и образования Северо-Запада России. – 2015. – Т. 1, № 1. – С. 230–238.

## THE ADVANTAGES OF USING TEXTILE AIR DUCTS TO PROVIDE A MICROCLIMATE OF PREMISES

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*The article is about textile ducts and diffusers. Textile ducting from the moment of production is also the diffuser. The calculation of the textile diffusers, as well as modeling of air flow, produced with the help of a program PRIHODASW. The verification obtained in the computer simulation results with tests in the blanket experimental chamber is carried out.*

Ventilation should provide the required climatic and sanitary conditions, especially in the working area. In practice, however, most often take the supply of clean air to the upper zone where it is superheated and saturated with gas and dust hazards, and from there transports them then in the working area. The upper distribution of supply air generally excludes the possibility of reliable maintaining the necessary purity of the atmosphere in the working area.

When choosing the method of air distribution into account direction of heat flow and areas of premises with a maximum flow of heat or moisture.

Textile ducts and diffusers are a relatively new concept in ventilation technology [1]. The method of distribution of the air in the system with textile ducts is different from standard systems as systems with textile ducts don't have diffusers or grilles installed in metal ducts. Textile ducting from the moment of production is also the distributor.

In ventilation systems, air conditioning and air heating with the use of textile air ducts can be selected from the following air distribution:

- ventile fabric,
- microperforation,
- perforation,
- small nozzle,
- large nozzle.

Textile ducts can be manufactured from ventile and airtight fabric. In most cases, ventile fabric used not as a method to supply air to the serviced space, and as a means of preventing condensation on the surface of the duct.

The microperforation is made through from holes the size of 0.2-0.4 mm, which are made in the duct at the factory with a laser machine. Perforation is made from through holes with a diameter from a few millimeters to several centimeters.

To ensure standardized values of microclimate parameters in the catchment area, you can specify the distribution direction of the air flow through the perforation and microperforation, to adjust the number of rows and the diameter of the perforation with the use of the software.

Small nozzles can have a diameter of 20, 30 or 40 mm, the diameter of the large nozzles is approximately 80-100 mm. Large nozzles allow maximum range of the air stream. There are 3 varieties of large nozzle: fixed nozzle, adjustable nozzle, directed nozzle.

Taking into account the distance from the working area until the textile of the valve, the pressure value at the beginning of the duct and the required air velocity in the working area, you can select the most suitable method of air distribution:

- microperforation  $0^{\circ}$ – $360^{\circ}$  (over diffuser),
- microperforation  $90^{\circ}$ – $270^{\circ}$  (in lower section),
- microperforation  $270^{\circ}$ – $90^{\circ}$  (in lower section),
- the ranks of directed perforation,
- the ranks of directed small nozzle.

For each of the selected methods of air distribution diagram of air flow was conducted for each of the three temperature regimes:

- 1)  $t_n = t_g$  (isothermal process);
- 2)  $t_n < t_g$  (the process of conditioning or air cooling in the room);
- 3)  $t_n > t_g$  (process air heating in the room),

where  $t_n$  – the temperature of supply air, °C;  $t_g$  – the normalized temperature of the internal air, °C.

Thus, combining every method of air distribution with each temperature regime produced 15 different models of air flow.

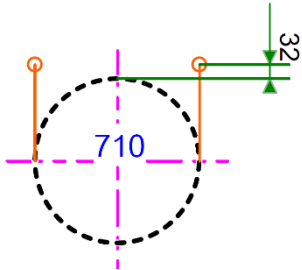
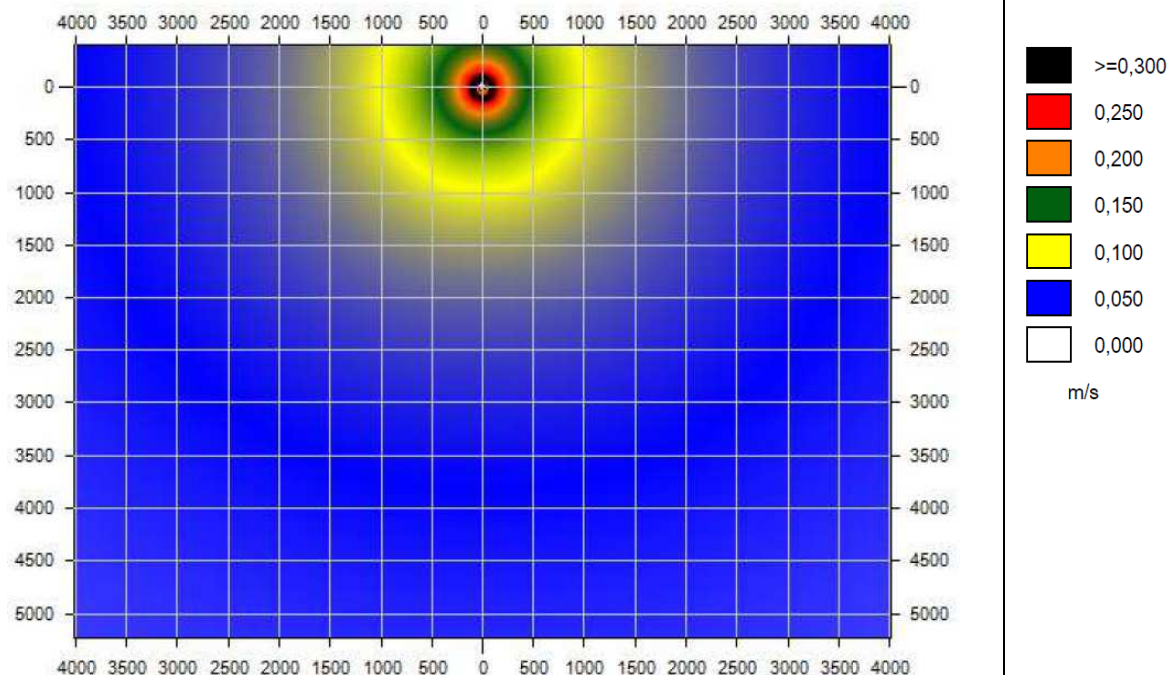
The calculations of the textile diffusers, as well as modeling of air flow were made using the program PRIHODASW. PRIHODASW is software of a Czech company-manufacturer of textile ducts designed for creating textile air distribution systems. Calculations produced by the program can be output in pdf-format.

In addition, the program PRIHODASW also allows simulation of air flows at the exit of the textile air ducts.

Verification obtained in the computer simulation results were produced in the course of the internship based on the company Prihodas.r.o. (Czech Republic) testing in the blanket experimental chamber.

The results of computer simulation for each experiment are presented in table 1 with the indication input data for modeling air flow, type and scheme of air distribution, distribution graphs, and type codes.

Table 1 – The results of computer modeling experience №1

<p>Basis of design for modeling:</p> <p><math>L = 10000 \text{ m}^3/\text{h} = \text{const}</math>  <math>P_{\text{system}} = 200 \text{ Pa} = \text{const}</math>  <math>d = 710 \text{ mm}</math>  <math>l = 20 \text{ long meter}</math>  <math>t_n = +18 \text{ }^\circ\text{C}</math>  <math>t_e = +18 \text{ }^\circ\text{C}</math></p>	<p>The type of air distribution:                  microperforation <math>0^\circ\text{--}360^\circ</math></p> <p>The scheme of air distribution:</p> 
<p>Diagram of distribution of the air flow in the room</p> 	

The resulting diagram of the air flow is confirmed by tests in the experimental blanket camera (Fig. 1).

Description of the resulting diagram (experiment 1).

As can be seen from the diagram, when  $t_n = t$  (isothermal process) and microperforation  $0^\circ\text{--}360^\circ$  (over the duct), the distribution of the air flow has a uniform character in all directions.

Recommendations for use (experiment 1).

In general, the microperforation is applied in cases when the duct is located a short distance from the work area. This method of air distribution allows to distribute the air in the room without disturbing the normalized values of air flow in the working area. In most cases, sent to the micro. The micro is the same for all of the square duct is used in those cases when the total length of the diffuser is not enough to distribute in the room the

entire volume flow with the necessary speed. Most often, this method of air distribution is found in premises with mass stay of people and low ceilings (shops of different profile, cafe), and some production facilities with a limited amount of space.



Fig. 1. Tests in the experimental blanket camera (experiment 1)

As an example of this type of air distribution at a given temperature regime given shop cheese products Volkovysk JSC "Bellakt" and specialty store football club FC Slavia (Prague).

Similar studies were conducted for 15 of the experiments, which allows to develop General guidelines for application of each individual method of air distribution at a given temperature regime and propose to use them in specific areas of public buildings and workshops of industrial enterprises.

In addition, one important factor is the economic effect of the application of the textile air ducts. Comparative analysis by criteria such as purchase price, installation cost, delivery cost and commissioning works, designed for both metal and textile air ducts, showed that the reduction of load bearing building constructions of the building is about 97%, and the estimated cost of construction is reduced by 30–40%.

#### REFERENCES

1. Отопление, вентиляция производственных помещений / Гримитлин А.М. [и др.]. – СПб. : АВОК Северо-Запад, 2007.
2. Королева, Т.И. Преимущества использования текстильных воздуховодов для обеспечения микроклимата помещений / Т.И. Королева, С.В. Ланкович, В.А. Пшеничнюк // Инновационные технологии в промышленности: образование, наука и производство : сб. материалов Всероссийской науч.-практ. конф. с междунар. участием. – Уфа : Нефтегазовое дело, 2016. – С. 215–216.

UDC 67.09.33

**SULFUR CONCRETE AS A CONSTRUCTION MATERIAL****IRYNA LAZOUSKAYA, DZMITRY LAZOUSKI**  
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*This article highlights the experience of the usage of sulfur concrete, its advantages and disadvantages (compared to traditional concrete, based on Portland cement), particular manufacturing technologies of the sulfur concrete, its applications in construction.*

**Introduction.** Concrete is one of the most popular building materials in the world. It is used in almost all civil and industrial construction sites. Traditional concrete, consisting of a binder (e. g. Portland cement), large and small aggregates, different additives and water, is usually made using technologies, which allow to achieve the high quality of finished products. However, the construction industry is growing and there are new ways to improve the quality of construction materials.

**Sulfur as a binder for the production of concrete.** Several investigations, aimed at creating new construction and building materials, based on the previously idle connections and including elemental sulfur are conducted in many countries of the world. Nowadays, in the world industry, and particularly in oil-refining industry of Belarus, there is a problem of sulfur waste, produced during the purification of gasoline and diesel. The situation with sulfur determines the need of looking for new directions for its use, including the usage of sulfur as a binder in the production of sulfur concrete and sulfur-based products.

Sulfur concrete is a composite material which includes sulfur binder, inert aggregates and extenders. The presence of sulfur binder is a sulfur concrete difference from traditional (based on Portland cement) concrete, so it is necessary to know about the properties of sulfur to produce sulfur concrete.

Sulfur is able to compound with almost all chemical elements, it is one of the most common non-metallic elements in nature, its compounds can occur in all aggregate states (solid, liquid, gas). Based on the physical characteristics, sulfur is a crystalline solid, stable in two modifications: orthorhombic (density 2.07 g/cc) and monoclinic (density 1.97 g/cc). The melting point of the sulfur is about 118 °C, the boiling point is 445 °C. In the sulfur market there often appear its lump, granular or liquid forms.

The binding properties of sulfur are known from the 17<sup>th</sup> century. At first, it was used for connections of the metal and stone elements in the production of ship anchors. Sulfur has been actively explored for its usage in the construction, firstly in the US, and later in the Soviet Union.

Sulfur concrete was actively investigated in North America in the 70-s of the 20<sup>th</sup> century, when it has been proved that sulfur is safe to environment. Initially sulfur concrete was investigated as a two-component compound (sulfur and a filler). There are some advantages that have been identified in relation to traditional concrete: low water absorption, high corrosion resistance, fast curing and the preservation of high strength. But the disadvantages of the sulfur concrete, produced in that period of time, were also present (low resistance to high temperatures, low fire resistance). In addition, when large amounts of sulfur concrete harden, shrinkage occurs to considerable number of cracks. The other disadvantage of sulfur concrete is the need to maintain the temperature of 140 °C during its production, as well as the high requirements for the precision production technology compliance [1].

With the development of technology and improvement of sulfur concrete, it became known that under the influence of changing in temperature, solar radiation and other effects, the sulfur structure can be changed by changing its molecules from one allotropic state to another, which leads to the emergence of dangerous internal stresses which can destroy the integrity of the material, thereby reducing the durability of the material. In addition to adversely affecting the sulfur concrete weather, particular attention was paid to the fragility of sulfur, which led to higher brittleness of sulfur concrete (compared to the cement concrete). Many of the shortcomings could be eliminated by improving the material and technology, however, many are preserved to this day.

To reduce the impact of the above-mentioned shortcomings in the quality of the sulfur concrete, researchers have proposed to add in the sulfur binder various plasticizing and structuring additives – modifiers. This modifies are divided into four groups: plasticizers, stabilizers, flame retardants and antiseptics. Plasticizing agents are added into the sulfur binder to reduce the brittleness and increase the strength of the sulfur, to slow crystallization upon cooling. These plasticizing agents include: naphthalene, paraffin, dicyclopentadiene, polystyrene, coumarone resin, carbon black, graphite. Stabilizing additives are intended to change the structure of sulfur and to increase its resistance to atmospheric conditions. These include: dicyclopentadiene, thiokol, iodine, phosphorus, selenium, arsenic, antimony trichloride, bitumen, carbon black, naphthalene. Flame retardants are used to reduce the flammability of the sulfur compositions. Antiseptics are used to increase the biological stability of the sulfur concrete. There are positive and negative qualities of sulfur concrete, made of modified sulfur [6].

Moisture resistance of sulfur concrete is better up to 20%, compared with traditional concrete, acid resistance – up to 3,5 times, frost resistance – up to 6 times, abrasion resistance – up to 6 times, compression strength – up to 3 times, bend strength – up to 2 times, tension strength – up to 2 times, curing speed – up to 80 times [2, 3].

The main advantages of sulfur concrete over traditional one are its higher strength properties (compressive and flexural), the ability of this material to work under the tension loads (depending on the modifier, this index is increased), high chemical (corrosion) resistance, lower rates of water absorption and water permeability, high frost resistance, fast curing, the possibility of winter concreting. In addition, products, made of sulfur concrete can be subjected to repeated heating and re-processing of molding designs, eliminating the waste and scrap. It is worth noting another important advantage of the concrete made using the sulfur binder – is the lack of water in the manufacturing process, which allows for operation at low temperatures. Sulfur concrete absolutely hydrophobic and does not absorb water, so is ideal for the manufacture of deep foundations in the grounds of a high water table. Depending on the characteristics defined for the manufactured building material, every manufacturer and patent holder of technology defines its requirements for raw materials [5].

The first patent relating to the properties of sulfur concrete and its production technology has been registered in the United States. In this document it was mentioned such a thing as a sulfur modifier for the production of higher-quality sulfur concrete for the first time. However, the trade production of the sulfur concrete (and products based on it) was firstly established by Canadian company StarCrete (previously it was called Sulfurcrete) in 1975. His company, together with Cera Innovations Ltd, has developed a technology for the production of concrete on the basis of the modified sulfur. According to this technology, molten sulfur and the modifier is applied to the concrete preparation place, where it is mixed with a pre-warmed aggregates and fillers, forming sulfur concrete mixture. Currently, products under the brand name StarCrete widely used for the manufacturing of corrosion-resistant structures for the protection and repair of concrete floor coatings in chemical and food industries and others [1].

Later, the technology, alternative to that was introduced on Sulfurcrete enterprise, was mastered. The main difference – modifiers are entered directly while stirring the melt with warm sulfur aggregates. In 1991, the US Patent about the preparation of granulated sulfur concrete technology was published. Its appearance was due to the need for the manufacture of construction materials anytime, anywhere (before this technology it was necessary to maintain a certain temperature of the solute, that add additional place and time limits). In principle, the technology of producing sulfur concrete granules were differed from the others in the disposition of the ready mixture in a unit, where the concrete is exposed to the effects of gas (high-pressure) or water, and that contributed to the formation of granules. This allowed to transport it in a packaged form or in bulk over long distances and produce products directly on the construction site. For further use it was needed to reheat the pellets to the melting temperature about 140–150 °C.

Another country, that has actively explored sulfur for its possible use in construction, was the Soviet Union, in which the first application of sulfur concrete was carried out in 70-s of 20<sup>th</sup> century. Nowadays in Russia there is not any large-scale production of sulfur concrete. JV LLC “Inter-S” (Astrakhan region) has a manufacturing technology of such material, developed jointly with “Astrakhangazprom”, NIIZhB and the Ministry of Construction of the Russian Federation, but actually it is producing only a modified sulfur (sulfur cement) for the production of sulfur concrete. However, the production of sulfur cement has no foreign analogues in Russia.

Traditionally, the sulfur polymer cement is produced in a circular manner in a batch reactor equipped with a stirrer, using expensive chemical modifiers. The process for this reaction, to afford the final product, takes up to several hours. The technology, offered by LLC “Astrakhangazprom”, is different from usual in that the process takes place in a continuous technology, using low-cost and environmentally safe chemical modifier. “Gazprom Sera” (Astrakhan) is actively engaged in a large-scale production of sulfur concrete, but it is not possible nowadays. The lack of opportunities is occurring due to the lack of precision equipment, capable of regulating the heating of the mixture in the range of  $\pm 1$  °C. Upon heating the mixture above 150 °C, it is released hydrogen sulfide and sulfur dioxide - gases which have nerve activity and pose a threat to humans. Therefore, it is especially important to the establish industries that can produce large quantities of sulfur concrete with the strict compliance with technological standards.

Another country actively engaged in the production of sulfur concrete is Kazakhstan. The company “Serobeton Story” has received the money grand and has developed the sulfur concrete waste-free production process. Innovative technology provides up to 100% replacement of Portland cement products for certain sectors of construction and solves environmental problems of oil producing regions of Kazakhstan through the use of technogenic waste (lump sulfur) [4].

Several European countries, such as Poland, Germany, France and other are using sulfur concrete not only for the production of structural materials (replacing traditional concrete), but also in road construction (for road paving).

With regard to our region (Belarus), sulfur is not used as a binder in the concrete production at present time. But it is investigated for the reason of practical application and further development of a large volume



scale. The scientific interest to the subject of sulfur concrete use is due to not only to the its unique properties, but also due to the problem of recycling of the technical sulfur. The stocks of it are increasing due to ever-increasing volumes of recycling of sulfur-containing hydrocarbon feedstock (natural gas, oil) and a deeper cleaning of sulfur refined products.

**Conclusion.** According to the properties of the sulfur concrete, the usage of sulfur in the construction industry of the Republic of Belarus can be a cost-effective direction. It could be because of the number of advantages of the products, made of sulfur concrete, comparing with traditional concrete (better performance and physical and mechanical properties for some sectors of construction, increased durability). Based on this, we can make a conclusion about the curracy of investigating the properties of sulfur concrete, as well as the technology of its production.

#### REFERENCES

1. Аналитический портал химической промышленности [Электронный ресурс] // Newchemistry.ru. – 2006. – Режим доступа: [http://newchemistry.ru/letter.php?n\\_id=3861&cat\\_id=5&page\\_id=1](http://newchemistry.ru/letter.php?n_id=3861&cat_id=5&page_id=1). – Дата доступа: 25.01.2017.
2. НЕРУД-БКС [Электронный ресурс] / ООО "Неруд-БКС". – Режим доступа: <http://neruds.ru/staty/beton4.html>. – Дата доступа: 25.01.2017.
3. Техничко-экономическое обоснование эффективности строительства и эксплуатации универсальной установки для производства молотой серы, объемом 5 тыс. тонн в год и модифицированной серы объемом 10 тыс. тонн в год [Электронный ресурс] / Техничко-экономическое обоснование. – Режим доступа: <https://sites.google.com/site/serobeton/home/tehkross/tehniko-ekonomiceskoe-obosnovanie>. – Дата доступа: 23.01.2017.
4. Маргайлик, Е.Г. Актуальность производства серобетона и серобитума. Использование серы в дорожном строительстве США, Канады, Франции, Польши [Электронный ресурс] / Е.Г. Маргайлик. – Верное решение. – Режим доступа: <http://www.решение-верное.рф/serobeton-actual>. – Дата доступа: 24.01.2017.
5. Пастухов, Н. Серобетон и сероасфальт – уникальные технологии и оборудование [Электронный ресурс] / Н. Пастухов. – Бетон и строительные технологии – помощь. – Режим доступа: <http://www.helpbeton.ru/serobeton-i-seroasfalt-unikalnye-tehnologii-i-oborudovanie-dlya-ix-proizvodstva.html>. – Дата доступа: 24.01.2017.
6. Новые модификаторы серного вяжущего для получения серобетонов повышенной прочности [Электронный ресурс] / ООО "ИЦ "Химтэк". – Режим доступа: <http://chemteq.ru/chem-tech/sulpho-concrete.html>. – Дата доступа: 25.01.2017.

UDC 624.078.4

**RESISTANCE OF THE PRECAST PRESTRESSED HOLLOW-CORE SLABS  
 WITH ADDITIONAL REINFORCEMENT OVER SUPPORT IN PLATFORM JOINT**

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Analytical model allowing calculation of relation "bending moment - rotation angle" based on general deformation model and block model of reinforced concrete resistance and describing stress-strain state of the precast prestressed hollow-core slabs in platform joint zone is considered. The model considers transversal pressure, ratio of reinforcement installed in concrete of hollow void filling to concrete, achievement of yield strength of reinforcement.

The proposed analytical model for the stress-strain state assessment of the precast prestressed hollow-core floor slabs in platform joint zone is based on block resistance model for bending reinforced concrete element, initially offered by H. M. Westergaard in 1930 [1]. This block model was developed by P.I. Vasilyev, E.N. Peresyypkin [2], V.I. Belov [3], S.E. Peresyypkin [4], Y.V. Pochinok [5], M.V. Brovkina [6], P. Croce, P. Formichi [7], A. Borosnyói, and G.L. Balázs [8], A. Casanova, L. Jason and L. Davenne [9] etc. The basic assumptions of the analytical model are stated in previous works [10].

The maximum value of the bending moment from concentrated load  $P_1$ , which is applied at  $L$  distance from the axis of platform joint (support) is given by:

$$M = P \cdot (L - l); \tag{1}$$

At the same time bending moment in the plastic hinge formation zone does not extend to the end sections of slabs, which are cutting off by critical cracks and influencing vertical pressure (Fig. 1).

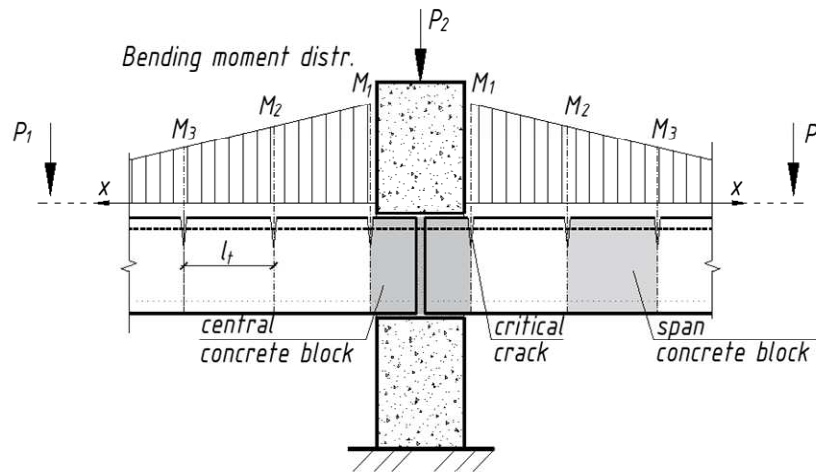


Fig. 1. The scheme of slabs dividing into blocks between cracks

Concrete blockstaken for the analysis and allocated by neighboring cracks along the element length include: central block between two critical cracks with vertical grout in platform joint zone, span concrete blocks to the left and to the right of platform joint with free ends. In case of geometrically and physically symmetric system it is possible to consider the span block on one side of platform joint only.

Crack width between two concrete blocks is defined as the sum of slip  $s(x)$  between reinforcement and tension concrete along the transmission zones  $l_t$  to the left ( $l$ ) and to the right ( $r$ ) from crack edges:

$$w = \int_{-l_t(l)}^{l_t(r)} s(x) dx = \int_{-l_t(l)}^{l_t(r)} [\epsilon_s(x) - \epsilon_{ct}(x)] dx. \tag{2}$$

The crack is formed on the end area of transmission zone where the strain in reinforcement is the same as that in the surrounding concrete ( $\epsilon_s = \epsilon_{ct}$ ), under bending moment, which is equal to the cracking moment  $M_{cr}$ . At the subsequent loading stages, geometrical and physical properties of slabs and of hollow voids filling along their span concrete blocks are allocated with length of:  $L_m < [l_{t(l)} + l_{t(r)}]$  or  $L_m \geq [l_{t(l)} + l_{t(r)}]$ , depending on moment distribution.

In the first case (Fig. 2, a), on the whole length of concrete block strain of concrete at the reinforcing bars axis does not exceed the ultimate tensile concrete strain  $\epsilon_{ct1}$ , i.e. transmission zones on the left (l) and on the right (r) are overlapped, and the condition  $\epsilon_{ct} < \epsilon_{ct1}$  is valid for any cross-section in concrete block. For such concrete block the first stage of crack formation is completed and at the subsequent loading stages there is a redistribution of stresses between reinforcement and tensile concrete without formation of new cracks in the form of accumulation of slip which can be seen in the opening of cracks.

In the second case (Fig. 2, b), in the middle part of concrete block length there is a joint deformation zone of reinforcement and concrete with length of  $[L_m - (l_{t(l)} + l_{t(r)})] > 0$ , i.e. transmission zones on the left (l) and on the right (r) are not overlapped. The concrete block at this stage of loading is at the first stage of crack formation. At the subsequent stages of loading depending on moment distribution from external loading, geometrical and physical properties of slabs and of hollow voids filling along their span for the considered concrete block there are two possible ways: further division by new cracks on smaller concrete blocks (as it is described above), or its transition to the second (established) crack formation stage.

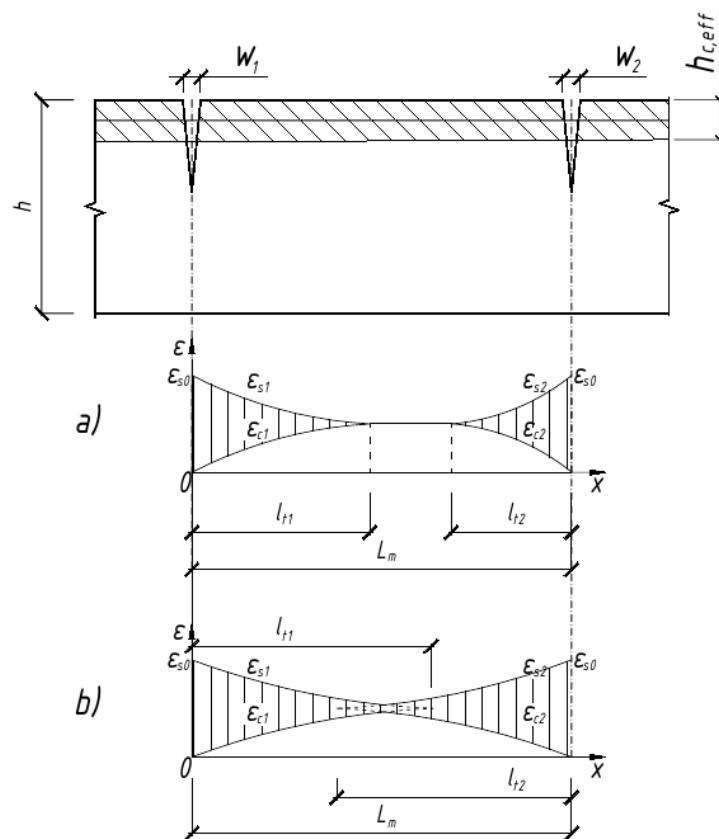


Fig. 2. Initial stage of crack formation (1<sup>st</sup> case) (a) and redistribution of stresses between reinforcement and tensile concrete (2<sup>nd</sup> case) (b)

Central concrete block with cracks on both sides of the joint and vertical grout directly in zone of platform joint are further considered. As it was pointed, the central concrete block in case of pressing by vertical bearing walls is under the transversal pressure influencing the bond of additional and slab's reinforcement and with the surrounding concrete.

For the assessment of reinforcement and tensile concrete strains distribution along the central concrete block length, subjected to transversal pressure, on the basis of taken assumptions and the bond-slip law  $\tau_b = f(s)$  effective area of concrete of tensile zone  $A_{c,eff}$  with length of  $dx$  can be taken with a bar of additional reinforcement over support with area of  $A_{s,ad}$  (Fig. 3).

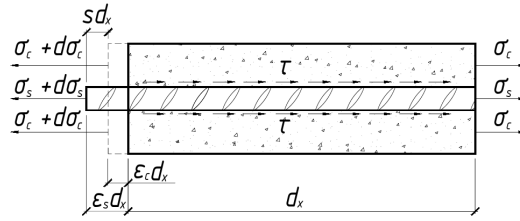


Fig. 3. Free body equilibrium for the central concrete block [7]

Tension of the upper prestressed reinforcement of slabs at their end faces as a part of surrounding concrete of central block tension zone is considered in the specified cross sectional area,  $A_{c,red} = A_{c,eff} + \alpha_E \cdot A_p$ . According to the accepted assumptions bending moment from external loading along the central block influenced by vertical pressing is absent. The  $N$  force in the tension zone of the central concrete block from action of tensile stresses in cross-sections with cracks on the ends of the block without taking into account tension of the vertical elements transferring pressure at geometrically and physically symmetric system is distributed uniformly along the block (otherwise, linear distribution of  $N$  force along of the block is considered).

For any cross-section at the block length, the total force in tensile concrete  $N_c$  and reinforcing bar  $N_s$  is constant on the whole length of the block. Then equilibrium conditions within concrete block should be written:

$$d\sigma_s \cdot A_{s,ad} + d\sigma_{ct} \cdot A_{c,red} = 0. \quad (3)$$

From equilibrium conditions the stresses in reinforcing bar with the diameter of  $\varnothing$  as a resultant of the tensile stresses  $A_{s,ad}$  are distributed on its cross sectional area, and shear (tangent) stresses  $\tau_b$  on the contact area of reinforcing bar with surrounding concrete, and also differences of the strains of reinforcement  $\epsilon_s$  and concrete  $\epsilon_{ct}$  as the slip  $s$ , the bond-slip law  $\tau_b = f(s)$ , connecting tangent stress on the contact area of the reinforcing bar with concrete and its slip considering the transversal pressure can be written:

$$d\sigma_s \cdot \frac{\pi\varnothing^2}{4} = \pi\varnothing \cdot \Omega_{p,tr} \cdot \tau_b(s)dx \quad (4)$$

$$(\epsilon_s - \epsilon_c)dx = ds \quad (5)$$

$$\Omega_{p,tr} \cdot \tau_b = f(s) \quad (6)$$

The parameter  $\Omega_{p,tr}$  for bond-slip law takes into account transversal pressure  $p_{tr}$  in concrete of average strength  $f_{cm}$  according to [11].

If reinforcement strains achieves and exceeds the yield strains  $\epsilon_s \geq \epsilon_{sy}$  QUOTE (  $s \geq s_y$  ) the reducing parameter  $\Omega_y$  is taken for the bond-slip law [11].

For the resistance problem solution, the central concrete block in the tension zone of section depth  $h_{eff}$ , allocated with the neighboring cracks, is divided with  $n$  cross-sections into  $(n - 1)$  intervals with length of  $\Delta x$ . The interval  $\Delta x_k$  borders are matched with borders of vertical grout between end faces of hollow-core slabs (see Fig. 2). At the same time, taking into account a low adhesion of the concrete of vertical grout filling with concrete of the slabs, transversal tension of the concrete of the grout in the sections matching its borders is not considered. Therefore on the interval equal to length of vertical grout  $\Delta x_k$ , it is accepted the "σ-ε" diagram of for concrete of hollow voids filling and that the effective cross sectional area of the tension zone in concrete of filling  $A_{c,eff,ad}$  without consideration of upper reinforcement of slabs.

Equations (4)..(6) can be rewritten as a following system of equations:

$$\begin{cases} \frac{d}{dx} s = \epsilon_s(\sigma_s) - \epsilon_{ct} \left( \frac{N - \sigma_s A_s}{A_{c,eff}} \right); \\ \frac{d}{dx} \sigma_s = \frac{4}{\varnothing} \Omega_y \Omega_{p,tr} \tau(s). \end{cases} \quad (7)$$

Since boundary conditions depend on the strain distribution in reinforced concrete element, the solution of system (7) requires an iterative procedure. The proposed procedure is based on the iterative solution of system of the differential equations (7). Also for the central concrete block the process of crack formation takes place into two stages as well as for span concrete blocks. The feature of the central block is the reduction area of concrete in the tension zone in the place of vertical grout (only concrete of hollow voids filling  $A_{c,eff}$  is taken into consideration) that during symmetric loading of hollow-core slabs to the left and to the right from platform joint at the end of the first stage of crack formation facilitates the appearing of crack in this place.

For cracked sections (at the edges of the allocated block) values of stresses  $\sigma_{s,(l)}$  and  $\sigma_{s,(r)}$  are known, but values of slips  $s_{(l)}$  and  $s_{(r)}$  – are unknown. The iterative procedure of the solution of the system of equations (7) for the central block is as follows:

1. Initial parameters of iterative process are assumed: the block length ( $\Delta L$ ), the area of tensile reinforcement ( $A_s$ ), the effective area of the tensile concrete  $A_{c,eff}$ , the  $N$  force corresponding to force in the tension zone of the considered central block. In the first approximation the initial slip  $s_0$  is recommended to take equal to product of the maximum reinforcement strain  $\varepsilon_{s,max}$  at the cracked section with and block length ( $\Delta L$ ):

$$s_0 = \varepsilon_{s,max} \cdot \Delta L . \quad (8)$$

2. Diagrams "σ-ε" for reinforcing steel and concrete, bond-slip law "τ-s" are defined. Besides, the parameters  $\Omega_y$  and  $\Omega_{p,tr}$  [11] are taken into account if the effects of yield strength and transversal pressure of concrete block are considered.

3. The considered central block is divided into ( $n$ ) elements of equal length  $\Delta x$ .

4. As the origin of axis  $x$  ( $x = 0$ ) cracked section is taken. Stress in reinforcement ( $\sigma_{s,0}$ ) and in tension concrete are known ( $\sigma_{ct,0} = 0$ ). Under the taken bond-slip law tangent stress  $\tau_{b,0}(s_0)$  is calculated.

5. Tension stress in reinforcing bar at the first ( $n = 1$ ) section at distance  $\Delta x$  from origin of axis  $x$  is calculated:

$$\sigma_{s,1} = \sigma_{s,0} - \frac{4}{\varnothing} \cdot \tau_{b,0} \cdot \Delta x . \quad (9)$$

6. Concrete tension stress at the considered section is calculated:

$$\sigma_{ct,1} = \frac{(N - \sigma_{s,1} \cdot A_s)}{A_{c,eff}} . \quad (10)$$

7. Reinforcing bar  $\varepsilon_{s,1}$  and concrete  $\varepsilon_{ct,1}$  strains are defined from "σ-ε" diagrams.

8. The slip  $s$  is calculated for the considered section ( $n = 1$ ):

$$s_1 = s_0 - (\varepsilon_{s,1} - \varepsilon_{ct,1}) \Delta x \quad (11)$$

9. Under the taken bond-slip law tangent stress  $\tau_{b,1}(s_1)$  is defined.

10. The iteration procedure repeats for the subsequent sections. For the any  $i$ - section at the length of the concrete block the equations can be written as:

$$\sigma_{s,i} = \sigma_{s,i-1} - \frac{4}{\varnothing} \cdot \tau_{b,i-1} \cdot \Delta x , \quad (12)$$

$$\sigma_{ct,i} = \frac{(N - \sigma_{s,i} \cdot A_s)}{A_{c,eff}} , \quad (13)$$

$$s_i = s_{i-1} - (\varepsilon_{s,i} - \varepsilon_{ct,i}) \Delta x . \quad (14)$$

Criteria of convergence of the iterative procedure are the achievement of concrete strain the values of the ultimate strain of concrete ( $\varepsilon_{ct} = \varepsilon_{ct,ult}$ ) that indicates a new crack formation; achievement of concrete strain the strain of reinforcement ( $\varepsilon_{ct} = \varepsilon_s$ ) that indicates the completion of zone of stresses transition and the beginning of zone of joint deformations of concrete and reinforcement. As soon as the convergence is reached, the iterative procedure is finished. Otherwise, new value of initial parameters are defined and the iterative process repeats.

After the achievement of the iterative procedure convergence, the distributions of strains along the concrete block  $\varepsilon_s(x)$  and  $\varepsilon_{cr}(x)$  and the location of neutral axis in sections with crack are received. In this case distribution of section curvatures along the length of the block allocated with cracks is possible to calculate:

$$\varphi_i = \frac{\varepsilon_{s,i}}{d - x_{c,i}} = 0, \quad (15)$$

where  $d$  – effective depth of section;

$x_{c,i}$  – depth of the neutral axis in  $i$  section. For intermediate sections of concrete block is calculated by linear interpolation of change between  $x_1$  and  $x_n$  – values on the ends of the block.

For the known curvatures  $\varphi_i$  distribution along the block length, rotation angle are determined by integration of the equation:

$$\theta = \int_{l_p} \varphi(x) dx, \quad (16)$$

where  $\varphi(x)$  – distribution function of curvatures along the block  $L$  for any stage of loading.

Carrying out monotonous loading the relation "bending moment – rotation angle" is received which is applied in nonlinear analysis of structural system.

**Conclusions.** The proposed analytical model is based on general deformation model and block model of reinforced concrete resistance and describe stress-strain state of precast prestressed hollow-core slabs in platform joint zone. The model considers transversal pressure, ratio of reinforcement installed in concrete of hollow void filling to concrete, achievement of yield strength of reinforcement. The model allows calculating relation "bending moment on the support – rotation angle" for nonlinear deformation of hollow-core floor slabs in the zone of platform joints of buildings in nonlinear analytical methods.

#### REFERENCES

1. Westergaard, H.M. Computation of Stresses in Bridge Slabs Due to Wheel Loads / H.M. Westergaard // Public Roads. – 1930. – Vol. 11, No. 1. – P. 1–23.
2. Васильев, П.И. Раскрытие швов и трещин в массивных бетонных конструкциях / П.И. Васильев, Е.Н. Пересыпкин // Аннотации законченных в 1967 г. научно-исследовательских работ по гидротехнике. – Л. : Энергия, 1968.
3. Белов, В.И. К вопросу исследования напряжённо-деформированного состояния железобетонных балок как систем, составленных из упругих блоков / В.И. Белов, П.И. Васильев, Е.Н. Пересыпкин // Вопросы прочности бетона и железобетонных конструкций : тр. координационных совещаний по гидротехнике. – 1973. – Вып. 82. – С. 60–64.
4. Пересыпкин, С.Е. Внецентренное сжатие бетонных элементов с учётом влияния поперечных сил (расчёт по деформированной схеме на основе блочной модели) : дис. ... канд. техн. наук / С.Е. Пересыпкин. – СПб., 1995. – 124 л.
5. Починок, Ю.В. Блочная деформационная модель в расчётах железобетонных стержневых изгибаемых элементов с трещинами : дис. ... канд. техн. наук : 05.23.01 / Ю.В. Починок. – Ростов н/Д, 2004. – 241 л.
6. Бровкина, М.В. Прикладные методы расчёта прочности и деформативности изгибаемых железобетонных элементов блочной структуры : дис. ... канд. техн. наук : 05.23.01 / М.В. Бровкина. – СПб., 2004. – 194 с.
7. Croce, P. Numerical Simulation of the Behavior of Cracked Reinforced Concrete Members [Electronic resource] / P. Croce, P. Formichi // Materials Sciences and Applications, 5, 883-894. – 2014. – Mode of access: <http://dx.doi.org/10.4236/msa.2014.512090>.
8. Borosnyóí, A. Models for Flexural Cracking in Concrete: The State of the Art. / A. Borosnyóí, G.L. Balázs // Structural Concrete. – 2005. – № 6. – P. 53–62.
9. Casanova, A. Bond Slip Model for the Simulation of Reinforced Concrete Structures / A. Casanova, L. Jason, L. Davenne // Engineering Structures. – 2012. – № 39. – P. 66–78. – Mode of access: <http://dx.doi.org/10.1016/j.engstruct.2012.02.007>.
10. Тур, В.В. Расчетная модель сопротивления изгибу многопустотных плит перекрытий безопалубочного формирования в составе платформенных стыков зданий / В.В. Тур, А.Д. Лазовский // Вестник Полоцкого государственного университета. Серия F, Строительство. Прикладные науки. – 2016. – № 16. – С. 108–119.
11. CEB-FIB Model Code for Concrete Structures. – 2010.

UDK 697.922.2

**MODELLING OF HEAT MASS EXCHANGE PROCESSES AND DESIGN PROCEDURE  
OF INNOVATIVELY MODERNIZED SYSTEMS OF AERATION  
OF SHOPS WITH SURPLUSES OF WARMTH**

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*The article outlines the conceptual possibilities and methods of physico-mathematical modeling of static, dynamic and heat and mass transfer processes in the shops of the extract in terms of exposure to gravitational forces and wind pressure on the building when natural ventilation is active by a method of aeration by the "bottom-up".*

**Introduction.** The technology of foundry manufacture is characterized by a considerable amount of heat, allocated in a working zone from technological furnaces, the process equipment, the heated and fused metals continuously or is long on time in the form of radiating radiant thermal energy from heated surfaces and a convection component of a thermal stream in the form of hot gases or overheated air owing to what working conditions of the working considerably worsen.

For improvement of quality of the air environment in hot shops the way of ventilation by a method of aeration by natural airing of a working zone of shop external supply ventilating air which arrives in premises through the special aeration supply apertures located in external walls of a building in two levels is used: for the summer period of year - in the bottom zone near to a premise floor, and for the winter period of year of an aperture are located at height  $h = 4,5$  m from a floor.

Removal of ventilating air at building aeration is carried out through special aeration lanterns with the exhaust apertures located above a roof, or exhaust mines.

For quantitative regulation of the expense of ventilating air in supply and exhaust apertures adjustable lattices are established.

In the course of natural circulation of air streams in premises of hot shops with intensive heat input some zones with various temperatures are formed [1].

**The basic part.** For definition of a physical picture aerostatic, aerodynamic and the heat mass exchange processes proceeding in the conditions of changing temperatures, it is necessary to present initially a premise, as a vessel filled with an air-gas mix then under laws of aerostatics pressure change  $dP$  in a layer  $dh$  gasvariably on height and makes

$$dP = \frac{\rho \cdot g}{F} \cdot dV, \quad (1)$$

where  $\rho$  – density of gas (air), kg/m<sup>3</sup>;  
 $g$  – acceleration of free falling, m/s<sup>2</sup>;  
 $F$  – the area of cross-section section of a premise, m<sup>2</sup>;  
 $V = h \cdot F$  – Volume of a column of gas (air), m<sup>3</sup>.  
 As  $dV = F \cdot dh$  to expression (1) will become

$$dP = \rho g dh. \quad (2)$$

Integrating expression (2) we will receive

$$P_h = P_a - g \int_0^h \rho \cdot dh, \quad (3)$$

where  $P_a$  – atmospheric pressure upon earth surfaces at  $h = 0$ .

In stationary conditions without any heat input air temperature indoors remains invariable. Then also air density is constant, and after integration expression (3) looks like

$$P_g = P_a - \rho gh, \text{ Па.} \quad (4)$$

The physical picture described above aerostatic processes by expressions (1)–(4) is presented in figure 1.

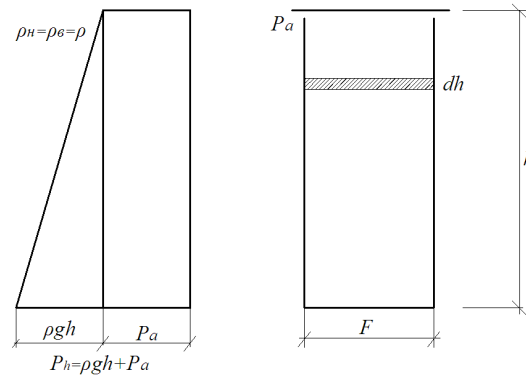


Fig. 1. Change of aerostatic pressure on premise height

at  $t_H = t_ε$  ( $t_ε, t_H$  – air temperatures accordingly inside and outside of a premise, wasps)

If in a considered premise the source of heat input (Fig. 2) the physical picture cardinally changes at  $t_H < t_ε$  is established. The line I on the schedule (Fig. 2) corresponds to change of aerostatic pressure outside of a building according to expression  $P_H = P_a - ρ_H gh$ , and the line II on the schedule corresponds to change of aerostatic pressure in building  $P = P_a - ρgh$  then the remained shaded part of the schedule will correspond to difference of aerostatic pressure outside and in a building, i.e.

$$\Delta P = P_H - P_ε = P_a + ρ_H gh - P_a - ρ_ε gh \quad (5)$$

Whence after transformations we will receive

$$P_{zp} = \Delta P = gh(\rho_H - \rho_ε). \quad (6)$$

On the schedule (fig.2) the shaded part is settlement diagram superfluous gravitational (aerostatic) pressure at action only forces of gravitation [2].

In the course of natural circulation of air streams in premises with plenty of heat characteristic zones with various temperatures are formed some.

At aeration of buildings outside of premises with plenty of heat external temperature  $t_{Hε}$  of air for calculation of ventilation of the summer and winter periods of year is accepted.

The temperature of air in premises from the party supply apertures  $t_{np}$  (°C) is accepted on + 5 wasps above, than  $t_{Hε}$ , i.e.

$$t_{np} = t_{Hε} + 5. \quad (7)$$

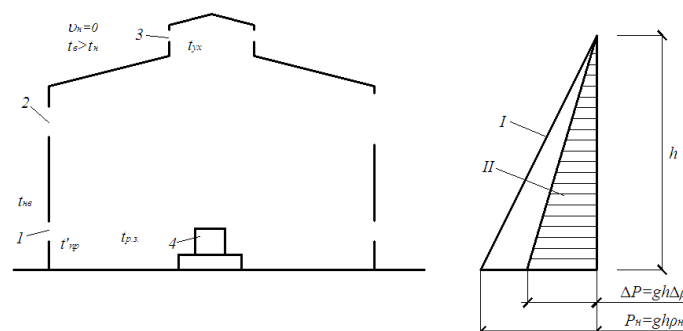


Fig. 2. Change of aerostatic pressure on premise height at  $t_H < t_ε$  :

1 – supply apertures in the summer; 2 – supply apertures in the winter; 3 – exhaust apertures



Total influence on a building gravitational  $P_{zp}$  and wind  $\Delta P_v$  pressure will define construction diagram pressure upon a building for the summer and winter periods of year.

On Fig. 3 construction diagram pressure for the summer and winter periods of year is executed at joint influence on a building gravitational  $P_{zp}$  and wind  $\Delta P_v$  pressure, forming a thermal and air mode of buildings at aeration.

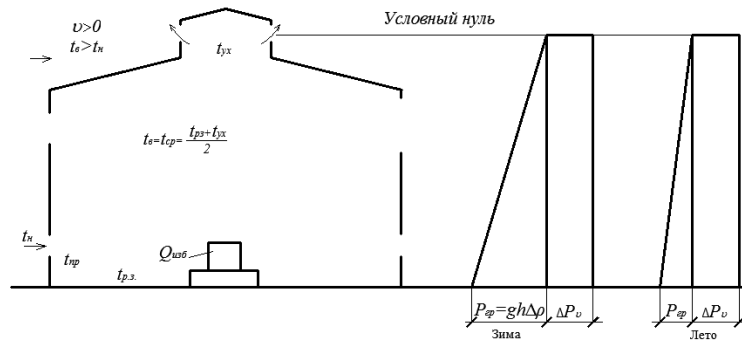


Fig. 3. Construction diagram pressure at joint influence of gravitational and wind pressure upon a building in the summer and in the winter

Dynamic processes in hot shops are closely connected with heat mass exchange. Total thermal emissions from heated surfaces of the furnaces which are cooling down and the fused metal are carried out for the account convection and emissions.

With a view of decrease in harmful influence on working heats from heated surfaces of active sources of heat input it is offered to apply in hot shops the technological scheme operated the screen-rolling aeration limiting a zone of heats from a working zone of premises how it is shown on fig. 4.

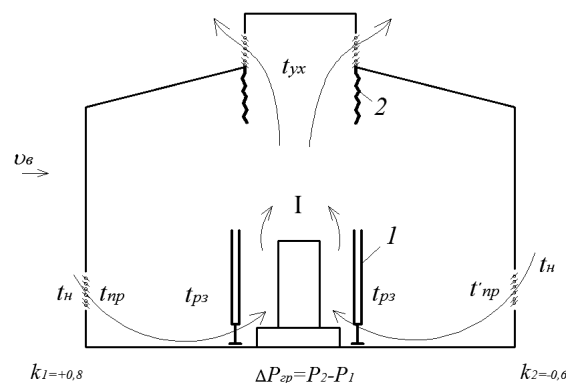


Fig. 4. The scheme operated the screen-rolling aeration limiting thermal horizontal influences in a working zone with possibility of moving of superfluous warmth ascending vertical convective by streams I, forming circulation in a building

The easy portable screens 1 executed from sheet materials, well reflecting radiant energy from the fused metal or heated surfaces of the equipment of hot shops, for example, an aluminium foil with a rigid skeleton from any profile metal, will create screened protection of a working zone.

Rolls 2 of a heat-resistant material, for example, from the fiber glass fabric, going down from above from a design aeratelantern or the exhaust mine established on a roof, allow to isolate as much as possible a working zone from active influence of getting thermal radiation from hot sources from which upwards rise convective streams overheated air.

Offered technical decisions for struggle against thermal radiation from a source of warmth of hot shops differ from all known similar devices simplicity of a design, profitability in manufacturing, by small massiveness, mobility in operation as their designs can move on shop in space on the area and on height and if necessary to be established in any place or to be dismantled for some time.

The height of screens 1, and also depth overhangs 2 can be regulated if necessary for achievement of the maximum effect localisation of thermal air streams and a conclusion of superfluous warmth from a working zone of hot industrial premises [3].

Analyzing and generalising the above-stated, it is possible to draw following **conclusions**:

- at aeration of shops with plenty of heat on formation of air streams joint influence is rendered by forces of gravitation with the directed movement "from below-upwards" and horizontally directed movings of air weights under the influence of wind pressure;
- thermal influence on working from heated surfaces occurs as at the expense of emission, and convection, that causes discomfort in a working zone;
- for decrease in harmful influence on working heats, it is possible to provide necessary sanitary-and-hygienic effect by the device of special protective screens and the curtains which designs are simple in manufacturing.

#### REFERENCES

1. Бромлей, М.Ф. Проектирование отопления и вентиляции / М.Ф. Бромлей, А.П. Щеглов. – М. : Гос. изд-во строит. лит-ры, 1965. – 260с.
2. Кострюков, В.А. Сборник примеров расчёта по отоплению и вентиляции / В.А. Кострюков. – М. : Госстройиздат, 1962. – 200 с.
3. Рысин, С.А. Вентиляционные установки машиностроительных заводов : справ. / С.А. Рысин. – М. : Машиздат, 1964. – 704 с.

UDC 691

## OPTIMIZATION OF STRUCTURAL SOLUTIONS OF REINFORCEMENT CAGES OF BENDABLE REINFORCED CONCRETE ELEMENTS

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*This article discusses the comparison of the design solutions of welded and knitted reinforcement cages used for reinforcement of concrete structures and evaluated their advantages and disadvantages*

**Introduction.** In recent years in the construction industry of most developed industrial countries has clearly identified the trend towards saving energy expended in the production of concrete products, since the reduction in energy consumption directly associated with a decrease in the cost of production needed by all industries. Cost reduction means increasing the competitive ability on the markets of construction materials and products. Against the background of these data can be considered possible options for making reinforcement cages with justification costs, the identification of the advantages and disadvantages of the options. Spatial reinforcement frames are a separate kind of metal used for reinforcing concrete constructions. Reinforcement cages three-dimensional structures depending on the features of the manufacture are divided into several types

**Welded frames:** Performed using the pin-point or arc welding with pre-selection mode ensuring when testing cruciform joints in shear breaking strength required by the current normative-technical documentation. Welding is used only in the case if the properties of the chemical composition of the core allow it to do (see Fig. 1).

**Knitted frames:** Knitted scaffolds can be applied to all classes of reinforcing bars. Is used for binding steel wire with low carbon content. Tally of elementorganic special crochet hook or a gun (see Fig. 2).



Fig. 1. Welded frames



Fig. 2. Knitted frames

The analysis of previously completed work shows that research in the field of reinforced concrete elements collapsing on the inclined cross sections are relevant. In line with this, the present study aims at comparative evaluation of the experimental data on the work of designs with different types of connection of longitudinal and transverse reinforcement, taking account of questions of technology and economic costs. In accordance with the tasks designed and constructed reinforced concrete beam of rectangular cross section in the amount of four pieces with the size of the cross section  $140 \times 300$  mm, 1750 mm long, reinforced with longitudinal and transverse rods of steel class S500. Connection of longitudinal and transverse rebar in the frame beams was implemented in two variants (see Fig. 3):

- “knitted” in the form of closed stirrups, longitudinal reinforcement envelope;
- “weld”, made with contact-spot welding with the advanced selection mode that provides for testing of cruciform joints in shear stress, equal to 100% and 30% breaking strength clamps.

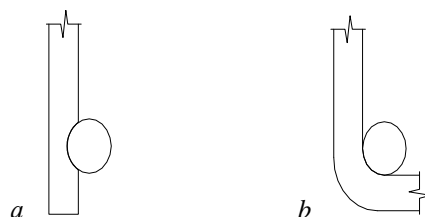


Fig. 3. Connection of longitudinal and transverse rebar in the frame beams:  
*a* – coupling; *b* – closed clamps

Transverse reinforcement made frames, as shown in Fig. 4.

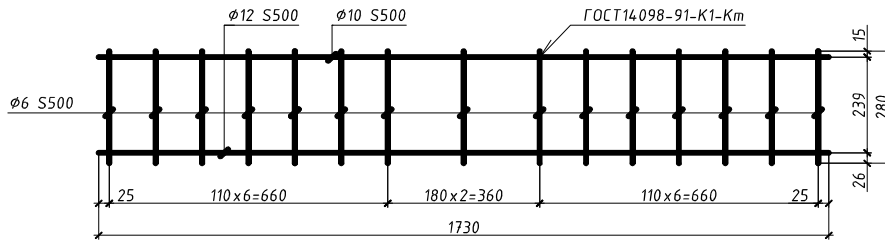


Fig. 4. Diagram of transverse reinforcement prototypes.

Prototype testing of bending was carried out in a hydraulic press PR-1000 in accordance with the scheme of Fig. 5.

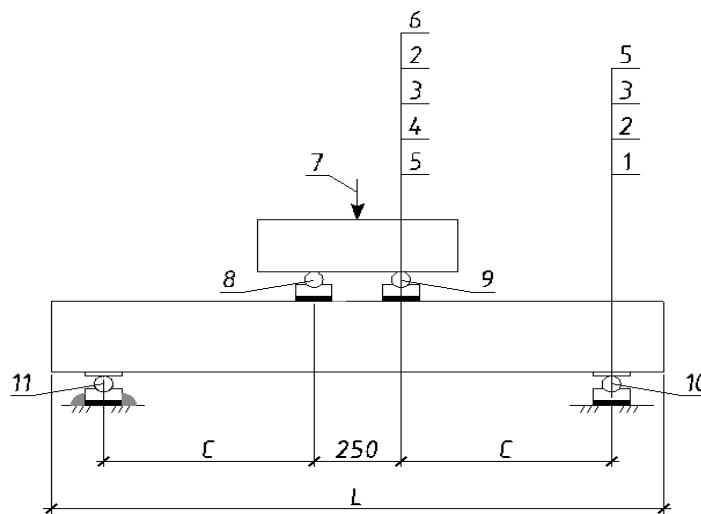


Fig. 5. Scheme of tested beams:

1 – support; 2 – steel packer; 3 – steel plate; 4 – solution of cement; 5 – test beam;  
 6 – traverse camshaft; 7 – the test load; 9,10 – movable support; 8, 11 – fixed support

When loading the prototypes in accordance with the adopted test procedure were controlled by the nature of the formation and opening of cracks and breaking load. The number of inclined cracks formed in the process of loading not influenced by the type of connection of longitudinal and transverse reinforcement. Measurements of widths of cracks is determined that the maximum opening had cracks that intersect the transverse rods located in the middle of the span length of the cut beams, crack widths in beams with a “knit” and “welded” connection was recorded approximately the same. The bearing capacity of specimens with welds and “equally strong” connections was approximately the same. The efforts correspond to the width of inclined cracks is equal to 0.4 mm was obtained at the level of (0.6–0.9)Qu.

Consideration of technological features of manufacture of the frames shows:

- welded frame has 4 cut transverse reinforcement in the section plane, in contrast to the untethered jailbreak that has one RES;
- welded frame used contact spot or arc welding with eight locking points;
- knit frame consolidation takes place after a preliminary bend of transverse reinforcement to form a closed rectangle, and the frame is additionally fixed with reinforcement elements, which are designed to eliminate bias during transportation and concreting;
- knitted frame, not raskreplennye welding is highly deformable;
- the main negative option is the use of welded frames is the possibility of weakening of the valves in the heat-affected zone high temp.

Given the technological and design features of making the most rational frameworks should recognize the frame having end portions (in the area of anchorage) welded transverse rods. These rods provide additional anchoring and spatial resistance in the stage of transportation and concreting.

## REFERENCESE

1. LRFD Bridge Design Specifications / AASHTO (American Association of State Highway and Transportation Officials). – 1st ed. – Washington, D.C., 1994. – 1091 p.
2. Case hardening steels. Methods of tensile tests : GOST 12004-81. – M. : Publishing house of standards, 1980. – 45 c.
3. Welded joints of reinforcement and embedded products for reinforced concrete structures : GOST 14098-91. – M. : Stroyizdat, 1992. – 32 p.
4. Reinforcement and cage welded products, welded joints of reinforcement and embedded intelimentemente designs : GOST 10922-90. – M. : Stroyizdat, 1990. – 24 p.
5. Zalesov, A.S. Resistance of reinforced concrete elements by the action shear forces. Theory and new methods of strength calculation : abstract. diss. ... doctor. tech. Sciences : 01.23.01/NIIZHB / A.S. Zalesov. – M., 1980. – 46 p.
6. Klimov, Yu.A. Theory and calculations of strength, crack resistance and deformation of reinforced concrete elements by the action shear force : diss. ...doctor. tech. sciences : 05.23.01 / Yu.A. Klimov. – Kiev, 1992. – 503 p.
7. Koltunov, A.I. Strength and fracture toughness of the inclined section of bendable reinforced concrete elements with shear reinforcement class At600c. diss. ... kand. tech. sciences : 05.23.01 / A.I. Koltunov. – Novopolotsk, 1998. – 153 p.

## CLT PANELS: HISTORY, ADVANTAGES AND DISADVANTAGES

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*We also discuss the history of construction of multistorey buildings from wooden CLT plates as well as their advantages and disadvantages.*

People have been building wooden houses since the ancient times. Mainly the following types of structural timber have been used:

- regular and rounded timber – for log buildings;
- square-sawn timber – profiled and glued-laminated – for timber beam buildings;
- wooden plates – for stick-frame or prefabricated wooden plate buildings;
- wooden blocks – for timber beam of rounded log buildings.

Modern construction materials and technologies make it possible to build high-rise buildings with more than 25 floors. It is possible due to using CLT panels (Fig. 1) that mean cross laminated timber. So, today construction of high-rise wooden buildings is not considered as a fantasy of architects: more and more new projects are appearing in different countries.

The first samples of cross laminated timber were invented in Switzerland in the early 1990's. The first samples of modern CLT panels were created in 1996 in Austria during scientific research works. In the following couple of years the progress in this sphere was slow, but at the beginning of 2000's the use of CLT panels in construction rapidly increased due to popularization of sustainable construction techniques, increase in the efficiency of materials and better marketing policies [1].

The important factor was the understanding that CLT is not an "easy" construction material. In Europe many residential apartment blocks and public buildings are built from CLT panels. The biggest CLT producing countries are Austria, Germany, Switzerland, Sweden, Norway and the United Kingdom. New CLT factories will open soon in Sweden, Australia and North America. The first multistorey building built from CLT is a 9-floor, 29-apartment Stadhaus in London Borough of Hackney. It was built in 28 days by only four workers [2].

CLT (Cross Laminated Timber) in its simple meaning is a multi-layer timber. It is used for making bearing structures and beams, floor slabs and wall panels. The panels are a laminated solid structure made of slats turned on 90 degrees relative to one another. Each slat is also made of laminated planks or beams with oppositely directed wood fibres. Cross lamination provides the total absence of internal tension and deformation of material, increased durability, excellent resistance to compression and tensioning. At the same time the material is eco-friendly because it consists of only natural laminants that allow timber to "breathe" [2].



Fig. 1. A CLT panel

CLT panels have many advantages compared with other construction materials (reinforced concrete, metal):

- Light weight. Such a panel made of crosswise located slats has five times lighter weight than a concrete one. It allows to save on their transportation and on preparing of foundation (it can have a lighter weight than a foundation for a concrete or a brick building).
- Fast and easy installation. All panels come numbered and cut. To build a house from CLT panels is the same as to build a Lego house, but of a bigger size.
- Absence of gaps. Due to the solid structure of a plate a premise will be protected from draughts and other negative weather factors.
- Eco-friendliness. Construction of houses from CLT panels is a green technology.
- High bearing capacity. CLT panels are used for construction of bridges.
- Durability. Some research was carried out in Japan. The result of this research showed that buildings made of CLT panels can hold seismic vibrations with the intensity up to 7,5.
- No building settlement. Unlike laminated square timber, CLT panels don't swell or shrink under high temperatures and humidity because of their cross layers.
- Fire resistance. CLT panels cannot be compared to any other construction timber in terms of fire resistance because they are totally protected from fire. A factory test was carried out: during one-hour burning of a fireplace with a temperature of 1200 °C the temperature of the other side of a panel (with the thickness 18 cm) rose only by 10 °C.
- Good sound isolation. Long service life. European companies that produce such panels give a 200-year warranty for their products.
- Ideal geometry. At factories panels are already produced with consideration of locations of openings for windows, doors and utilities. All of them have ideally straight lines and flat surface.
- High thermal insulation characteristics. Compared to laminated square timber, CLT panels have a 35% higher thermal insulation level [3].

As any other material, CLT panels have their own disadvantages:

- If a house is built in a place with a cold climate it is required to make the weatherization of walls, which results in additional expenses;
- Production of such material requires expensive equipment that affects the price of CLT panels. The construction work should be done by highly qualified personnel;
- Although the laminant with low formaldehyde content not exceeding the natural limits is used for production of CLT panels, the words about eco-friendliness of houses made from CLT panels should be taken with some degree of scepticism;
- As the technology has become to be implemented only in the recent years, the developers, who will be interested in this material, should remember that because of the small service life of buildings made using this technology it is difficult to forecast how a building will behave in the future [4].

The technology of building houses from CLT panels is simple. For installation of a building (Fig. 2) only basic electrical tools, a lifting crane and a small group of workers are needed. All panels are numbered and are delivered in accordance with the building plan. Installation work is carried out in a short time: installation of one panel requires around 20 minutes, and a full scope of work, for example, building a house for one family, takes around 8 hours [1]. The dry method of construction allows to begin interior fit-out work immediately, which shortens the building commissioning time – panels do not shrink, warp or get cracks. A factory laminated solid wooden board made of dry wood doesn't require plastering, that allows to shorten the period of fit-out work and building commissioning time. More often panels with 3–7 layers are used. At a factory panels containing all necessary openings and, sometimes, holes for electric wiring and utility installations are cut in accordance with detailed drawings. The maximum possible sizes are 16,5 m × 2,95 m × 0,5 m, but usually the length is smaller: sizes of panels are limited due to the necessity of transportation.

After that all panels are marked and delivered to a construction site together with an assembly diagram. This stage is one of the longest because in many cases bulk timber materials are transported from one country to another not only by land but also cross an ocean: for example, bearing structures for the residential house in Melbourne were produced in Austria [5].

**Conclusion.** Based on the afore said, it is possible to say that CLT panels are a modern and advanced material for construction of multistory buildings. Construction of houses from CLT panels has lots of advantages, for example, high thermal insulation characteristics, light weight, absence of gaps, eco-friendliness, high speed and easiness of installation, high bearing capacity, durability, absence of shrinkage, fire resistance, good sound isolation and ideal geometry.



Fig. 2. Construction of a residential building Forté in Melbourne

#### REFERENCES

1. Панели из поперечно-клееной древесины [Electronic resource]. – Mode of access: <http://derevo.ua/>. – Date of access: 28.07.2013.
2. Самые современные технологии. Новинка на российском рынке стройматериалов [Electronic resource]. – Date of access: <http://www.pslcomp.ru/>
3. CLT панели в строительстве – технология будущего [Electronic resource]. – Mode of access: <http://haikara.ru>
4. Деревянный монолит. Дом из CLT панелей [Electronic resource]. – Mode of access: <https://www.forumhouse.ru/>. – Date of access: : 23.04.2014
5. Жить в дереве [Electronic resource]. – Mode of access: -<http://archi.ru/>. – Date of access: 26.08.2014



UDC 691.328.4

## ANALYSIS OF EXISTING METHODS FOR DETERMINING LENGTH FIBERGLASS ANCHORAGE REINFORCEMENT IN CONCRETE

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*Considered and analyzed existing methods used for calculating the anchorage length of reinforcement in concrete. Determined by the use of techniques for fiberglass reinforcement.*

Polymer materials and polymer composites have gained an important place in modern technology. Reinforced polymer composite materials (PCM) with unidirectional fiber orientation substantially exceed all modern metal construction materials. These advantages are even more significant if we take into account the low density of PCM (1300-2000 kg / m<sup>3</sup>).

For the moment the most common in the construction of composite material is fiberglass reinforcement. Fiberglass reinforcement is characterized by a heterogeneous system consisting of oriented glass fibers and a polymer binder. Fiberglass reinforcement properties depend on the properties and characteristics of the glass fibers and the polymer matrix structure, and physic-chemical interactions of these components, they work together in the perception of external loads, corrosive reagents and other factors. Knowledge of the properties of the raw materials allows you to control the properties of fiberglass reinforcement. High-strength glass fiber almost entirely perceived influence of tensile forces, determines the deformation properties of reinforcement, explains the change in strength characteristics under the influence of external factors. For all types of fiberglass reinforcement elongation is directly proportional to tensile loading up to failure. This is the cause of brittle failure of reinforced concrete structures reinforced with fiberglass reinforcement only. In [7], confirmed that the strength and the tensile modulus substantially depend on the diameter of the bar: the smaller the diameter of the armature, the higher its strength and modulus.

Properties that do not allow to perform a complete replacement of the metal reinforcement in the composite:

- Low modulus of elasticity;
- Low strength transverse loads;
- Lower fire products, reinforced composite reinforcement;
- Difficulties in the manufacture of prestressed structures;
- Knowledge gap on the bond strength of composite reinforcement with concrete.

Adhesion to concrete reinforcement is a key factor in ensuring their co-operation in reinforced concrete structures. Investigation of the influence of the diameter and length of bars embedment strength and deformability of adhesion to concrete composite reinforcement in flexural elements received considerable attention.

Made in Belarus and imported to the republic composite bars is wide variation in the physical and mechanical characteristics, geometrical parameters and raw materials. The lack of regulations standards the requirements for composite reinforcement, leading to differences in manufacturing technology and the geometric dimensions of periodic profile. Fittings from different manufacturers will have excellent adhesion characteristics with concrete.

The length of the anchoring fiberglass reinforcement in concrete may be determined according to the guidelines SNB 5.03.01-02, SNIP 2.03.01-84 \* TAP EN 1992-1-1-2009, CAN / CSA-S6-00, CAN / CSA-S6-02, JSCE.

Methods for calculating the SNB 5.03.01-02 is based on tests with a favorable combination of structural factors (large concrete cover, concrete subjected to compression).

Calculation of anchoring tensile reinforcement is made using the parameter – the basic (nominal) length of anchoring ( $l_b$ ). This value is determined by the conditions under which the force in the longitudinal reinforcement is perceived resistance of concrete adhesion to the reinforcement ( $f_{bd}$ ) on the perimeter of the bar ( $U_s$ ) over the length of the anchorage.

Adhesion resistance determined depending on the tensile strength of concrete ( $f_{ctd}$ ).

$$f_{bd} = \eta_1 \cdot \eta_2 \cdot \eta_3 \cdot f_{ctd}$$

Basic anchorage length is determined by the conditions under which the clutch stress contact concrete and reinforcement do not reach the limit values to achieve in the armature stress corresponding to the Settlement armature resistance ( $f_{yd}$ ).

$$l_b = \left( \frac{\varnothing}{4} \right) \cdot \left( \frac{f_{yd}}{f_{bd}} \right)$$

Hence, the base anchoring length, according to the calculated dependence, does not guarantee the reliability of the anchorage at stresses in the armature corresponding to the physical limit yield.

On the basis of the basic anchorage length is determined by the calculated anchoring length, taking into account the additional factors: the thickness of the concrete cover, transverse compression within the length of anchoring, the ratio between the actual and the desired area of the valve on the calculation, etc.

$$l_{bd} = a_1 \cdot a_2 \cdot a_3 \cdot a_4 \cdot l_b \cdot \frac{A_{s,req}}{A_{s,prov}} \geq l_{b,min} .$$

The minimum length of anchoring  $l_{b,min}$  must not be less than a multiple of  $l_b$  (Tab. 1).

Table 1. – The minimum length of anchoring  $l_{b,min}$

Normative document	For the tensilebar is equal to the greater of the following values:	For compressed bar equal to the greater of the following values:
SNB 5.03.01-02	{0,6 $l_b$ ; 15Ø; 100 mm}	{0,3 $l_b$ ; 15Ø; 100 mm}

It can be concluded that the SNB 5.03.01-02 guidelines allows large stocks when determining the length of the anchoring base and minimum values of the tensile length of the anchoring rods; limits the minimum length of the anchoring bars is cut off in span and for intravascular inner face of the support.

When using this method for fiberglass reinforcement, you must first calculate the required value of the coefficient  $\eta_3$ .

$$\eta_3 = \frac{\sigma_{s,max} d}{4\eta_1 \cdot \eta_2 \cdot f_{ctd} \cdot l_{3adon}} .$$

Calculation of anchoring tensile reinforcement according to EN 1992-1-1 TAP guidelines is also performed using the parameter – the basic (nominal) length of anchoring ( $l_{b,rqd}$ ), which is determined by the worst combination of structural factors (minimally acceptable standards of concrete cover, the distance between the bars, etc.), which can be reduced under favorable conditions.

The formula for determining the basic anchorage length does not depend on the calculated armature resistance, and depends on the operating stress in the bar ( $\sigma_{sd}$ ) in place, which is measured with the anchoring must be taken into account the form of reinforcing steel and adhesion properties to the bars.

$$l_{b,rqd} = \left( \frac{\varnothing}{4} \right) \cdot \left( \frac{\sigma_{sd}}{f_{bd}} \right) .$$

Ultimate bond stress ( $f_{bd}$ ) should be sufficient to avoid the failure of the debonding.

The estimated length of the anchoring  $l_{bd}$  determined based on the length of the anchoring base, taking into account the effect of the bar at a sufficient protective layer; the minimum thickness of the protective layer of concrete, etc.:

$$l_{bd} = a_1 \cdot a_2 \cdot a_3 \cdot a_4 \cdot a_5 \cdot l_{b,rqd} \geq l_{b,min} .$$

The minimum length of anchoring  $l_{b,min}$  must not be less than a multiple of  $l_b$  (Tab. 2).

Table 2. – The minimum length of anchoring  $l_{b,min}$

Normative document	For the tensilebar is equal to the greater of the following values:	For compressed bar equal to the greater of the following values:
TAP EN 1992-1-1-2009	{0,3 $l_b$ ; 10Ø; 100 mm}	{0,6 $l_b$ ; 10Ø; 100 mm}

When calculating the length of the anchoring SNIP 2.03.01-84 longitudinal rods are tensile and compressed reinforcement should be instituted for the normal to the longitudinal axis of the cross section for the length of not less than  $l_{am}$ , defined by the formula:

$$l_{am} = \left( w_{am} \frac{R_s}{R_b} + \Delta\lambda_{am} \right) d .$$

But at least  $l_{an} = \lambda_{an} d$ .

Values  $w_{an}$ ,  $\Delta\lambda_{an}$ ,  $\lambda_{an}$  defined in Table 3.

Table 3. The coefficients for determining the anchoring Free of tension reinforcement

Operating conditions Free of tension reinforcement	The coefficients for determining the anchoring Free of tension reinforcement							
	Periodic Profile				Smooth			
	$w_{an}$	$\Delta\lambda_{an}$	$\lambda_{an}$	$l_{an}$ , mm	$w_{an}$	$\Delta\lambda_{an}$	$\lambda_{an}$	$l_{an}$ , mm
			No less				No less	
1. Closing the valve: • Tensile in cracked concrete • Compressed or tensile in the compressed concrete	0,7	11	20	250	1,20	11	20	250
	0,5	8	12	200	0,80	8	15	200
2. Overlap joints reinforcement • In tensile concrete • The compressed concrete	0,9	11	20	250	1,55	11	20	250
	0,65	8	15	200	1,00	8	15	200

For the elements of fine concrete values are increased by  $l_{an} 10d$  for concrete in tension and  $5d$  – compressed. If rods anchorage bars are delivered with a margin on the cross-sectional area compared to the required calculation, the anchorage length may be reduced, by multiplying by the ratio required for the calculation and the actual area of the valve section.

The Canadian Standards [13] and [12] proposed formula to calculate the required length of anchoring NCA. In the recommendations [13] provides for the estimated demand for carbon fiber and organic-fitting. Fiberglass reinforcement only considered as constructive. Standards [12] provide for the use of glass-fiber reinforcement, but only as a tendon whenever possible to ensure its longevity.

The formula determining the necessary anchorage length of the zone is based on a similar formula for the steel reinforcement of the Canadian regulations and has empirically established coefficients, specifying actual work for steel reinforcement:

$$l_d = 0.45 \frac{k_1 k_4}{d_{cs} + K_{tr} \frac{E_f}{E_s}} \cdot \frac{f_{yd}}{f_{bd}} A,$$

where  $l_d$  – anchoring zone length;

$k_1$  – the coefficient corresponding to the position of reinforcement;

$d_{cs}$  – the shortest distance from the core center to the edge of concrete or step bars, mm;

$K_{tr}$  – index of transverse reinforcement;

$k_4$  – additional indicator clutch NCA, equal to the ratio of strength NCA adhesion to strength clutch steel bars, but not more than 1.

In accordance with Japanese standards JSCE [11] the length of the anchoring base is determined by the formula:

$$l_d = \alpha_1 \left| \frac{f_{fd}}{4 f_{bod}} \right| d > 20d ,$$

where

–  $\alpha_1$  accepted:

– 1,0 for  $k_c \leq 1.0$ ;

– 0.9 for  $1.0 < k_c \leq 1.5$ ;

– 0.8 for  $1.5 < k_c \leq 2.0$ ;

– 0.7 for  $2.0 < k_c \leq 2.5$ ;

– 0.6 for  $2.5 < k_c$ ;

– calculated strength  $f_{bod}$  clutch is determined by the formula

$$f_{bod} = \alpha_2 \left( \frac{0.28 f_{ck}^{\frac{2}{3}}}{\gamma_c} \right) < 3.2 \text{ MPa},$$

$\gamma_s = 1.3$  at  $f_{ck} < 50$  MPa and  $1.5$  for  $f_{ck} \geq 50$  MPa;

$\alpha_2$  – ratio, which expresses the ratio of the strength of adhesion to the NCA corrugated steel reinforcement bond strength, but not more than 1.0.

A total of, the following conclusions.

Standards of various countries provided many techniques to determine the length of anchorage reinforcement in the concrete, but not all of them adapted to the fiberglass reinforcement. To determine the applicability of each of the methods for calculating the additional investigations necessary.

#### REFERENCESE

1. Холмянский, М.М. Контакт арматуры с бетоном / М.М. Холмянский. – М. : Стройиздат, 1981. – 184 с.
2. Фролов, Н.П. Стеклопластиковая арматура и стеклопластбетонные конструкции. – М. : Стройиздат, 1980. – 104 с.
3. Коррозия бетона и железобетона, методы их защиты / В.М. Москвин [и др.]. – М. : Стройиздат, 1980. – 536 с.
4. Астрова, Т.И. Анкеровка стержней арматуры периодического профиля в обычном и предварительнонапряжённом железобетоне / Т.И. Астрова // Расчет железобетонных конструкций : сб. тр. – М. : НИИЖБ, 1961. – С. 74–126.
5. Бетонные и железобетонные конструкции : СНБ 5.03.01-02.
6. Проектирование железобетонных конструкций : ТКП EN 1992-1-1-2009. Еврокод 2.
7. Особенности сцепления с бетоном стержневой арматуры различных профилей / А.С. Семченков [и др.] // Экспертиза. – 2008. – № 8. – С. 58–62.
8. Хотько, А.А. Расчетная оценка анкеровки в бетоне ненапрягаемой арматуры с различными видами периодического профиля / А.А. Хотько, Ю.В. Попков, А.В. Василевский // Перспективы развития новых технологий в строительстве и подготовке инженерных кадров Республики Беларусь : сб. науч. тр. – Могилев : Белорус.-Рос. ун-т, 2005. – С. 480–487.
9. Бабич, Є. М. Зчеплення арматури класу А500С з бетоном різної міцності / Є.М. Бабич, О.С. Чапук // Механіка і фізика руйнування будівельних матеріалів та конструкцій.
10. О нормировании анкеровки стержневой арматуры / И.Н. Тихонов [и др.] // Бетон и железобетон. — 2006. – №3. – С. 2–7.
11. JSCE, Recommendation for Design and Construction of Concrete Structures Using Continuous Fiber Reinforcing Materials, Tokyo, Japan: Japan Society of Civil Engineers, 1997.
12. CAN/CSA-S6-00, Canadian High Bridge Design Code, Canadian Standards Association, 2000.
13. CAN/CSA-S6-02, Design and Construction of Building Components with Diber-Reinforced Polymers, Canadian Standards Association, 2002.

UDC 666.973.2:666.972.1

## NOILS OF FLAX FIBER AS AN AGGREGATE FOR HEAT-INSULATING PLATES

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*Heat-insulating materials on the basis of flax fiber are considered. It was offered to use waste of flax-processing plants – noils flax fiber as a fibrous aggregate for production of a heater. The results of the carried-out testing testify greater efficiency of heat-insulating materials from noils fiber in comparison with heaters on the basis of flax fibers.*

It is impossible to call the market of heat-insulating materials underdeveloped – heaters of various groups attract consumers' attention. The most widespread heat-insulating materials are as follows: mineral (glass wool, fibers-based product of working off of blast furnaces, and also rocks), synthetic (received as a result of thermal and chemical processes – for example, polyfoam) and natural materials. The last group is less widespread and respectively less popular with users, though it doesn't give way to recognized materials. And taking into account the increasing requirements to ecological purity of heaters, the use of vegetable raw materials for production of heat-insulating materials is especially urgent. Herewith new heat-insulating materials have to possess a complex of the operational characteristics providing formation of a favorable microclimate of rooms and economy of thermal energy at the operation of buildings. Nowadays natural heaters from hemp, cellulose, cane, pith agglomerate are produced, but flax thermal insulation is one of the best according to its heat and technical indicators [1].

The Belarusian company JSC «AKOTERM FLAKS» offers heat-insulating plates of flax fiber (85%) with a binding component – the conjugate polyester fiber (15%) which is regularly distributed throughout the volume of the plate [2]. This material is optimum for low construction and is used for internal and external warming of walls. The durable natural heat-insulating "breathing" material possesses the following physic-mechanical characteristics: density of 30 kg/m<sup>3</sup>, heat conductivity rate of 0,038 Watt/(m·°C), sound-absorption rate of 0,84 (100–4000 Hz), vapor permeability rate of 0,4 mg/(m·h·Pa), group of combustibility – G4, service life – 70 years and more.

The heat-insulating plates «Ekoteplin» manufactured in Russia have the following compounds of components: linen fibers are used as filler, natural starch is used as binding, and salts of boron are applied as fire- and bioprotection [3]. The production technology of a heater provides receipt of plates with uniform structure, without the use of synthetic additives. Plates apply both in low construction, and for warming and sound insulation of apartments. The heater of «Ekoteplin» is a hypoallergenic material and is completely safe for health. At the density of 32 kg/m<sup>3</sup>, heat conductivity rate is 0,038 Watt/(m·°C), sound-absorption rate is 0,84, vapor permeability rate is 0,4 mg/(m·h·Pa) at group of combustibility G1. Service life of material is not less than 60 years.

The task of conducting a research of noils of flax fiber as the main component of heat-insulating material is set in the work. Samples of a heater were formed from flax noils, and also from mix of fibers and noils of flax at a ratio 80:20. Noils of flax fiber and the mixture of fibers and of noils of flax fiber were used as aggregates in the samples of heaters. Flax fibers up to 90 cm long were used in the research. Noils of flax present themselves departure in the form of short fibers 5–10 cm long, received when carding of the scutched flax. Liquid sodium glass was used as a binder, providing rigidity and durability of heat-insulating material, and also increasing resistance of noils and fibers of flax to burning. The results of the research are given in table 1.

Table 1 – Physicomechanical characteristics of heat-insulating plates

Composition No.	Expense of components per 1 m <sup>3</sup> (fraction from a unit)			Density, kg/m <sup>3</sup>	Heat conduction rate, Watt/(m·°C)	Durability on compression at 10% of deformation, MPa
	flax fiber	noils flax fiber	liquid sodium glass			
1	0,74	0,19	0,07	70	0,038	0,026
2	-	0,93	0,07	70	0,034	0,025
3	0,65	0,17	0,19	85	0,04	0,032
4	-	0,81	0,19	85	0,035	0,03
5	0,58	0,15	0,27	100	0,043	0,043
6	-	0,73	0,27	100	0,037	0,04

The analysis of the results of compounds 1 and 5 showed that increase in a consumption of liquid sodium glass leads to increase in heat conductivity rate by 0,005 Watt/(m·°C) and durability on compression at 10% of deformation by 65 per cent. Also there is an increase in durability by 60 per cent and heat conductivity rate by

0,003 Watt/(m<sup>2</sup>·°C) at compound 6 in comparison with characteristics of compound 2. The analysis of physico-mechanical characteristics shows that application of noils of flax as an aggregate (compounds 2, 4, 6), instead of mix of fiber and noils of flax (compounds 1, 3, 5), at the identical density of heaters, heat conductivity decreases by 0,004–0,006 Watt/(m<sup>2</sup>·°C), and material durability practically doesn't change. When comparing the received results of compounds 2, 4 and 6 with characteristics of the heat-insulating materials "AKOTERM FLAKS" and "Ekoteplin" it was established that at increase in average density of experimental compounds on 40–70 kg/m<sup>3</sup> there is a decrease in heat conductivity rate to 0,034–0,037 Watt/(m<sup>2</sup>·°C), when ensuring durability on compression at 10% of deformation at the level of 0,025–0,04 MPa and group of combustibility G1.

Rather often in operating process heat-insulating materials can be in conditions of the increased humidity of air or be exposed to moistening as a result of violation of a integrity and leakages of a covering of a roof or the ventilated facades [4]. For ensuring durability of heat-insulating materials in such service conditions, first of all, it is necessary to provide the water resistance of liquid sodium glass as the binding heater component. On this purpose, the study of liquid sodium glass in water resistance according to methodology described in [5] was additionally carried out. Solubility of binding was determined by a drying method with the use of flannel fabric. Samples of flannel fabric with the size of 100×100 mm impregnated with liquid sodium glass, dried up in a drying cabinet at a temperature of 80–110 °C. On reaching constant weight samples cooled and immersed in the container with water with a temperature of 20 ± 5 °C. 2 hours later flannel samples with a binder were taken from capacity. To remove the surplus of water the fabric was hung in a free state for 30 minutes. Then the samples of flannel were placed in a drying cabinet and on reaching constant weight the fabric was weighed. Further the samples were immersed in the container with water again, dried up and weighed. The number of experiments was defined by the constancy of mass the three consistently dried up flannel samples. Change of mass of samples was expressed as a percentage. Before and after soaking and drying determined a relative indicator of solubility by the size of change of mass of the impregnated flannel samples binding and the insoluble rest (water resistance). The received samples were tested 1 day later, after full drying. Liquid sodium glass without additives after the first cycle was exposed to considerable dissolution, and the insoluble rest on weight made 24%. After the second cycle of tests the firm phase of liquid glass wasn't recorded.

During the tests for water resistance 8% of additive of lime and plaster from the mass of binding was used, replacing liquid sodium glass. In the course of hashing the binder with additives lime was added first, and gypsum was the second to be added. Adding of 16% of Ca (OH)<sub>2</sub> + CaSO<sub>4</sub> led to the formation of 99% of the insoluble rest after 4 cycles of tests.

The influence of additives on heat conductivity and durability on compression at 10% of deformation of heat-insulating plates was also investigated. Table 2 shows data on the effect of lime and gypsum on physical and mechanical properties of the insulation.

Table 2 – Physico-mechanical characteristics of heat-insulating plates

Composition No.	Expense of components on 1 m <sup>3</sup> in shares from unit				Density, kg/m <sup>3</sup>	Heat conduction rate, Watt/(m <sup>2</sup> ·°C)	Durability on compression at 10% of deformation, MPa
	noils flax fiber	liquid sodium glass	lime	gypsum			
1	0,84	0,16	-	-	92	0,035	0,028
2	0,84	0,134	0,013	0,013	92	0,035	0,028
3	0,72	0,28	-	-	102	0,037	0,041
4	0,72	0,0236	0,022	0,022	102	0,037	0,041

As the results of the experiments show, there were no recorded changes of values of density, heat conductivity and durability on compression at 10% of deformation after adding lime and plaster (compounds 2, 4). Thus, the use of additives not only doesn't worsen physico-mechanical indicators of a heater, but also provides the water resistance of liquid sodium glass and as a result durability of heat-insulating material increases.

**Conclusions.** The conducted researches confirmed the possibility of use of noils of flax fiber for the production of effective heat-insulating material. The heater on the basis of this filler including liquid sodium glass is environmentally friendly and safe for people. Additives like lime and plaster in quantity of 8% of the mass of the binder contribute to the increase in water resistance of liquid sodium glass up to 99%. At the identical density of samples the indicators of heat conductivity rate, durability on compression at 10% of deformation are identical with the characteristics of compounds without additives.

In comparison with the existing heat-insulating materials on the basis of flax fiber the developed heater has a lower coefficient of heat conductivity of 0,034–0,037 Watt/(m<sup>2</sup>·°C) and belongs to the group of combustibility G1. Unlike analogs, the developed heat-insulating material has durability at 10% of deformation of 0,025–

0,04 MPa, which allows to expand its use, including warming of the ventilated facades and roofs, and the arrangement of termoshuba.

The use of noils of flax fiber for the production of heat-insulating materials solves a problem of utilization of vegetable waste of a flax-processing and expands the nomenclature of natural effective heaters.

#### REFERENCES

1. Льяной утеплитель: обзор натуральных утеплителей из льна [Электронный ресурс] / Remontami. – Режим доступа: <http://remontami.ru/lnyanoj-uteplitel-obzor-naturalnyh-uteplitelej-iz-lna/>. – Дата доступа: 25.01.2017.
2. Акотерм флакс [Электронный ресурс] / АКОТЕРМ. – Режим доступа: [http://akoterm.by/ru\\_RU/льняная-теплоизоляция/](http://akoterm.by/ru_RU/льняная-теплоизоляция/). – Дата доступа: 25.01.2017.
3. Экотеплин – льяной утеплитель [Электронный ресурс] / ЭКОПЛАНЕТА. – Режим доступа: [http://www.ekoplaneta.su/eco\\_shop/for\\_in/ekoteplin/](http://www.ekoplaneta.su/eco_shop/for_in/ekoteplin/). – Дата доступа: 25.01.2017.
4. Давыденко, Н.В. Теплоизоляционные плиты на основе отходов растениеводства и неорганического вяжущего : дис. ... канд. техн. наук : 05.23.05 / Н.В. Давыденко. – Новополоцк, 2015. – 121 с.
5. Повышение водостойкости жидкого стекла, применяемого в качестве вяжущего при производстве теплоизоляционных костросоломенных плит / Н.В. Давыденко, А.А. Бакатович // Вестн. Полоц. гос. ун-та. Сер. Ф, Прикладные науки. – 2015. – № 8. – С. 71–75.

## INSULATING MATERIAL ON THE BASIS OF BARK FIBRE OF THE OLIVE PALM TREE

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*The relevance of use of bark fiber of the oil palm tree for the production of effective heat-insulating materials is justified. Compounds of heat-insulating plates on the basis of bark fiber are picked up. Results of the research of the main physico-mechanical characteristics of the developed heater are given.*

Cultivation of the oil palm tree on an industrial scale began in the XX century. At that time companies manufacturing soap and margarine were engaged in the production of oil from palm fruit. Large-scale cultivation of the palm tree began in Indonesia in 1911, in Malaysia – in 1919. During that period the areas with landings of olive palm trees in the African countries began to be expanded [1].

In the last decades in connection with the world growth of consumption of palm-oil in the food and cosmetic industries the landing areas of plantations of olive palm trees have significantly increased. The leading position in production of palm-oil is taken by Malaysia. However, today, Malaysian producers of oil face the problem of recycling of a large number of the cut-down old palm trees. It should be noted that separate parts of the olive palm tree are used quite variously: fibers of young leaves are used for the production of ropes, dry leaves are used for weaving mats and curtains, and roofs for huts, stalks are used for spin baskets. Quite tasty young escapes are applied in food (palm cabbage), from juice of the palm tree wine is produced. As a rule, trunks of the cut-down trees decay, or are burned on plantations. Bark of an olive palm tree easily is removed from a trunk and has fibrous structure. 10–15% of the mass of a trunk of a palm tree fall to the share of bark. As a result, it is annually necessary to utilize about 210 thousand tons of bark [2].

At the beginning of the XX–XXIst century the relevance of use of vegetable waste has got the new reconsideration caused by ecological purity of materials and fast renewability of raw materials. In this regard, today much attention is paid to scientific research on rational recycling of crop production. Vegetable raw materials, as the main component of construction materials, have been used in the construction of various objects for hundreds of years, as they have valuable properties, such as, availability and prevalence, low density and low heat conductivity, low cost. The listed positive characteristics provide a demand and great opportunities for application of vegetable raw materials in construction [3].

For example, the natural heater "Bauplit Cocos" consisting for 85% of coconut fiber and for 15% from polyester fibers as a binding component is manufactured in Russia. The material is applied for warming of external walls, internal partitions, floors and interfloor overlappings. Moreover, "Bauplit Cocos" possesses high sound-proof characteristics. The main distinctive feature of material is high moisture resistance, thanks to the high content of lignin in coconut fiber. The lignin interferes with the emergence of mold and the destruction of fibers. "Bauplit Cocos" is capable of absorbing moisture with the subsequent return, but at the same time the structure of a heater remains former. This heat-insulating material possesses good physical characteristics: a density of 30 kg/m<sup>3</sup>, a heat conduction coefficient of 0,038–0,042 Watt/(m·°C), its vapor permeability rate is 0,59 mg/(m·h·Pa), but at the same time it is a combustible material – group of combustibility G4 [4].

For the countries with warm climate, including Malaysia and Indonesia, the presence of thermal insulation materials in enclosing structures is also important to keep cool inside and prevent the heating of buildings, which saves on the air conditionings.

The purpose of the conducted research was to establish a possibility of use of bark fiber of the oil palm tree for the production of effective heat-insulating material. Fibers of bark of the palm tree were the main components in the heater; liquid sodium glass performed the function of binding. For increase in water resistance of liquid sodium glass additives from plaster and lime in quantity of 8% of the mass of binding were used. The quantitative structure of the components of heat-insulating plates is brought in table 1.

Table 1 – Quantitative compound of components of heat-insulating plates

Composition No.	Expense of components per 1 m <sup>3</sup> , kg			
	Bark fiber	liquid glass	lime	gypsum
1	2	3	4	5
1	66	17	1,6	1,6
2	94	17	1,6	1,6
3	122	17	1,6	1,6
4	150	17	1,6	1,6



Table 1 Conclusion

1	2	3	4	5
5	178	17	1,6	1,6
6	66	34	3,2	3,2
7	94	34	3,2	3,2
8	122	34	3,2	3,2
9	150	34	3,2	3,2
10	178	34	3,2	3,2
11	66	51	4,8	4,8
12	94	51	4,8	4,8
13	122	51	4,8	4,8
14	150	51	4,8	4,8
15	178	51	4,8	4,8

The research of physico-mechanical characteristics of the received samples has been conducted. The average density and coefficient of heat conductivity were determined on sample plates 25×25×3 cm. Durability on compression at 10% of deformation was investigated on sample cubes 10×10×10 cm. The results of the research are given in fig. 1–3.

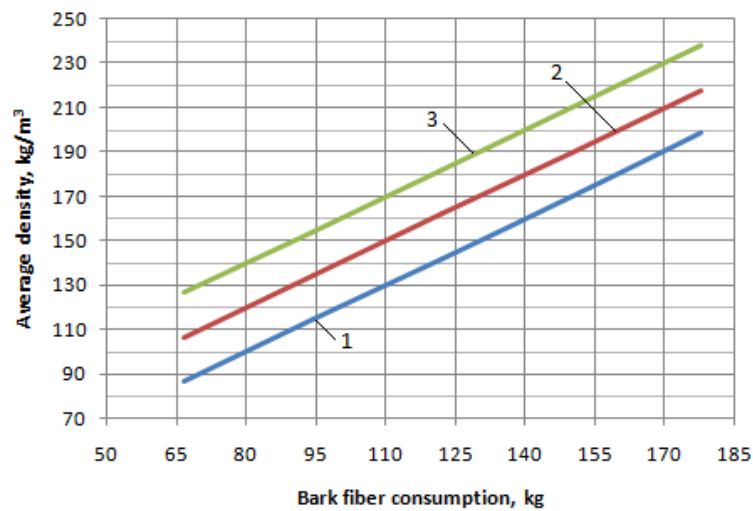


Fig. 1 – Dependence of average density of a heater on a consumption of fibers of bark:  
 1 – for compounds 1-5; 2 – for compounds 6-10; 3 – for compounds 11-15

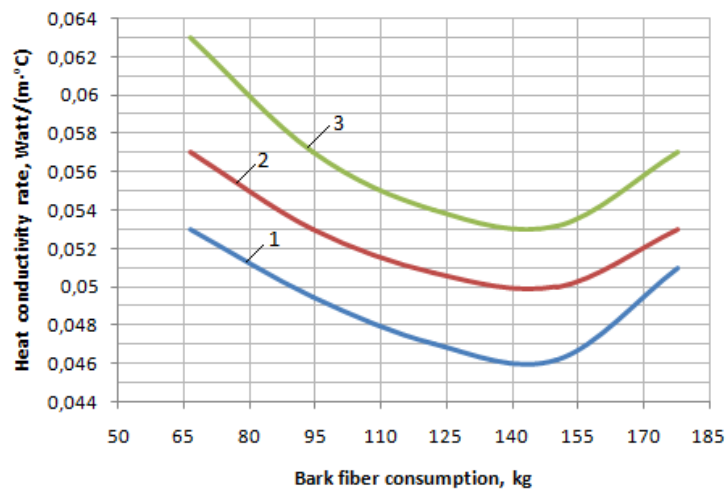


Fig. 3 – Dependence of heat conductivity rate of a heater on the consumption of bark fibers:  
 1 – for compounds 1-5; 2 – for compounds 6-10; 3 – for compounds 11-15

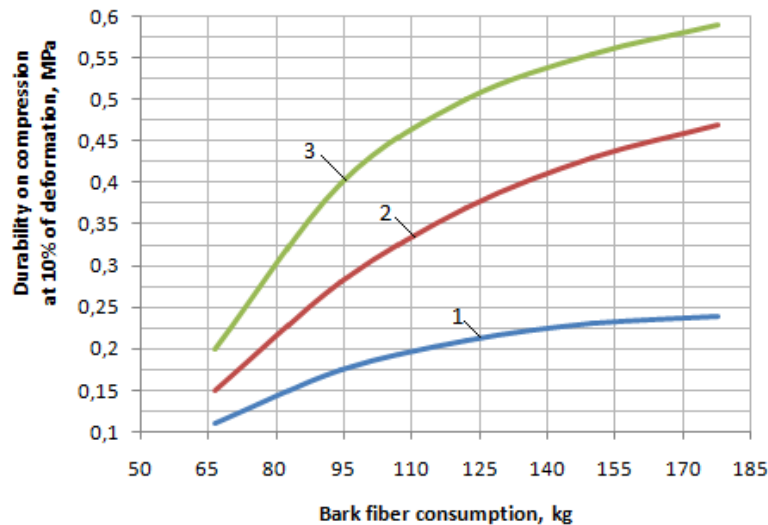


Fig. 3 – Dependence of durability on compression at 10% of deformation of a heater on the consumption of bark fiber:  
 1 – for compounds 1–5; 2 – for compounds 6–10; 3 – for compounds 11–15

From the obtained dependences (Fig. 1) it follows, that the variation in the amount of fibers of bark, binder and additives allows to obtain a material with an average density from 87 (compound 1) to 238 kg/m<sup>3</sup> (compound 15). The change of mass of fiber from 66 to 178 kg (compounds 1–5), at the fixed amount of additives leads to increase in an average density by 2,3 times up to 198 kg/m<sup>3</sup>. For compounds 6–10 the minimum value of average density of 107 kg/m<sup>3</sup> corresponds to the consumption of 66 kg of aggregate, and at the maximum consumption of 178 kg of bark fiber an average density increases twice and makes 218 kg/m<sup>3</sup>. Similar dependence is established for compounds 11–15. With the fixed amount of bark fiber, for example 178 kg per m<sup>3</sup> (compounds 5, 10, 15), increase in the consumption of binding and additives causes increase in an average density by 1,2 times from 198 to 238 kg/m<sup>3</sup>. Thus, the quantitative content of bark fiber, liquid sodium glass with additives as part of a heater has significant effect on the size of average density, and allows reaching a wide range of change of this indicator.

The analysis of the received dependences (Fig. 2) allows to draw a conclusion that increase in the amount of bark fiber up to 143 kg per 1 m<sup>3</sup> independently on the consumption of binding and additives leads to reduction in heat conductivity rate, and further increase or reduction in the consumption of aggregate causes increase in the studied parameter. For example, at the consumption of 178 kg of aggregate per 1 m<sup>3</sup> for compound 5 heat conductivity makes 0,051 Watt/(m·°C). Reduction of the consumption of aggregate by 20 per cent causes decrease in coefficient of heat conductivity up to 0,046 Watt/(m·°C). Further reduction of amount of bark fiber causes increase in heat conductivity by 15 per cent up to 0,053 Watt/(m·°C). At the consumption of 66 kg of aggregate per 1 m<sup>3</sup> for compound 6 heat conductivity makes 0,057 Watt/(m·°C). Decrease in coefficient of heat conductivity up to 0,05 Watt/(m·°C) happens at increase in the consumption of aggregate by 2,15 times. Further increase in amount of bark fiber leads to increase in heat conductivity rate up to 0,053 Watt/(m·°C). For compounds 11–15 the minimum value of heat conductivity rate of 0,053 Watt/(m·°C) corresponds to the consumption of 143 kg of aggregate of per 1 m<sup>3</sup>. At the reduction of the consumption of aggregate (compound 11) it is established, that heat conductivity rate increases by 19 per cent up to 0,063 Watt/(m·°C), and at increase in amount of bark fiber (compound 15) there is an increase in the studied parameter up to 0,057 Watt/(m·°C). It is also established what with a constant mass of the aggregate, increase in the consumption of binding and additives causes increase in heat conductivity rate. For example, when using 66 kg of aggregate (compounds 1, 6, 11) the gain of heat conductivity rate makes 19 per cent. In the considered ranges of expenses of components, heat conductivity rate of a heater changes from 0,046 to 0,063 Watt/(m·°C).

The received dependences of durability (Fig. 3) demonstrate that increase in the consumption of bark fiber binding and additives leads to increase in durability at 10% of deformation from 0,11 to 0,59 MPa. For compound 5 the indicator of durability reaches the greatest value of 0,24 MPa that exceeds the indicator of compound 1 2,2 times. At the consumption of 66 kg of aggregate per 1 m<sup>3</sup> for compound 6 the durability on compression at 10% of deformation makes 0,15 MPa. Further increase in the consumption of bark fiber causes increase in durability by 0,32 MPa (compound 10). At the maximum consumption of 178 kg of bark fiber per 1 m<sup>3</sup> (compound 15) the value of durability is equal to 0,59 MPa, i.e. increases by 2,9 times in comparison with the indicator of compound 11. It should be noted that at the consumption of 66 kg of fiber of per 1 m<sup>3</sup>, the difference

between the maximum and minimum indicator of durability makes 0,09 MPa, and at 178 kg of aggregate per 1 m<sup>3</sup> there is an increase in an interval between extreme values of durability up to 0,35 MPa.

**Conclusions.** Compounds 3 and 4, characterized by an average density of 142 and 170 kg / m<sup>3</sup>, have the best heat conductivity rates of 0,046 and 0,047 Watt/ (m·°C). Compounds 14 and 15, at the average density of 170 and 198 kg/m<sup>3</sup>, have the highest indicators of durability of 0,55 and 0,59 MPa at 10% of deformation. Thus, the composition of insulating material on the basis of bark fiber of the palm tree is selected according to the required physic-mechanical parameters of a heater.

The conducted research has confirmed the possibility of using bark fibers of the olive palm tree to obtain effective heat-insulating materials. The heater produced on the basis of this aggregate including liquid sodium glass, lime and plaster is environmentally friendly and safe for people. The use of bark fibers of the olive palm tree allows Malaysia, Indonesia and also other regions of Asia and Africa to solve the problem of recycling of vegetable waste and produce effective natural heater from local natural raw materials.

#### REFERENCES

1. Масличная пальма где растет? [Электронный ресурс] / FB.ru. – Режим доступа: <http://fb.ru/article/247580/maslichnaya-palma-gde-rastet>. – Дата доступа: 25.01.2017.
2. Давыденко, Н.В. Теплоизоляционные плиты на основе отходов растениеводства и неорганического вяжущего : дис. ... канд. техн. наук : 05.23.05 / Н.В. Давыденко. – Новополюк, 2015. – 48 с.
3. Plant wastes in wood concrete manufacturing / S. Romanovsky [et al.] // European & national dimension in research. – 2016. – Vol. 3 : Technology. – С. 78–79.
4. Утеплитель из кокоса Bauplit [Электронный ресурс] / GreenBuildTrade. – Режим доступа: <http://g-b-t.ru/collection/kokosovye-utepliteli/product/uteplitel-iz-kokosa-bauplit-cocos>. – Дата доступа: 25.01.2017.

**MODERN TECHNICAL SOLUTIONS OF FOREIGN BATTERY MOULD**

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*Review of foreign battery mould production Weckenmann (Germany), EBAWE (Germany), Elematic (Finland) is made in the article. It is noted that the use of optimized designs of battery form allows you to get inside the wall panels with precise geometric dimensions, the required category of the concrete surface, which does not require additional processing on the construction site.*

In the long-term production of concrete panels, experience shows that in comparison with other modes of production, tape technology provides higher productivity, requires much smaller production areas, reduces the consumption of electricity and heat, and in steady-state production ensures high stability of product quality, eliminates manual labor. Winter conditions determine the priority role of construction using precast concrete.

Modern building panels established themselves as a technology that can provide the required amount of budget accommodation at a low cost and short construction time. Projects of modern series of panel buildings allow to build facilities of more than 20 floors. Erected housing meets the requirements of quality, comfort and safety. Improved layout of the apartments, a large number of options for the interesting and unusual appearance, a well-developed internal infrastructure of buildings can compete successfully with cast-frame technology. In the Republic of Belarus large-panel construction accounts for 21.5% of total housing [1]. This was made possible by the existing network of concrete plants and their efficiency.

Most of the plants of the Republic of Belarus use tape manufacturing technology of internal wall panels. The following objectives are urgent for the tape technology: the improvement of technological processes of manufacture of precast concrete structures, the improving of their quality, the reduction of the material of construction, the use of cost-effective methods and heat treatment regimes for concrete, the reduction of the vibration of the equipment, as well as the development of chemical-technological processes for obtaining materials with desired properties.

A feature of cassette technology is molding in a vertical position in fixed detachable metal group form-cassettes, i.e. laying, compaction of the concrete mix, as well as the curing is performed in a narrow and high (slit-shaped) cavity working compartments. Depending on the material of the dividing walls cassette metal, concrete and armocement are distinguished. According to the construction of cluster dividing walls may be of flexible forms - metal steel sheet 24 mm thick and continuous armocement sheets up to 50 mm thick or rigid - spatial metal boxes or concrete slabs 100–120 mm thick [2].

Hard metal hollow walls are used when they are used for cooking and as a concrete wall when pulling force reinforcement, and in the case where the molded article has a complicated profile. Hard partition walls require significant consumption of metal. Noted [2] that the flexible dividing wall construction must ensure the immutability of geometrical sizes of products and the efficient transmission of vibration from the vibrator to the concrete mix. Since it is practically impossible to apply the concrete mix uniformly in all molding compartments, partition walls experience significant hydrostatic pressure. To prevent the bending of the wall, they set the locking cones which are provided with additional supports and accurate design position of the walls in molding articles.

Battery formwork manufactured by Weckenmann (Germany), are traditional, well-established, but considerably optimized and newly redesigned (Fig. 1). Obvious advantages are filling separate compartments, reliable design with margin of safety with minimal tolerances for flatness; principle of service to the shop floor, providing easy access to the space between the disclosure of the boards and easy stripping using a device with a small lifting height; the use of special vibrators with optimized design to achieve high quality concrete compaction and perfect surface appearance, without unnecessary noise and wear of equipment; heating system using hot water or thermal oil, ensuring minimum uneven temperature distribution in the working surface of formwork; hydraulic coupler formwork with a pressure control system to ensure absolute tightness [3].

The new development of the company Weckenmann is a mobile battery mould that allows you to make concrete wall panels in the vicinity of the construction site. The technical solution includes installation of a cassette formwork on a special vehicle in the form of a semi-trailer, which can be combined with a conventional tractor (Fig. 2) [4]. Trailers are used for transporting the core and the outer formwork. Central formwork and other components of formwork cassette, for example, the control system, the heating elements and the hydraulic

unit are fixedly mounted on the trailer. Additional work platforms, for final assembly of formwork and other small components are delivered to the construction site by conventional trucks [5].

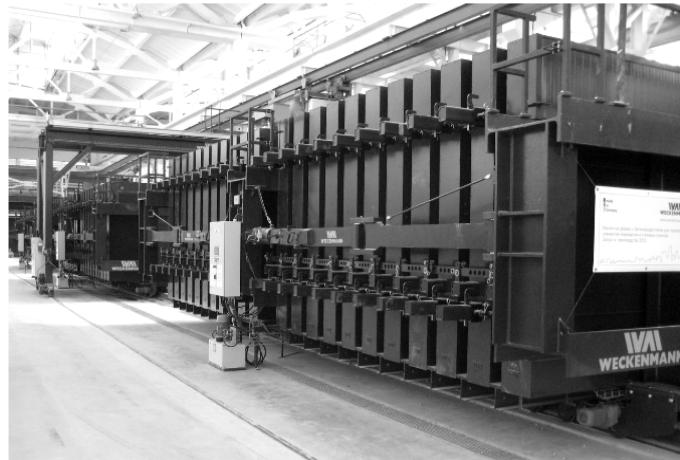


Fig. 1. Weckenmann Anlagentechnik GmbH battery Mould



Fig. 2. The Mobile Battery Mould Weckenmann Anlagentechnik GmbH

Battery mould is composed of:

- rigid central member;
- two mobile external panels with easy-to-service electromechanical drive;
- several (typically – 18 pcs) movable intermediate shuttering panels;
- vertical side and horizontal supporting of formwork panels according to the thickness of the element.

Their position is adjusted according to the size of various elements;

- electric vibrators for compacting the concrete mix integrated into the wall of formwork, which are powered by a frequency converter, providing stepless speed control. This allows you to optimize the quality of the sealing and noise emissions;

- a heating element disposed within the formwork to accelerate the hardening of concrete with reduced power consumption;

- hydraulic power unit and two hydraulic cylinders for reliable and hermetical formwork [4].

The first two units were delivered in 2015, to two major construction companies in Singapore. There were [6] prospects of using mobile Battery Mould in a city with a population of nearly 5.5 million people, which is an active construction, and there is little room for the industrial zones for stationary concrete products.

EBAWE Anlagentechnik GmbH (Germany) offers battery mould (Fig. 3), consisting of intermediate walls, between which it is possible to simultaneously mould multiple concrete elements. The number of intermediate walls defines the number of caulking sections - it varies depending on the required performance. Axial wall with built-in hydraulics determine the position of a package of intermediate walls. During manufacture they compress the whole package. Vibrators at the intermediate walls provide effective sealing of fresh concrete. Cassette forms may be of different sizes having different numbers of compartments casting, and be single or double [7].



Fig. 3. Battery mould EBAWE Anlagentechnik GmbH

In The leading supplier of equipment for the manufacture of precast concrete products in the CIS countries, the Baltic States and Western Europe is Elematic (Finland). The company manufactures production lines for the production of large volume and wide range of precast concrete products [8]. Technological lines PRO. and EDGE include cluster systems for manufacturing solid wall panels and slabs. Dispensers can be single- or double-sided. Both sides of the tape can be used independently.

2013, the Finnish company Elematic won the tender for the supply of technological equipment of large-panel house building «Construction and mounting trust №16». The implementation of the investment project "Reconstruction and modernization of large-panel construction «Construction and mounting trust №16» allows the company to issue a series of articles modernized to 100 000 m<sup>2</sup> of housing per year [9]. The introduction of a new technological line allowed the company to increase the production capacity of the plant of large-panel house building, improve product quality and reduce operating costs.

In the current economic conditions panels compete with the framework design scheme due to lower costs and reduced time of construction of buildings. In this regard, the definition of areas of improvement of technological processes of production of cassette panel construction, improve their quality is an urgent task for the plant of concrete products and panel construction.

Analysis of international experience shows that getting the internal wall panels with precise geometric dimensions, the required category of the concrete surface, which does not require additional processing on the construction site allows the use of cluster systems of optimized and customized designs. Modern cluster installations have robust, sealed construction with hydraulic coupler of formwork and special vibrators to ensure high quality sealing of concrete and the perfect appearance of surfaces.

#### REFERENCES

1. Пилипенко, В. Перспективы развития сборного железобетона в Беларуси / В. Пилипенко // Жилищное строительство. Архитектура и строительство. – 2010. – № 1 (212). – С. 45.
2. Мастерская своего дела [Электронный ресурс] / Технология бетонных и железобетонных изделий. – Александрия, 2006. – Режим доступа: <http://msd.com.ua/tehnologiya-betonnyx-i-zhelezobetonnyx-izdelii/obshhaya-karakteristika-kassetnogo-sposoba-proizvodstva/>. – Дата доступа: 25.10.2016.
3. «Еуро'ра» – новое слово в панельном домостроении / Д. Косяков [и др.] // ЖБИ и конструкции. – 2010. – №3. – Р. 52–53.
4. МЖБИ Мобильный завод по производству железобетонных изделий, 2015 : каталог-справочник / сост. В. Шульц. – Кельн, 2015. – 33 с.
5. Transportable precast factories in operation in Singapore // CPI – Concrete Plant International. – 2015. – № 6. – Р. 174–175 .
6. Asian companies choose new production concept with mobile battery formwork // CPI – Concrete Plant International. – 2015. – № 2. – Р. 200–202.
7. Беларусь продолжает инвестировать в будущее – при помощи двух новых производственных линий фирмы Еbawe КУП «Брестжилстрой» построит в будущем новые жилые комплексы / Д. Косяков [и др.] // ЖБИ и конструкции. – 2011. – № 2. – Р. 26–28.
8. Стеновые панели Acotec от Elematic: «антикризисная» технология строительства // Технологии бетонов. – 2016. – № 9–10. – Р. 26–28.
9. Куртова, Н. Не стоять на месте / Куртова, Н.Н. Дубовик // Знамя новостройки. – 2013. – 26 нояб. – С. 1.

UDC 642.154:624.131

**INVESTIGATING THE BEHAVIOR OF AXIALLY LOADED BORED PILES EMBEDDED IN SOIL USING FINITE ELEMENTS METHOD**

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*This comparative study is performed on bored piles by varying the basic problem parameters that are expected to affect pile carrying capacity and comparing the obtained results with those of the original basic problems, in order to get more knowledge about the behavior of bored piles under compressive load, and to include the best design for future pile construction.*

The advancement of digital computers makes possible the development of sophisticated numerical solution techniques such as (F.E.M) for solving boundary value problems in geotechnical engineering. The advantages of the (F.E.M) is that it can be systematically programmed to accommodate such complex and default material properties usually accruing in soils such as, non-homogenous, anisotropic, non-linear, time dependent and difficult boundary conditions. Many investigations have employed the (F.E.M) to analyze the behavior of the pile–soil system.

The major objective of this study is to extend the application of the (F.E.M) to analyze the behavior of axially loaded bored piles embedded in soil.

**Methodology**

The basic problem was analyzed in nine stages of construction including two stages of excavation, two stages of concrete casting and five stages of incremental loading.

To assess the effects of changing construction sequence three different cases of construction are adopted:

- First case consists of five stages of loading only; there are no excavation and filling stages.
- Second case consists of one stage of excavation in natural soil then followed by one stage of concrete casting and five loading stages.
- Third case consists of four stages of excavation and concrete casting and five stages of loading.

**Results**

The load–displacement curves of the basic problem (nine stages of construction) is shown in Fig.1 together with other different cases of simulation. It is clear that construction simulation has a very limited effect on the load–settlement behavior.

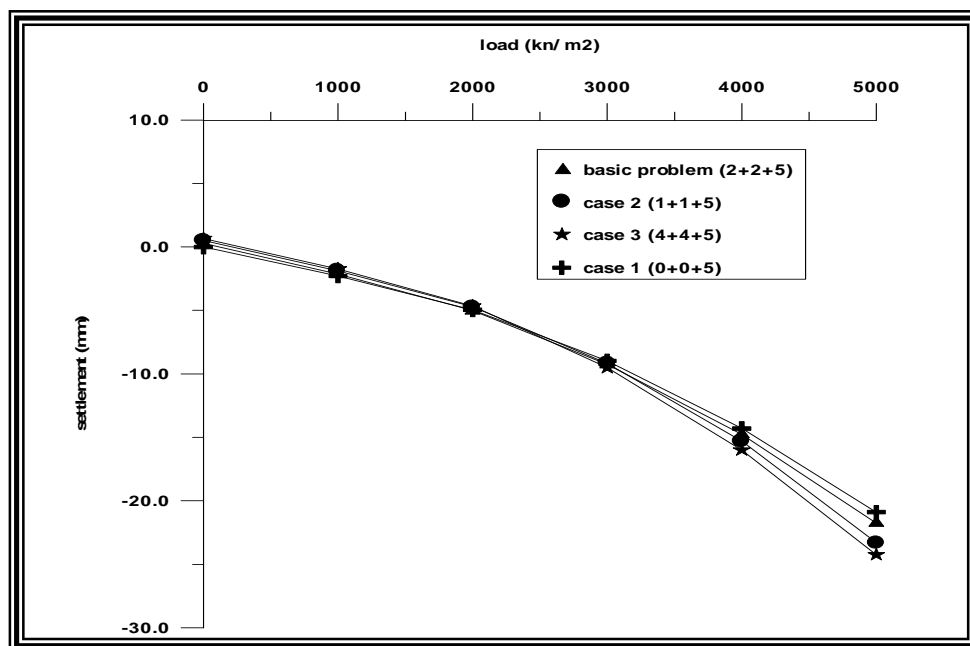


Fig. 1. Effect of construction simulation on load –displacement relationship

The vertical displacements of ground surface are shown in Fig.2, and the lateral displacements for interface elements are shown in Fig.3. It is obvious that construction simulation has a very limited effect on the vertical and lateral displacements.

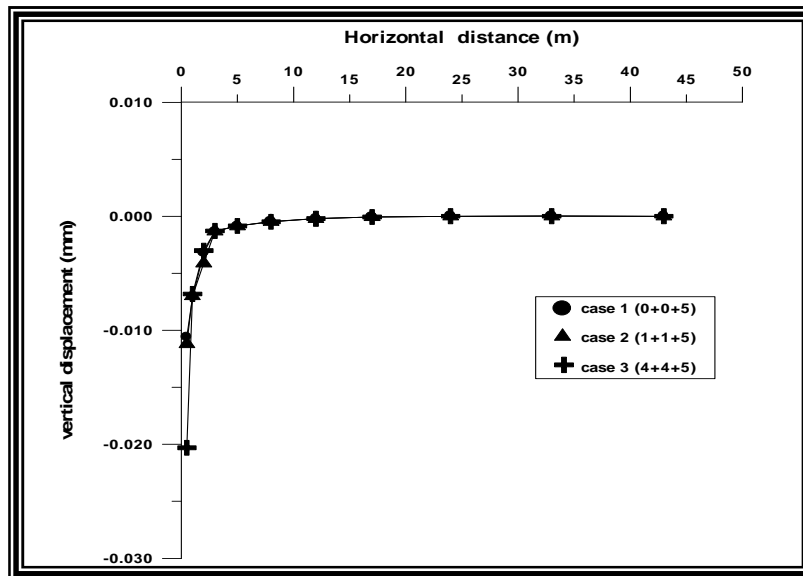


Fig. 2. Effect of construction simulation on vertical displacements of ground surface

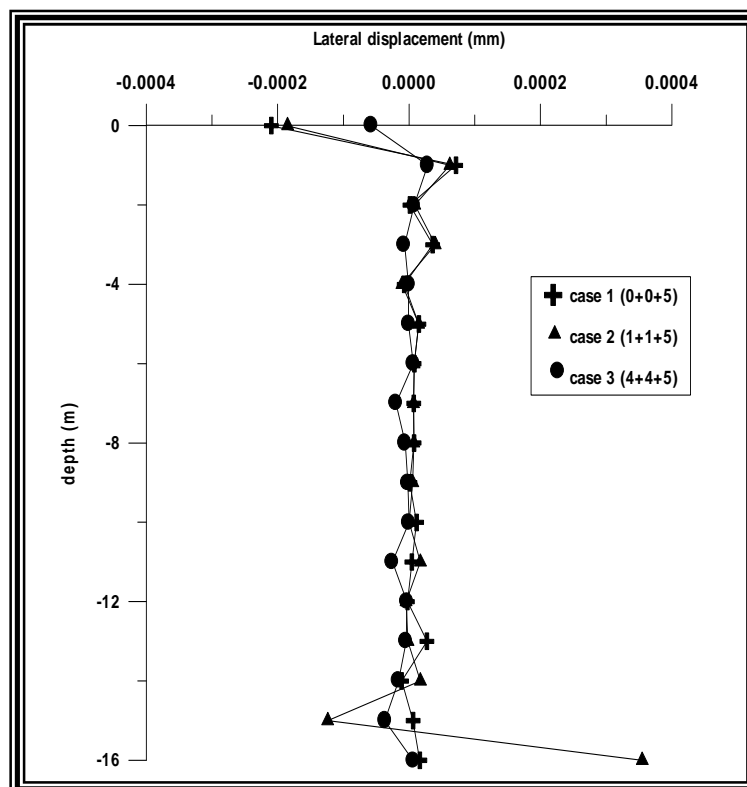


Fig. 3. Effect of construction simulation on lateral displacements of interface

Figure 4 shows the simulation of the failed elements at the last increment of each case of construction. These figures indicate that the number of failed elements increases as a result of decreasing the number of stages. The elements have failed gradually throughout the incremental loading.

Figure 5 shows the effect of construction simulation on the shear stresses generated in the surrounding soil. It can be seen that the effect is very limited.



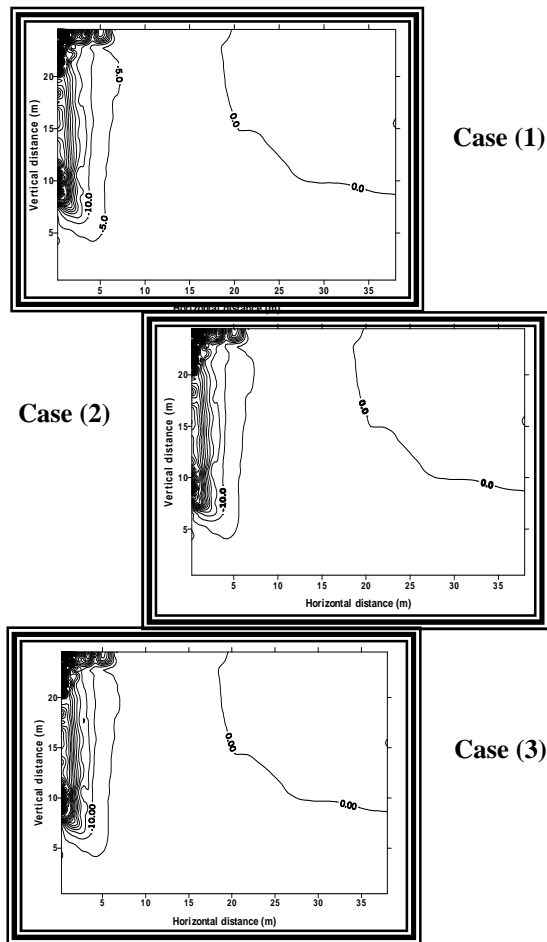


Fig. 4. Effect of construction simulation on the propagation of failure zone around pile

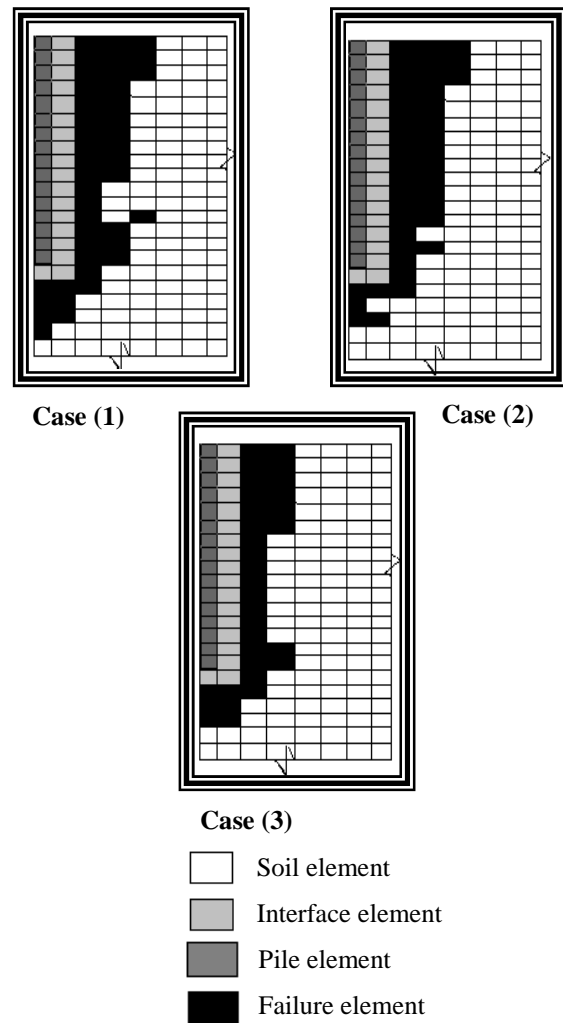


Fig. 5. Effect of construction simulation on shear stresses in soil around pile

### Conclusions

From the results and the parametric study; the following conclusions can be drawn:

1. First of all the importance of interface elements was shown. Especially for the shaft resistance the results of a calculation without interface elements were heavily mesh dependant. When using interface elements the mesh dependency is negligible. For the base resistance, one needs at least two or three elements at the pile tip to get rid of the mesh dependency.
2. The best results of load-displacement curve are obtained by using the non linear behavior for both soil and interface elements.
3. The construction simulation has a very limited effect on the load- displacement curve and has a similar effect on the shear stresses, while the number of failed elements is very sensitive to construction simulation, its increase as a result of decreasing the number of stages.

### REFERENCES

1. Abdelrahman, G.E. Three-Dimensional Analysis of Single Pile in Sand Using Drager-Prager Model / G.E. Abdelrahman, A.F. Elragi. – Civil Department, Faculty of Engineering, Cairo University, Fayoum Branch. – Egypt. 1997. – 297 p.
2. Smith, I.M., A Survey of Numerical Methods in Offshore Piling / I.M. Smith // First International Conference of Numerical Mathematics in Offshore Piling, Institute of Civil Engineers, London, 1980. – P. 1–8.
3. Soltani, A., A FEM Model to Investigate the Lateral Behavior of Cylindrical Piles in Saturated Clay / A. Soltani // Electronic Journal of Geotechnical Engineering. – 2010. – Vol. 15. – P. 373–384.

**CHOOSING THE HEAT FLUX DENSITY NORM SIN CALCULATING HEAT  
SUPPLY PIPELINES CONSTRUCTIONS INSULATION WITH GIVEN  
GEOMETRICAL CHARACTERISTICS AND EFFICIENCY COEFFICIENT**

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*The article Investigates the relationship between thermal insulation surface density heat flux and thermal networks coefficient of efficiency on the basis of its geometrical characteristics and power heat consumption for the residential development area. It also presents analytical and graphical dependencies, which allow to choose normalized heat flux density for designing insulation construction with an earlier pre-assigned thermal network efficiency coefficient value.*

**Introduction.** Heat supply system efficiency is the ratio of the useful system effect to the total energy costs to acquire it. Energy spending in the heat supply system consists of the equipment actuator power consumption and the heat generation fuel consumption.

A heat supply system consists of a thermal energy source, a distribution network (heat network) and a heat consumer user-side. According to various estimates, the efficiency coefficient of the heat supply system elements under real conditions is: heat source – 80...96%, heat network – 60...92%, heat using plant – 80...95%. The energy source losses are caused by the imperfect fuel to thermal energy conversion. Energy losses in the heat networks occur due to the heat leaking into the environment and consumers' energy losses – due to the thermodynamic imperfection of the energy-consuming equipment. So, a heat supply system total coefficient of efficiency is a multiplication of the efficiency coefficients of each individual element and ultimately equals 40 to 85 percent. The weakest link of this chain is a thermal energy to heat networks transportation system.

A lot of research has been carried out to establish a relationship between the thermal energy efficiency coefficient and its geometrical parameters. In particular, works [1–3] show the relationship between the heat network geometrical parameters, its load and coefficient of efficiency, however a clear accounting methodology for the thermal network coefficient of efficiency, when designing thermal insulation for newly created or assessing its state for existing heating systems, was not provided.

**The aim of this work is to study the relationship** between the efficiency of thermal insulation and a heat supply load, connected to the source collectors, based on the geometrical characteristics of the heat network. The purpose of thermal insulation is to reduce heat losses from pipelines into the environment. The basic, most often used criteria of efficiency are the following:

- *normalized value of heat flux density;*
- *normative values of temperatures on the surface of the insulation;*
- *acceptable values of the coolant temperature drop along the length of the heat network.*

These criteria should at all times remain in unity with the efficiency of the whole heating system. This requires additional research, which this work is devoted to. As per tradition, let's call the efficiency of a heat supply system and its constituent elements a coefficient of efficiency (COE). Also let's take into account only its fuel component, connected to the generation of thermal energy, considering the heat source to be non-generative, in regard to the area of residential development.

**Theoretical substantiation and development of mathematical model study.** COE of a heating network  $\eta_{mc}$  is the ratio of the amount of heat transmitted to consumers,  $Q_{nomp}$ , to the amount of heat  $Q_{omn}$  released into the heat network by the source:

$$\eta_{mc} = \frac{Q_{nomp}}{Q_{omn}} = \frac{Q_{omn} - \Delta Q_{m.n.}}{Q_{omn}} = 1 - \frac{\Delta Q_{m.n.}}{Q_{nomp} + \Delta Q_{m.n.}}, \quad (1)$$

$\Delta Q_{mn}$  is the difference between the released and consumed heat, which is equal to the heat loss in heat transport in heating systems from source to consumers.

Fig. 1 presents a graphical dependence of the network COE and the ratio of heat loss values on the amount of heat energy released by the heat source.

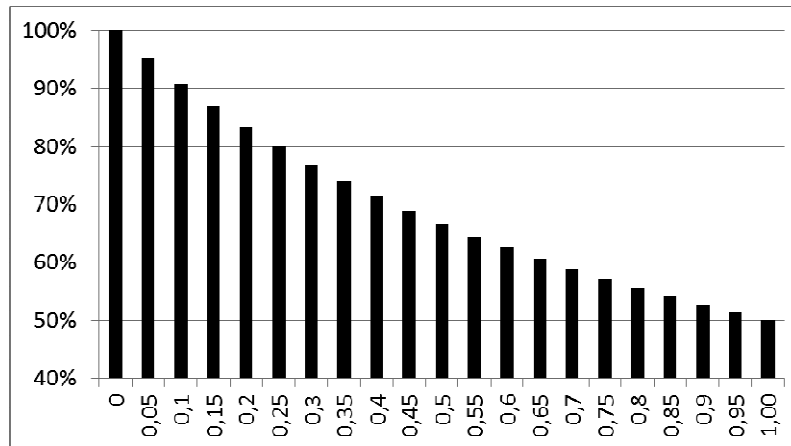


Fig. 1. Dependence of the network COE and the ratio of heat loss values on the amount of heat energy released by the heat source.

The amount of heat loss is directly proportional the difference between the coolant,  $\tau_{cp}$ , and the environment,  $t_{oc}$ , average temperatures of the heat transfer surface and inversely proportional to the thermal resistance of the insulating structure,  $R_{u,k}$ , averaged across the entire network, while the heat exchange surface is proportional to the length,  $l_i$ , and diameter,  $d_i$ , of the pipelines:

$$\Delta Q_{m,n} = \frac{(\tau_{cp} - t_{o,c})}{R_{u,k}} \cdot \pi \sum d_i \cdot l_i \quad (2)$$

Two complexes can be highlighted in the above expression:

$$q_F = \frac{(\tau_{cp} - t_{o,c})}{R_{u,k}} \quad \text{and} \quad M = \sum d_i \cdot l_i \quad (3)$$

Here  $q_f$  is a heat flux density related to a singular material characteristic of the heat network, and  $M$  is a material characteristic of the network.

Performing substitution of equations (3) into equation (2) yields:

$$\Delta Q_{m,n} = q_f \cdot \pi \cdot M \quad (4)$$

The size of the heat consumption,  $\Delta Q_{nomp}$ , included in equation (1), is defined depending on the area of the building territory, residential density, specific heat consumption values, duration of the heating period and other characteristics of district heat consumption.

In general terms, a magnitude of the accounted annual heat consumption applied to residential settlement construction can be expressed on the basis of the methodology represented in [4], as follows,  $W \cdot h$ :

$$Q_{nomp}^{zod} = a \cdot F \left[ q_0 \cdot (1 + k_1 + k_1 \cdot k_2) \cdot \frac{t_6^p - t_u^{cp}}{t_6^p - t_{ho}^p} \cdot n_0 + \frac{q_{z6}}{f} \cdot (n_0 + n_{ho}) \right], \quad (5)$$

and the calculated heat load [4] the following way:

$$Q_{nomp}^{pacv} = q_0 \cdot a \cdot F \cdot (1 + k_1 + k_1 \cdot k_2) + q_{z6} \cdot \frac{a \cdot F}{f}, \quad (6)$$

$q_0$  and  $q_{z6}$  – enlarged values of, respectively: the maximum heat consumption for heating of residential buildings at 1 m<sup>2</sup> of total space, W/m<sup>2</sup> and the average heat flow of the hot water supply for one person, W/person;

$k_1$  – coefficient that accounts for heat consumption on heating of public buildings;

$k_2$  – coefficient that accounts for heat consumption on ventilation of public buildings; in the absence of specific data those are taken according to the requirements [4];

$a$  – dwelling density, m<sup>2</sup>/ha, taken on the basis of requirements [5];

$F$  – gross building territory area, ha;

$F$  – projected norm of total area per person, m<sup>2</sup>/person;

$t_{ho}^p, t_g^p, t_n^{cp}$  – the estimated internal, outdoor and the average air temperatures during the heating period respectively, °C;

$n_{no}, n_o$  – duration of a heating and non-heating period, h.

Material characteristic of a thermal network when designing a mathematical model can be calculated on the basis of the known relations [6]

$$d_i = A_d \cdot \frac{G_i^{0,38}}{R^{0,19}};$$

$$M = \sum A_d \cdot \frac{G_i^{0,38}}{R^{0,19}} \cdot l_i; \quad G_i = \frac{Q_{nomp.,i}}{c \cdot (\tau_1^p - \tau_2^p)};$$

$$M = \sum A_d \cdot \frac{Q_{nomp.,i}^{0,38}}{R^{0,19} \cdot [c \cdot (\tau_1^p - \tau_2^p)]^{0,38}} \cdot l_i,$$
(7)

$A_d$  – a coefficient dependent on the roughness of the pipes;

$R$  – specific friction pressure loss, Pa/m;

$\tau_2^p, \tau_1^p$  – calculated temperatures of the supplier in a supplying and reversed heating networks respectively, °C.

By generalizing equations 1–7 it is possible to get a correlation between the thermal network COE, building density, normalized density of a heat flow from the surface of a thermal insulator and a physical characteristic of the network:

$$\eta_{mc} = 1 - \left\{ 1 + \frac{a \cdot F \left[ q_o \cdot (1 + k_1 + k_1 \cdot k_2) \cdot \frac{t_g^p - t_n^{cp}}{t_g^p - t_{ho}^p} \cdot n_o + \frac{q_{ce}}{f} \cdot (n_o + n_{no}) \right]}{q_F \cdot \pi \cdot M \cdot (n_o + n_{no})} \right\}^{-1}$$
(8)

The dependence following from this equation allows taking the magnitude of the normalized heat flow from the surface thermal insulation depending on the pre-assigned value of the heating network COE:

$$q_F = \frac{(1 - \eta_{mc}) \cdot a \cdot F \left[ q_o \cdot (1 + k_1 + k_1 \cdot k_2) \cdot \frac{t_g^p - t_n^{cp}}{t_g^p - t_{ho}^p} \cdot n_o + \frac{q_{ce}}{f} \cdot (n_o + n_{no}) \right]}{\eta_{mc} \cdot \pi \cdot M \cdot (n_o + n_{no})}$$
(9)

**Study of the developed mathematical model.** Based on equations 7–9, numerical investigations of the obtained mathematical model when changing its individual settings were carried out. Based on general theoretical notions, with heat loss per unit increasing and other parameters remaining constant COE of a thermal network should decrease. Increasing the length of a network and/or individual diameters of its segments is also expected to reduce the thermal COE of the network. Inversely, with residential density increasing and the physical characteristics of the network remaining unchanged the thermal network COE should increase monotonically, asymptotically approaching its maximum value. The density of residential development in the model is a scale of useful heat consumption volume, whereas the density of the heat flow and physical characteristics of the network allow to perceive the amount of heat loss into the environment.

The following studies of the mathematical model have been conducted:

1) determined the character of COE dependency on the residential development density with varying parameters of the overall network length, but with the value of pressure losses  $R$ , used to calculate the diameter of sections, remaining constant.

2) identified the character of the calculated heat flow values divided by the unit of material characteristics of the network from the surface of the thermal insulation into the environment dependency on the density of residential development at different network length and pressure losses  $R$  remaining constant.

3) found a complex relationship between the COE of a thermal network density of residential development and normalized density of the heat flow from the surface of the insulation into the environment. The results of numerical experiments conducted are presented graphically in Figures 2–4.

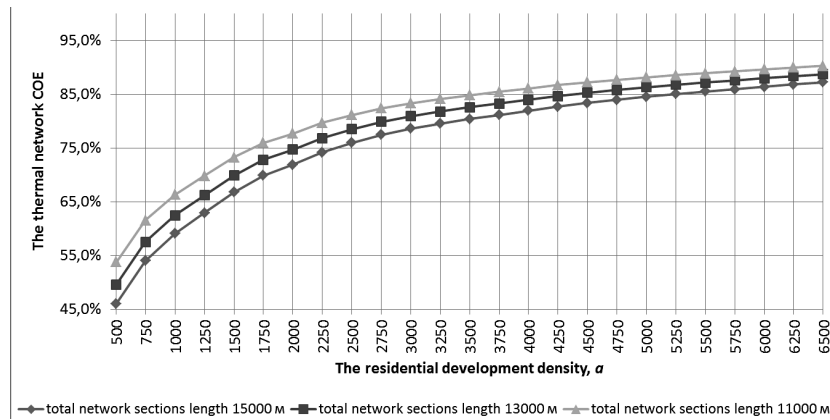


Fig. 2. Dependence of the thermal network COE on the residential development density,  $a$  with different values of total network sections length and  $R = \text{const}$ .

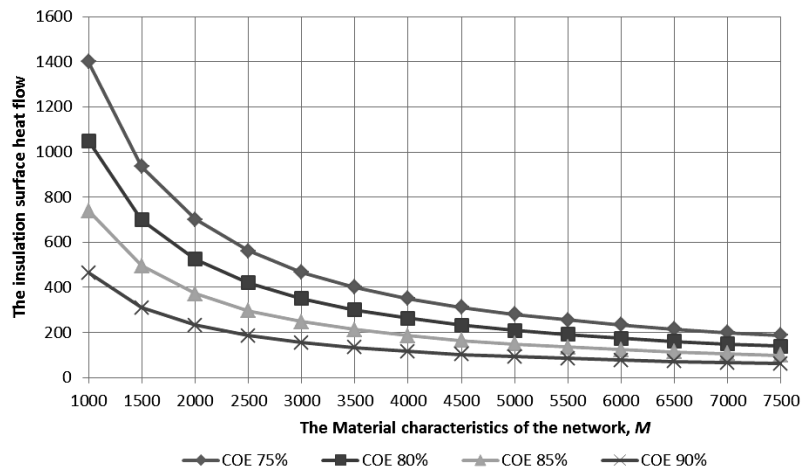


Fig. 3. Dependence of the insulation surface heat flow on the material characteristics of the network with different specific values of the heating network COE

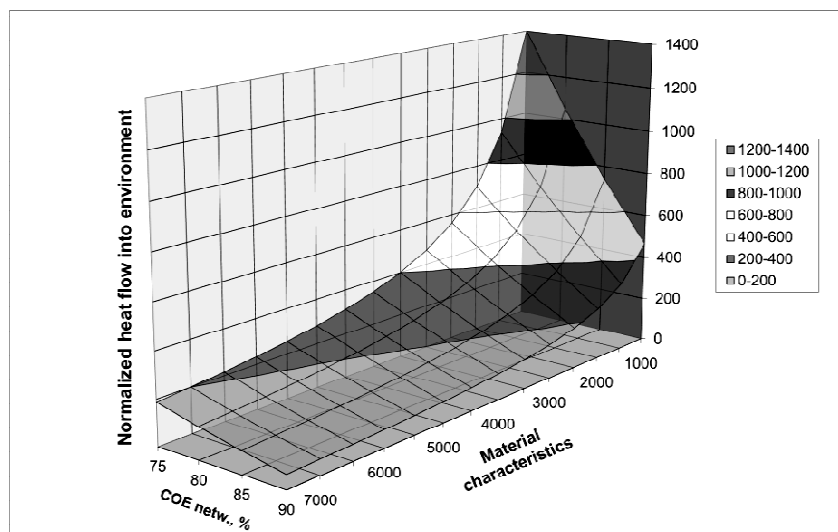


Fig. 4. Dependence of the normalized heat flow into the environment on the specific heating network COE and its material characteristics with residential development density remaining constant

**Conclusion.** The results of the conducted studies show that in order to meet the requirements to the heating network COE residential development density has to be accounted for during the stage of insulation layer thickness selection. With residential development density decreasing, useful heat load of a network tends to drop as well; COE of thermal energy supply also decreases significantly. That is why values of the normalized heat flows given in [7] can only be used to a degree of finding a specific COE of the network. Thus, the COE of a heating network, along with the normalized heat flow, becomes an additional criterion which allows us to assess the quality and condition of the thermal insulation of existing conduits and an additional factor when designing newly created networks. The generalized graph provided in Figure 4 allows for adjustments to the calculations of the specific values of the normalized heat flow while taking pre-assigned COE into account.

#### REFERENCES

1. Соколов, Е.Я. Метод определения материальной характеристики и протяженности тепловой сети в пределах площади застройки / Е.Я. Соколов, Г.А. Побегаяев // Изв. вузов. Энергетика. – 1985. – № 3.
2. Папушкин, В.Н. Радиус теплоснабжения. Хорошо забытое старое / В.Н. Папушкин // Новости теплоснабжения. – 2010. – № 10.
3. Цыганкова, Ю.С. Оценка транспортных потерь тепловой энергии через теплоизоляционные конструкции трубопроводов тепловых сетей : автореф. ... дис. канд. техн. наук : 05.14.04 / Ю.С. Цыганкова ; Сибирский федеральный университет. – Красноярск, 2012. – 19 с.
4. Тепловые сети. Строительные нормы проектирования : ТКП 45-4.02-182-2009 (02250). – Введ. 01.07.2010. – Минск : М-во архитектуры и стр-ва Респ. Беларусь, 2010. – 70 с.
5. Градостроительство. Населенные пункты. Нормы планировки и застройки : ТКП 45-3.01-116-2008 (02250). – Введ. 01.07.2009. – Минск : М-во архитектуры и стр-ва Респ. Беларусь, 2009. – 83 с.
6. Соколов, Е.Я. Теплофикация и тепловые сети / Е.Я. Соколов. – М. : Издат. дом МЭИ, 2000. – 472 с.
7. Тепловая изоляция оборудования и трубопроводов. Строительные нормы проектирования : ТКП 45-4.02-91-2009 (02250). – Введ. 01.07.2010. – Минск : М-во архитектуры и стр-ва Респ. Беларусь, 2010. – 38 с.

UDC 699.828.2

**THE USE OF LIME CONCRETE DRAINS FOR THE DEVICE IN HEAVING SOILS  
 AND HUMID SOILS**

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*Purpose to the study described in the article was to ensure the hard unsettled base using technogenic waste foundry under cement concrete foundations, roads and airfield pavements, and reinforcement of their fiberglass fittings periodic profile. It was suggested that the device drains from lime concrete with the addition of foundry waste (spent molding sand, slag).*

One of the main reasons for the emergence and development of premature deformation of foundations, airfield pavements, and pavements is the use of soil moisture. At present, the construction of many objects is conducted on new technologies with the use of new materials. One of these methods provides a drainage device of non-woven synthetic material or glass [1]. Also, there are recommendations for the use of vertical sand drains [2]. Investigating the causes that give rise to the destruction of building structures, found that the occurrence of deep recesses associated with thinning of ground water or saturated soils during freezing and thawing. To prevent the effects of groundwater seepage waterlogged soils using a perforated tubular Dren with a reverse filter of pure frost rubble. The perforated tubular Dren is advisable to pre-wrap synthetic nonwoven or glass fiber. Accumulates in the tubular Moisture Transport System in the overall drainage system [3]. In recent years, successfully used the construction of interceptor drains of continuous corrugated plastic or aluminum vertical permeable sheets, the bottom of which is a horizontal drain is a perforated tube [4]. The need for measures to drain the soil caused by the appearance of swelling and usually deformation of building structures. Processing methods for their removal are similar in content to the drainage of water-logged soil, i.e. perforated tubular device drains that wraps synthetic nonwoven or glass fiber [5].

Developed a variety of binders, including quick-lime binders. His grasping begins within 2 h; acquires final strength after about 1 day. Cementing includes activated lime pozzolanic materials (ash -unos et al.). Grasping knitting is completed within 1 day, while their strength becomes sufficiently high. Adding sand binders, low cost solutions are prepared [6]. In the production of various products of metallurgical slag-forming mixture and waste that are not in the moment of a qualified application, which creates serious problems and, therefore, raises the problem of developing a method of disposal. Studies carried out by the authors, can be recommended for the device intercepting drains from lime concrete with the addition of foundry waste (spent molding sand, slag) (Fig. 1).

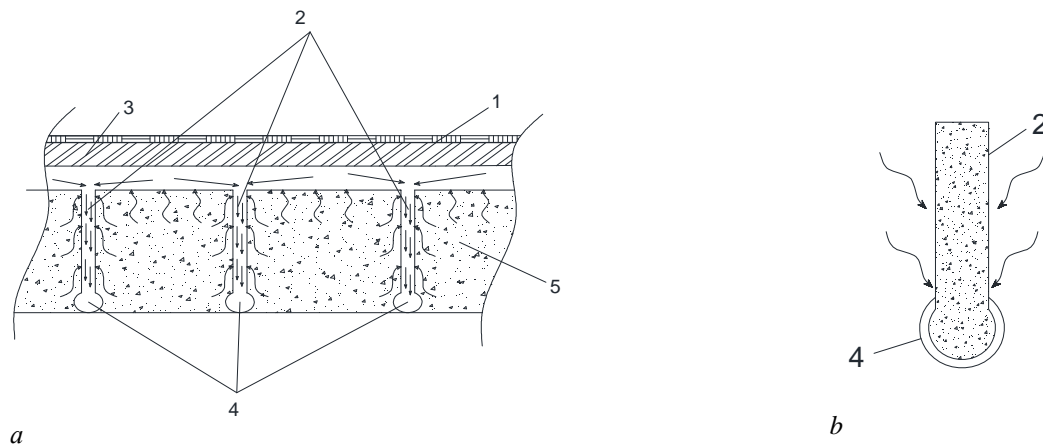


Fig. 1. Drainage from drains from lime concrete foundry waste: *a* – general view; *b* – Section of drains;  
 1 - building; 2 – drains from the filter material of lime concrete and foundry waste; 3 – base;  
 4 – tube drain is; 5 – waterlogging or heaving soils

This approach vertical drains the device allows you to create a rigid substrate for unsettled cement concrete foundations, roads and airfield pavements. The developed method of using technogenic waste can solve not

only the problem of disposal of foundry waste and create a rigid base unsettled, as well as achieve a positive economic effect.

## REFERENCES

1. Ширшов, Е.В. Строительство земляного полотна автомобильных дорог из грунтов повышенной влажности с вертикальными песчаными дренами : дис. ... канд. тех. наук : 05.23.14 / Е.В. Ширшов – Ленинград, 1984. – 154 с.
2. Лысенко, М.П. Состав и физико-механические свойства грунтов / М.П. Лысенко – М. : Недра, 1980. – 272 с.
3. Нечаев, Б.Н. О некоторых свойствах синтетических нетканых полотен / Б.Н. Нечаев, Л.И. Фуднецова // Транспортное строительство / Б.Н. Нечаев. – М., 1984. – С. 5–7.
4. Седергрэн, Г.Р. Дренаж дорожных одежд и аэродромных покрытий / Г.Р. Седергрэн – М. : Транспорт, 1981. – 280 с.
5. Ширшов, Е.В. Осушение переувлажненных связанных грунтов вертикальными дренами / Е.В. Ширшов // Повышение качества строительства автомобильных дорог в нечерноземной зоне РСФСР / Е.В. Ширшов – Суздаль, 1983. – С. 21–23.
6. Rai, M. Building materials for lowcost housing / M. Rai, N.G. // Dave Building and environment. – 1991. – Vol. 26. – № 3. – P. 295–300.



UDC 624.072.2

**DESIGN OF BENDING CONCRETE ELEMENTS WITH RIGID REINFORCEMENT****YURY TRUBACH, ALEXANDR KOLTUNOV**  
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*The article considers the main points of the construction of bent reinforced-concrete elements with rigid reinforcement in the form of metal-profile double-T or T-section paired. The possible application methods the rigid reinforcement in conjunction with flexible rods, whose task is to eliminate the possibility of spalling (flaking) of concrete from metal rolling profiles. The methods provide concrete collaboration and metal-rolling profile by means of the use of short stacks from the corner, as well as ensuring the anchorage all rolled sections in the body structure by the use of channel-short stacks at the ends of the profiles.*

Application of structures with a rigid reinforcement is a less common phenomenon in the modern world of reinforced concrete structures, but it does not exclude the use of metal-profile as a design element - which will take the main tensile forces in bent elements.

Selection of rigid reinforcement must be made in accordance with the expectation of it as a metal beam on the load arising in the course of works, excluding working with concrete. In the future, during the transition to the operational loads corresponding concrete cross-section is taken into account, if necessary enhanced with flexible reinforcement. This order of selection of cross-sections serves for the minimum discharge of metal [1].

But some design requirements, such as conditions of beams contiguity to the purlins, prevention of chipping, etc., can induce usage of the profile of larger cross-section than that required by metal reinforcement beams work during erection.

The most common and frequently used type of rigid reinforcement beams is rolled *H* sections, cross sections are displayed in Fig. 1 *a, b*. When they need to ensure greater stability in the process of building twin beam channels can be applied to powerful beams, as shown in Fig. 1.

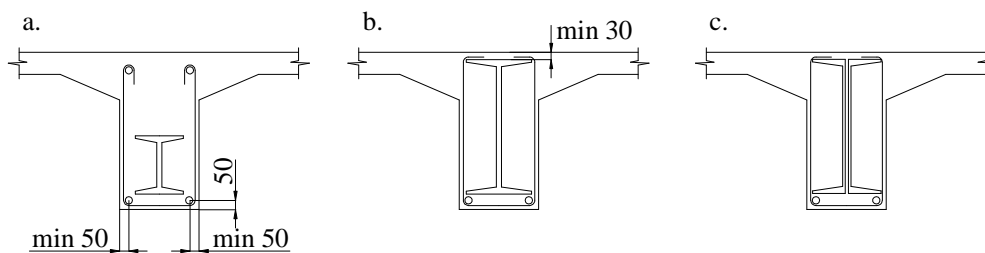


Fig. 1. The cross sections of bent elements with the use of rigid reinforcement

Rigid reinforcement from I-beams or twin channel bars can be located completely in the stretched beam area, and throughout the height of the section, entering the compressed zone, in this case, the metal-rolling profile perceives both tensile forces and compression, and a continuous design and appearance to outer parts of tensile stresses in the upper part of the section Metal-profile will be used to perceive the tension [1].

In designing of bent reinforced concrete structures with a rigid reinforcement the important factor which can not be ignored is the protective layer. The thickness of the lower protective layer in the beams with a rigid reinforcement must be at least 5 cm, to ensure the reliability of concrete casting of the lower layer and create a proper fire protection. The distance from the side edges to the wall or the edge of shelves profile rigid reinforcement should be selected taking into account the size distribution of coarse aggregate used concrete, but it is recommended to take no less than 5 cm, to ensure the density of the filling of the lower protective layer. The thickness of the upper protective layer, as compared with the bottom, can be reduced to 3 cm, as it does not affect the ease of beams concrete casting, with a fire protection point of view as the upper surface located in more favorable conditions.

In some exceptional cases, if the conditions permit exploitation of a plate, to simplify formwork and concrete casting the beam can be designed without the bottom protective layer. The lower bound of the beam will be confined to the lower shelf rigid reinforcement.

To improve the bearing capacity and crack resistance of the bent elements with hard reinforcement they can effectively use clamps and spirals that do not allow early spalling of concrete from the metal profile and concrete spalling from the inner part of the profile. Reinforcing straps should be considered necessary in all cases, except for the beams without the lower protective layer and reinforced profiles securely connected with

the compressed area. Clamps are made 6–8 mm in diameter and are located through the 20–30cm. To connect the clamps mounting rods 8–10 mm in diameter are placed at top and bottom. (Fig. 1, *a*) When a high-profile rigid reinforcement is used, clamps can be mounted on top of the shelves of I-beams (Fig. 1, *b* and *c*). In this case, there's no in the upper mounting rods.

In the case of the beams reinforcement not only tough with sheet metal profile, but also with additional flexible reinforcement rods, the latter will also be used to link clamps and replace them with the appropriate parts of the mounting rods.

Reinforcement on chipping over clamps is necessary at a relatively low altitude rigid reinforcement, when concrete shear is likely to occur above the metal profiles. When more working flexible reinforcement is used in the beam, shearing can be performed with the corresponding bending of the rods as shown in Figure 2, *a*, and in the absence of operating rods in the bottom section or impossibility of attachment thereto, special oblique rods are welded to the upper shelf Profile rigid reinforcement (Fig. 2, *b*).

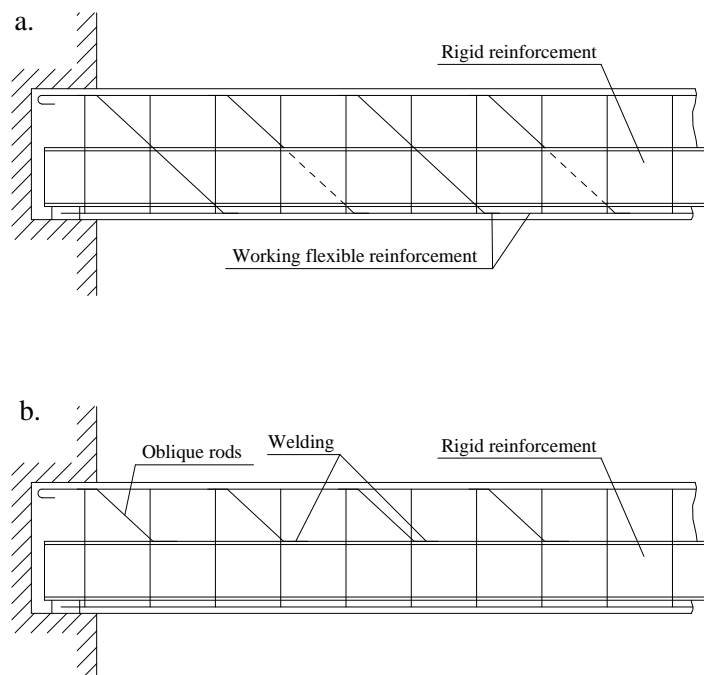


Fig. 2. Reinforcement beams oblique bars

At relatively high metal profiles welding oblique rods to the top shelf becomes irrational. In these cases, in the areas where reinforcement against chipping is needed, it is advisable to replace oblique rods with a spiral, which is made of round bars with a diameter of 12-14 mm (see Figure 3).

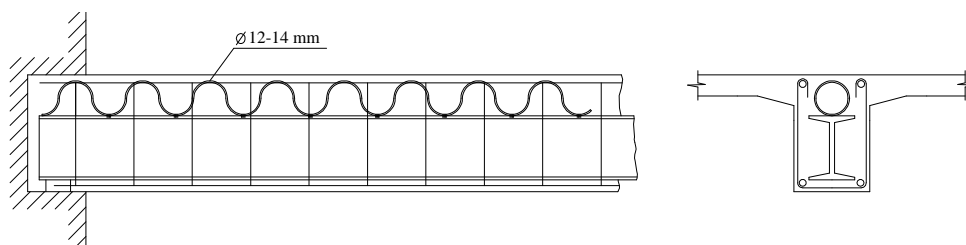


Fig. 3. Reinforcement beams rigid armature, fitted with spiral

Connection of rigid reinforcement with concrete compression zone can also be accomplished by welding transverse angled short stacks to the top shelf. This method of ensuring joint work of metal-profile and the concrete will be used in my doctoral research on the topic: "The bearing capacity and deformability of joints connections of reinforced concrete structures with a rigid reinforcement".

Welds short stacks, and the spiral must be designed for full shear of shear forces.

Anchoring all rigid reinforcement beams improves the conditions of work and allows you to cut down a special reinforcement on chipping, but the full binding of all rigid rods can be achieved only in the frame, where the beams are rigidly connected to columns or girders riveted, welded or screwed. With the free support beams when the ends of the rigid reinforcement remain unanchored, special anchoring with welding plates or channel- short stacks at the ends of the profiles can be applied (Figure 4) [1].

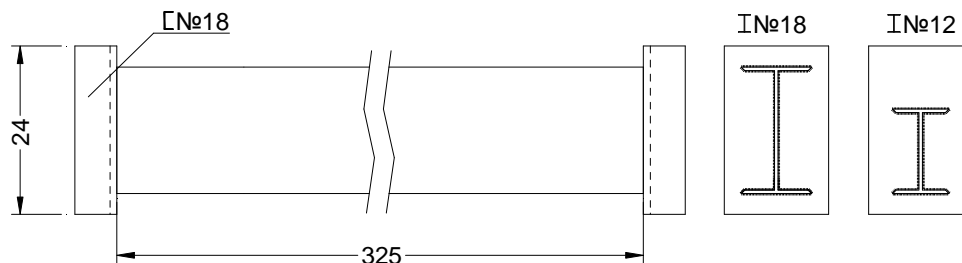


Fig. 4. Anchoring the ends of experienced rigid reinforcement beams

The continuous beams, girders and rigid reinforcing frame profiles at a relatively low height are located in the last zone of the transit portion of the stretched construction. However, they are not sufficient for the perception of the tensile forces on the supporting parts, as they are a large part of its cross section and are located in the compressed zone and excessively removed from the stretched fiber concrete. Under these conditions extra flexible reinforcement is required above the support.

At relatively high rigid reinforcement profiles tensile force can be perceived both in the middle and on the continuous beams support portions. However, in this case, it may be necessary to extra reinforce the beam support portions, as in the largest support moments rigid reinforcement, satisfying untrapped sections, may be insufficient. Strengthening of abutment sections can be made with flexible fittings and sheet riveted or welded to the shelves of rigid reinforcement sections.

#### REFERENCES

1. Васильев, А.П. Железобетон с жесткой арматурой // А.П. Васильев, А.А. Гвоздев ; под общ. ред. Г.И. Бердичевского. – М. ; Л. : Гос. изд-во строит. лит-ры, 1941. – 124 с.
2. Трубач, Ю.В. Экспериментальное исследование прочности и жесткости стыкового соединения железобетонного фундамента и набетонки с жестким армированием / Ю.В. Трубач, А.П. Кремнев, В.Д. Гринев // Проблемы современного бетона и железобетона. – Минск : Ин-т БелНИИС, 2014. – С. 151–163.
3. Васильев, А.П. Проектирование железобетонных конструкций с жесткой арматурой// А.П. Васильев ; под общ. ред. А.А. Гвоздева. – М. : Стройиздат, 1943. – 51 с.
4. Trubach, Y. Methods of providing combined action of concrete and metal rolled stock in reinforced concrete constructions with rigid armoring / Y. Trubach, A. Koltunov// European and national dimension in research : materials of VIII junior researchers' conference : in 3 parts. – Novopolotsk, 2016. – Part 3. Technology. – P. 65–68.

WIND AND ITS EFFECTS ON HIGH-RISE BUILDINGS

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*This paper examines the relation between high-rise buildings and wind, how wind flows, the action and interaction of the wind with structures, and the design factor which is considered a critical factor in the construction of skyscrapers.*

**Introduction.** In the course "Building Physics", some engineering points of view are taken into consideration such as the temperature, acoustics, humidity, ventilation and light, and the way they act upon the building. Yet, air resistance isn't concerned that much, as well as the way air acts upon high rise buildings. For instance, we notice that some unmentioned domains in the region of building physics can relate to these high rise buildings, and they are studied under the name of "Building Aerodynamics". When we talk about building aerodynamics, we take into consideration the wind factor, the way it acts on buildings, the way engineers solve problems concerning wind affecting skyscrapers, and the wind loads. In the field of wind, we relate to lateral loads leading to dynamic responses (resonance, acceleration, damping, oscillations) which are very severe and dangerous for people. Engineering is here for us to solve these problems.

**Task formulation.** The study of wind's interaction with high-rise buildings.

**Basics of turbulent flow.**

Wind is the flow of air characterized by its complicated dynamic displacement, and is studied in the field of "Fluid Mechanics". Flows of air can be laminar or turbulent. Laminar flow is a flow regime characterized by high momentum diffusion and low momentum convection, whereas the turbulent flow is a regime characterized by chaotic changes in pressure and flow velocity. Determining if a flow is laminar or turbulent depends on the viscous and inertial forces of the flow. The ratio of inertial to viscous forces is Reynolds number (Re). Building-Architectural aerodynamics is mostly related to the turbulent flow, where the velocity component and other factors (density, pressure, temperature) fluctuate in three dimensions, are time-dependent and rotational, which sets a very hard task even on developed methods for potential flow to calculate these fluctuations. The wind vector  $\vec{v}$ , at some stationary point in the flow may be regarded as the sum of mean wind vector  $\bar{v}$  – static component and turbulent fluctuation vector  $v'$  – dynamic component (fig. 1) [1].

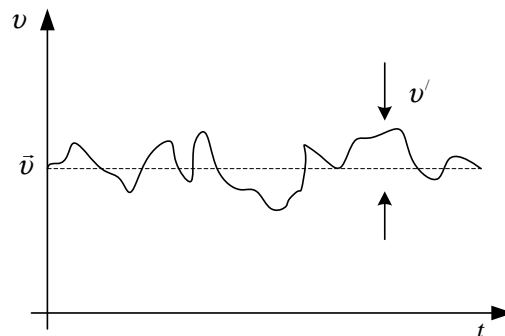


Fig. 1. Mean wind vector  $\bar{v}$  and turbulent fluctuation  $v'$  as a function of time  $t$

The differential equations of mass, momentum and energy balance express fundamental physical laws for laminar and turbulent flows, since the mathematical models can't separately calculate the turbulent flow. For us to calculate these flows, we use "time-averaged" versions of these differential equations that are very effective in averaging out some fluctuation contributions. Before considering how the differential equations should be time-averaged, it is helpful to establish several rules. First of all, we define a time-averaged quantity  $\bar{a}(t)$  as the average of the instantaneous quantity  $a = \bar{a} + a'$  over a time period  $T$ , where  $T$  is much longer than any turbulence time scale, but much shorter than the time-scale for mean flow unsteadiness, e.g. wave fluctuation [2].

The period  $T$  has to be sufficiently long so that the fluctuations in the equation are averaged to zero

$$\bar{a}'(t) = \frac{1}{T} \int_{t-0.5T}^{t+0.5T} a'(t) dt = 0.$$

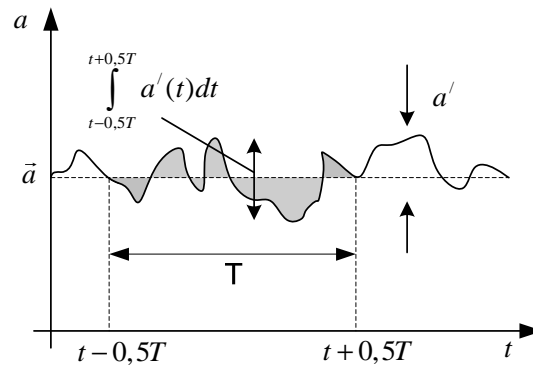


Fig. 2. Time-averaged velocity vectors as a function of time

Mentioning skyscrapers, different phenomena give rise in the dynamic response of structures on the wind, such as buffeting, fluttering, galloping, and vortex shedding. Engineers only take vortex shedding into consideration, since it has a big effect in the oscillation of the building. Wind comprises eddies of different sizes, where large eddies decompose into smaller ones by losing their mechanical energy. These eddies give the wind its gusty and turbulent character. We also set to notice that after air's collision with the surface of a building, air converts its kinetic energy into potential. This basic loss of energy is what is noticed in the phenomenon "Vortex shedding". Getting into more details, the eddies created by vortex shedding are related to the building's surrounding. For instance, if we have a building surrounded by other structures, we notice that the air turbulence differs from that which isn't surrounded by anything. This is clarified according to the gradient wind's alteration with the variation of height from the surface to the upper troposphere. There are several reasons to explain this tendency. First, especially in the middle latitudes, the pressure gradient increases with height. A second reason for the variation of wind gradient with height, especially near the ground, is due to surface friction. A third reason is due to air density which in turn decreases with height [3].

**Wind loads and their effects on high-rise buildings.** Wind exerts dynamic and static loads on a building, that lead to major types of deformation into shear, bending, twisting and deflection (curvature). Depending on the shape of the building, different loads will have different degrees of effect on the building. Static (dead) wind load is the horizontal pressure that tries to push the structure sideways, which creates elastic bending, deflection and twisting of the building, while dynamic (live) wind load creates vertical fluctuating forces all over the structure that creates motions, most commonly oscillations (thus dynamic). Taller, slender structures are impacted more significantly affected by dynamic wind loads. The taller the building, the stronger the force as wind is affected less by friction with the earth and surrounding topography, thus making wind load a greater challenge for high-rises.

Air's collision with a building's surface, changes its momentum, spawning the phenomenon of vortex shedding which basically leads to large wind pressure fluctuations, tending to vibrate the building's façade in the rectilinear and torsional modes. Under the action of wind, tall buildings are simultaneously loaded in the along-wind, cross-wind and torsional directions [4].

Along-wind causes windward and leeward pressures, denoted by pressure and suction respectively. Wind pressure is exerted uniformly on all the faces of the building, just as conventional pressure, with exception for the wind-ward side which is affected differently based on the height. These pressures are subjected to be "Shearing wind forces" and "Bending moments" that tend to pull the building on two countering directions on two parallel horizontal axis and curl the building at two ends on two parallel horizontal axis at both ends respectively.

The torsional wind twists the building's axis in the direction of the torsional moments created. The cross-wind mainly created by vortex shedding, generates an oscillatory motion derived by the resonance of the building. Tall buildings are bluff (as opposed to streamlined) bodies that cause the flow to separate from the surface of the structure, rather than follow the body contour. For a particular structure, the shed vortices have a dominant periodicity that is defined by the Strouhal number. Hence, the structure is subjected to a periodic cross pressure loading, which results in an alternating crosswind force. If the natural frequency of the structure coincides with the shedding frequency of the vortices, large amplitude displacement response may occur and this is often referred to as the critical velocity effect. The asymmetric pressure distribution, created by the vortices around the cross section, results in an alternating transverse force as these vortices are shed. If the structure is flexible, oscillation will occur transverse to the wind and the conditions for resonance would exist if the vortex shedding frequency coincides with the natural frequency of the structure. This situation can give rise to very large oscillations and possibly failure [5].

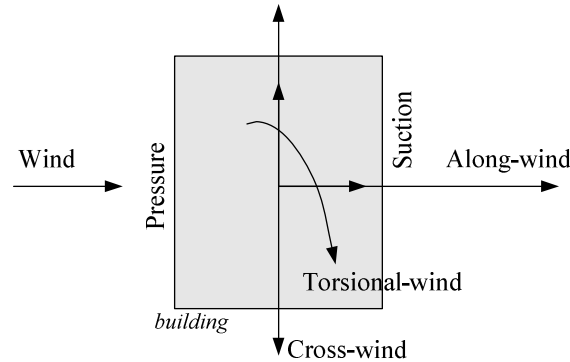


Fig. 3. Action of lateral wind on the facade of a building

**Design criteria.** In terms of designing a structure for lateral wind loads, the following basic design criteria need to be satisfied.

- **Stability** of the building against overturning (falling down), uplift and/or sliding of the structure as a whole.
- **Strength** of the structural components of the building is required to withstand imposed loading without failure during the life of the building.
- **Serviceability** where overall deflection is expected to remain within acceptable limits. Control of curvature and deflection is essential for high-rise buildings with the aim of limiting damage and cracking of non-structural members (ceiling, internal partitions, etc.). An additional criterion that requires careful consideration in high-rises is control of sway acceleration and damping when subjected to wind loads. This criterion is based on human tolerance to vibration discomfort in the upper levels of the buildings.

Wind response is relatively sensitive to both mass and stiffness, where response accelerations can be reduced by increasing either or both of these parameters.

In the process of designing high-rise buildings, some criteria should also be preserved by the structure itself.

- High-rise buildings should have a positive relationship with relevant topographical features and other high-rise buildings.
- The high-rise building must conserve, or not damage or detract from:
  1. World heritage and local historical sites and their settings,
  2. Registered ancient monuments, their settings, and registered buildings,
  3. Conservation areas and their settings,
  4. Other open spaces, including rivers, waterways, the Straits, their settings and views from them,
  5. Other important views, prospects and panoramas.

The architectural quality of the building including its scale, form, massing, proportion and silhouette, facing materials and relationship to other structures. The design of the top of a high-rise building is also important when considering the effect on the skyline [6].

## REFERENCES

1. Levicky, R. CBE333. Introduction to Turbulent Flow / R. Levicky. – 2002. – Mode of access: 1,2.faculty.poly.edu/~levicky/Handout15\_6333.pdf].
2. Wind Loading on Tall Buildings / P. Mendis [et al.]. – 2007. – Mode of access: [https://www.inti.gob.ar/cirsoc/pdf/accion\\_viento/200704.pdf](https://www.inti.gob.ar/cirsoc/pdf/accion_viento/200704.pdf).
3. SEVENTHEORY.MIT. 2005. – Mode of access: <http://www.mit.edu/course/1/1.061/www/dream/SEVEN/SEVENTHEORY.pdf>.
4. Sukanta. Adhikari. Effect of wind on structure / Sukanta. Adhikari. – 2010. – Mode of access: [http://www.sefindia.org/forum/files/Effect\\_of\\_wind\\_on\\_structure\\_141.pdf](http://www.sefindia.org/forum/files/Effect_of_wind_on_structure_141.pdf).
5. Rafik, R. Gerges. Structure Magazine. Structural Performance. Across-Wind Response of High-Rise Buildings / Rafik R. Gerges, Kal Benuska. – 2013. – Mode of access: <http://www.structuremag.org/wp-content/uploads/C-StrucPerformance-Gerges-July131.pdf>.
6. Aysin, Sev. CTBUH Research paper. Design Criteria for High-Rise Buildings in Historical cities: The Case of Istanbul / Aysin Sev, Aydan Ozgen, Bohar Basaris. – 2011. – Mode of access: <http://global.ctbuh.org/resources/papers/download/881-design-criteria-for-high-rise-buildings-in-historical-cities-the-case-of-istanbul.pdf>.

UDC 539.3/.6

**DETERMINATION OF THE DEFLECTION  
 OF A BEAM USING INITIAL PARAMETERS METHOD**

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*This article describes the determination of the deflection of a cantilever I-beam using the method of initial parameters. A comparative analysis of theoretical calculations and calculations in the program of finite-element analysis ANSYS is shown in this article.*

**Introduction.** The method of initial parameters has been widely used in a variety of engineering problems. It was originally developed by Soviet scientists such as N.P. Puzyrevsky, P.G. Kulikovskii, N.K. Snitko, N.I. Bezukhov, A.A. Umansky and others.

This method doesn't require the composition of bending moments expressions and integration of the differential equation of the bent axis of the beam. The number of constants to be determined does not exceed two regardless of the number of sections in the beam.

**Task formulation.** The study of a cantilever I-beam loaded with a system of external forces.

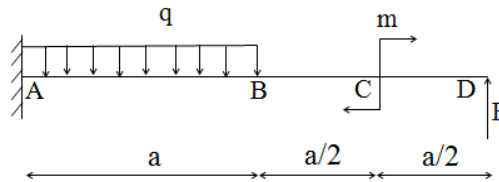


Fig. 1. The schema of loading the I-beam

We write the displacement and slope equations for the sections at points B, C and D. For the cross-section at point B, the equations will have the form:

$$EJ_z f_B = EJ_z f_A + EJ_z \theta_A \cdot a + M_A \frac{(a-0)^2}{2} + R_A \frac{(a-0)^3}{6} - q \frac{(a-0)^4}{24}; \quad (1)$$

$$EJ_z \theta_B = EJ_z \theta_A + M_A (a-0) + R_A \frac{(a-0)^2}{2} - q \frac{(a-0)^3}{6}. \quad (2)$$

For the cross-section at point C, the equations will have the form:

$$EJ_z f_C = EJ_z f_A + EJ_z \theta_A \cdot 1,5a - M \frac{(1,5a-1,5a)^2}{2} + M_A \frac{(1,5a-0)^2}{2} + R_A \frac{(1,5a-0)^3}{6} - q \frac{(1,5a-0)^4}{24} + q \frac{(1,5a-a)^4}{24}; \quad (3)$$

$$EJ_z \theta_C = EJ_z \theta_A - M (1,5a-1,5a) + M_A (1,5a-0) + R_A \frac{(1,5a-0)^2}{2} - q \frac{(1,5a-0)^3}{6} + q \frac{(1,5a-a)^3}{6}. \quad (4)$$

For the cross-section at point D, the equations will have the form:

$$EJ_z f_D = EJ_z f_A + EJ_z \theta_A \cdot 2a - M \frac{(2a-1,5a)^2}{2} + M_A \frac{(2a-0)^2}{2} + F \frac{(2a-2a)^3}{6} + R_A \frac{(2a-0)^3}{6} - q \frac{(2a-0)^4}{24} + q \frac{(2a-a)^4}{24}; \quad (5)$$

$$EJ_z \theta_D = EJ_z \theta_A - M(2a-1,5a) + M_A(2a-0) + F \frac{(2a-2a)^2}{2} + R_A \frac{(2a-0)^2}{2} - q \frac{(2a-0)^3}{6} + q \frac{(2a-a)^3}{6}. \quad (6)$$

Where  $f_A, \theta_A$  are respectively equal to the displacement and curvature slope at the origin at point A, which by this type of consolidation at the left end of the beam, are equal to zero.

The numerical values of displacements and curvature slopes of the given points are shown in Table 1.

**The results of the calculations:** To determine the numerical values of deflections and slopes, the following data are used:  $q = 20 \text{ kN/m}$ ;  $M = 15 \text{ kN} \cdot \text{m}$ ;  $F = 50 \text{ kN}$ ;  $a = 3 \text{ m}$ . The material of the beam is steel of first kind modulus  $E = 2 \cdot 10^5 \text{ MPa}$ . The cross-section of the I-beam has the profile № 16. The axial moment of inertia for this I-beam is  $J_z = 873 \text{ cm}^4$ .

As well as in the program of finite-element analysis ANSYS, the bending of the I-beam was modeled (simulated) and the results of displacements and slopes at critical (key) points were calculated.

The comparative analysis of theoretical calculations by formulas (1) – (6) and the computer modeling by the program ANSYS are listed in Table 1.

Table 1 – Results of the calculations of deflection theoretically and by ANSYS

	Displacement of the section at B, cm	Displacement of the section at C, cm	Displacement of the section at D, cm	Slope at B, degrees	Slope at C, degrees	Slope at D, degrees
Theoretical calculations	0,005154	0,01411	0,0239	0,003608	0,0061849	0,009407
Program ANSYS	0,0063135	0,0014579	0,0024659	0,00045586	0,0062105	0,00069417

The deformation of the beam caused by the external forces are shown in (Fig. 2).

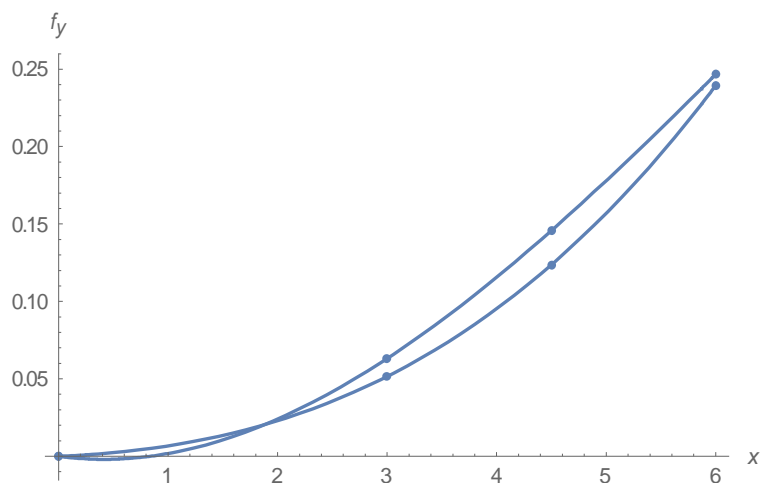


Fig. 2. Beam flexural deformation

**Conclusion.** Displacements and curvature slopes of the cantilever beam due to bending are calculated using the method of initial parameters. Theoretical calculations are approximately consistent with calculations in the program finite-element analysis ANSYS.

#### REFERENCES

1. Дарков, А.В. Сопротивление материалов / А.В. Дарков, Г.С. Шпиро. – 4-е изд. – М. : Высш. шк., 1975. – 654 с.
2. Сопротивление материалов : учеб.-метод. комплекс для студентов специальности 1-70 02 01 / А.Г. Щербо, В.К. Родионов ; под ред. А.Г. Щербо. – Новополок : ПГУ, 2006. – Ч.1. – 272 с.
3. Александров, А.В. Сопротивление материалов / А.В. Александров, В.Д. Потапов, Б.П. Державин; под ред. А.В. Александров. – 3-е изд. – М. : Высш. шк., 2003. – 560 с.
4. Каплун, А.Б. АНСИС в руках инженера : практическое руководство / А.Б. Каплун, Е.М. Морозов, М.А. Олферьева. – М. : Едитория УРСС, 2003. – 272 с.



UDC 691.327:502

**SULFATE CORROSION OF CONCRETE CAUSED BY THIONIC BACTERIA**

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*The article deals with conditions for the occurrence of sulfate corrosion of concrete. It is noted that thionic bacteria, changing pH of the medium at the expense of formed sulfuric acid, are active corrosion agents. The activity of thionic bacteria leads to concrete corrosion of the second and the third type. It is shown that the intensity of biocorrosion destruction is determined by the rate of chemical reactions and microorganisms and internal diffusion of metabolic products in the concrete structure is determined by the rate of chemical reactions and internal diffusion microorganisms and products of their metabolism in the concrete structure. The article presents modern methods of protection from sulfate corrosion.*

Concrete is the most common building material for the manufacture of structural elements of buildings and structures. Concrete and cement stone in environments is exposed to corrosive influences of various aggressive environments. One of the factors influencing the development and intensity of corrosion processes are microorganisms such as bacteria, fungi, algae, lichens and mosses. The products of microorganisms are organic and inorganic acids, sulfates, ammonia and other compounds which cause the destruction of concrete and the reinforcement in concrete structures. The degree of activity of the microorganisms causing corrosion of concrete depends on the temperature, humidity, pH, redox potential of the medium [1].

Biodegradation of concrete, mainly reduced to the violation of the clutch of cement stone and aggregate as a result of exposure to mineral or organic acids of microbial origin. The destruction of concrete structures is due to chemical reactions between cement stone and products of microorganisms. The most dangerous areas on the surface of concrete structures are cracks. Colonization of cracks leads to the penetration of microorganisms and their metabolic products in the mechanical damage increasing the internal pressure in the material.

According to conventional classification, corrosive effects of corrosive media on the concrete are divided into three main types:

- The first type includes corrosion processes occurring in the concrete when exposed to water with a low hardness when the components of the cement paste dissolve moving washed and entrained aqueous medium;
- Corrosion of the second type includes processes that develop in the concrete when exposed to liquids containing chemical substances that come into exchange reactions with components of the cement paste to form easily water-soluble or amorphous products, non-binding capacity of the masses in the zone reaction;
- Corrosion of the third type includes all processes of concrete corrosion by the activity of liquid corrosive media, the development of which in the pores, capillaries and other concrete voids is an accumulation of poorly soluble salts, the crystallization of which gives rise to considerable effort in the walls of the cement stone structure, limiting the growth of crystal formations.

One of the varieties of the third type is the corrosion of concrete in sulfate environments. Corrosion of concrete due to the activity of sulfates depends on the mineralogical composition of cement used and on the density and structure of concrete. Water containing more than 5000 mg / L of sulfates is aggressive even in relation to particularly dense concrete, a preparation of sulfate-resisting Portland cement [2]. It is also noted [3] that the concrete on the corrosion rate in sulfuric acid has a greater influence aggregate form, compared with cement views. Weight loss in the samples produced on calcareous aggregate was 4 times less than in the samples of quartzite aggregate. The layer of concrete destroyed disappeared much more slowly than the cement concrete stone grains of coarse aggregate of carbonate rocks, concerning the fracture surface of the concrete.

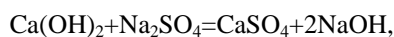
Thionic bacteria are active corrosion agents, forming a sulfate environment on the surface of concrete structures. Possessing a potent enzymatic apparatus of thionic bacteria by its oxidative activity can compete with chemical oxidation of metal sulfides, elemental sulfur, ferrous sulfate. The sulfuric acid microbiological aggression caused by thionic bacteria is the main cause of corrosion damage to the reinforced concrete drainage pipes, in addition to chemical corrosion processes [4].

The authors of [5] that thionic bacteria begin to develop at pH values of the surrounding environment below 8. The ageing of concrete and the interaction with the environment is a gradual acidification to the pH at which they are populated by bacteria. First, *Thiobacillusthioparus* start to develop which form elemental sulfur and reduce the pH to 5.0, followed by *Thiobacillusthiooxidans* already oxidized sulfur to sulfuric acid, the pH of the aqueous medium may be reduced to 2 or below. The relationship between pH and the number of bacteria in the acidification of the medium is linear. Exposure to microbiological and chemical factors leads to the destruction of concrete. Microscopic examination [5] sample surface of building materials exposed to corrosive changes

showed that the cement structure is completely destroyed at the surface and burst sand. These results are also confirmed by X-ray phase analysis.

The mechanism of the activity of microorganisms on the concrete, according to B.Isachenko [6], can be represented as follows. When repairing, concrete is covered with a protective film formed by calcium carbonate  $\text{CaCO}_3$ . As long as the film is intact, it prevents the diffusion of water into the concrete masonry and protects concrete from destruction. Thionic bacteria settles on the surface of the carbonate layer, destroys it by changing the pH of water surrounding them which was formed by acids. In addition, thionic bacteria hamper the production of sulfate.

Sodium sulfate  $\text{Na}_2\text{SO}_4$  initially reacts with  $\text{Ca}(\text{OH})_2$  according to the following scheme:



and then  $\text{CaSO}_4$  – with mineral  $\text{C}_3\text{A}$ .  $\text{CaSO}_4$  calcium sulfate reacts immediately with mineral  $\text{C}_3\text{A}$  under the scheme:



Calcium sulfate has a higher solubility product than the starting material, and is leached from the concrete (corrosion of the second type). Crystalline three sulfate hydroaluminate (ettringite) due to the difference in coefficients of expansion (volume 2.8 times greater than the volume of the starting materials) causes cracking (the third type of corrosion).

It is known [7] that the reaction of calcium silicate and calcium hydroxide in the presence of carbonate ions results in the formation of thaumasite (calcium hydrated calcium sulfokarbo-silicate). Crystal formation requires thaumasite sources – calcium silicates, sulfates, and carbonates. The source of calcium silicate is cement stone and sulfates – thionic bacteria carbonates contained in the lime constituents of cement stone, large or fine aggregate [8].

Thus, in microbiological effects thionic bacteria on concrete structures there is a significant removal of surface oxide and calcium relative accumulation of oxides of silicon, aluminum, potassium, sodium and sulfur.

The intensity of corrosion damage in the biodegradation proceeds similarly to the degradation of chemically aggressive media and is determined by the rate of chemical reactions on the surface of the material, internal diffusion of the microorganisms and their metabolic products in the structure of the material and the passage with chemical reactions.

Depending on the ratio of diffusion the rates of chemical interaction and failure occur in one of three areas [9]:

- external diffusion-kinetic, when the diffusion rate of the medium speed less than degradation and destruction of the material occurs in the surface layer (heterogeneous degradation);
- internal kinetic, when the diffusion rate of the medium exceeds the velocity of chemical reactions and the destruction of the entire volume of material is exposed (homogeneous degradation);
- internal diffusion-kinetic, when the chemical reaction rate commensurate with the rate of diffusion of destructive processes and accumulate over time (diffusion degradation).

The depth of concrete damage by chemical corrosion can be defined by the formula

$$a = K\sqrt{\tau}. \quad (1)$$

Where  $a$  – is the depth of corrosion;

$\tau$  – is the exposure of the material in a hostile environment;

$K$  – is coefficient of aggressiveness

Aggression factor is the determining criterion for assessing the chemical resistance of concrete and represents the ratio of the strength of concrete after exposure to aggressive environments ( $R_\tau$ ) or to original strength ( $R_0$ ) [10]:

$$K = R_\tau / R_0. \quad (2)$$

When biocorrosion of normal kinematic equations of chemical corrosion is added to the equation of bacterial biomass, depending on the range of environmental conditions, it ensures the functioning of this type of microorganisms.

According to GOST 25881 [10], biochemical resistance of concrete is projected on the basis of the specific conditions of their operation in time for economically viable life of the structure ( $\tau$ , the number of years),

and it is assumed that under the influence of aggressive environment during this term allowable strength of reduction should correspond to the value for  $S$ . received the life of the chemical resistance of concrete products and structures It shall be provided on condition that:

$$K \geq 1 - C, \quad (3)$$

To determine the chemical stability of the coefficient  $K$  for the life of the adopted (with  $\tau \geq 30$  days) use the relationship:

$$\lg K = a + b \cdot \lg \tau, \quad (4)$$

where  $\lg K$ ,  $\lg \tau$  – logarithm of the chemical resistance and received lifetime;

$a$  and  $b$  – constant for a given type of concrete and the coefficients of the medium

Evaluation of resistance of concrete according to the following criteria:  $K > 0.8$  – highly resistant;  $0.5 < K < 0.8$  – resistant;  $0.3 < K < 0.5$  – a relatively stable;  $K \leq 0.3$  – unstable [9].

Modern methods of protection from sulfate corrosion are [3]:

- Use of modern complex additives on the basis of dispersed silica and efficient water-reducing additives that reduce the permeability of the diffusion of concrete by 1–2 orders of magnitude;
- The suppression of life thionic bacteria through the use of biocide additives;
- Treatment by compositions of Ksaypeks, Penetron and Kalmatron that penetrate into the concrete and cause the pores and capillaries of the crystal growth, creating he so-called "crystallization barrier" that reduces the permeability of concrete;
- application of protective coatings made of polyethylene: smooth plastic film, polyethylene ribbed sheet, reinforced bearing precast concrete structures from total sectional elements with factory corrosion-resistant ribbed polyethylene coating.

#### REFERENCES

1. Шауро, А.А. Особенности протекания процессов биокоррозии цементных бетонов / А.А. Шауро // Электронный сборник трудов молодых специалистов Полоцкого государственного университета. Сер. Строительные материалы. – Вып. 14 (84). – С. 107–109
2. Рекомендации по применению низкоалюминатных портландцементов в условиях сульфатной агрессии / НИИЖБ Госстроя СССР. – М., 1977. – 9 с.
3. Розенталь, Н.К. Коррозия и защита бетонных и железобетонных конструкций сооружений очистки сточных вод / Н.К. Розенталь // Бетон и железобетон. Оборудование, материалы, технология : сб. науч. тр. – М., 2011. – № 2 : Бетонные изделия. – С. 78–85.
4. Калимуллина, Д.Д. Аэробный вид коррозии водопроводных сетей / Д.Д. Калимуллина, А.М. Гафуров // Междунар. науч. журн. «Инновац. наука». – 2016. – № 6. – с. 96–98.
5. Исследование биостойкости бетонов / Е.Н. Гончарова [и др.] // Вестн. БГТУ им. Шухова. – 2015. – № 4. – С. 102–105.
6. Биологическое сопротивление материалов / Соломатов В. И. [и др.]. – Саранск : Изд-во Мордов. ун-та, 2001. – С. 196.
7. Базанов, С.В. Система этрингит – таумасит: отличительные черты разрушения бетона / С.В. Базанов, М. Торопова // Популярное бетоноведение. – 2005. – № 5 (7). – С. 111–119.
8. Огрель, Л.Ю. Коррозия и защита строительных материалов и конструкций : учеб. пособие / Л.Ю. Огрель, А.Н. Володченко, Р.Г. Шевцова. – Белгород : Изд-во БГТУ, 2011. – 172 с.
9. Орловская, Е.В. Микробиологическая и химическая коррозия бетонов, в том числе, модифицированных серой / Е.В. Орловская, Н.А. Чак // Сб. науч. тр. / Нац. акад. природоохранного и курортного стр-ва. – Симферополь, 2005. – Вып. 12 : Строительство и техногенная безопасность. – С. 101–107.
10. Бетоны химически стойкие. Методы испытаний : ГОСТ 25881-83. – Введ. 01.07.1984. – М. : Госстандарт : НИИЖБ Госстроя СССР, 1983. – 8 с.

**TECHNIQUES OF DETERMINATION SETTING TIME OF CEMENT SYSTEMS**

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*During concrete works in many cases one of the factors influencing manufacturing techniques of designs is the "setting time of cement system" parameter. In the work it is shown that today in different sources the term "end and beginning of setting" is interpreted in different ways. Methods of their determination are also various. So, it is possible to draw a conclusion that first of all it is necessary to concretize and tie the beginning and the end of a setting to internal processes in the cement-water system.*

The regulating document used in Republic of Belarus and Russia GOST 30515-97 [1] enters such indicator of quality of cement as setting times. GOST 30515-97 [1] defines setting time of cement as the start and end of the cement paste setting in the normalized conditions. According to setting time cements are divided into:

- slow-setting — with the normalized starting time of a setting more than 2 h;
- normal-setting — with the normalized starting time of a setting from 45 min. to 2 h;
- fast-setting — with the normalized starting time of a setting less than 45 min.

At the same time the encyclopedia of terms, determinations and explanations of construction materials [2] defines the term "setting" as the irreversible process of slump loss of the cement paste up to transition to a firm condition characterized by indicators of the beginning and end of a setting.

According to [3] setting is the process during which rather fluid mix of cement with water gradually gets denser and obtains such initial durability at which its mechanical conversion becomes almost difficult and even impossible (at the end of a setting). Therefore the binders including cement should be characterized by such terms of setting which give the possibility to prepare mortar and concrete mixes and to use them. Prior to the beginning of a setting paste has thixotropic properties. As approaching the end of a setting cement paste or concrete mix becomes worse processed. Setting of cement in accordance to GOST 30515 97 [1] is called irreversible slump loss of the cement paste as a result of hydration.

Process of cement hardening according to the theory of hardening of binders, developed by the academician A. A. Baykov [4], is conditionally divided into three periods: preparatory, kolloidation and crystallization. In the preparatory period particles of cement are moistened with water and are dissolved from a surface; with time saturated solution is formed. During this period, lasted 1 ... 3 h, cement paste is plastic and easily formed. During the period of kolloidation the concentration of new hydrated growths increases in the solution. The formed connections differ in smaller solubility from clinker minerals. Therefore the solution saturated in relation to initial connections is oversaturated in relation to new growths. Hydrated new growths in the form of the smallest colloidal parts — submicrocrystals — are allocated from solution, forming cement gel. Emergence of a large amount of gel leads to thickening of the cement paste which loses plasticity. The moment of thickening (setting) of cement paste comes in 3 ... 5 hours after mixing with water cement. Strength of the thickened paste during this period is still small. The beginning of a setting is characterized by formation of reversible coagulative and crystallizational structure of a cement stone when separate particles are linked in pitches, chains, spatial grids through liquid layers by van-der-vaals forces. The period of crystallization is characterized by further hydration of cement. Gel will gradually be transformed into crystal joints. The condensation and crystallizational structure of a cement stone with chemical bonds between particles is formed. Cement gel loses a significant amount of water, and there comes the end of a setting. The structure loses ability to dissolve and restore thixotropically after removal of mechanical influence.

Now the mechanism of hydration of cement components is a subject of discussions and disagreements [5]. The early theory of La-Chatelie says that hydration of cement happens through dissolution of waterless connections, which are followed by bounding and crystals setting of the hydrated connections. Mikhaelis considered that cohesion is the result of formation and the subsequent drying of gel. The idea of the topochemical or solid phase mechanism was developed.

The idea of the mechanism of hydration of  $C_3S$ , main phase of cement isn't still clear. It's offered to take into consideration some stages of process of hydration. 5 stages on a thermokinetic curve calorimetry in isothermal conditions are noted. At the 1<sup>st</sup> stage there is jump of speed of a thermal emission, then the fall within 15–20 minutes. It is the preinductive stage. On the 2<sup>nd</sup> stage the speed of reaction is very low. It is the inductive period, lasting several hours. It is supposed that the 1<sup>st</sup> and 2<sup>nd</sup> stages, which can be influenced by the means of additives, significantly influence the subsequent hydration of  $C_3S$ . At the 3<sup>d</sup> stage the reaction goes actively, reaching a maxi-

imum by the end of the stage. Time of "the beginning of a setting" approximately matches with the time when the speed of reaction begins to increase greatly. Time of "the end of a setting" is the completion time of the 3<sup>d</sup> stage. At the 4<sup>th</sup> stage speed of a thermal emission decreases and hydration of  $C_3S$  continues. On the 5<sup>th</sup> stage a small amount of products of hydration of  $C_3S$  is formed. According to Akhverdov N. I. [6] the term "the beginning and the end of a setting" can be nominally characterized by the beginning and the end of the induction period.

The kinetics of structuring of the cement paste is characterized by reversible and irreversible processes depending on properties of the bonds of the crystal hydrate of complexes. If by the term "the beginning of setting" is meant an initial stage of forming of a microstructure of the cement paste, during which it has the reversible thixotropic properties, contributing not only to initial reduction, it is possible to tell that such phenomenon corresponds to the end of adsorption of liquid of all hard phase. Therefore, this should be corresponded by the structure of the cement paste which is created at a final stage of the induction period.

The concept "the beginning of a setting" is characterized by rheological properties of cement mixture and is only on average connected with internal physical and chemical transformations. All internal processes after the beginning of interactions of cement with water go cyclically as cement and water are heterogeneous in composition [7]. Therefore, even under production conditions in the work shop the time of the beginning of treatment during molding designs from several portions of the concrete mixtures, that shut at different times, (to determine the moment of the beginning of setting) is an intractable problem. Moreover the usage of all offered methods of active and passive impacts, even such low-power-intensive as magnetic handling and especially electrohandling, in technology of monolithic concrete is rather problematic.

In case of construction of monolithic designs usually several batches are loaded into means for delivery of concrete mixture. During transportation, because of various impacts there is a consolidation of all batches in single mass. For average mass even if it satisfies all requirements of technology, the concept of the moment of a mixing becomes abstract, but not the initial datum point in the transformations happening in already difficult cement system. In all considered handling types the moment of the beginning of impact is connected with the certain interval of time, which counting is conducted from the beginning of mixing.

Stacking of concrete mixture is performed by three methods: with sealing, casting (concrete mixtures with supersofterners) and pressure tight packing. For each method of packing the basic rule should be followed - the new portion of concrete mixture shall be laid prior to the beginning of cement setting in earlier placed layer [8]. According to foreign researchers [9–13] terms of cement setting can be determined by means of Gillmore apparatus (ASTM C 266) [9] and Vicat apparatus (ASTM 191) [10].



Рис. 1 Vicat's device



Рис. 2 Gillmore's device

Table 1 – The results of determination of setting time by means of Vicat apparatus and Gillmore apparatus

Setting time	Vicat apparatus	Gillmore apparatus
<b>Portland cement</b> (ASTM C 150) [ 11 ]		
the beginning setting (ht., min.)	0: 45	6:15
the end of setting (hr.,min.)	1:00	10:00

Working procedure with the help of Gillmore apparatus is the following: on flat pat from the cement paste with the diameter of 75 mm and with the thickness 12,5 mm, formed on glass, a prick with a needle is put. To determine the time prior to the beginning of a setting the needle with the weight of 113,4 g and with a diameter of 2 mm is used, however for determination of time until the end of a setting the similar needle has the mass of 453,6 g and the diameter of 1 mm. The time prior to the beginning of a setting is determined as time when the

first needle of Gillmore doesn't leave a noticeable prick, and the time until the end of a setting — when the same occurs with the application of the second needle. All standard cements must have the time prior to the beginning of a setting not less than 60 min., and the time until the end of a setting — no more than 10 h; when applying a Vicat needle — 45 min. and 8 h respectively.

The technique of work with Vicat apparatus is similar to the described above; only the weight and the diameter of a needle and the sizes of a sample from the cement paste are various. The moment of the beginning of a setting is determined at free lowering of a needle. The needle is immersed into paste every 10 min., moving a ring after each immersion so that the needle doesn't get to the former place. In this method the time prior to the beginning of a setting is fixed when the needle passes into paste to the depth of 25 mm, and the time until the end of a setting is fixed when a needle doesn't get into cement paste considerably. The beginning of a setting of the cement paste is considered as the time which passes from the beginning of a mixing (the water sticking moment) to the moment when the needle doesn't reach a plate on 2-4 mm. The end of a setting of the cement paste is considered the time from the beginning of a mixing to the moment when the needle falls to dough no more than by 1-2 mm. As it is seen from table 1, the beginning and the end of a setting on ASTM C 150 [11], considerably differ from each other.

According to the Canadian CSA CAN 3-A5 [12] standard the determination of the time prior to the beginning of a setting is only provided. The usage of Vicat apparatus is stipulated also in the British standard of BS 12:1978 [13]. For testing cement mortar is used. Penetrometer is applied to determine the time before the beginning and the end of a setting. The force required for penetration of the needle to a depth of 25 mm is determined. The force per unit area, created by a needle and maintained by a paste surface is called penetration resistance. The time prior to the beginning of a setting is the time from the moment of contact of cement with water, which is necessary preparation of the cement mortar, sifted from concrete to the achievement of resistance of a penetration of 3,5 MPa. The time until the end of a setting is the quantity equal to 27,6 MPa.

Researchers in Russia and the Republic of Belarus also use Vicat apparatus in accordance with ГOCT 56587-2015 and ГOCT 310.3-76 for determination of terms of a setting respectively [14, 15].

In the patent of the Russian researchers Bulat A. D. and Tsaryov A. M. [16] the method of control and management of setting terms, stages and processes of structuring of mortar and concrete mixtures is offered. The invention can be used in production of concrete and reinforced-concrete workpieces of the increased durability and in construction of monolithic buildings and constructions. The technical result is a possibility of determination of time of the beginning and end of a setting, maintenance of functional inspection of a condition and formation of stages of hardening of mixtures on the basis of cement.

As an analog for determination of the beginning and the end of a setting the known penetrometry method of Vicat performed according to GOST 310.3-76 according to item 2 is used. The needle of the device of Vicat is immersed in cement paste every 10 minutes. Under the conditions of mixture hardening the quality of control sharply decreases. The beginning of a setting of the cement paste is considered at the time which passes from the beginning of a mixing until the moment when the needle doesn't reach a plate on 2–4 mm. The end of a setting of the cement paste is considered as the time from the beginning of a mixing to the moment when the needle falls to dough no more than by 1–2 mm. At the same time if the beginning of a setting of the cement paste to some extent corresponds to the beginning of the induction period, then the end of a setting doesn't correspond to the end of the induction period, it can't be precisely determined. In case of setting cement paste hardens and it is impossible to lower a needle into paste. Besides, this method isn't suitable for concrete mixture at all, as the penetration of a needle into concrete mixture is interfered, besides, by filler grains. The device has a big instrument error, and thus low accuracy of determination of stages of hardening. If the beginning of a setting of the cement paste can be determined with a low error using this device, then this method isn't suitable for control of the termination of a setting and stages of hardening of mixture.

The closest method according to technical solution as a way of determination of terms of a setting of concrete mixture and control of kinetics of concrete hardening is the method of conductivity change with connection to the power supply [6]. In N. I. Akhverdov's experiments portland cement is used, to which the distilled water was added so that to exclude the distorting influence of the salts dissolved in it. Cement paste of various consistencies was placed in dielectric bowls. The results of experiments by means of Vicat apparatus and a method of conductivity allow to assume that they characterize various properties of the cement paste: the first allows to judge indirectly the mechanical durability of a macrostructure of the cement paste, and the second allows to judge the physical and chemical transformations causing formation of its microstructure.

Analyzing the existing techniques of determination of terms of a setting of cement systems, it is possible to draw a conclusion that they have disadvantages and in them there is no unambiguous definition of the term of the beginning and the end of a setting. Also the beginning and the end of a setting are not connected with the electrochemical processes happening in cement system when cement is mixed to water.

## REFERENCES

1. Цементы. Общие технические условия : ГОСТ 30515-97. – М. : Межгосударственная научно-техническая комиссия по стандартизации, техническому нормированию и сертификации в строительстве (мнткс), 1998. – 47 с.
2. Схватывание цемента [Электронный ресурс] / Энциклопедия терминов, определений и пояснений строительных материалов. – Режим доступа: <http://enciklopediyastroy.ru/sxvatyvanie-cementa/>. – Дата доступа: 22.11.2016.
3. Минеральные вяжущие вещества. [Электронный ресурс]. – Режим доступа: <http://www.bibliotekar.ru/spravochnik-72/76.htm>. – Дата доступа: 10.10.2016.
4. Портландцемент. Производство портландцемента. Схватывание и твердение портландцемента. Свойства портландцемента [Электронный ресурс]. – Режим доступа: <http://tehlib.com/stroitel-ny-e-materialy/portlandsement-proizvodstvo-portlan>. – Дата доступа: 01.12.2016.
5. Раманчандран, В.С. Добавки в бетон ; справ. Пособие / В.С. Раманчандран. – М. : Стройиздат, 1988. – 567 с.
6. Ахвердов, Н.И. Основы физики бетона / Н.И. Ахвердов. – М. : Стройиздат, 1979. – С. 144.
7. Пшеничный, Г.Н. Цикличное вибрирование бетонных смесей и его влияние на свойства цементного камня и бетона : дис. ... канд. техн. наук : 05.23.05 / Г.Н. Пшеничный. – Краснодар, 1981. – 201 л.
8. Руководство по производству бетонных работ. – М. : Стройиздат, 1975 – 314 с.
9. ASTM C 266 Test Method for Time of Setting of Hydraulic-Cement Paste by Gillmore Needles. – Current Edition Approved, 2007.
10. ASTM 191 Standard Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle. – Current Edition Approved, 2007.
11. ASTM C 150, Standard Specifications for Portland Cement. – Current Edition Approved, 2007.
12. CSA CAN 3-A5. – Current Edition Approved, 2007.
13. BS 12:1978 Specification for ordinary and rapid-hardening Portland cement. – Current Edition Approved, 1978.
14. Смесей бетонные. Метод определения сроков схватывания : ГОСТ 56587-2015. Нац. стандарт РФ. – М. : Стандартинформ, 2015. – 11 с.
15. Цементы. Методы определения нормальной плотности, сроков схватывания и равномерности изменения объема. – ГОСТ 310.3-76 : с изм. № 1 от 01.01.1985. – М.: ИПК Изд-во стандартов, 2003. – С. 6.
16. Способ контроля и управления сроками схватывания, стадиями и процессами структурообразования растворных и бетонных смесей : пат. № 2231510 / А.Д. Булат, А.М. Царев. – Оpubл. : 27.06.2004.

**TECHNOLOGY, MACHINE-BUILDING, GEODESY**

UDC 620.91:338=111

**PROSPECTS AND POSSIBILITIES OF NATURAL GAS  
AS THE UNIVERSAL ENERGY SOURCE OF THE FUTURE****OLGA ATROSHCHENKO**  
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*Natural gas plays one of the main role in global energy consumption, being relatively affordable, ecological and reliable source of energy. Prospects and possibilities of natural gas as the universal energy source of the future does not cause any doubt.*

Environmental problems, shortages and high prices on gasoline forced many countries to actively transfer vehicles to alternative fuels. Very often the choice falls on natural gas, which is one of the most environmentally friendly and cheap sources of energy. Practice shows that the use of natural gas as a motor fuel leads to a more rational use of natural resources, small business development, improves budget efficiency and living standards of the population.

Judging by the high growth rates of the world gas market in the last decade, it can be argued that the transfer of the vehicles to gas fuel is a global trend, which in the near future will continue to skyrocket.

The main benefits of using natural gas as a motor fuel can be divided into environmental, resource, technical and economic.

Gasification of road transport is primarily caused by the need to improve the ecological situation in the major cities, whose inhabitants are choking with smog. Due to air pollution, which is estimated from 50 to 90% caused by the emission of harmful substances when operating vehicles, people often suffer from respiratory diseases, cancer and other serious diseases.

Natural gas is the purest among hydrocarbon fossil fuels. When burnt it forms only water and carbon dioxide, while combustion of petroleum products and coal forms more soot and ash. The research of Swedish ecologists has shown that natural gas is 75% better than diesel fuel and 50% than gasoline; at 60% less harmful to humans, contains practically no carcinogenic components; at 60-80% less destroys the ozone layer; at 50% less contributes to acid rain.

Cars on gas fuel reduces emissions of carbon dioxide (the main greenhouse gas) to 13%, nitrogen oxides – at 15–20%, at 8–10 times reduces the opacity of the exhaust gases and completely eliminates emissions of lead compounds. The use of natural gas in modern engines with minimal modifications allows to reach the emission standards, Euro-compliant 5.

The technical advantages of the use of natural gas include: oil change frequency (increases in 1.5–2 times); his performance (reduced consumption 15-20%); resource engine (increased by an average of 35%); service life of spark plugs is increased by 40%; service life of the engine and overhaul mileage increases; excludes detonation engine (due to its high octane rating of methane).

Economic benefits of gaseous motor fuel are determined by the costs of its production (production and transportation to service stations) and the prices of compressed natural gas (CNG). A peculiarity is that obtained from the bowels of the gas is used almost without further processing. This determines its relative low cost compared with other products of oil processing, such as petrol and diesel. According to the decision taken in the year 2016 in the Republic of Belarus ecological tax rates, by burning CNG as fuel payments drop twice, when using liquefied natural gas-and-a-half.

Table 1 presents data on an average fuel consumption by road transport, depending on the type of vehicle. When calculating the benefits when used CNG, for example, for a passenger car (taxi) have adopted the following assumptions: a daily mileage is 200 km, average cost per RB 1 l gasoline –11000 rub., and 1 m<sup>3</sup> gas-6500 rub. Thus, operating costs when using gasoline as fuel, would amount to 101.981 million. USD/year, while using gas as fuel 63.583 million. USD/year. The annual savings on fuel would be approximately 38.398 million. USD/year.

From the table 1 it is possible to draw a conclusion about transfer of the car on gas fuel: even if there are some big expenses, there are profits, as well, because of the price of gas. This trend can be seen with other modes of transport.

When using gas as a motor fuel is reduced operating costs and cost of transport work. The amount of funds being released annually by switching to cheaper fuel is comparable with the cost of renovations to the vehicle. Transfer of vehicles with high lifetime and have, in view of the technical condition of the engines,



increased fuel consumption is most effective, since in this case the payback period decreases due to the effect on the fuel component.

Table 1 – Expenses motor fuel by motor vehicles

Type of vehicle	Fuel consumption per 100 km			
	gasoline, l	diesel, l	liquefied gas, l	compressed gas, m <sup>3</sup>
trucks	25	34,1	39,7	30,3
buses	31	34,2	44,2	41,7
cars	12,7	12,3	16,8	13,4

One of the main issues in transition of road transport to gas fuel is a question of the feasibility of retrofitting for the use of compressed and liquefied petroleum gas. But about the fundamental criterion for calculating economic impact during operation cars on gas fuel is to reduce operating costs.

In the Decree of the Council of Ministers of the Republic of Belarus from 10.16.2003 No. 1331 "On the use of gas as a motor fuel for motor vehicles" on this day, is an example of the calculation of the economic impact of the use of gaseous motor fuel. The calculation results are presented in table 2.

Table 2 – Example of calculating the economic effects transfer of different types of vehicles to natural gas in the conditions prevailing in fuel prices and gas equipment

	Vaz-2106	GAS-31	Gaz-3302
Annual mileage, thousand km	25	25	30
Annual fuel consumption, l	2250	3250	5100
The annual savings on fuel, mln rub.	6.27	16.2	25.4
The cost of the CNG equipment, mln rub.	15	16.3	18
Payback, months	29.9	16.1	12.3

The use of natural gas is important in the commercial and public sectors. Reducing fuel costs gives a quick economic effect. In some regions of Russia all public transport has been translated into methane.

Translation of transport on gas fuel meets the following basic priorities of modern policy of the State in socio-economic sphere: reducing the inflation rate, one of the most important factors which is the increase in the prices of motor fuel; the rational use of natural resources, including hydrocarbons; gas is relatively cheap fuel available for low-income population; small business development (including transport); increasing efficiency in handling of funds budgets, reducing expenditure budgets.

Since environmental problems, gas and gas processing technology improved, and oil reserves are being depleted, interest in methane as an energy source and alternative motor fuel continues to grow. Methane as motor fuel is particularly valuable for countries which have large reserves of natural gas or biomethane opportunities to develop, as well as for those countries where there are issues of increasing budgetary efficiency, improving environmental conditions and ensuring energy security.

#### REFERENCES

1. Natural gas-motor fuel era [Electronic resource]. – Mode of access: <http://www.propan.ru/motortop/metan21.html>. – Date of access: 15.09.2017.
2. Kirillov, N.G. CNG-universal energy fuel of the 21st century / N.G. Kirillov // Oil, gas & ORS. – 2004. – № 2. – S. 39–43.
3. Karasevich. Expanding the sources of gas supply / Karasevich, N. Yaryginy, Yu. Drozdov // Gasification/gas. Special issue, 640/2009. – P. 23–25.
4. Lazarev, A.N. World trends in the production and use of liquefied natural gas (LNG) as the universal energy carrier and motor fuel / A.N. Lazarev // Engine building. – 2010. – No 2. – P. 27–33.

## USE OF PLASTICS IN MECHANICAL ENGINEERING

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*In the transition to a market economy saving of material resources becomes one of the most important tasks of every enterprise because material costs make up a large part of the costs of production on which the profit margin depends directly.*

For processing methods, plastics have a significant advantage over many other materials. Due to the production of plastic products by the methods of pressing, molding, injection molding, extrusion and other methods, production wastes (chips) are removed, there is a possibility for extensive automation.

Finally, the biggest advantage of plastics over other materials is unlimited and the available resources (oil gas, oil, coal, waste of timber industry, agriculture and others).

**The task** of the research is to substantiate effectiveness of the use of plastics in mechanical engineering.

Plastics are organic materials, which are based on synthetic or natural macromolecular compounds (polymers). Plastics based on synthetic polymers are used exclusively widely [1].

By the nature of the binder, plastics are divided into thermoplastics, obtained on the basis of thermoplastic polymers, and thermosets, obtained on the basis of thermosetting resins. Thermoplastics are convenient for processing into products and give a negligible mould shrinkage (1–3 %). The material has great elasticity and low brittleness. Thermoplastics are usually manufactured without any filler. Thermosets become fragile after curing and the transition of the binder to the thermostable state, often give greater shrinkage (10–15 %) during their processing, so their composition is administered with reinforcing fillers.

**Thermoplastics**

In the basis of thermoplastics there are polymers of linear or branched structure, and sometimes plasticizers are administered. Thermoplastics have limited operating temperatures, when heated over 60–70 °C they begin to lose their physical and mechanical properties dramatically. More heat resistant structures can work up to 150–250 °C, and heat-resistant with rigid chains and the cyclic structure is stable up to 400–600 °C.

Under long static loading forcedly-elastic deformation appears and the strength decreases. The strength limit of thermoplastics is 10–100 MPa. The modulus of elasticity is 1800–3500 MPa. They are good at resisting fatigue, their durability is higher than that of metals. The endurance limit is 0.2–0.3 of the strength limit. When the loading frequency is above 20 Hz the material heats and its strength decreases. Properties of some thermoplastics are listed in Table 1[2].

Table 1 – Physical and mechanical properties of thermoplastics [2]

Material	Density, kg/m <sup>3</sup>	The maximum temperature of long-term work, °C	Strength limit, MPa			Impact strength, kJ/m <sup>2</sup>	The modulus of elasticity	Brinell Hardness
			tensile	compression	bending			
Teflon-3	2090–2160	125	30–45	—	60-80	20–160	—	100–130
Organic glass	1200	60	63–100	100-105	90-120	8–18	2900–4160	10–300
Polyvinylchloride	1400	65–80	40–120	80–160	40-120	70–80	2600–3000	10–160
Polyamides	1100–1140	60–110	38–60	—	35-70	80–125	1200–1500	74–150
Polycarbonate, DIFLON	1200	130–140	70	—	24–120	150	—	80–160
Polyarylate	1200	155–250	55–120	105–145	100–125	120	1650	—
Pentaplast	1400	150	80–110	—	—	12–16	—	—
Polyformaldehyde Stabilized	1140–1400	130	20–55	85–95	60-85	24–140	—	110–140
Polypropylene	900	150	25–40	11	—	33–80	1700	59–64
Polystyrene	1050–1080	90	37–48	90–100	65–105	10–22	3000–3300	140–200

**Thermosets**

In thermosets as binders thermosetting resins are used, in which sometimes plasticizers, curatives, accelerators or retarders, solvents are introduced. The main requirements for the binder is a high adhesive strength (adhesion), high heat resistance, chemical resistance and electrical insulation properties, ease of processing technology, small shrinkage and absence of toxicity (hazard). The resin glues both separate layers of filler and filaments and perceive the load simultaneously with them, however, after curing the binder should have a sufficient

peel strength by splitting material. It is necessary that the temperature coefficients of linear expansion of the binder and filler are similar in magnitude. Properties of some thermosets are listed in Table 2 [2].

Table 2 – Physical and mechanical properties of thermosets [2]

Materials	Density, kg/m <sup>3</sup>	The maximum temperature of long-term work, °C	Strength limit, MPa			Impact strength, kJ/m <sup>2</sup>	The modulus of elasticity	Brinell Hardness
			tensile	compression	bending			
Powder	1400	100-110	30	50-150	60	4-6	6 300-8 000	300-400
Fibrous:								
FRP	1350-1450	110	30-60	80-150	50-80	9-10,4	8 500	250-270
asbovoloknit	1950	200	—	110	70	20	18 000	300
GFP	1700-1900	280	80-500	130	120-250	25-150	—	—
Layered:								
getinaks	1300-1400	150	80-100	160-290	80-100	12-25	10 000	—
textolite	1400	125	65-100	120-150	120-160	30	5 000-10 000	—
asbotekstolit	1600	190	55	—	—	20-25	20 000	186-300
particleboards	1350	140-200	180-300	100-180	140-280	80-90	18 000-30 000	—
glass fiber	1600-1900	200-300	250-600	210-260	150-420	50-200	18 850-30 000	—
SVAM	1800-2000	200	350-1000	350-450	500-700	180-500	35 000	—

In mechanical engineering thermosetting pressing masses produced on the basis of phenolic resins or their modifications (phenolics) are widely used.

Depending on the composition and destination, phenolics are divided into the following types:

- О — general purpose;
- Сп — special without ammonia;
- Э — electric insulating;
- Вх — moisture and chemical resistance;
- У — shockproof;
- Ж — heat-resistant [3].

The main applications of plastics in mechanical engineering are:

- **Gear and worm wheel:** polyamides, polypropylene, pentaplasts, polycarbonates, polyformaldehydes, phenolics, FRP, textolite, particleboards;
- **Pulleys, flywheels, handles, buttons:** polyamides, aminoplasts, phenolics, FRP, textolite, particleboards;
- **Rollers, runners:** polyamides, polyvinylchloride, polypropylene, polycarbonates, particleboards;
- **Slide bearings:** polyamides, polyethylene, polypropylene, polyacrylates, epoksiplasts, pentaplasts, polycarbonates, polyformaldehydes, phenolics, FRP, textolite, particleboards;
- **Guides of machine tools:** polyamides, epoksiplasts, textolite;
- **Parts of rolling bearings:** polyamides, polycarbonates, polyformaldehydes;
- **Brake pads, linings:** phenolics, FRP, particleboards;
- **Pipes, armature parts, filters of oil and water systems:** polyethylene, polyvinylchloride, polypropylene, polycarbonates, GRP;
- **Working bodies of fans, pumps and hydraulic machines:** polyamides, polyethylene, polyvinylchloride, polypropylene, pentaplasts, polycarbonates, GRP.
- **Seals:** polyamides, polyethylene, teflons, polyvinylchloride, polypropylene;
- **Housings, cases, covers, reservoirs:** polyethylene, aminoplasts, polyvinylchloride, polypropylene, polystyrene, polyacrylates, polycarbonates, phenolics, GRP;
- **Details of devices and machines of precision mechanics:** polyamides, polyethylene, polyvinylchloride, Polypropylene, pentaplasts, polycarbonates, polyformaldehydes, phenolics, FRP;
- **Bolts, nuts, washers:** polyamides, polyethylene, aminoplasts, polyvinylchloride, polypropylene, pentaplasts, polycarbonates, polyformaldehydes, phenolics, FRP;
- **Springs, cam mechanisms, valves:** polyamides, polyvinylchloride, polypropylene, polycarbonates, polyformaldehydes, текстролит, GRP;
- **Large structural elements, tanks, trays, etc. :** polyethylene, polyvinylchloride, polystyrene, GRP;
- **Electrical insulating parts, panels, dashboards, instrument cases:** polyamides, polyethylene, teflons, aminoplasts, polyvinylchloride, polypropylene, polystyrene, polyacrylates, epoksiplasts, pentaplasts, polycarbonates, polyformaldehydes, phenolics, FRP, textolite, particleboards, GRP;

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— **Light-transmitting optical parts (lenses, sight glasses, etc.):** polyethylene, aminoplasts, Polypropylene, polystyrene, polyacrylates, polycarbonates;

— **Copiers, check patterns:** polyethylene, polyvinylchloride, polypropylene, epoksiplasts;

— **Cold sheet stamps:** epoksiplasts, pentaplasts, phenolics, GRP;

— **Foundry models:** polystyrene, polyacrylates, epoksiplasts, phenolics, GRP[4].

Features of the plastic materials are: low density (1–2 t/m<sup>3</sup>); low thermal conductivity, high thermal expansion, 10–30 times more than steel; good dielectric properties; high chemical resistance; friction and antifriction properties. Strength power of plastics is comparable to the strength of steel and above. Plastics have good technological properties [2].

One of examples of using plastics in mechanical engineering are bearings made of caprolon. They are widely used in many industries due to their high physical and mechanical properties:

- 1) Durability, even under constant mechanical load;
- 2) Low friction when paired with any metal;
- 3) Ability to work without lubrication in friction units;
- 4) Reliable and quiet operation of devices and mechanisms;
- 5) Corrosion-resistance;
- 6) Adaptability to manufacture.

In addition, caprolon is 6 times lighter than steel and the is 10–12 times cheaper than bronze. The bearings made of caprolon in the presence of the lubricant can operate at circumferential speeds of up to 15 m/s and a pressure of 50 kgf/cm<sup>2</sup>. The coefficient of friction on steel and bronze with lubrication (water, oil) is 0,04 – 0,08. Wear per 1000 hours of operation shall be 0.10 mm [5].

Disadvantages of plastics are: low heat resistance, low elastic modulus and impact strength compared to metals and alloys and the fact that some plastics have propensity to aging [2].

The use of plastics reduces costs significantly, as it lowers the complexity of design work and need for equipment. The effectiveness of the use of plastics in manufacturing is expressed in cost and mass reduction, lowering the costs of material (materials consumption), reducing the complexity of manufacturing of plastic parts compared with metal (a reduction of wages per unit of product); shortening of the production cycle and timing for the design and development of new constructions.

The effectiveness of the use of plastics in exploitation is reflected in the reduction of the structural mass, reducing operating costs (lubrication, repair, etc.), increase of operational reliability of machines, the expansion of the technical capabilities of construction and improving its technical and economic parameters (capacity, efficiency, service time, etc.).

So, replacing metal parts with plastic ones is very effective. This reduces the weight of construction by 4–5 times; complexity of manufacturing parts is reduced by 4–5 times; the number of operations and their labor intensity is reduced by 5–6 times, thus reducing cycle times and freeing up working capital. Capital cost (the cost of buildings, equipment, inventory) is also reduced by 4–6 times. Production costs are reduced by 2–3 times.

Plastic materials are not only by 4–9 times cheaper than nonferrous metals, but in some cases (molded) are 2–6 times smaller than ferrous metals.

In the constructions of aircraft, engines and other devices plastic and other non-metallic materials are increasingly used, on average, they make up 7–25% of the mass of subsonic transport aircraft and up to 20–50% of the mass of a rocket (without fuel).

In the agricultural machinery replacement of sintered parts in ethylene copolymers parts will extend the life of the bearing bushings of cultivators by 2.4–3 times. In cement production using liner copolymers instead of steel sheets increases the service time of bins and chutes by several times.

The economic effect is achieved in the mining and processing enterprises, factories of ferrous and nonferrous metallurgy (1 ton of sheet of low pressure polyethylene or ethylene copolymers can save 16–20 tons of stainless steel) and others [2].

## REFERENCES

1. Пластмассы [Электронный ресурс] // Википедия. – 2017. – Режим доступа: <https://ru.wikipedia.org/wiki/Пластмассы>. – Дата доступа: 09.01.2017.
2. Лахтин, Ю. М. Материаловедение / Ю.М. Лахтин, В.П. Леонтьева. – Л. : Машиностроение, 1990. – 528 с.
3. Классификация пластмасс, применяемых в машиностроении // knigitut.net [Электронный ресурс]. – 2017. – Режим доступа: <http://knigitut.net/2/89.htm>. – Дата доступа: 09.01.2017.
4. Применение полимеров в машиностроении // MPlast.by [Электронный ресурс]. – 2017. – Режим доступа: <http://mplast.by/encyklopedia/primeneniye-polimerov-v-mashinostroenii>. – Дата доступа: 09.01.2017.
5. Капролон, производство капролона, продажа капролона, полиамид-6 блочный : Капролон [Электронный ресурс] // ГлавМехСЕРВИС. – 2017. – Режим доступа: <http://kaprolon.biz/?id=2>. – Дата доступа: 18.01.2017.

UDC 621.91.01/02

**MODELLING OF DISPLACEMENT PROCESSES AND FORCES IN  
THE THREADED CONNECTIONS OF BORING CUTTING TOOLS****ANDREW GERASIMOV, NIKOLAI POPOK**  
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*Modeling of displacement processes in SolidWorks. Modelling of forces in the threaded connections of boring cutting tools.*

**Introduction.** Mechanical engineering is a key industrial sector, because without the use of its capacity for the production of the necessary parts, products, equipment, etc. cannot do any other industry.

Compared with other methods of production of machine parts machining provides the greatest accuracy and highest production flexibility makes it possible to quickly move from one size machining workpieces to a different size.

Cutting tool, cutting relatively thin layers of material, gives the workpiece desired shape and size. The efficiency of the cutting tool, its reliability had a significant impact on the economic efficiency of the production process.

Quality and tool life in many ways determine the performance and effectiveness of treatment, and in some cases, and the possibility of gaining parts of required form, quality and accuracy in general. Improving the quality and reliability of cutting tools enhance productivity of metal cutting [1].

One of the perspective ways of boring tools constructions development is using the principle when they are made from different modules.

When we use this principle, we increase the safety during their work and maintenance conditions by reducing the amount of module constructions. In addition, the using of these modules in projecting reduce time and labor content for engineer these constructions, give the opportunities for using new methods of engineering.

Special attention is given for the constructions of micrometer adjustment and movement of cutting blades assemblies, cartridges and cutting blocks as well.

The disadvantages of modular tool units are their reduced stiffness and accuracy as compared with solid tools, and the lower, the more modular elements in the block. To increase the accuracy of blocks, resort to using elements for adjusting the size of the cutting tools [2].

In metal treatment of precise holes increasing application get boring heads. They allow to set the size of the tool with high precision and achieve high-quality and accurate processing. The ability to control the size of the tool can improve the processing efficiency by reducing tooling costs and improve performance through the use of cutting teeth made of modern instrumental materials (hard metal, mineral ceramics and super-hard materials), allowing the use of higher cutting data [3].

Boring heads have higher performance as compared to other boring tools.

**Formulation of a problem.** There are many ways to make the preload in the micro metric threaded connection of microbores [4]. However, the easiest to manufacture of the resilient member is the form of a slotted spring.

During the design and development of a new boring tool with micrometric adjustment blades solved the problem of backlash sample (reduce it to the required value) in the threaded connection of the boring head. It was found that the amount of movement in the sample is affected by several factors: the parameters of the split grooves on the housing sleeve and the efforts of its pre-compression or wedging (to bring it to preload) [4].

**Modeling and experiment.**

One of the technical characteristics of boring heads with micrometric blades adjustment is discrete adjustment for the size of 0.005 mm in diameter.

The main element for the size adjustment in the design of the boring head is the slide, displacement of which depends on the accuracy of the threaded connection M12x0,5-6H.

Therefore, it was analyzed the ability of using the spring washers to eliminate gaps during movement of the slider to a specific size in this compound. It should be noted that all of the leading manufacturers of boring heads with micrometric adjustment of the blades recommends to make the setting up the tools in one direction. For example, by sliding the slider one more time in order to increase the size of boring diameter, at first the slide must be retracted, and then the slider could be set up to the desired diameter.

After analyzing the structure of the sample of boring head with a spring and a lock nut in a slider design, that was proposed by RUE "Orsha Toolmaker" following should be noted:

1. Figure 1 shows the load diagram of turns of the screw shaft with preload via lock nuts and disk spring. Loaded hand turns in the thick line. Since the spring pushes the slider and the lock nut from each other, then the preload loaded the versatile surfaces of thread locknut and slider.

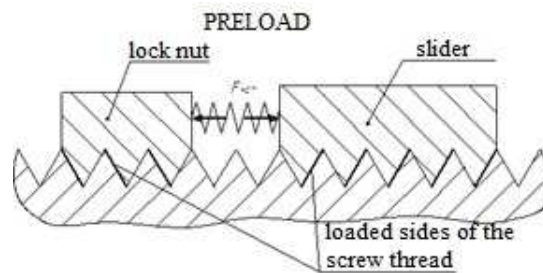


Fig. 1. The scheme of turns of the screw shaft with preload via lock nuts and disk spring

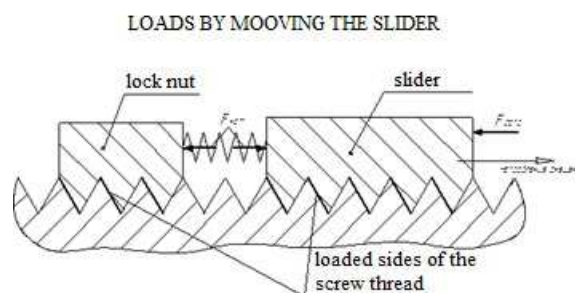


Fig. 2. The scheme of turns of the screw shaft with preload via lock nuts and disk spring (increase size)

When you move the slider for adjustment (increase size) in contact of screw and the slider should work the other side of the thread of the screw shaft (Fig. 2). However, since the preload occurred in the opposite direction, there is a load uncertainty. The gap in the connection of "screw - nut slide" will depend on the interference of force ratio  $F_{ham}$  and total resistance force  $F_{comp}$  of the slider movement.

This uncertainty may be one of the reasons for the uneven displacement of the slider when setting up, and as a result, the bore size installation inaccuracies.

To minimize uncertainty of loading will allow the accommodation of locknut on the other side of the slide, or compression preload of lock nut and slider (at an invariance of their location).

Initially were created three-dimensional solid models of split bushings and screws in the program SolidWorks (Fig. 3).

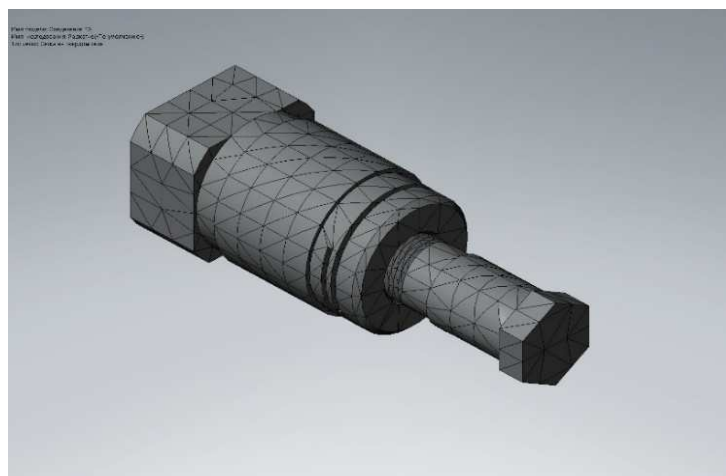


Fig. 3. Connection, broken into finite elements in SolidWorks

After analyzing the structure using FEM program SolidWorks (Fig. 4), we can make preliminary conclusions about the acceptability of this type of backlash in the threaded connection of cutting tools.

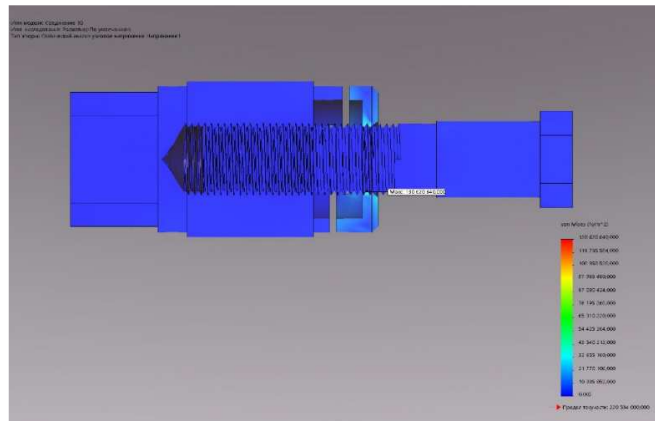


Fig. 4. Map of the distribution of stresses, resulting in the program SolidWorks

After conducting research and calculations using SolidWorks software, experiments were conducted on natural samples of split sleeves.

During the experiment, the split sleeve disjoining with measuring plates, and then when screwing and unscrewing the screw, was measured torque that occurs in the threaded joint. (Fig. 5).



Fig. 5. Measurement of torque with a torque wrench

The rigidity of sleeves is measured using the ЗИП 05-82 (Fig. 6).

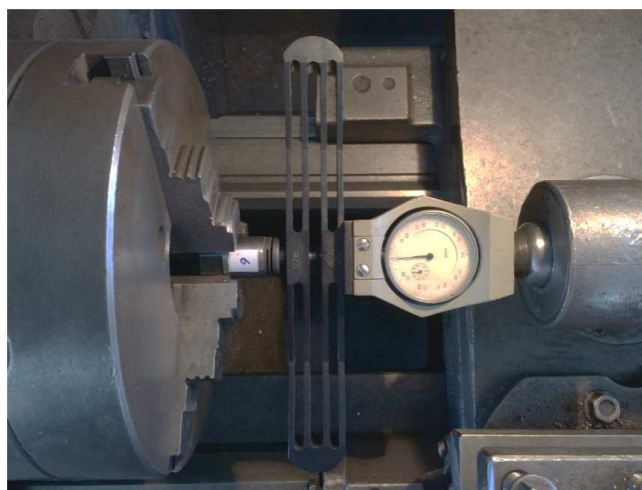


Fig. 6. Measurement of hardness using ЗИП 05-82

**Conclusions.** The most appropriate is the initial version of the design with cutting through slots in the slider - which allows to exclude the gaps in the transmission of the screw-nut. It is necessary to pay attention to the sequence of the assembly adjustment for appropriate the size.

When analyzing the structure using the finite element method in the program SolidWorks, we can draw preliminary conclusions on the admissibility of this type of gapscompensation in the threaded connection of micrometer screws in precision cutting tools. However, due to the nature of the calculations in SolidWorks Simulation it is not possible to situate the compression of split bushing and then screwing the screw. Thus, a further simulation carried out on real models. It turned out that there are moments when screwing screws into the sleeve cut with insufficient depth of the groove. Suitable torque observed when the width and step values of sleeve grooves are in the interval of one to two pitches of the thread. Rigidity of sleeves decreases with increasing of depth and width of the grooves in the sleeves.

#### REFERENCES

1. Металлорежущие инструменты : учебник для вузов по специальностям «Технология машиностроения», «Металлорежущие станки и инструменты» / Г.Н. Сахаров [и др.]. – М. : Машиностроение, 1989. – 328 с. : ил.
2. Режущий инструмент : учебник для вузов / под ред. С.В. Кирсанова. – 3-е изд. – М. : Машиностроение, 2007. – 528 с.: ил.
3. Аверьянов, О.И. Режущий инструмент : учеб. пособие / О.И. Аверьянов, В.В. Клепиков. – М. : МГИУ, 2007. – 144 с.
4. Пат. 2349426 РФ, МПК В23В29/034. Расточная головка.
5. Herasimau, A. Cartridge toolholders and boring heads for high-precision holes treatment / A. Herasimau, N. Papok // Materials of VI junior researchers' conference / Polotsk State University. – Novopolotsk, 2012. – P. 91–94.
6. Винарский, М.С. Планирование эксперимента в технологических исследованиях / М.С. Винарский, М.В. Лурье // Техника. – 1975. – 168 с.



UDC 528.48

## INSTRUMENTAL METHODS OF LAYOUT GRID RESTORATION ON THE CONSTRUCTION SITE

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*During the preparatory period of construction a geodetic layout grid is created on a building site in the form of a construction grid, principal and main axes of buildings and constructions.*

The main axes of the building are taken out on batter boards, and also are fixed by permanent and temporary signs outside the earthworks. Longitudinal and transverse axes have the design of coordinate that is expressed in a single coordinate system for the project.

Axes are used at all stages of construction and therefore it is important to ensure their safety and stability.

As a result of the work of digging machines and other equipment on a construction site there are cases of loss or displacement of axial signs. In that case there is a need for axe restoration. Thus the problem of axe restoration becomes complicated as axial signs can have only one coordinate of X or Y proceeding from what axis they fix. The problem of axe restoration has not been studied enough therefore a research objective is the development of modern methods of axe restoration.

In this article four instrumental methods of axe restoration are displayed.

Basic data of our research are the axial signs representing axes with the coordinate of X (point A and B) (Fig. 1) and one axial sign of axes with Y coordinate (point C). There is a problem of staking-out of the second axial sign forming an axe with Y coordinate (point D).

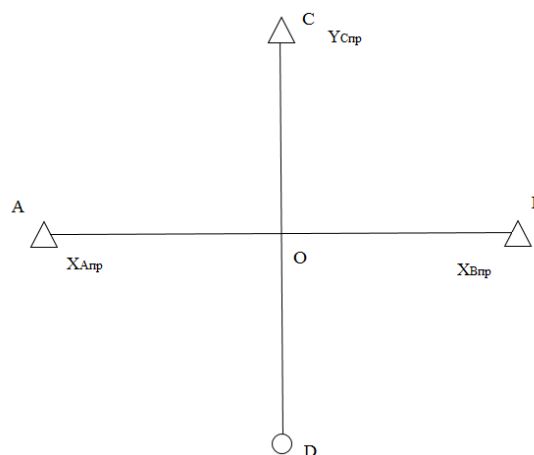


Fig. 1

The first method aims to execute installation of the device at A point, with the direction of a reference point to the other point. As abscissae and ordinates respectively are known in longitudinal and transverse axes, in coordinates of station of the device one parameter will be designed (known), and the other parameter will be conditional. So at station A coordinate is X – designed, and Y coordinate – conditional.

We perform measurements on point C for receiving its coordinates of X and Y. We compare the new coordinate Y with its design value. The value of the received difference of coordinate Y is considered at repeated installation of the device at station A. We repeat the actions described above until the value of coordinate Y of point C coincides with design with the demanded accuracy. Intermediate control will be the equality of values of coordinates X of points A and B with their design value, carrying out measurements on B point in the last approach. Similarly we receive coordinates of point C carrying out installation of the device on B point. Equality of coordinates of point C, received from points A and B will be final control. The device installed in the design system of coordinates of a building site allows staking-out the point D with the design coordinate X forming the lost axis. The solution of the resection at station in point D can be the control of staking-out of point D.

The essence of the second method consists in measurement of corner  $\beta_{AC}$  and the distances of  $D_{AC}$ , having installed the device at station A (Fig. 2).

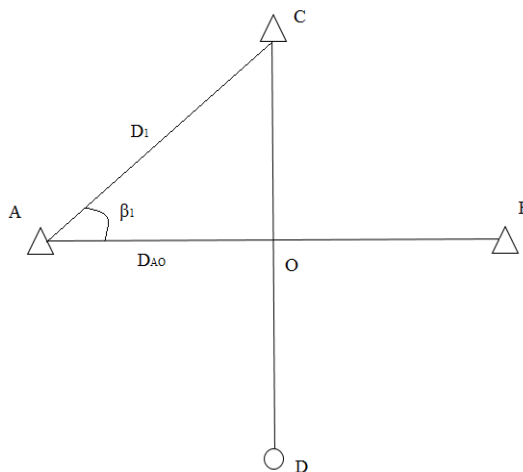


Fig. 2

Using the properties of a rectangular triangle, we find the distance:  $D_{AO} = D_{AC} \cdot \cos \beta_{AC}$ . Having postponed the given distance from an axial point A, we will receive a point of intersection of axes – point  $O_1$ . For a control we carry out similar measurements from point B and we receive point  $O_2$ . The points of axe intersection received from two points have to coincide.

In the third method axial points are coordinated in conditional system of coordinates using a method of free station of the device. The purpose of the method is to find out a point of axe intersection whose arrangement won't depend on the used system of coordinates as all points will be defined in uniform system. The coordinates  $X_A, Y_A; X_B, Y_B; X_C, Y_C$  of points A, B, C, are determined respectively (Fig. 3). The coordinates of points O, that forms the lost axis and is the point of axe intersection is determined by the parametric equation of a line on the plane (1).

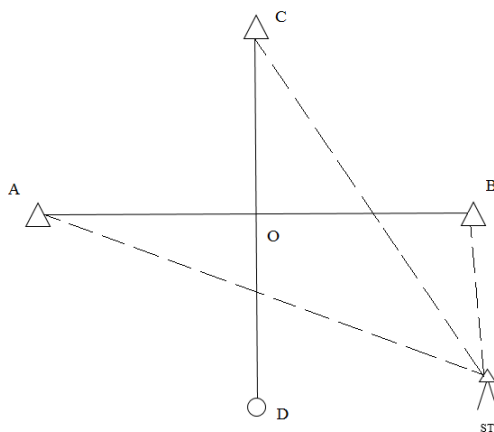


Fig. 3

$$\begin{cases} X_O = X_A + mt \\ Y_O = Y_A + nt \end{cases} \quad (1)$$

where  $(m, n)$  – coordinates of vector direction of the line:  $m = X_B - X_A; n = Y_B - Y_A;$

$$t = \frac{m(X_C - X_A) + n(Y_C - Y_A)}{m^2 + n^2}$$

The fourth method is realized also in conditional system of coordinates, known values (design) abscissae of axial points A and B ( $X_{A_{np}}, X_{B_{np}}$ ), and value of ordinate of an axial point  $CY_{C_{np}}$  are basic data. Installation of the device is carried out by method of free station on condition of visibility of all axial points (Fig. 4).

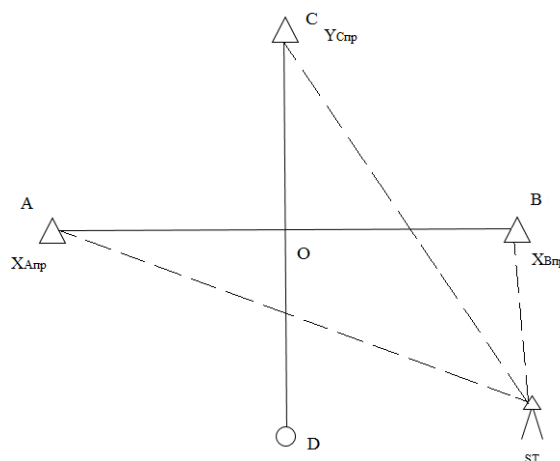


Fig. 4

Using the internal software of the device, we define the distance from point A to point B corresponding to the difference of ordinates of these axial points ( $\Delta Y$ ). We appoint coordinates to an axial point A: known design value of an abscissa  $X_{Amp}$  and conditional value of ordinate  $Y_{A1}$ .

Coordinates of an axial point B will be:  $X_{Bmp}, Y_{B1} = Y_{A1} + \Delta Y$ . We carry out the installation of the device by method of free station, using the appointed coordinates of points A and B. We perform measurements on point C for receiving its coordinates ( $X_{C1}, Y_{C1}$ ) and compare the received  $Y_{C1}$  coordinate with known from a condition design value  $Y_{Cmp}$ . The received difference of ordinates  $\Delta Y_1 = Y_{Cmp} - Y_{C1}$  we consider at purpose of new coordinates of an axial point A in the new approach:  $X_{Amp}, Y_{A2} = Y_{A1} + \Delta Y_1$ . We carry out installation of the device and repeatedly we receive coordinates of an axial point C until value of coordinate  $Y_{Cn}$  doesn't coincide with reference design value  $Y_{Cmp}$  with the demanded accuracy. Thus, the transition from conventional coordinate system to the coordinate system of the construction site is performed by approximations. Without changing stations of the device we take out an axial point D in nature, restoring an axis.

Our research results show that the offered methods allow making external layout grid development and restoration under various conditions on the building site as well as carrying out instrumental check of an external layout grid.

#### REFERENCES

1. Машимов, М. М. Уравнивание геодезических сетей / М.М. Машимов. – М. : Недра, 1979 – 367 с.
2. Геодезические работы в строительстве. Правила проведения : ТКП 45-1.03-26-2006 (02250). – Введ. 07.01.06. – Минск : Минстройархитектуры, 2006. – 62 с.

## RECOVERY ALTITUDE SETTING-OUT BASE OF CONSTRUCTION OF POLOTSK HYDROELECTRIC POWER STATION

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*We consider the problem of recovery altitude setting-out base of construction and give calculations of the required accuracy location survey and describe the field and office work.*

Location survey in the course of construction has to provide setting out from points of a geodetic setting-out base with the set accuracy of axes and marks defining situation in the plan and on height of parts and structural elements of buildings according to the project documentation. As it is shown below, the accuracy of location survey in many respects is defined by the accuracy of a setting-out base. Therefore points of a geodetic setting-out base have to be in process of construction under observation for their safety and stability and to be checked instrumentally at least 2 times a year [1].

The article discusses the examination, recovery and development of the existing geodetic basis for the construction of Polotsk hydropower plant. This problem has arisen in the construction of the gantry crane. The scheme of location of points of a marking basis of rather main constructions of hydroelectric power station is provided in figure 1.

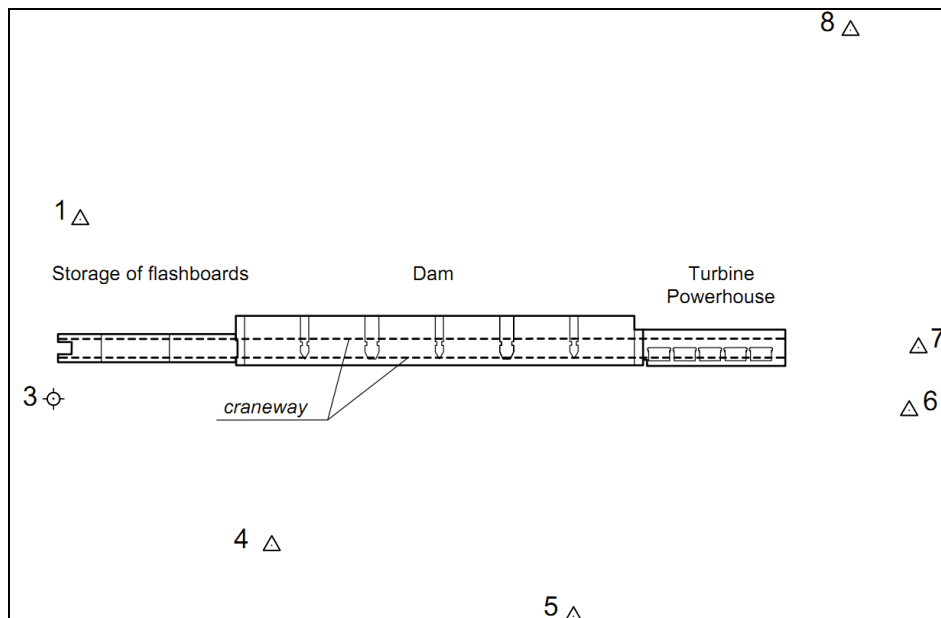


Fig. 1. The scheme of location of points of a setting-out base

Points of setting-out base fixed film reflectors which are widely used in geodesic industry. Film reflectors glued to any stable designs and coordinated from points of the terrestrial network points polar manner (at a distance of no more than 150–200 m) or direct line-angle intersection [2].

It is known that errors of carrying out of axes and marks consist of errors of location survey and mistakes in coordinates of points of a geodetic setting-out base:

$$m^2 = m_p^2 + m_u^2, \quad (1)$$

where  $m$  – average square error of the position staked point;  $m_p$  – average square error of the position staked point due stakeout measurements;  $m_u$  – average square error of the position points geodetic setting-out base.

Efforts should be made to the error in the position of the starting points is practically no effect on the accuracy of the setting-out. In [3] it is shown that the compliance with the criterion

$$m_u \leq 0,43m \quad (2)$$

coordinates of the source points can be considered infallible.

The project documentation for the construction of the facility is set next tolerance, referring to the position of crane runaway relative to the main and the principal axes of the object:

- a common center line, measured along the running surface, must not deviate more than 10 mm from the theoretical lines in both horizontal and vertical planes;

Then, taking  $m = 10$  mm, we obtain the  $m_u = 4,3$  mm. Thus, if the position error points of setting-out base do not exceed 4.3 mm, the location survey can be considered infallible.

#### **Instrumental verification of the provision of points of a setting-out base.**

For verification we compared the a priori and the actual (calculated measurement) values of the accuracy of the resection from the points setting-out base. If the actual mistakes exceed aprioristic more than for 10% [3], then on condition of high-quality measurements it is possible to speak about existence of mistakes in the provision of points of a setting-out base.

When calculating the following basic data were used:

- coordinates of starting points have an error of  $m_u = 4,3$  mm;
- coordinates of the station were modelled proceeding from possible installation sites of the tacheometer at setting-out;
- the resection was solved from three starting points, at the same time the maximum distance from the station to starting points didn't exceed 200 m, the maximum angle of inclination  $20^\circ$ .
- average square errors of measurement of angles –  $2''$ , distances – 3 mm;

Precalculation of accuracy of high-rise situation at a resection from three points is executed on the formulas given in [2]. We will receive the accuracy of determination of height from one point on a formula:

$$M_h^2 = (m_\alpha D \cos \alpha / \rho)^2 + m_D^2 \sin^2 \alpha, \quad (3)$$

where  $m_\alpha$  – error of measurement of a vertical angle,  $m_D$  – error of measurement of distance,  $\alpha$  – the angle of inclination,  $D$  – distance,  $\rho = 206265''$ .

At our basic data we will receive  $M_h = 2,1$  mm. At a resection from three points  $M_h = 2,1 / \sqrt{3} = 1,2$  mm. Then we will receive the maximum mistake in high-altitude position of the station:

$$m = \sqrt{m_p^2 + m_u^2} = \sqrt{1,2^2 + 4,3^2} = 4,5 \text{ mm.}$$

The actual errors of position of the station were calculated on measurements on starting points by means of the built-in program of the tacheometer and exceeded in certain cases 10 mm on height.

Instrumental verification showed that it is impossible to use points 1, 5, 8 for setting-out. This fact, and also need of obtaining coordinates of point 3 served as the reasons of performance of work on restoration of a setting-out base.

#### **Field works on restoration of a setting-out base.**

Measurements on points of a setting-out base were performed by a polar cross-bearing the tacheometer.

Measurements were carried out from four stations. At the first and second stations the tacheometer was installed so that it was possible to measure on all points (1, 3, 4, 5, 6, 7, 8). Distances from the station to points have made from 140 to 230 meters. At the third station of measurement were carried out on points 1, 3, 4, distances to points didn't exceed 150 meters. At the fourth station – on points 5, 6, 7, 8. Distances to points didn't exceed 160 meters. The third and fourth stations got out so that to reduce distance to points, vising accuracy thereby increased, and also to provide an optimum angle of falling of a laser beam on the reflecting surface [4]. The measurements connecting stations among themselves weren't made.

In table 1 heights of points and results of measurements of heights are given in each station.

Table 1 – Input heights and results of measurements

Num. points		Station 1	Station 2	Station 3	Station 4
	H <sup>0</sup> , m	H <sup>1</sup> , m	H <sup>2</sup> , m	H <sup>3</sup> , m	H <sup>4</sup> , m
1	125,065	125,074	125,073	125,073	
3		125,625	125,619	125,624	
4	118,756	118,752	118,752	118,753	
5	116,769	116,781	116,773		116,777
6	128,300	128,301	128,299		128,299
7	129,910	129,913	129,908		129,909
8	123,789	123,802	123,797		123,799

**Cameral works on restoration of a high-altitude setting base.**

The measured heights of points at each station should be considered as heights of the same points in different systems of heights. The reason of it that before measurements determination of coordinates of the station and orientation of the tacheometer it was carried out roughly owing to mistakes in coordinates of starting points. Theoretically measurements at each station can be performed without binding on starting points, i.e. in conditional system of heights. Further processing of results means transformation of heights to system of one of stations. System of the station to which we will transform, we choose proceeding from existence of the greatest number of points measured on her. These are stations 1 and 2.

So, we have heights of points in initial system of heights  $H^0$  and height of the same points received from the measurements executed on four stations  $H^1, H^2, H^3, H^4$ , (Tab. 1).

Let's transform heights received at stations 2, 3, 4 in system of heights of the station 1. Transformation of coordinates comes down to parallel translation in the vertical plane of system of each station at a size  $\Delta H^k$ , calculated on a formula

$$\Delta H^k = \frac{1}{r} \sum_i^r H_i^1 - \frac{1}{r} \sum_i^r H_i^k, \quad (4)$$

where  $k$  – station number (2, 3, 4),  $r$  – number of the measured points at the station,  $H^k$  – heights measured at the station,  $H^1$  – heights measured at the station №1.

In tab. 2 the example of transformations of heights for the station 4 is given.

Table 2 – Results of transformations of heights of the station 4

Num. points	$H^1$ , м	$H^4$ , м	$H^1 + \Delta H^4$ , м
5	116,781	116,777	116,780
6	128,301	128,299	128,302
7	129,913	129,909	129,912
8	123,802	123,799	123,802
Average	124,699	124,696	124,699
$\Delta H^4$	0,003		

The results of transformation, arithmetic-mean values of heights (Hcp), average square error of measurement of heights of  $m_h$ , calculated on Bessel's formula are given in tab. 3

Table 3 – Results of transformations of heights and assessment of accuracy

Num. points	Station 1	Station 2	Station 3	Station 4	Average	ASE
	H, m	H, m	H, m	H, м	Hcp, м	$m_h$ , М
1	125,074	125,076	125,073		125,075	0,002
3	125,625	125,623	125,625		125,624	0,001
4	118,752	118,756	118,753		118,754	0,002
5	116,781	116,776		116,780	116,779	0,002
6	128,301	128,303		128,302	128,302	0,001
7	129,913	129,912		129,912	129,912	0,000
8	123,802	123,801		123,802	123,801	0,001

We will transform the received average values of heights to system of heights  $H^0$  Iso through parallel translation in the vertical plane at a size  $\Delta H$ , calculated on a formula

$$\Delta H = \frac{1}{r} \sum_i^r H_i^0 - \frac{1}{r} \sum_i^r H_i^{cp}, \quad (5)$$

where  $r$  – Number of starting points,  $H^{cp}$  – Average heights,  $H^0$  – Initial heights.

As a result we will receive  $\Delta H = -0,006$  nd we will calculate final values of heights  $H_{ok}$  and the amendment to heights of starting points which are given in table 4.

Table 4 – Final values of heights

Num. points	Start	Final	Corrections
	H <sup>0</sup> , m	Hок, m	v, m
1	125,065	125,069	0,004
3		125,618	
4	118,756	118,748	-0,008
5	116,769	116,773	0,004
6	128,300	128,296	-0,004
7	129,910	129,906	-0,004
8	123,789	123,795	0,006

Analyzing corrections to heights of starting points, we see, the mutual provision of the next points differs from actual on 12 mm (points 1, 4) and on 10 mm (points 7, 8). It once again confirms need of the carried-out works on restoration of high-rise network.

New heights are received with the mean square mistake which isn't exceeding 2 mm that conforms to requirements of location survey accuracy.

#### REFERENCES

1. Геодезические работы в строительстве. Правила проведения : ТКП 45-1.03-26-2006 (02250). – Введ. 07.01.06. – Минск : Минстройархитектуры, 2006. – 62 с.
2. Создание геодезической основы для строительства объектов энергетики / Китаев Г.Г. [и др.] // Известия высших учебных заведений. Геодезия и аэрофотосъемка. – 2013. – № 4/С.
3. Геодезические работы при строительстве мостов / В.А. Коугия [и др.]. – М. : Недра, 1986, – с. 248 : ил. 88.
4. Назаров, И.А. Исследование влияния угла падения лазерного луча и отражающих свойств поверхности на точность измерения расстояний безотражательным электронным тахеометром [Электронный ресурс] / И.А. Назаров // Интернет-вестник ВолгГАСУ. Сер.: Политематическая. – 2011. – Вып. 2(16). – Режим доступа: URL: <http://vestnik.vgasu.ru/?source=4&articulo=548>.

## THE RIGHT WAY TO CHOOSE MOTOR OIL

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*The article provides guidelines for choosing of the motor oil for an automotive engine. Specifications on recommended motor oil are explained in accessible language, understandable to the vast majority of drivers.*

This question is usually asked by car owner when the car warranty period is over. Generally during the warranty period the oil change takes place at an authorized service station with the usage of oil grades which are approved by the car manufacturer and the car owner doesn't usually pay attention to what the exact oil grade is. So what are his options?

The basis for the selection of a particular brand is the recommendations of the manufacturer of your car which are given in the operation manual. If the car is not new and information given in the operation manual is not sufficient, then you need to choose the oil brand by yourself. You'll need to choose:

- the viscosity grade SAE (Society of Automotive Engineers);
- the service rating by ACEA (European Automobile Manufacturers' Association) or by API (American Petroleum Institute);
- mineral, semi synthetic or fully synthetic oil.

**Motor oil classification on viscosity grade by SAE.** Currently accepted international classification system for engine oil viscosity is SAE J300 (Fig. 1), developed by the Society of Automotive Engineers USA. The oil viscosity for this system is expressed in standard units – degrees of viscosity. The larger the number included in the designation of the SAE is, the higher is the viscosity of the oil. Specification describes three series of oil viscosity: winter, summer and all-season.

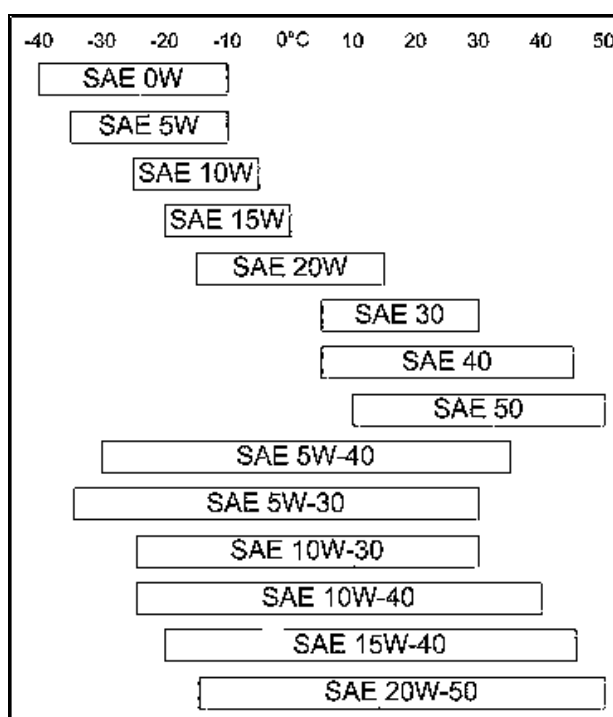


Fig. 1. Oil classification according to SAE J300

A range of winter oils: SAE 0W, 5W, 10W, 15W, 20W, 25W – marked by number and letter “W” (winter).

A range of summer oils: SAE 20, 30, 40, 50, 60 – denoted by the number without the letter designations.

A range of multigrade oils: SAE 0W-20, 0W-30, 0W-40, 0W-50, 0W-60, 5W-20, 5W-30, 5W-40, 5W-50, 5W-60, 10W-20, 10W-30, 10W-40, 10W-50, 10W-60, 15W-30, 15W-40, 15W-50, 15W-60, 20W-30, 20W-40,



20W-50, 20W-60. The designation consists of a combination of winter and summer range separated by a dash. Multigrade oils must simultaneously meet criteria for both winter and summer oil. The smaller the number before "W" is, the less is the oil viscosity at low temperatures, the easier is cold start of engine and the better is pumpability of the oil in the lubricating system. The higher the number standing after the letter "W" is, the greater is the viscosity of the oil at high temperature and the more reliable is lubrication of the engine in hot weather.

#### **How to choose the right grade of motor oil quality**

There are two most common engine oil quality classes:

- API – American Petroleum Institute;
- ACEA – Association of European manufacturers.

Nowadays, the API specification has the following active classes:

– for petrol engines SJ, SL and SM the requirements for the usage can be found in the operation manual for vehicles starting from 2001 year of manufacture. But even if the car is older and in the manual recommends one of the older classes – for example, the SG or the SH – there is no need to search oil with the same quality class by API which has not the most perfect performance. No wonder the recommendations of the car manufacturer sound something like the following: "Recommended engine oil grade not lower than SH API". Thus, the engine oil of the latest classes SJ, SL and SM is absolutely universal (from the point of view of the API);

– for diesel engines of passenger cars, vans, jeeps, etc., CF is a working class which is universal (from the point of view of the API) for all diesel engines.

Unlike the API, ACEA specification takes into account the structural features of the European engines and their operational modes in the European conditions more completely. Its requirements for individual tests greatly exceed the requirements of API. For European cars, of course, we should prefer the oil brands tested according to the ACEA and received the appropriate class of quality according to this specification.

Specification ACEA currently has the following classes:

- for gasoline engines A1-96(98), A2-96, A3-96(98) and A5-02;
- for diesel engines of passenger cars, vans, jeeps, etc. – B1-96(98), B2-96(98), B3-96(98), B4-and B5 98-02.

Oil, which simultaneously meets the requirements of classes A3 and B3, has the most perfect features and is suitable for use in all petrol and diesel engines of passenger cars, vans, jeeps, etc., regardless of the year of manufacture (e.g., Q8 Formula Special, Q8 Formula Excel, Q8 T 670 and Q8 Formula Advanced).

When choosing motor oil look for the information on the existing approvals for use issued by various car manufacturers. The presence of such approval speaks to the fact that the oil was tested at the car manufacturing plant and fully meets the special design requirements of the applicable engines. So, finally, the preference should be given to the oil on the label which is the approval of the car manufacturer.

One should distinguish the phrase on the packaging of oil "meets manufacturer specifications" and "approved by manufacturer". The first case means that the manufacturer of oil unilaterally believes your product is suitable for the usage in engines of certain cars.

The second case refers to the situation when a particular car manufacturer has independently tested a specific product and on the basis of test results issued its own statement endorsing the usage of this product in the engines of their cars. Such tests are very costly, so they can afford only the most eminent manufacturers of lubricants. The rest are limited to the mention of "compliance".

#### REFERENCES

1. Балтенас, Р. Моторные масла / Р. Балтенас [и др.]. – СПб. : Альфа-Лаб, 2000. – 272 с.
2. Гнатченко, И.И. Автомобильные масла, смазки, присадки : справ. пособие / И.И. Гнатченко, В.А. Бородин, В.Р. Репников. – СПб. : ООО «Полигон» АСТ, 2000. – 360 с.
3. Джериков, В.Б. Автомобильные эксплуатационные материалы : учеб. пособие / В.Б. Джериков. – СПб. : Гос. архитектурно-строит. ун-т, 2009. – 256 с.
4. Хитрюк, В.А. Автомобильные эксплуатационные материалы : учеб. пособие / В.А. Хитрюк, А.К. Трубилов. – Минск : РИПО, 2013. – 323 с.
5. Трофименко, И.Л. Автомобильные эксплуатационные материалы : учеб. пособие / И.Л. Трофименко, Н.А. Коваленко, В.П. Лобах. – Минск : Новое знание, 2008. – 232 с.

## OVERVIEW OF SYNCHRONIZATION TECHNIQUES IN ULTRA-WIDEBAND COMMUNICATION SYSTEMS

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*The main synchronization methods for ultra-wideband communication systems are described, the principle of each method to identify the system weaknesses is explained and the requirements for the design of highly stable ultra-wideband telecommunications systems are formulated.*

Trends in the development of ultra-wideband (UWB) communication systems are given due to the presence in them of a number of advantageous factors to narrowband telecommunication systems. Among the advantages the following should be noted: high secrecy link (thanks to the low power spectral density of a UWB signal), high subscriber capacity, the ability to achieve high data rates, good noise immunity [1-2]. Furthermore, due to attenuation of the broadband the short-pulse signal is sufficiently small in different environments [2].

An important factor that contributes to the correct operation of UWB systems is to synchronize the transmitter and receiver. In UWB radiolocation devices the synchronization task is not a technical complexity, because the structure of such systems usually involves placing the transmitter and receiver in a single general corps or the chassis, depending on the structural elements. The transmission clock signal in this case is provided by a standard wireline. But in telecommunications systems, the receiver and transmitter are away from each other at some distance. It is necessary to synchronize them using a wireless communication channel. Today, there are several ways to solve this problem. Thus it is necessary to analyze the existing approaches in order to create optimal criteria for high-precision and stable synchronization in the construction of the UWB communication systems.

**Using two independent channels** (Fig. 1). The essence of the acquisition process is to use two independent radio channels - radio UWB or wideband (WB) with frequency-modulated (FM) and phase-modulated (FM) radio signals, which concurrently uses, for example, a code sequence clock signal. Moments phase changes or frequency of WB radio signal should correspond to the time windows UWB radio signal at the center of each time window. The synchronization acquisition and maintaining it at regular intervals of time, during which the UWB radio signal does not go beyond the time window for all destabilizing factors, are provided by WB radio channel. In the intervals between the clock signals WB radio can transmit other information. Isolation moments phase changes or frequency WB radio signal are carried out in its amplification processes, conversion to an intermediate frequency and to digital form by an analog-to-digital converter (ADC) and the subsequent processing of the wavelet filter [3].

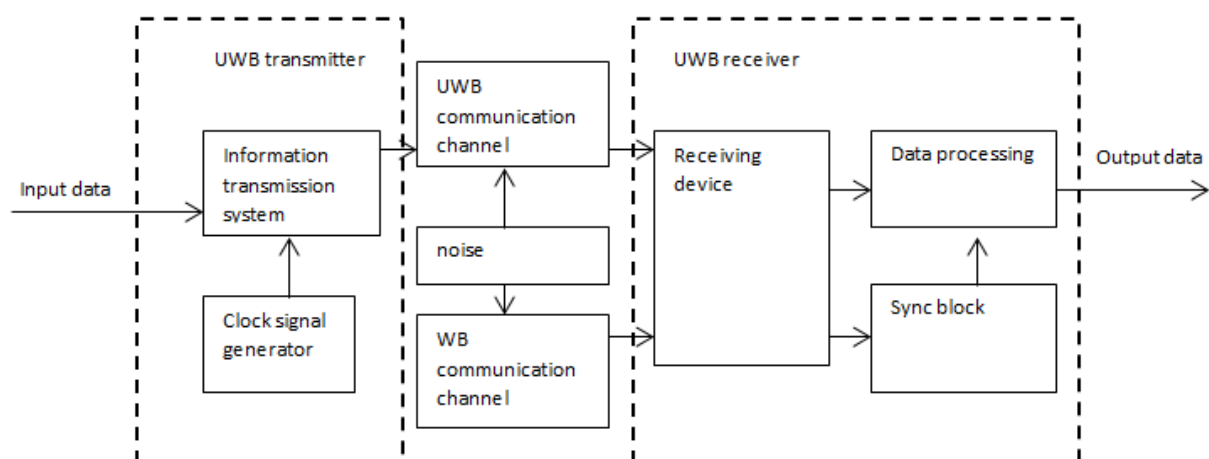


Fig. 1. A generalized block diagram of the UWB communication system with two transmission channels

The disadvantage of this system is the only operation in the absence of multipath in the WB radio channel [4].

**Correlation processing code sequence in the multipath propagation.** Unlike the previous method, the system uses one common channel for UWB communication and data synchronization. The essence of the synchronization acquisition process is to use any part of the code sequence multipath UWB signal [5]. Due to the increased pulse stream, multipath correlation processing operation is carried out with a model pulse stream and, in the case of coincidence of system, synchronization is acquired. When thresholding of at least one part of the reflected multipath after checking for synchronization, the system performs rapid capture. Thus, the method of synchronization is to receive the pulse signal, the measurement model (copies) of the pulse stream, finding a pulse signal due to the shift up pulse stream until they match.

The disadvantage of this system is non-functionality in a mobile version as well as the fact that the condition of multipath unexpectedly varies depending on the distance and the relative position of the receiver and the transmitter [3].

**Method of fast synchronization.** The method for identifying an input UWB signal phase involves several steps: receiving input pulses of UWB signal pulses which arrive adjacent at fixed intervals; local generation of pulses in the UWB receiver; correlation with the local pulse input pulses and receiving the correlation function; determination of the maximum of the correlation function for each shift of local pulses in the UWB receiver, determining a first maximum in the first phase interval, the analysis of the correlation function to find the second pulse which exceeds the first peak; search intervals around the second peak around the second phase interval and determine whether it is indeed the second maximum [3, 6].

**Method of fast synchronization with a floating threshold.** The method consists of receiving the input UWB signal, formation of copies in the UWB receiver, analyzing the input UWB signal and comparing with its copy with a predetermined threshold, receiving the comparison result, a shift input copy when the analysis result is larger than the predetermined threshold, changing the threshold value, repetition of these comparisons, the input offset copies [3, 7].

The disadvantage of the above two methods in the efficiency of the system is only high signal / noise ratio at the receiver input.

**Synchronization with increased accuracy and synchronization stability** (Fig. 2). The structure of this system includes at least two radio stations each of which has a common transmitting (Tx) and reception (Rx) side. The transmitter of the first radio station emits at each interval Tx clock and data signals, and the receiver of the second station receives these signals and using a local digital frequency synthesizer (DFS) based on the pulse-system phase locked loop (PSPLL) tunes and synchronizes its Rx slots at intervals of Tx first radio station to an accuracy of the phase. Increased accuracy is achieved by the fact that the first radio transmitter and receiver of the second station begins to work from one reference oscillator to the first station. Similarly, the second radio transmitter radiates in each interval Tx clock and data signals, the first radio station and the receiver receives these signals, and using the first radio DFS synchronizes their slots Rx Tx intervals of the second station up to the phase. As a result, two PSPLL synchronous systems are formed, each running on its own reference oscillator. The synchronization is saved for all the destabilizing factors and in the high-speed mobile devices [4].

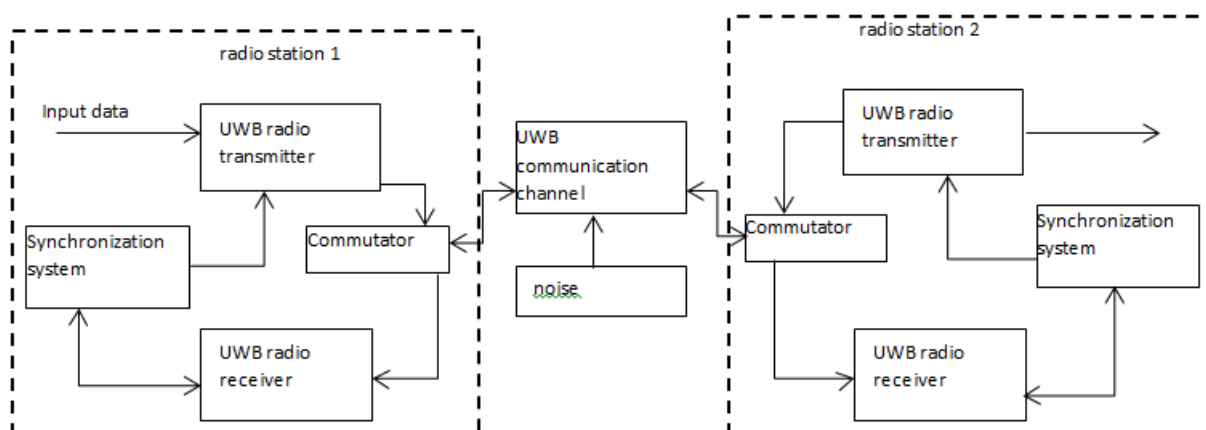


Fig. 2. A generalized block diagram of a UWB communication system with improved accuracy and stability of synchronization

The disadvantage of this method is increasing costs at the time of synchronization acquisition.

As a result of the analysis of the methods, the following general requirements for the device synchronization, when designing a highly stable UWB communication system, were formed: the ability to work in the mobile version of multipath signal propagation, low probability of de-synchronization, high noise

immunity, high degree of synchronization accuracy (up phase) in order to minimize data loss on the receiving side and the minimum time of synchronization acquisition.

## REFERENCES

1. Дмитриев, В. Технология передачи сигналов с использованием сверхширокополосных сигналов (UWB) / В. Дмитриев // Компоненты и технологии. – 2004 – № 1.
2. Шахнович, И.В. Современные технологии беспроводной связи / И.В. Шахнович. – 2-е изд. – М. : Техносфера, 2006. – 288 с.
3. Способ и система связи с быстрым вхождением в синхронизм сверхширокополосными сигналами : пат. RU 2354048 / Г.А. Кыштымов, В.В. Бондаренко, С.Г. Кыштымов. – Оpubл. 27.04.09.
4. Система связи сверхширокополосными сигналами с повышенной точностью и стабильностью синхронизации : пат. RU 2441320 / Г.А. Кыштымов, С.Г. Кыштымов, Е.И. Стецура, И.П. Усачев. – Оpubл. 27.01.12.
5. Method and system for fast acquisition of ultra-wideband signals : pat. US 6925109 / James L. Richards, Mark D. Roberts. – Publ. data 02.08.2005.
6. Ultrawide bandwidth system and method for fast synchronization : pat. US 6925108 / Timothy R. Miller, Martin Rofhear. – Publ. data 02.08.2005.
7. Ultrawide bandwidth system and method for fast synchronization using sub-code spins : pat. US 6967993 / Timothy R. Miller. – Publ. data 22.11.2005.

UDC 629.33

**TIRE RECYCLING IN BELARUS AND THE CIS COUNTRIES**

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*Recycling tires is one of the most pressing challenges posed by the global automotive industry to modern mankind. The dynamic growth of the number of vehicles in developed countries leads to a constant accumulation of waste tires. Modern production is focused not only on the production itself, but also the preservation of the environment, as well as eco-mission feedstock.*

The fact that the bulk of waste tires stockpiled, including those developed spontaneously leads to the following main negative consequences:

- Adverse ecological situation in the areas of landfills;
- Release of toxic substances in fire;
- Inefficient use of resources;
- Violation of international environmental standards.

In addition, Article 15.63 “Belarus Code of Administrative Offences” №194-3 from 21.04.2003 year. It provided for the imposition of an administrative fine for violation of waste management legislation:

- on citizens in the amount of 5 to 50 “basic units”;
- on the SP - 200 “basic units”;
- for legal entities - up to 1,000 “basic units”;

This state of affairs is due to the lack of an organized system of collecting tire wastes. More than half of waste tires generated in the private sector. In this case an ordinary motorist is not ready to take on the costs of transporting tires in the reception point for their further utilization. Operating the processing enterprises mainly work with raw materials coming from legal entities (fleets, tire service, car service, etc.). The main consumers of discarded tires we are undertaking "Krasnoselskstroyaterialy" and Belarusian Cement Plant in Kostjukovichi on which tires are used as fuel. Recycling of tires is also engaged in private enterprise "Ecological Alternative" in Grodno. It is clear that they cannot cope with the entire volume of this type of waste, which the country has more than 65 thousand tons. According to Leonid Litskevich, General Director of JSC "Brestoblresursy" (the enterprise - the main procurer of tires in the Brest region), to take the rubber recycling, rather than simply take to the dump, you need to pay 450 thousand Br for the delivered ton. This money goes to the maintenance and upkeep of the temporary storage sites tires, tires transportation to the place of disposal, and these plants are transferred free bus. Despite the problems of national importance tire recycling, government regulation and funding of this issue is not enough. It is also a clear need in the construction of the Belarusian special plants for the disposal of used tires. Such plants are already operating in Greece and Italy. It is expected that the plant will process about 20 thousand tons of tires a year, the rubber crumb is produced from steel cord – purified high-alloy steel, textiles – pellets. Although the rubber crumb in our country is not widely used, but in great demand in Europe and Russia. In many European countries utilize almost 100% of the old rubber. This occurs as follows. Manufacturers and importers of tires produce permanent benefits, funds from which are used for processing of worn tires. In Russia, we decided to practice a different model, which is considered promising. Reception points are likely to be placed on the car repair. After passing the recycling of tires and their payment will be sent for processing. Technology for processing of old tires is quite simple. It is first cooled and then blown to give small lumps, which are then ground into crumb. The resulting chips are used to repair asphalt, everything playgrounds, roof decking, etc. In general, the idea of recycling old rubber is very correct. After all, for the manufacture of most of the tires used synthetic rubber derived from oil. Correct disposal and recycling of old tires will improve the environmental and economic situation, as it will disappear from the landfill "avtohlama" and will develop resource-saving technologies.

The use of used tires, in addition to containing a rubber technical properties which are close to the original, a large number of reinforcing textile and metal materials, is a source of saving natural resources.

In addition, the elimination of landfill waste tires will free for the intended use large areas of land occupied by them.

In order to successfully address the problem of reuse and recycling of used tires in Belarus is necessary to develop and adopt a set of measures governing the procedure for their accounting, collection, storage and delivery for processing, preparation and promotion at the federal and regional legislation, stimulating an increase in the volume of repair and recycling used tires. also requires the creation of a market of products and materials produced from the resultant with recycling. Such work is already underway for a long time in the United States

and Western European countries, with the active assistance of the World Association of recyclers of tires (ITRA) and ETRA.

## REFERENCES

1. Palgunov, P.P., Sumarokov M. Disposal of industrial othodov / P.P. Palgunov, M. Sumarokov. – M. : Stroyizdat, 1990. – 352 p.
2. Pererabotka worn-out car tires with metal cord / N.D. Rashevsky [et al.] // Ecology and industry Russia. – 2000. – № 12. – P. 17–20
3. Plotnikov R.S. Ecological problems of recycling tires and apparatus for their recycling // Ecology and industry Russia. – 2009. – № 6. –P. 12–13.
4. Kim, K.K. A new method for recycling automobile tires with metal / K.K. Kim // Health and Safety. – 2007. – № 7. – P. 24–27.

UDC 666.97.031:693.542

### A TEST CIRCUIT CHOICE OF COMPOSITE CONCRETE CONSTRUCTIONS FOR CONTACT JOINT STRENGTH TEST

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*A significance of contact joints in Construction is being shown. Presumable test circuits of composite concrete constructions are being analyzed. A test circuit for contact joint strength test is being rated. Contact joints strength is being investigated by the results of a conducted experiment.*

Today it is very perspective to use materials with various properties in many fields of national economy such as mechanical engineering, metalworking, chemical industry, medicine, civil engineering, etc.

The main advantage of using of materials with various properties is the opportunity to compound two or more elements with various characteristics in one product. In the process the advantages of every material individually are being used and in this way the universality of a result product is ensured, along with its combined action and dependable service.

In any field of national economy the usage of materials with various properties combines one thing: combined action of two or more materials which from the beginning can differ in properties, composition and manufacturing technique.

In the field of Construction contact joints are of great significance. From its strength and deformability the further strong combined work of a whole construction or a building is dependent. There are contact joints both in new construction (while manufacturing industrialized components, during concrete pause in monolithic construction, right up to long-delayed construction) and reconstruction. Also there are contact joints in composite reinforced concrete constructions, steel elements, etc.

One of the most important and difficult questions is the investigation of contact joints resistance to shearing action. When shear the work of contact joints has quite a complicated character depending on many factors. At the same time it is very important to investigate shear strength of contact joints because a combined action of adjoined elements and a bearing strength of whole construction are dependent on it [1].

There is a large quantity of investigations in the field of contact joints strength and deformability. There are some of native and foreign researchers: Gvozdev, Gorodetskiy, Mersh, Poliakov, Adamenkov, Medvedev, Valeev, Martynova, Korovin, Lazovski, Vasilyev, Mattock, Kaar, Saemann, Washa, Furtak and many others [2].

In spite of the large quantity of investigations there is a problem to choose a proper form of a model and a test circuit when conducting a shearing test.

The following test circuits of composite concrete constructions are offered by the above mentioned researchers (fig.1):

- a test circuit №1 offered by Gvozdev, Vasilyev and Dmitriev;
- a test circuit №2 offered by Khagger;
- a test circuit №1 offered by Mersh.

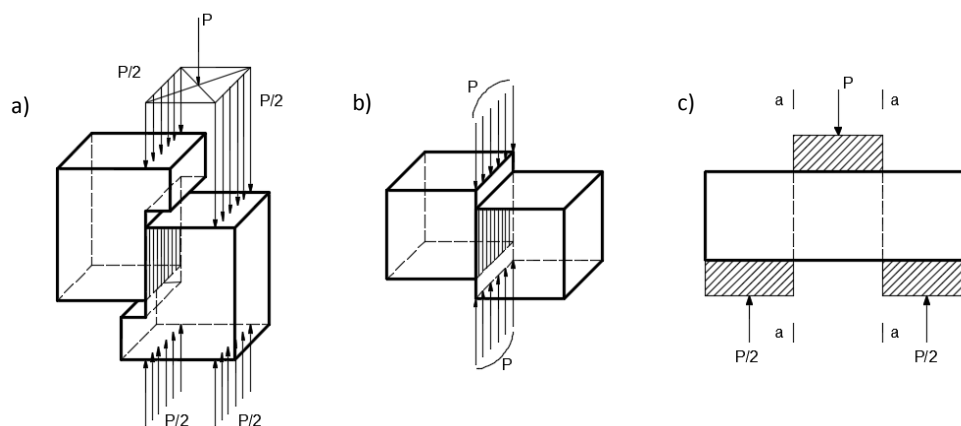


Fig. 1. Test circuits of composite concrete constructions:  
 a – № 1; b – № 2; c – № 3

Test circuit № 1 (Fig. 1, *a*) ensures a shear at the place of a studied section, but it's too cost-based. Test circuit № 2 (Fig. 1, *b*) ensures a shear at the place of a studied section, but the models do not possess resistance and require pin-point accuracy of installation. Test circuit №3 (Fig. 1, *c*) doesn't ensure a pure shear, but the models have a bigger surface of contact in comparison to previous test circuits.

The research work on contact joints strength test of composite concrete constructions is being conducted at Polotsk State University. As the basis of the test circuit test circuit № 3 was laid along with some additional development according to test circuits № 1 and № 2. Test circuit of this kind allows reaching much more accurate results owing to a big area of contact joint between old and new concrete. Also a significant advantage is simplicity of fabrication and economy of materials (Fig. 2).

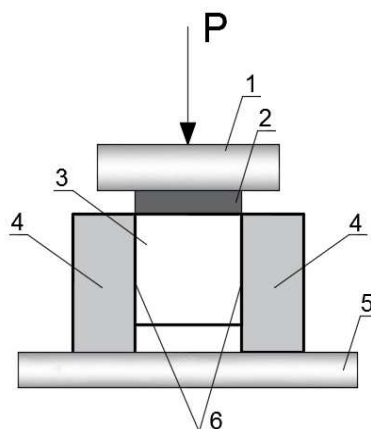


Fig. 2. An experimental test circuit: 1 – a working press rod making a shearing force; 2 – a metal plate, which transfers a load on a middle part of a model; 3 – an “old” concrete; 4 – a “new” concrete; 5 – pressure pad of a press; 6 – a surface of shear

There were the investigations about strength test of contact joints modified with hyperplasticizer STACHEMENT-2000M witnessed according a chosen test circuit. Experimental models were a combination of an “old” concrete (in the middle) and “new” modified concrete (along the edges). A concrete mix of the “old” part was the same for every model. The surface was previously cleaned through cement skim erasing. The sets differed by concrete mix. The first concrete mix of “new” part was without any admixture, the second – with hyperplasticizer STACHEMENT-2000M (table 1).

Table 1 – The strength characteristics of composite elements

Number of a set		The used admixture	Percent of admixture, %	$f_{c,cube}^G$ , MPa of “new” concrete	Conditional strength class of “new” concrete
Without admixture	C2-12-0%	-	0	39,45	C 31,56 / 39,45
With admixture	C2-12-0,7%	STACHEMENT-2000M	0,7	58,67	C 46,94 / 58,67

According to the results of investigations the following deductions were made:

- there is enough quantity of test circuits for shear of composite concrete constructions, but the most efficient have not been discovered yet;
- the research work on contact joints strength test of composite concrete constructions is being conducted at Polotsk State University ;
- the best strength of contact joint is reached when the dosage of the admixture is 0.7% by weight of cement.

#### REFERENCES

1. Скворцов, А.Г. Сопротивление контактных швов железобетонных конструкций при действии сдвигающих сил : автореф. дис. ... канд. техн. наук : 05.23.01 / А.Г. Скворцов. – М., 2000. – 126 л.



2. Хасанов, Р.Р. Прочность и выносливость плоских контактных швов сборно-монолитных железобетонных конструкций в зоне действия изгибающих моментов и поперечных сил : автореф. дис. ... канд. техн. наук : 05.23.01 / Р.Р. Хасанов. – Казань, 2002. – 193 л.
3. Гвоздев, А.А. Изучение сцепления нового бетона со старым в стыках железобетонных конструкций и рабочих швах / А.А. Гвоздев, А.П. Васильев, С.А. Дмитриев. – М. : ОНТИ, 1936. – 54 с.
4. Головнев, С.Г. Сцепление бетона в зоне технологического шва / С.Г. Головнев, С.Б. Коваль, М.В. Молодцов // Вестник Южно-Уральского гос. ун-та. Сер.: Строительство и архитектура. – 2005. – Вып. №13(53). – С. 71–75.

**CONTACT JOINTS STRENGTH OF MODIFIED CONCRETE  
COMPOSITE CONSTRUCTIONS**

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*The availability of modified concrete in industrialized construction, monolithic construction and reconstruction is regarded. The influence of hyperplasticizer STACHEMENT-2000M upon the contact joints strength of concrete composite constructions is viewed. An experimental data analysis of contact joints strength was carried out and inferences about the availabilities of hyperplasticizer in concrete composite constructions were drawn.*

The guaranteeing of strong and solid conjunction of concrete and reinforced concrete composite constructions is a very relevant question relating to new construction (while manufacturing industrialized components, during concrete pause in monolithic construction, right up to long-delayed construction) and reconstruction [1].

Concrete admixtures have found their use all over the world. They enable not only to enhance the mobility of concrete, to increase concrete strength and water resistance, but also to reduce cement content, to increase frost-resistance, rust resistance, to adjust mobility of concrete and rate of strength gain, etc.

There is a large variety of concrete admixtures in Vitebsk region, but the most common ones are the following – S-3, FREM production, STACHEMENT, Penetrat, etc.

Concretes with admixtures possess high technological and running ability properties and can increase final strength characteristics, reduce shrinkage of hardening concrete, so there is a chance to get high-strength concrete and reinforced concrete elements. While using concrete admixtures it is very important to save not only on building materials, but also on energy supply and manpower.

But there is no information about the impact of concrete admixtures on load-carrying ability of a composite construction. Another question is whether a strong combined action of such an element will be ensured. There is a need to carry on an investigation because of insufficient information on the use of modified concrete of combined constructions. The aims of this investigation are as follows: 1) the analysis of strong and solid conjunction of contact joint and 2) further combined action of composite concrete and reinforced concrete elements right up to destruction [2].

To implement a specified goal an investigation into contact joint strength of “old” and “new” concrete with hyperplasticizer STACHEMENT-2000M was carried out.

The investigations were conducted on  $\Pi$ -shaped composite elements. STACHEMENT-2000M was added to concrete mix of “new” concrete. An “old” concrete was without any admixture. An experimental model is shown on Fig. 1.



Fig. 1. An experimental model

Experimental models were designed to determine such a concrete mix of a “new” concrete, which will ensure the highest strength of concrete joint. The investigation was approached to real conditions. In this connection every “old” concrete element was of the same strength class and they were 1.5 years of age. The first concrete mix of a “new” concrete model was without any admixture (a reference specimen C1-6-0%, C2-12-0%). The second concrete mix was with hyperplasticizer STACHEMENT-2000M (0.7% by weight of cement) and with water variation in such a way that a slump test changed (C2-12-0.7%, C1-18-0.7%).

Composite construction manufacturing technique of every element was equal and was confined as follows: the “new” concrete was put onto a prepared surface of the “old” concrete element. The surface was previously cleaned through cement skim erasing [3]. Before putting the “new” concrete the surface of the “old” element was moistened.

While carrying out the investigations we identified the contact joint strength. The mode of failure of experimental models was investigated. The results of investigations are showed in table 1.

Table 1 – The strength characteristics of composite elements

Experimental model		A percent of admixture used, %	A slump test, cm	$f_{c,cube}^G$ , MPa of “new” concrete	Conditional strength class of “new” concrete
With admixture	C2-12-0,7%	0,7	12	58,67	C' 46,94 / 58,67
	C1-18-0,7%	0,7	18	46,75	C' 37,4 / 46,75
Without admixture	C1-6-0%	0	6	45,75	C' 36,6 / 45,75
	C2-12-0%	0	12	39,45	C' 31,56 / 39,45

The analysis of the mode of failure shows that every experimental model broke down in the place of contact between the “old” element and the “new” element. The failure had an abrupt character. The models with admixture had adhered parts of the “new” concrete on the surface of the “old” concrete element and the surface of the models without admixture was clean and smooth (Fig. 2).

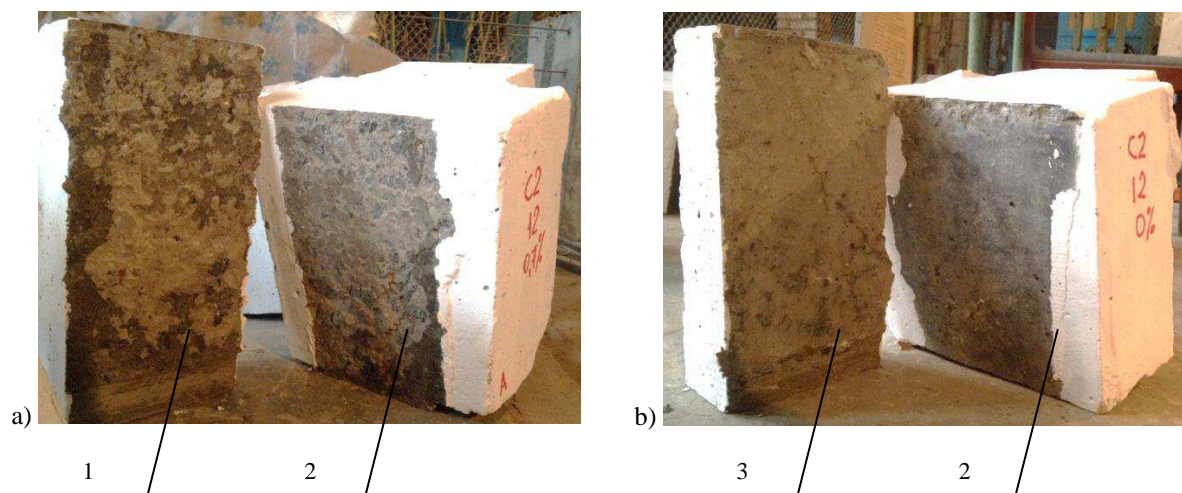


Fig. 2. A general view of failure models: a) with admixture, b) without admixture; 1 – “new” modified concrete, 2 – “old” concrete, 3 – “new” concrete without admixture

According to the results of the investigations the following deductions were made:

- The contact joint strength when hyperplasticizer STACHEMENT-2000M of 0.7% by weight of cement was added is superior to the reference specimen (models without admixture);
- The contact joint strength when hyperplasticizer STACHEMENT-2000M was added and with a slump test of 12 cm is superior to the models with a slump test of 18 cm;
- When hyperplasticizer STACHEMENT-2000M is added the contact joint strength is 1.5 and even higher that can guarantee a strong and solid conjunction of “old” and “new” concretes and also ensures combined action of composite elements.

## REFERENCES

1. Чикалина, О.П. Усиление железобетонных конструкций намоноличиванием с применением модифицированных бетонов : автореф. маг. дис. ... магистра техн. наук : 05.23.01 / О.П. Чикалина. – Новополоцк, 2003. – 77 с.
2. Головнев, С.Г. Сцепление бетона в зоне технологического шва / С.Г. Головнев, С.Б. Коваль, М.В. Молодцов // Вестн. ЮУрГУ. – 2005. – № 13. – С. 71–74.
3. Хаменок, Е.В. Особенности подготовки контактных швов в строительстве / Е.В. Хаменок // Труды молодых специалистов Полоцкого государственного университета. Строительство. – 2007. – Вып. № 22. – С. 64–66.
4. Изделия строительные железобетонные и бетонные заводского изготовления. Методы испытаний нагружением : ГОСТ 8829-94.
5. Бетоны. Методы определения прочности по контрольным образцам : ГОСТ 10180-2012.

UDC 912.4+94

## GEOINFORMATION ANALYSIS OF HISTORICAL MAPS OVER POLOTSK REGION

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*The article presents the results of application of geoinformation technologies for analysis of historical and modern maps over the territory of Polotsk, Novopolotsk and surrounding area to study dynamics of socio-topographic factors from 18<sup>th</sup> century up to now.*

**Introduction.** Historical maps are an important and quite objective source of information about the area, the living conditions of people of a certain historical period. Analysis of series of historical maps let us evaluate the historical aspects of the dynamics of the natural and built environment, land use planning, land development and their consequences, look into the past of modern settlements, assess the pace of their development.

A number of historical cartographic data over the territory of Polotsk including surrounding area are known. Among them are two plans of Polotsk from 1579, plan of Polotsk from 1707, plan-reconstruction of the 16-17th centuries, plan of 1779, recovery plan of the city of 1778, two plans of the 18<sup>th</sup> century, a number of plans and maps of the 19 – 20th centuries, as well as the frescoes in the Vilna church of St. Francis and Bernadine depicting Polotsk in the middle of the 16th century. The study of these data is done by a number of scientists [1-3].

Over the last twenty years along with other methods of historical analysis geographic information systems (GIS) have been applied to conjugate analysis of multitemporal spatial data. Despite the undeniable advantages of GIS applications for the analysis of spatial data, the use of GIS in historiography is still quite limited.

**Methods.** In current work GIS is used for analysis of the historical and modern maps from 1790 up to now to study the historical and topographical conditions of the territory of Polotsk region (appr. 20 x 25 km<sup>2</sup>) including Polotsk, Novopolotsk and the surrounding area. Maps of 1790, 1861, 1939 and 1989 are downloaded from Internet [4-6]. The scale range of the maps of the 18 – 20th centuries is 1: 84 000 – 1: 200 000. Data from OpenStreetMap [7], public land information map of the Republic of Belarus [8], public cadastral map of the Republic of Belarus [9] are used as sources of modern cartographic data. The list of settlements of Vitebsk province [10] issued by Vitebsk Regional Committee in 1906 is also used in order to obtain information about the population of settlements of study area.

Among the main components of the natural and built environment analyzed in current study are the territorial changes of settlements, population distribution. Changes of lakes, rivers, forest areas as well as road network are also analysed for mentioned years.

Current study involves the following steps:

- georegistration and transforming of data into WGS 84,
- digitizing of boundaries of settlements and other objects of interest and forming groups of thematic layers for each historical map (year) of study,
- joint analysis of multi layers, qualitative and quantitative data analysis.

Data analysis is performed using QGIS software – a free cross-platform GIS.

Georegistration and transformation is quite time-consuming and laborious process. In order to identify changes in objects between two dates presented by corresponding maps one needs to have maps in common projection and coordinate system. The base cartographic data to which all maps are bound is OpenStreetMap data in the WGS-84 coordinate system. If the original projection and coordinate system of a map are known, map has coordinate grid, than georegistration is as follows: the definition of projection and the parameters of the original map, determining of map in its theoretical coordinate system, than transforming of the original map into the coordinate system of the base map. However, for a number of historical maps it is quite difficult. Georegistration of the General land survey map of 1790 is the most trouble due to lack of information about the projection and coordinate system. Also significant changes of the territory have taken place for more than two hundred years. In this case it is necessary to perform transformation (binding) using ground control points (GCP). It is necessary to find such facilities on the old map, which have not changed their position up to now. It may be junctions, engineering objects etc. Using GIS software these objects are assigned coordinates. The maximum possible number of points are used for more accurate georegistration considering also unknown quality of scanning of the original paper copies of historical map. One must also consider specific features of mapping for a specified time period including systems of cartographic symbols, possible changes in the position of objects. In 1790 railroads did not exist. Some objects located on historical maps have not changed their position for a certain period of time. Definitely it is difficult to say by visual analysis of map whether the object has remained at the same place or not. For example, the road leading to Trosnitsa village located a few meters to

the north from current location. In some cases shift of an object may be probably within the accuracy of the map. For a more accurate transformation of maps one needs still to know the projections and coordinate system. Nearest neighbor method is used for resampling.

Digitizing of maps means the process of translating the original (analog) map into digital form. Digitizing is performed here during manual vectorization. Digitizing is carried out for 4 key dates represented by corresponding historical maps. Each map layer finally contains polygons of three categories: settlements, forest, hydrography. Linear layers are created for the road network (divided into types).

On historical maps the boundary of settlements are considered as city line or boundary of built-up area.

**Results.** In this paper the analysis of 4 main historical maps as well as contemporary historical maps over Polotsk region is conducted. The paper analyzes the historical and topographical conditions presented for main years: 1790, 1861, 1939, 1989 and 2015 by categories: settlements, forest, hydrography, the road network. As a result of work maps of the dynamics of the territory of Polotsk on 5 major time slices during the last 225 years is done.

Polotsk and Novopolotsk have been developed rapidly and expanded to the surrounding areas including rural settlements. Rapid growth of Polotsk was in the second half of the 19th century and the first half of the 20th century. This is due to the technological revolution, industrialization, the construction of railroads etc. With the growth of Polotsk rural settlements were included in the city limits (e.g. Боровая, Лазовка, Синицы, Пристеницы, Спас, Тогарщина, Селюны, Козьи Горки, Гозбузянщина, Присмироки, Борисовский etc).

On the territory of modern Novopolotsk (found in 1958) in 1905 the population was 1557 people and in 1938 it was 4060 people (villages Новый Бор, Хамлы, Подкастельцы, Василевцы, Плаксы etc). For comparison, the current population of Novopolotsk (in 2015) is 108,2 thousand people.

For 225 years analyzed in current study the names of some settlements of Polotsk region were lost. The reason is either complete disappearance of the resident population, or a change of name. Among the extinct settlements are Жабино, Вечгровы, Старонивье, Сеферовщина, Способы, Яськово, Анкудово, Рафиловка, Яциново, Середники. Some settlements were enlarged by annexing of nearest villages.

By the end of the 18th century settlements occupied only approximately 2.5% of the study area, but the number of settlements was much higher than now. The percentage of forest area was about 60%.

By the mid-19th century there were the first railroads. Production and trade prompted the city of Polotsk to rapid growth. Together with the industrialization there was a need in the fuel, which led to a reduction of more than a third of the areas occupied by forest by 1938. Settlements occupied approximately 5 % of study area. By 1989 settlements occupied already almost 14.5% of study area.

**Discussion and conclusion.** Geographic Information System is a powerful tool for analyzing historical topographical conditions using historical maps.

On the one hand historical maps let us study living condition of the past. On the other hand, multi-temporal analysis of historic and modern maps allows more detailed examination of the principles of mapping of a certain time period.

One should not forget that maps are not absolutely objective data. It should be noted that maps pass through the head and hands of a cartographer and therefore have a certain degree of subjectivity.

The results of using of GIS for analysis of historical maps over Polotsk region as well as quantitative assessing may help to expand the methodological basis of studying the historical topographical conditions of the territory of Polotsk and its surroundings. However, fairly wide range of scales of maps (the scale of historical maps of 1790 – 1989 is within 1: 84 000 - 1:200 000), the difference in survey methods, generalization, georegistration of maps, the mathematical basics of maps should be considered when using the results.

Work continues towards the formation of a historical GIS of Polotsk, refinement of the preliminary results, attracting additional maps and reference materials as well as satellite data.

## REFERENCES

1. Тарасов, С.В. Историко-топографическая структура Полоцка IX–XVII вв. [Электронный ресурс] : автореф. дис. ... канд. истор. Наук : 07.00.06 / С.В. Тарасов ; Институт истории АН Беларуси. – Минск, 1992. – 27 с. – Режим доступа: <http://cheloveknauka.com/v/402374/a/#?page=1>. – Дата доступа: 19.09.2016.
2. Дук, Д.У. Полацк XVI–XVIII стагоддзяў: нарысы тапаграфіі, гісторыі матэрыяльнай культуры і арганізацыі жыццёвай прасторы насельніцтва беларускага горада / Д.У. Дук. – Наваполацк : ПДУ, 2007. – 268 с.
3. Иезуиты в Полоцке: 1580 – 1820 гг.: в 2 ч. / сост., примеч. и вступ. ст. Л.Ф. Данько, А.И. Судник. – Полоцк: А.И. Судник, 2005. – Ч. 1. – 40 с.
4. Былое и глобус [Электронный ресурс]. – Режим доступа: <http://orda.of.by/.map>. – Дата доступа: 15.07.2016.

5. Старая карта вашей местности [Электронный ресурс]. – Режим доступа:<http://starayakarta.com>. – Дата доступа: 15.07.2016.
6. Знайдзі свае карані у Беларусі і Літве [Электронный ресурс]. – Режим доступа: <http://www.radzima.net>. – Дата доступа: 15.07.2016.
7. Openstreetmap [Электронный ресурс]. – Режим доступа: <http://www.openstreetmap.org/>. – Дата доступа: 23.01.2017.
8. Публичная земельно-информационная карта Республики Беларусь [Электронный ресурс]. – Режим доступа: <http://gismap.by/mobile/>. – Дата доступа: 23.01.2017.
9. Публичная кадастровая карта Республики Беларусь [Электронный ресурс]. – Режим доступа: <http://map.nca.by/map.html>. – Дата доступа: 23.01.2017.
10. Список населенных мест Витебской губернии / Витебский губернский статистический комитет, В.-1906. [Электронный ресурс]. – Режим доступа: <http://dlib.rsl.ru/viewer/01003739130#?page=7>. – Дата доступа: 23.01.2017.

**DEVELOPMENT OF METHODS FOR LIQUIDATION OF PIPELINES WHICH WERE BUILT BY HORIZONTAL DIRECTIONAL DRILLING***DZMITRY KISIALIOU, ANDREI KULBEI***Polotsk State University, Belarus**

*The problem of the elimination of pipelines by HDD under natural and artificial barriers is examined in this article. The modern methods of the elimination of pipelines are analysed. The advantages and disadvantages of alternative methods are formulated. The alternative methods of the elimination of pipelines are suggested.*

One of the alternative construction methods and perhaps the fastest-growing technology in the trenchless industry is horizontal directional drilling (HDD). HDD has experienced rapid growth in the construction industry over the past few decades. The horizontal-directional-drilling process represents a significant improvement over traditional cut-and-cover methods for installing pipelines beneath obstructions, such as roadways, driveways, historical areas, landscaped areas, rivers, streams, and shorelines, which warrant specialized construction attention.

The basic components of a horizontal directional drilling system include:

- Drill unit;
- Guidance system;
- Drilling fluid system;
- Drill pipe and downhole tools, including bits and back reamers;
- Drilling fluid mixing or recycling system.

Installation of a pipe by HDD is usually accomplished in three stages. The first stage involves directional drilling of a small-diameter pilot hole along a designed directional path. The second stage consists of enlarging (reaming) of the pilot hole to a diameter that will support the pipeline, and the third stage consists of pulling the pipeline back into the enlarged hole.

**Pilot Hole.** The first step in a HDD installation is to drill a carefully guided pilot hole that delivers the drill bit and bore head to the surface at the specified exit point. The bore is launched from the surface, and the pilot bore proceeds downward at an angle until the necessary depth is reached.

**Reaming.** Once the pilot hole is successfully drilled, the hole is often enlarged to a suitable diameter for the product pipeline. For instance, if the pipeline to be installed is 8 inches in diameter, the hole may be enlarged to 12 inches or more. This is accomplished by reaming the hole to successively larger diameters. Generally the reamer is attached to the drill string on the bank opposite the drilling rig, rotated, and pulled (pushed in some instances) back through the pilot hole.

**Pullback.** Once the drilled hole is enlarged, the product pipeline can be pulled through it. The pipeline is prefabricated and usually tested on the bank opposite the drilling rig. A reamer is attached to the drill string and then connected to the pipeline pull head via a swivel. The swivel prevents any translation of the reamer's rotation into the pipeline string, allowing for a smooth pull into the drilled hole. The product pipe has to be supported for the pullback operation [1, 2].

The process of liquidation pipelines can be accomplished by total unearthing, which involves a huge-scale digging. On the other hand, pipelines can be liquidated by pulling them out from the ground. This method demands a great force.

The main aims of this work are to elaborate on some methods for the liquidation of pipelines and to analyse some operational methods.

There are two methods of repairing pipelines: "pipe in pipe" and "breaking".

**Method of "pipe in pipe".** This method is based on the insertion of new pipelines in old ones. It is realized through the trench at the beginning of the site by pushing the previously welded stalk which has a smaller diameter.

The advantages of this method are:

- minimum friction in the inner surface;
- the pipe has no contact with the surrounding ground;
- repair works do not disturb the traffic;

The disadvantages of this method are:

- the decrease of pipelines diameter;
- the necessity of previous cleaning.



**Method of “breaking”.** This method is used when we need to keep or increase the diameter of pipelines. In this case we need to put some bars through the pipelines to be liquidated. Knife-reamer is fixed on the end of the initial bar which attaches with a new pipeline via a swivel. The bars are extracted cyclically and the process lasts until the full withdrawal of knife-reamer from the trench. The old pipeline is cut, widened and a new pipeline is pulled into an old one simultaneously [3].

The advantages of this method are:

- high performance (more than 100 meters of pipelines per day);
- the possibility of replacement of a similar pipe or the increase of the diameter of the existing pipe;
- repair works do not disturb traffic.

The disadvantages of this method are:

- environmentally unfriendly;
- the necessity of previous cleaning.

Then let us consider some alternative methods of the liquidation of pipelines.

The methods suggested below are aimed to decrease the force between the pipeline and the surrounding ground.

**Method of parallel drilling.** This method is based on drilling some parallel holes by HDD. The holes are drilled parallel with the old pipeline. It permits to decrease the force between the old pipeline and the surrounding ground. The quantity of holes is calculated. This method is presented in Figure 1.

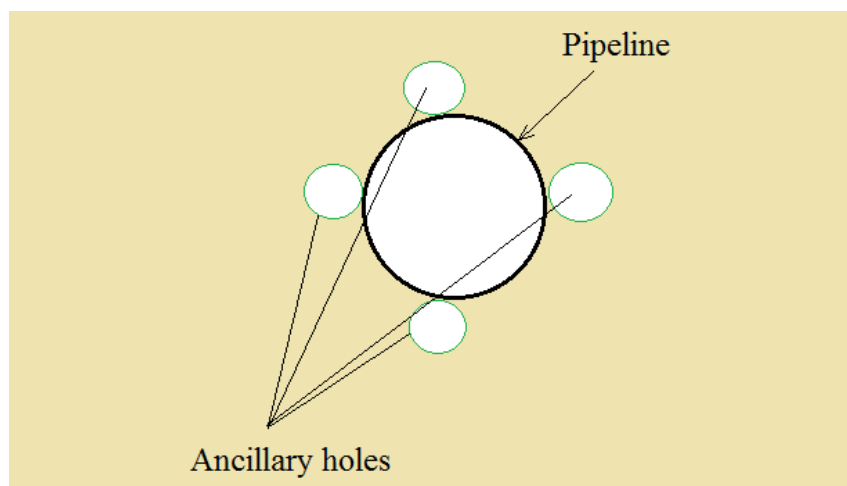


Fig. 1 Method of parallel drilling

The advantages of this method are:

- use of standard equipment (HDD rig);
- environmentally friendly;
- possibility of replacement of a similar pipe or the increase of the diameter of the existing pipe;
- repair works do not disturb traffic.

The disadvantages of this method are:

- high cost;
- demands high accuracy.

**Method of the mechanical separation of pipelines from the ground.** This method is based on the installation of some special equipment, which can separate the pipeline from the ground along the full length of the pipeline. This method is presented in Figure 2.

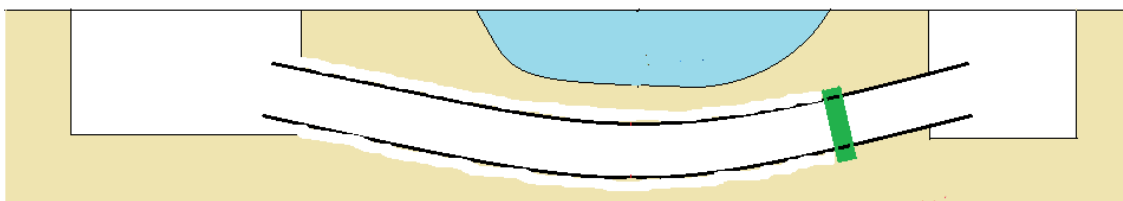


Fig. 2. Method of the mechanical separation of the pipelines from the ground

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Technology, Machine-building, Geodesy

The advantages of this method are:

- environmentally friendly;
- possibility of replacement of the similar pipe or the increase the diameter of the existing pipe;
- repair works do not disturb traffic.

The disadvantages of this method are:

- use of special equipment;
- big power inputs of this method.

**Conclusion.** In this work the operational methods have been analysed. The advantages and the disadvantages of these methods have been presented. Some alternative methods of the liquidation of pipelines have been suggested. Their advantages and disadvantages have been discussed.

## REFERENCES

1. David, A. Horizontal Directional Drilling / A. David. – Willoughby, 2005.
2. Сооружение подводных трубопроводов : учеб. пособие для вузов / Б.В. Самойлов [и др.]. – М. : Недра, 1995. – 304 с.
3. ООО «Микроцит» [Электронный ресурс]. – 2017. – Режим доступа: <http://www.beztranshey.ru/bestranshtech/methodsanac>. – Дата доступа: 03.01.2017.

UDC 614.83:66.02

## THE ANALYSIS OF THE INDUSTRIAL SECURITY LEVEL ACCORDING TO THE INTEGRAL CRITERION IN A BELARUSSIAN OIL REFINERY

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The following systematized data about frequency of accidents and their reasons (incidents, work injuries and occupational diseases) at one of the oil refineries of the Republic of Belarus over the period of 1967 – 2015 are based on the official statistical reporting. The analysis of the industrial security level was carried out according to the integral criterion. The obtained results could be the base for the prediction of the number of accidents and the reference point on addressing the regulated causes.

**Introduction.** The modern oil refinery is a complex technological unity, including process equipment, infrastructure and associated structures. It is characterized by the high threat level due to the use of toxic chemicals, hazardous chemicals, causing fire and explosion during the technological process, which can be the reason for accidents and incidents, work injuries and occupational diseases, with severe consequences like human losses, material-technical and financial losses and harm to region's ecology.

**Methods of research.** The accidents (incidents, work injuries and occupational diseases) were analyzed, which had been subjected to statistical recording in the largest oil refinery of the Republic of Belarus in terms of the processing of raw materials. The archival materials and accounting over the period of 1967 – 2015 were explored using the statistical method of analysis. The picture below shows the dynamics of crude oil distillation's volume and the number of accidents at the oil refinery.

**Results, their discussion and perspectives.** Over the indicated period of time 5 accidents, 8 occupational diseases, 513 work injuries and 614 incidents (refusals, injures and violations referred to incidents) were registered at the factory (Fig. 1).



Fig. 1. The dynamics of crude oil distillation's volume and the number of accidents. Years with number of: a – accidents; b – occupational diseases; c – fatal accidents

The retrospective analysis of the causes of accidents and incidents was carried out. The results are presented in Table 1. From Table 1 it is seen that the most frequent causes of accidents and incidents (about 30%) are connected with 'human factor', such as unskilled and erroneous activities of the staff, erroneous command transmission, un-cooperation, low-quality assembling and repairing work, violations of instruction or plan of the execution of works, implementation of hot works in an unprepared place. But the number of accidents and incidents caused by these reasons tend to reduce over a ten year period of observation. Causes connected with equipment failure due to its physical aging and conditioned by failure of electricity supply due to short circuit and insulation faults of supply cables are on the 2nd and 3rd places.

Table 1 – The dynamics of accidents and incidents' causes in the factory

Accidents and incidents' causes	% of the accidents and incidents number over the period of					
	1970–1979	1980–1989	1990–1999	2000–2009	2010–2015	1967–2015
Violations of production procedures' rules, instructions requirements, fallacious activities	46.15	27.92	24.22	17.61	4.55	24.51
Equipment failure and aging of equipment	4.40	24.87	18.75	13.21	11.36	15.68
Insufficient operating conditions of electrical equipment	4.40	15.74	10.16	25.16	4.55	13.70
Corrosion and erosion of equipment	2.20	4.57	7.03	6.29	15.91	5.63
Malfunction of control equipment and automation	6.59	2.03	7.81	6.92	6.82	5.18
Faulty installation and repair of equipment	8.79	8.12	3.13	1.89	2.27	4.87
Natural phenomena	3.30	4.57	3.91	6.92	2.27	4.41
Gasketdamage	6.59	4.06	3.91	5.03	4.55	4.41
Shafts burnout because of localized overheating and coke deposits	4.40	3.05	3.13	2.52	13.64	3.65
Constructional defects	6.59	3.05	1.56	2.52	6.82	3.20
Low quality of welds	-	4.06	2.34	1.26	9.09	2.59
The safety valve disruption	2.20	2.03	2.34	1.26	6.82	2.13
Overflow of tanks and industrial savage systems	4.40	3.05	0.78	1.26	-	2.13
Plugs, ingress of solid particles, accumulation of resinous compounds	3.30	1.02	2.34	3.14	-	1.98
Hydraulic shock, ingress of liquid in compressor cylinder	-	0.51	2.34	2.52	2.27	1.37
Project faults of process	1.10	1.02	2.34	0.63	-	1.07
Self-ignition of substances	1.10	-	4.69	-	-	1.07
Others	2.20	1.02	2.34	3.14	9.09	2.44

Moreover the dynamics of accidents and incidents number growth connected with insufficient operating conditions of electricity supply, as well as with corrosion of equipment is noticed.

Technological plants with the highest frequency of accidents and incidents rise are determined during the topographical analysis.

And 17.61% of incidents occur in a complex of crude oil distillation plants (EDP (Electrical Desalting Plant) AVD (Atmospheric Vacuum Distillation)-6, EDP AVD-2, AT(Single-flash pipe still)-3, AT-8, VT(Vacuum pipe still)-1, 'Purification', etc.), 13.57% are at the catalytic reformer. 12.92% are at the hydrofining of fuels plants. 7.43 % are in the complex 'Hydrocracking' and installation of soft hydrocracking. 6.46% are at plants complex on receipt of single aromatic hydrocarbons (releases of gross xylols, 'Tataray Unit', 'Detol', isomerization of xylols, receipt of paraxylene, orthoxylene, pseudocumene, ethylbenzene, etc.). 5.82% are at the electricity supply shop. 5.49% are at the commodity shop. 2.75% are at the plants for receipt of additives, sulfuric acid and in the recirculated water unit. 2.42% are at the plant 'Visbreaking-Thermal craking'. Deasphalting plant (3.23%), oils dewaxing plant (2.42%), oils selective treatment plants (1.94%) and bitumens production (1.62%) are singled out among other plants of oil lubricants and bitumens' production in frequency of accidents and incidents' causes.

The correlated connection between the size of primary oil distillation and the amount of work injury at the factory was fixed, the linear dependence between the lowering of the absolute number of accidents over the showed follow-up period ( $R_2 = 0,67$ ) and the low operating effectiveness of work safety system between 1996 and 2003 was confirmed.

The analysis of the structure of industrial injuries by kinds of accidents showed that 72.51% of accidents were brought by mechanical rammers, thermal burns account for 17.93% and chemical burns – 7.02%.

Distribution analysis of industrial injuries for petroleum-refining industry showed available lines and places with high injury risk and on the first place is the Oil fuel and aromatic hydrocarbon industry (19.16% of accidents), on the second place is the industry of Lubricating oils and bitumens (18.96% accidents), on the third and the fourth places are ancillary proceedings - Repair's proceeding (13.37%) and Commodity department (12.58%).

The highest number of victims at the factory was fixed among processing stations operators. That is 19.88% injuries of the total number, metalworkers – 18.32% and 8.58%. This can be explained by the fact that these workers make up the greater part of the labour force at the plant. In Table №2 are the results of analysis of reasons of injuries for the period between 1963 and 2015.

The retrospective study of the industrial injures at the factory shows, that about 80% of the industrial injures have organizational disruptions, linked to the human element and about 20% - to technical reasons. The safety engineering violation by the workers and victims' personal carelessness are the main reasons for industrial injures at the factory (23.11% and 19.72% of the total industry injuries number). The analysis of every ten years can tell the downtrend of the number of injures because of safety engineering violation by victims or by other people and because of application of dangerous work performance. It can be related to the rise in workers preparation level, in their competence in the protection of labour area and the improving of work by their study, instruction and administrative control toughening. Over the investigated periods attention was paid to the growing number of injuries because of victims personal carelessness, for the most part, because of dropping on the surfaces at the time of transportation.

Table 2. – Analysis of the industrial injuries causes

Cause	% of the whole injures number	% of the injuries from the NS number over the definite period					
		before 1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–2015
Safety specification's violation by the victim	23.11	27.47	24.82	25.74	20.72	16.18	7.41
Victim's personal carelessness	19.72	15.32	10.28	20.88	18.57	33.83	62.96
Safety specification's violation by other people	8.96	9.01	10.64	15.05	11.43	8.83	3.70
Unsatisfactory work organization	8.57	8.11	12.77	5.34	11.43	10.29	-
Application of dangerous work performance	8.76	7.66	6.74	2.91	2.14	1.47	14.81
Disrepair of facilities, mechanism and devices (including corrosion and aging equipment)	8.17 (1.67)	3.6 (0.90)	7.09 (0.71)	6.79 (1.94)	7.85 (2.14)	7.35 (2.94)	3.70 (3.70)
Personal protection equipment non-use	5.38	6.31	5.67	3.88	3.57	7.35	3.70
Unsatisfactory work places keeping	2.99	2.70	2.48	4.37	5.00	2.94	-
Careless and criminal activity by other people	1.79	0.90	-	0.97	2.86	2.94	-
Unsatisfactory wheeling and territory state	2.72	0.90	2.84	2.91	5.71	0.00	-
Design defects of means of production	2.72	6.31	2.84	2.91	6.43	4.41	-
Deficient victim's informing	2.39	8.11	10.99	4.37	1.43	-	-
Flowsheets imperfection	1.39	2.70	2.84	2.91	-	2.94	-
Personal protection equipment's neediness	1.00	0.90	-	-	-	1.47	-
Others	1.00	-	-	0.97	2.86	-	3.7

By these materials since the start of production activities of the factory, eight cases of occupation diseases were officially registered. The professional chronic intoxication with petrochemicals (hydrocarbons, benzol and it's homologue etc.) was diagnosed in 75% of cases, one incident was bronchial asthma and one – functional hand overstrain. The main occupational disease cause in 62.5% of incidents is long contact with petrochemicals in high resistances.

Analysis of the state of accident rate, occupational diseases and traumatism at a factory was the basis for the valuation of the safety at a factory by the integral criterion that took into account production and number of expressed accidents:

$$K_{\text{ПБ}} = \frac{\text{Д}}{\sum_{i=1}^n N_i \alpha_i} \quad (1)$$

$K_{\text{ПБ}}$  – the level of safety at a factory;

$\text{Д}$  – production, mln. tons / year;

$N_i$  – number of parameter;

$\alpha_i$  – coefficient of parameter concernment.  $\alpha_i = \bar{N}_{\text{un}} / \bar{N}_i$  ( $\bar{N}_{\text{un}}$  – average number of accidents over the definite period;  $\bar{N}_i$  – average number of accidents over the same period).

Index of dynamics of safety level at a factory over the period of 1969 and 2015 is on figure 2.

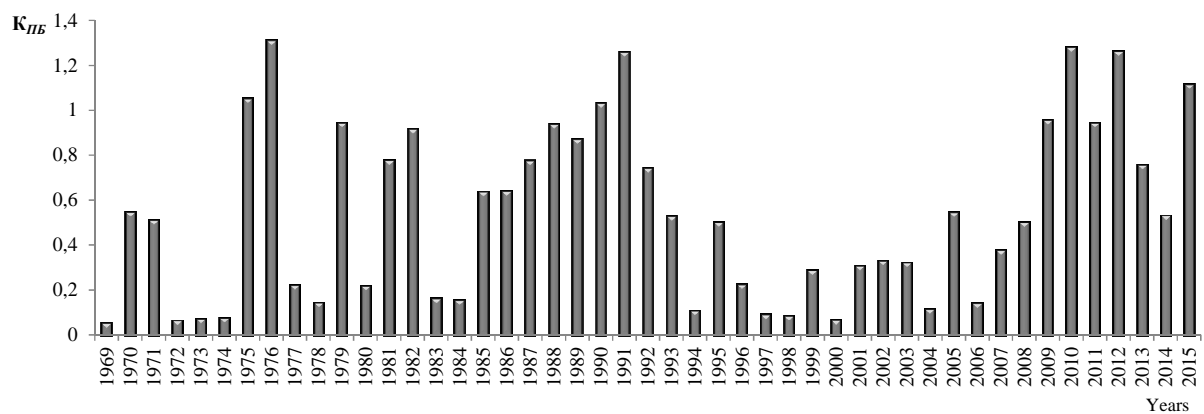


Fig. 2. Dynamic of safety level in factory

**Conclusion.** We can see that safety level at a factory has risen for the last ten years. These results can be basis to prediction of the number of accidents and to reference point to elimination dirigible causes of their rise.

#### REFERENCES

1. Булавка, Ю.А. Анализ производственного травматизма на нефтеперерабатывающем предприятии / Ю.А. Булавка // Вестник Полоцкого государственного университета. Сер. В, Промышленность. Прикладные науки. – 2011. – № 3. – С. 130–137.
2. Булавка, Ю.А. Анализ инцидентов на нефтеперерабатывающем предприятии / Ю.А. Булавка, О.О. Смиловенко, Е.В. Сташевич // Вестник Командно-инженерного института МЧС. – 2012. – №2(16). – С. 69–76.
3. Булавка, Ю.А. Апостериорная оценка состояния аварийности на нефтеперерабатывающем предприятии / Ю.А. Булавка, О.О. Смиловенко, П.В. Коваленко, Е.В. Сташевич // Вестник Полоцкого государственного университета. Сер. В, Промышленность. Прикладныенауки. – 2012. – № 9. – С. 122–128.

UDC 629.123: 665.61

**THE INFLUENCE OF QUICKLIME ON THE QUALITY  
OF EMULSIONS FOR RELEASE COATING****VIKTOR KRASOVSKY, VLADIMIR DRONCHENKO, VLADIMIR IVANOV**  
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*Experimental studies do not influence the quality of lime-based emulsion of oily waste containing fuel fractions, for use as a release coating forms during the manufacture of concrete products. The recommendations of practical use are given.*

**Introduction.** Oily waste products and solutions of technical detergents are considered to be among the most harmful chemical pollutants [1], which are subject to mandatory collection and disposal, and in some cases – destruction. Unfortunately, collection, recovery and disposal of oily waste products and technical detergent (TMS) is often neglected. As a result, at the present time on the territory of plants and refineries of our republic there are significant amounts of oily waste. This is largely explained by the requirements that must be applied to the waste oil intended for regeneration, purification, and use instead of, or along with other petroleum products. Thus, according to [2] a mixture of spent oil for use as a fuel oil component, should have a mass fraction of solids of not more than 1 percent, the mass fraction of water not more than 2 percent, moreover they should be no contamination. To meet the requirements [2] is necessary to have the company of expensive specialized equipment. This, in turn, combined with relatively small amounts of waste oil and the high cost of transportation to the places for centralized acceptance of the majority of small and medium-sized enterprises makes the collection, recovery and recycling to be not economic.

For such enterprises there is a promising search for ways to use waste oil-containing products directly to the enterprise or enterprises of the region, preferably with a minimum of cleaning and recycling. One possible application is to obtain such emulsions based on oily waste and waste solutions TMS using shock waves encountered when using pneumatic transducer with the subsequent use as a release coating forms during the manufacture of concrete products [3, 4].

Serious adverse events were observed during the initial experiments with oily waste enterprise: fraction diesel fuel and heavy fuel oil, which turned to move away, to defend the top of the emulsion. In further tests the emulsion as a release coating forms in the manufacture of concrete products, these fractions left dark grease stains on concrete, which not only spoil the marketable products, but also complicated the further processing of the outer surfaces. In addition, fuel fractions adversely affect the stability of the emulsion.

The purpose of this study is to obtain an emulsion based on oily waste containing fuel fractions, which when used as a coating does not leave grease stains on the concrete surface during the manufacture of concrete products.

**The methodology of the study.** One of the substances that contribute to the preservation of a homogeneous composition of the emulsion and prevent separation of the fuel fractions of the emulsion is quicklime [5]. It has been suggested that, when added to the emulsion along with the technical detergent Labomid 101, quicklime can prevent rapid sedimentation of light fractions on a dark surface and the emulsion will provide a release coating, the use of which eliminates the formation of dark spots on the surface of fat, manufactured concrete products.

It should be noted the possible negative impact on the stability of quick lime emulsion. Stability of the prepared emulsion was evaluated by the method described in [6].

We are conducting a pilot study to determine the optimal amount of quicklime in the emulsion, providing a normative quality of concrete structures and do not affect the stability of the emulsion. In all experimental studies, the amount of water in the emulsion was taken to 30%. The water was added in an amount of 101 Labomid 3.0% burnt lime and 0.5% increments from 0% to 4% (by volume of water). The content of the waste: 70-100% – oily waste without oil and diesel fuel, 0-30% – fuel oil and diesel fuel. The emulsion was prepared with the help of shock waves encountered when using pneumatic transducer within 15 minutes.

During the next 30 days visual observation of the presence of differentiation between the factions was carried out and there were taken 4 aspects:

- 1) a clear boundary between the factions;
- 2) fuzzy boundary between the factions;
- 3) «blurred» the transition from one faction to another;
- 4) homogeneous emulsion medium.

Each composition was also measured in the loss of water for 30 days. For the maximum number of fuel taken in the amount of the emulsion, wherein the emulsion separation of water for 30 days did not exceed 2% by

volume of the emulsion, and the emulsion used directly for the enterprise - less than 2% by volume of the emulsion for one week.

**Results and discussion.** The experimental studies have been conducted to determine the optimum amount of quicklime in the emulsion, providing quality reinforced concrete structures produced in the forms, which are covered with the prepared emulsion.

The experimental results are presented in Figures 1 and 2 (at the time of observation after 10 and 30 days, with the lime content of from 1 to 3%, in increments of 0.5% and a 6% fuel fractions). Results of the lime content of 3.5% and 4.0% are not shown, since such content it is not a stable emulsion is obtained.

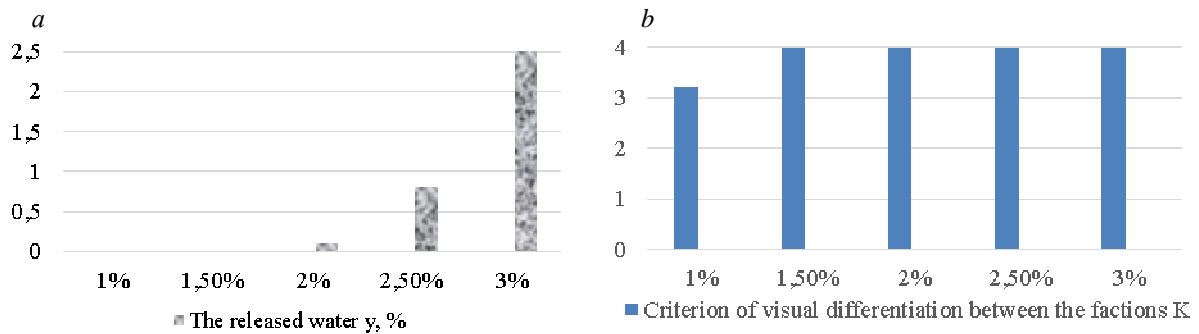


Fig. 1. – Dependence criterion visual distinction between fractions of the K (b) and the released water y (a) (%) of the quicklime content at a time, with the last day of 10 days of the emulsion manufacturing

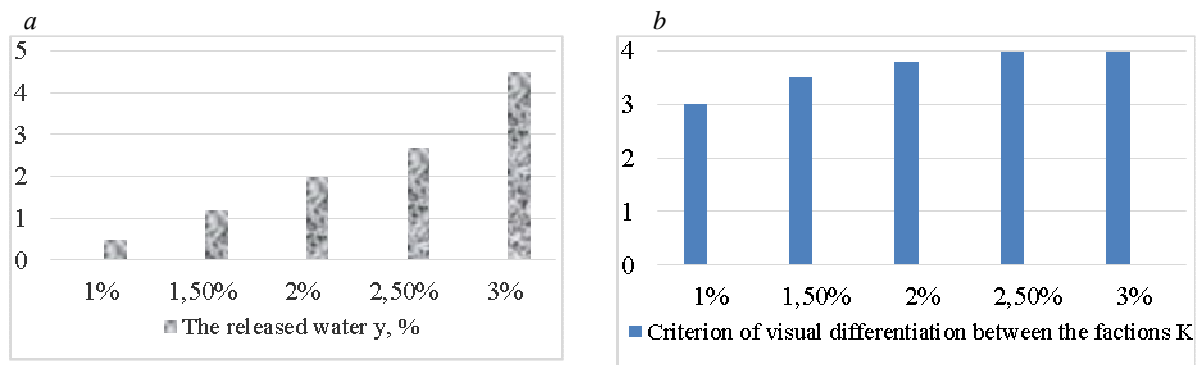


Fig. 2. – Dependence criterion visual distinction between fractions of the K (b) and the released water y (a) (%) on the content of quicklime at a time, from the date of the last 30 days of the emulsion manufacturing

The presence of the emulsion is not slaked lime contributes to the erosion of the boundaries between the fractions. When adding it more uniform emulsion is obtained in which the fuel fraction (if the composition of oily waste, used as the basis for preparation of the emulsion) are distributed evenly in the emulsion. As a result, when using the emulsion as a control is a surface coating on the forms in the manufacture of surface concrete constructions without turns dark oily stains. This in turn will enhance the competitiveness of the emulsion (for use as a release coating).

It was found that increasing the lime content of the emulsion affects the stability of the emulsion. Thus, when the amount of lime 2%, the stability of the emulsion reaches the maximum permissible values, and in some experiments exceeds them.

The analysis of the experimental results (see. Fig. 1 and 2) showed that the presence of fuel oil containing waste fractions used as a basis for the preparation of the emulsion (and then using the latter as a release coating to form in the manufacture of reinforced concrete structures) should be added to the burnt lime in an amount of 1.5%.

In the branch "Novopolotskzhelezobeton" of "Krichev cementnoshifer" produced manufacture staircases LMP 57.11.14-5 using emulsion based on oily wastes. The emulsion is applied to the working surface shapes, its consumption per 1 product amounted to 2,657 kg, which is comparable with the standards of consumption acquired in 2015 per unit of production of lubricants in the manufacture of a flight of stairs LMP 57.11.14-5 that made for industrial emulsol "AT-5 B" 2,646 kg and for emulsol «Betanol-C» - 2,275 kg. Indicators of the quality



of surfaces by using the proposed material, lubrication «AT-5-B» and lubricants «Betanol-C» meet the requirements of enterprise requirements to the quality of the surface of the flight of stairs LMP 57.11.14-5.

The resulting emulsion leaves on the surface of products from oils and grease, blistering and peeling; It does not cause corrosion to steel surfaces of the molds; the average relative value of adhesion reduction of 81.3%; it is able to be held on a vertical surface (an indicator of the ability is retained on the surface coating is based on NSO 76.4%). In the workshops of the branch «Novopolotskzhelezobeton» of «Krichevcementnoshifer» manufactured concrete products at positive temperatures with the categories of purity A3-A7 of the concrete surface. No product made using the control is a coating on the basis of VAT, has not shown the effectiveness of specific natural radionuclides exceeding 370 Bq / kg.

**Conclusion.** The emulsions of oil-containing waste, used as anti-adhesive coatings on the surface forms in the manufacture of concrete products comply with the requirements of STB 1707 «lubricants for molds and formwork. General technical requirements», set for release coating, and can replace industrial lubricants.

#### REFERENCES

1. Смазочные материалы и проблемы экологии / А.Ю. Евдокимов [и др.] ; РГУ нефти и газа им. И.М. Губкина– М. : ГУП Изд-во «Нефть и газ», 2000. – 424 с.
2. Нефтепродукты отработанные. Общие технические условия : ГОСТ 21046 –86. – Введ. 01.01.87. – М. : Изд-во стандартов, 2004. – 5 с.
3. Дронченко, В.А. Использование отработавших нефтесодержащих продуктов при производстве железобетонных изделий / В.А. Дронченко // *Материалы, оборудование и ресурсосберегающие технологии : материалы междунар. науч.-техн. конф.* – Могилев, 2015. – С. 231–232.
4. Приготовление эмульсий на основе отработавших пластичных смазок / В.П. Иванов [ и др. ] // *Проблемы трибології.* – 2016. – Т. 80, № 2. – С. 63–68.
5. Дронченко, В.А. Утилизация отработавших смазочных материалов автотранспортными и агросервисными предприятиями / В.А. Дронченко // *Vol. 45. Inginerieagerară şitransportauto.* – Chişinău: UASM, 2015. – P. 195–198.
6. Дронченко, В.А. Влияние содержания воды на стабильность эмульсии на основе отработавших нефтесодержащих продуктов / В.А. Дронченко // *Вестник Полоцкого государственного университета. Серия В, Промышленность. Прикладные науки.* – 2015. – № 11. – С. 82–86.

**THE PROBLEM OF QUALITATIVE AND QUANTITATIVE HEALTH ANALYSIS**

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*In this article hygienic and functional-physiological approaches at identifying psycho-physiological conditions among students are considered. Research methods: sanitary-hygienic, medical-statistical-depth study of individual health.*

Health monitoring is an observing system, which includes data collection, aggregation, analysis of current situation, forecasts for selecting priorities and decision-making in order to develop measures for preservation and improvement of public health.

There are diverse methodological principles and approaches to the health assessment and study. Summarizing the commonly used methods and techniques of studying health, we can identify the main groups of methods:

- Methods of statistical data study;
- studying of psychophysiological health indicators;
- Sociological methods of health study.

In most modern research they use statistics and sociological methods. Statistics, as well as sociological, methods allow giving a general description of the situation, for example, in different time intervals. Besides, among the obvious advantages of these methods one can mention the fact that they can cover a problematic situation quickly and see the patterns and the contradictions of this or that phenomenon, but at the same time, information allows to assess the health state by actual levels of morbidity only. Health is a continuous process of qualitative and quantitative characteristic change. The main drawback is that data of the visits to the hospitals do not reflect the true sickness rate. Firstly, there is no reasoned value attitude to their own health as necessary life resources; secondly, the qualitative aspects are ignored, primarily differences in disease severity. Sociological methods, such as questionnaires, allow taking into account the qualitative aspect of health partially, but a major limiting factor is questionnaires are subjective and reflect the social and economic factors of life. Using sociological information about population health state is reasonable and useful as an additional means of public health assessment and of health policy effectiveness [1, 2].

During the research we shouldn't underestimate the role of methods reflecting the adaptive capacity of the body or of the group, especially under conditions of high chronic disease. This group of methods includes, for example, the method of allocation of groups of health, developed in 70 - 80-ies. This typology is based on the analysis of medical statistics. However, due to the labor intensity and cost they are not frequently used in the study and identification of risk factors.

A look at the problem at every level makes it possible to identify patterns and characteristics, "invisible" on the other levels.

In our study we used methods of individual health analysis, along with statistical methods macropopulation analysis, in order to analyze the health of macropopulation as well as to rank the factors.

The first stage of the study included an analysis of students health state. The analysis of the students' incidence based on medical and statistical methods of research was carried out on the materials of the official medical statistics of 2005–2011. In addition, there used in-depth methods of medical and statistical investigation according to medical examinations of 2007–2013. To estimate the dynamic range of changes in students' functional indicators, we made the selection of students' medical cards and chose the ones with continuous training. The analytical system included a statistical processing of the data - descriptive statistics, correlation and regression analysis, evaluation and determination of the reliability of intergroup differences; median test (additionally for intergroup differences of average values). The data was considered to be sufficient at a significance level of  $p < 0,05$ .

The ranking places, respectively, are held by the respiratory diseases – 25,07%, acute respiratory infections of the upper respiratory tract – 22,05%, diseases of the genitourinary system – 6,63%, diseases of the musculoskeletal system and connective tissue – 5,32% , diseases of female pelvic organs – 4,80%. Respiratory diseases and diseases of the musculoskeletal system are leading at the same place in the rank structure of the total sickness rate of students. Speaking about the genitourinary system sickness rate, we identified significant differences in the proportion of total morbidity and, thus, different ranking positions in the structure of overall morbidity of students - the second and fourth places. Diseases of the nervous system and circulatory system diseases also have different ranking places, seventh and eighth, while marked with the same specific gravity (2%) in the overall students' sickness rate in the two compared educational institutions. Different positions in the

overall morbidity structure of students are also identified in eye and adnexa Disease, in digestive system, skin diseases and subcutaneous tissue. The number of general and primary morbidity didn't not make it possible to distinguish differences according to nosology forms of morbidity. Harmonic mean of general morbidity cases among students in two comparable institutions totaled 0,77 and 0,52.

Estimation of total frequency rate and the frequency rate of primary morbidity identified differences among the youth of the two educational institutions. Analysis of the primary disease quantity during the study period showed significant growth on respiratory diseases (0,8,  $p < 0,05$ ) and acute respiratory infections (0,82,  $p < 0,05$ ) with established significance for students of one educational institution. Thus, it was concluded that there were certain differences in the incidence of students of two different profiles.

The study of individual health outcomes of students in different profiles allowed investigating the pathological prevalence of diseases among students, as well as not only quantifying prevalence, but also the quality one. There were significant differences in the average morbidity of the students of Information Profile ( $2,31 \pm 2,47$ ,  $p < 0,05$ ), and between-group differences in the incidence of primary students of technical and humanities profiles- tend to be authentic. The growth and the relative share of the primary disease is also marked with significant differences. The growth of the primary disease was 1,9 times higher; the relative share was 1,33 times bigger. Changing of personal health by assessing the medical examination revealed a degraded health state in mentioned profile [3]. Thus, 5,14% of students move from health group D2 to D3, which is not observed in the second group [4].

We identified the basic forms of nosological classes, on which they observe the increase in general incidence to the end of studying.

Thus, in-depth statistical methods reveal the dynamics of the health change and the degree of that change; it allows us to develop effective corrective measures on the nosological entities that require mandatory supervision of persons with risk.

#### REFERENCES

1. Здоровье населения региона и приоритеты здравоохранения / под ред. акад. РАМН, проф. О.П. Щепина, чл.-корр. РАМН, проф. В.А. Медика. – М. : ГЭОТАР-Медиа, 2010. – 384 с.
2. Система образования Республики Беларусь в цифрах 1940–2000 годы (статистический сборник) / Под ред. Н.И. Листопада. – Минск : ГИАЦ Министерства образования, 2001. – 58 с.
3. Сравнительная характеристика заболеваемости студентов // М.Ю. Галева / Наука XXI века: новый подход: материалы XII молодёжной междунар. науч.-практ. конф. студентов, аспирантов и молодых учёных 28–29 янв. 2015 г., г. Санкт-Петербург. – СПб. : Айсинг, 2015. – С. 23–27.
4. Галева, М.Ю. Сравнительная динамика заболеваемости студентов при различных условиях использованием информационных технологий в обучении / М. Ю. Галева // Прогнозирование риска здоровью, обусловленного факторами окружающей среды ; Нижегородский НИИ гигиены и профпатологии. – Новгород, 2014. – Вып. 2. – С. 69–71.

## ANALYSIS OF METHODS OF RECEIVING SPHERICAL SURFACES OF DETAILS

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*Typical parts with spherical surfaces, defined requirements for precision and quality, applicable to spherical surfaces, comparative analysis of methods of cutting of spherical surfaces, the proposed method of milling of spherical surfaces at high cutting speeds.*

**Introduction.** Currently, machine-building industry produces a large range of parts with spherical surfaces. Such parts include ball finger car, pusher hydraulic valve, ferrule, tube ball valve, segment ball valve, spherical plain bearing, ball plug, ball lever, lens, etc.

Have parts like ball pin, the tip tube ball valve, segment ball valve, spherical plain bearing, the lens is focused on the requirements for precision and quality spherical surface. And the parts such as the ball cover and ball handle the requirements for aesthetic and ergonomic design of a spherical surface.

**Analysis of methods of producing parts with spherical surfaces.** In modern engineering with the goal of achieving high production efficiency and reducing the cost of manufacturing parts it is advisable to reduce the proportion of mechanical processing for improving the precision of the workpieces. In this regard, the use of rental as blanks for the manufacture of parts with spherical surfaces is only appropriate in a single production when the cost of rough machining, not comparable with the purchase of special equipment, dies or molds.

When the serial production of parts with spherical surfaces, it is advisable to use a billet obtained by casting, plastic deformation and powder metallurgy. These methods allow to obtain the billet with the shape and size closest to the finished part. Depending on the quality requirements and the accuracy of the details after receiving blanks these methods can produce mechanical processing.

For use as a method of obtaining the workpiece of the casting the part material must have certain physical and mechanical properties. Casting can be harvesting any spatial forms, in particular billets with spherical surfaces.

For example in [1] the method of producing blanks for tubes ball valve based upon receipt of a print in the mold on the model. The casting has the shape of a ball, gently rolling in a truncated cone, the upper base of which is the basis of profit. After crystallization, the profit dub.

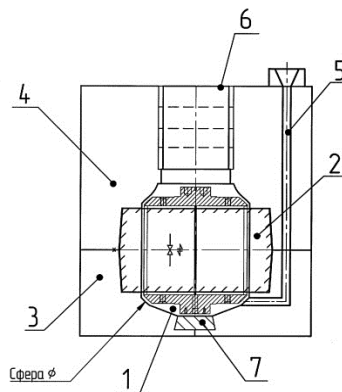


Fig. 1 – Mold for casting billet, tube ball valve

A method of manufacturing a spherical workpiece tube ball valve, schematically shown in figure 1, is as follows. Made a mold consisting of the following elements: 3 lower mold halves (for forming the lower hemisphere), the upper mold halves 4 (for forming the upper hemisphere) and the casting core 2 that is used for forming the holes of the main passage of the tube. For the manufacture of semi-molds 3 and 4 of the flask are installed on the model plate, the molding is filled with the mixture and seal it. After curing the molding sand of the mold halves is removed model. Received in proforma imprint corresponds with the future geometry of the casting, the axle tubes are "flooded" inside the sphere at the location of technological profits.

Casting rod 2 is produced by filling of the core box the core mixture with the subsequent consolidation and curing, then the rod corresponding to the diameter of the hole size of the main passage is extracted from the box.

Before assembly form on all formative elements put a layer of nonstick paint, shape collect. At the bottom floor set refrigerator 7, Gating-feeding system 5 make refractory articles, the terminal 2 is placed in the plane of the fret forms at the parting line.

The finished form through the feeding gate system is filled with molten metal the required grade. The resulting casting has the shape of a ball, gently rolling in a truncated cone, the upper base of which is the basis of profit.

After completion of the crystallization process of the casting 1 is removed from the mold, remove the Gating system 5 and 6 profit, produce a stump and the cleanup of the castings. In the end, to relieve residual thermal stress heat-treated castings obtained.

For the production of large workpieces spherical tube it is advisable to use a molten-welded method consisting of two stages: obtaining of castings of type "Hemisphere" and their subsequent Assembly by welding. For reducing metal casting can be manufactured with internal devastation (hollow), while depending on the size of the operating pressure during operation of the ball valve can be manufactured in the cavity of the casting of one or more ribs.

The use of the method of manufacturing a spherical workpiece tube ball valve allows to obtain blanks of spherical tubes with high quality precision and high utilization rate of metal, while the strength properties of the obtained billet is comparable to wrought iron.

Methods for producing blanks of plastic deformation can be divided into the following:

Open forging and stamping blanks (Fig. 2). Of the workpiece obtained by these methods are characterized by improved metal structure and high strength characteristics [2].

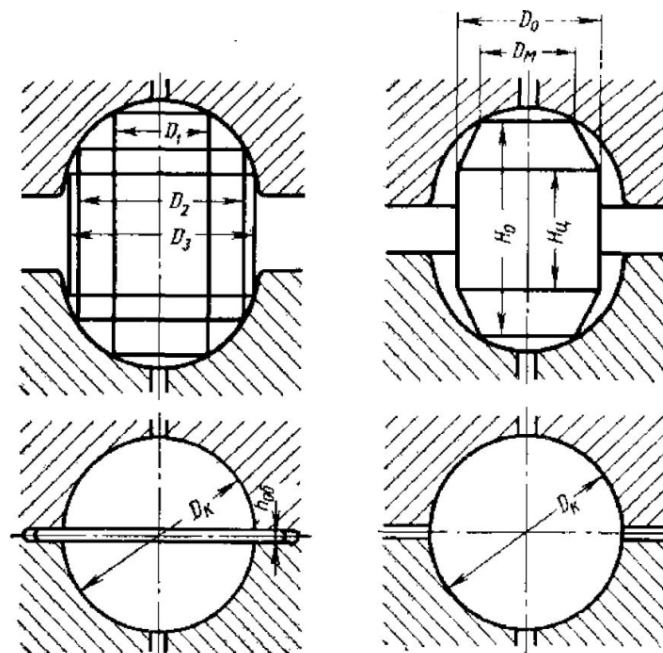


Fig. 2 – Transitions forming a spherical workpiece when stamping

In the production range of components with a large range of sizes should be making a costly special die tooling.

2. The forging of hollow billets [3–6]. This method is applicable for such items as tube ball valve. A method of producing a workpiece (Fig. 3) is that two billets, one of which is intended for the formation of a layered spherical shell, and the other to run through the passage in the sheath, placed in alignment one to another in two spherical volumetric. Then the outer tubular blank is crimped with a cross-longitudinal motion of a spherical volumetric, deform the sphere and the ends close with internal entrance tube.

In the production of spherical workpieces in this manner is quite difficult to obtain high-quality spherical surface due to the low controllability of the boundary conditions changes of size parameters of pressed blanks and the possibility of the appearance of annular folds and undulations in the Equatorial part of the sphere. To prevent the annular folds in the Equatorial portion of the workpiece can be obtained from two welded hemispheres.

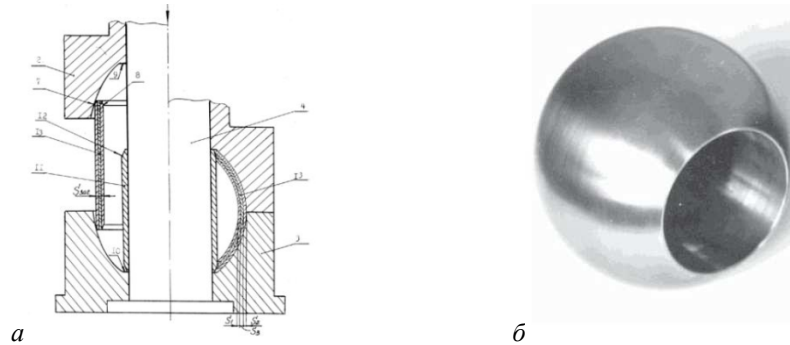


Fig. 3. The Process of stamping (a) and processing (b), obtained from the pipes:  
 1 – processing; 2, 3 – polimetrica; 4 – inner mandrel; 7, 8 – chamfer; 9, 10 – groove;  
 11 – internal feed-through pipe 12 and an external chamfer 13 is a multilayer pipe billet

3. Cross-wedge rolling [7]. Under cross wedge rolling of the two parts of the ball type pin (Fig. 4) the billet is heated and is fed automatically until it stops at the receiving prism wedge tool. When introducing the tool into the workpiece the groove is formed in the middle portion of the workpiece and formoobrazovanija two spherical surface of the ball studs on the wedges (section 1). Further formoobrazovanija cylindrical surface of the ball stud, and then by parallel rolling formoobrazovanija the conical surface of the ball stud (plot 2). Is the second transition, which is formed as a diameter (3 phase). In the final stage (phase 4) separated the waste end of the cutting knives, and then the workpiece along the Central groove is divided into two forgings with a knife. Blanks obtained by this method, and workpiece obtained by forging provide an improved structure of metal and high strength properties, also the accuracy of the diametral dimensions of the billet is within  $\pm 0.2$  mm.

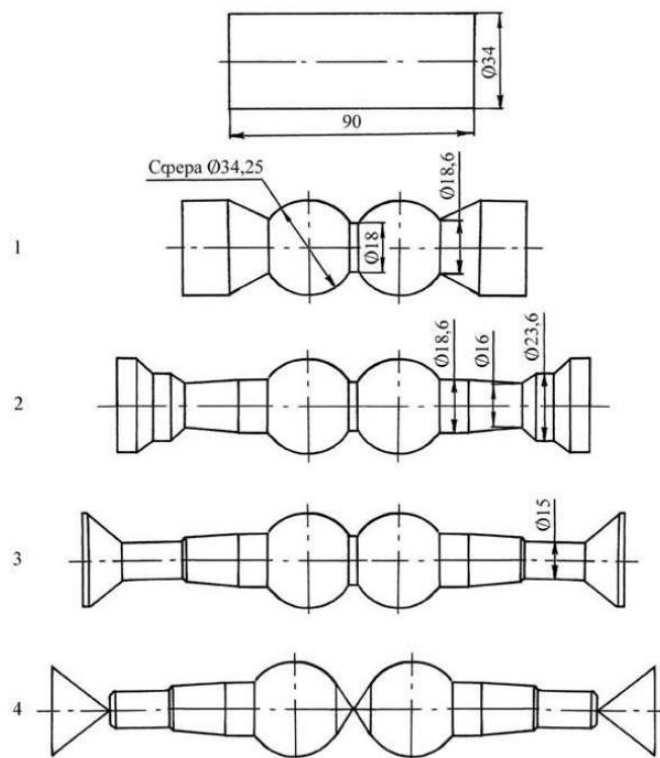


Fig. 4. Stages of cross-wedge rolling

Powder metallurgy allows to obtain products of various forms and purposes. In this method, in most cases, the utilization is about 100%. Typical technology of preparation production of goods by powder metallurgy method includes the following operations: receiving source material powder, molding of blanks, sintering.

One of the varieties of powder metallurgy is currently 3D printing on special installations. The difference of this method is that the material is sintered without step molding and extrusion billet. The shaping of the workpiece is carried out by applying substances to the surface of the Elevator, and sintered under the action of the laser beam in the solid layer corresponding to the parameters of the model and determining its form.

Spherical surfaces can be obtained by cutting. The evaluation of the methods of machining spherical surfaces showed [8–11] that:

- processing of specialized instruments, such as fittings, pipe cutter can result in the rejection of the shape of the surface in case it is not the tool manufacturer, and they have little versatility;
- treatment of non-core tool, for example a contour cutter, does not always give the required accuracy due to the discontinuity of the motion of the CNC machine, lack of rigidity copying machines and rotary fixtures;
- when processing tools on the site approximate to the longitudinal axis of the workpiece is formed over a high roughness due to the phenomenon of built-up edge during the machining process as the cutting speed starts to increase from zero value at the axis of the workpiece;
- devoid of these shortcomings, methods of treatment using a combination of head and special cutter in which the accuracy of formation of the spherical surface is determined by the accuracy of the trajectory of the workpiece and the tool, i.e. the kinematics of the process. From this we can conclude that to improve the quality and accuracy of obtaining spherical surfaces use the most cutting method, comprising cutting edge and abrasive processing.

From this we can conclude that to improve the quality and accuracy of a spherical surfaces, it is preferable to use a cutting method, comprising cutting edge and abrasive processing.

The use of the blade processing provides high performance, exception sergiovani abrasive grains, the chemical saturation of the surfaces of various substances and other side defects. For these purposes, is increasingly used milling at cutting speeds comparable to the speed of the abrasive treatment, the so-called high-speed milling.

The Department of technology and equipment of machine-building production developed method of processing the partial spherical surfaces. The scheme of processing of spherical surfaces by way of covering high-speed milling is presented in figure 2. In this way of handling the tool reported rotational motion with a rotational speed  $n_1$ . After the installation movement of the work piece in the working position, in which the cutting blades in the tool, the work piece is reported rotational movement around its own axis with the rotation speed  $n_2$ .

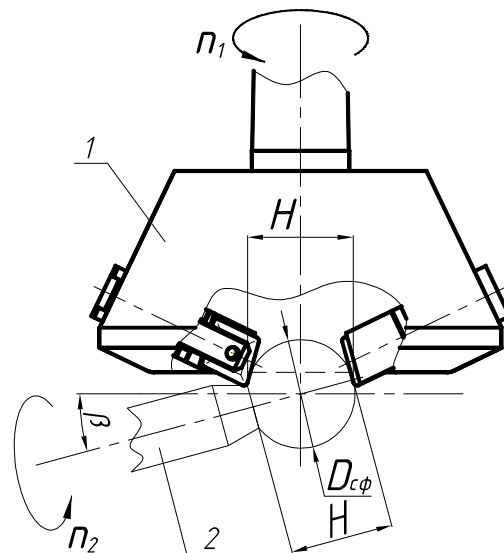


Fig. 5. The scheme of processing of the spherical surface by means of high-speed milling:  
 1 – cutting tool; 2 – the workpiece;  $n_1$  – rotational speed of the tool;  $n_2$  – rotational speed of the workpiece;  
 $D_{c\phi}$  – diam spherical surface,  $H$  – height of the spherical surface;  $D$  – diameter of cutter setting;  
 $\beta$  – the angle of the axis of rotation of the workpiece

**Conclusions.** Studies of this method of cutting has shown that he provides increased productivity by 3-4 times compared to turning on CNC machines and 30 times compared with slizyvaniye. The roughness of the processed spherical surface is  $1.6 \mu\text{m}$  and the geometric tolerance does not exceed  $\pm 0.01 \text{ mm}$ .

## REFERENCES

1. Способ изготовления сферической заготовки пробки шарового крана : пат. RU 2393047 / В.П. Анисимов, А.А. Цыбулаев. – Оpubл. 10.03.2010.
2. Охрименко, Я.М. Технология кузнечно-штампового производства / Я.М. Охрименко. – М. : Машиностроение, 1966. – 602 с.
3. Андрианов, В.Н. Неразъемный штампосварной шаровой кран из коррозионностойких материалов / В.Н. Андрианов, М.М. Тверской, В.А. Маркин // Арматуростроение. – 2006. – № 5 (44). – Режим доступа: [http://www.valve-industry.ru/pdf\\_site/44/44\\_nauka\\_sharovoi\\_kran\\_andrianov.pdf](http://www.valve-industry.ru/pdf_site/44/44_nauka_sharovoi_kran_andrianov.pdf) – 2 с.
4. Штамповка пробок шаровых кранов из трубчатых заготовок / Н.Н. Кузьмин [и др.] // Кузнечно-штамповочное пр-во. – 1985. – № 10. – С 19–20.
5. Агеев, Н.П. Разработки и исследование технологических возможностей изготовления двухслойных сферических пробок шаровых кранов из трубных заготовок способами обжима / Н.П. Агеев, Ф.М. Малых, К.О. Дубицкий // Изв. МГТУ «МАМИ». Сер. 2, Технология машиностроения и материалы. – 2013. – № 2 (16). – С. 23–27.
6. Аналитическое решение задачи о формообразовании шаровых пробок путем обжима трубных заготовок в полусферических матрицах / М.М. Тверской, С.П. Самойлов, В.Н. Андрианов, В.А. Иванов, Ю.М. Хищенко // Вестник ЮУрГУ. Сер. Машиностроение. – 2014. – Т. 14, № 2 : Технология – С. 39–49.
7. Кожевникова, Г.В. Теория и практика поперечно-клиновой прокатки / Г.В. Кожевникова. – Минск : Беларус. навука, 2010. – 291 с.
8. Анализ способов обработки сферических поверхностей деталей / Н.Н. Попок [и др.] // Вестник Полоцкого государственного университета. Сер. Прикладные науки. – 2006. – № 12. – С. 42–45.
9. Способы обработки сферических поверхностей деталей и технологическое оснащение для их реализации / Н.Н. Попок [и др.] // Материалы, технологии и оборудование в производстве, эксплуатации, ремонте и модернизации машин : сб. науч. Трудов VII междунар. науч.-техн. конф. : 3 т. / под общ. ред. И.А. Витязя, С.А. Астапчика. – Новополоцк: ПГУ, 2009. Т. II. – С. 315–319.
10. Хмельницкий, Р.С. Анализ конструкций технологического оснащения для точения выпуклых сферических поверхностей на универсальных токарных станках / Р.С. Хмельницкий, А.С. Максимчук // Труды молодых специалистов Полоцкого государственного университета. Промышленность, 2013. – Вып. 68. – С. 89–91
11. Хмельницкий, Р.С. Анализ способов обработки сферических поверхностей деталей / Р.С. Хмельницкий, А.С. Максимчук // Труды молодых специалистов Полоцкого государственного университета. Промышленность, 2013. – Вып. 68. – С. 92–94.



UDC 412.625

**APPLICATION OF HYDRAULIC TURBINES IN THE MAIN OIL PIPELINES****VLADISLAVA KOVRIZHNYKH, ALIAKSEI VARONIN**  
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*In this article, in order to follow the world trends in energy savings and finding alternative ways of generating electricity the possibility of using hydro turbines on the main oil pipeline has been offered. A placement of hydraulic turbine on the main oil pipeline was proposed by the end of the gravity section of the pipeline route.*

Over the past few decades in most industrialized countries fairly sophisticated systems for the conversion of fossil fuel energy into electricity have been established and implemented. A further increase in the technical and economic indicators of those facilities requires finding new non-traditional methods with which it would be possible to significantly improve technical and economic performance of power equipment and improve environmental performance at the same time.

One of possibilities to solve this problem at industrial plants which use natural gas, liquid as fuel is the use of detanders or hydraulic turbines.

The turbine is a device that converts the potential energy of substance into mechanical energy. These devices can be divided into liquid (hydraulic turbine) and gas (detanders) according to the type of used energy sources.

Detanders are used in the technological processes with the use of steam as the primary energy source (oil refineries and chemical plants) as well as in oil and gas fields with the use of the transported material.

Hydraulic turbines are categorized into active and reactive. The wheel of reactive turbines is completely submerged in the water flow as well as in the active turbines working wheel operates at atmospheric pressure and is driven by individual water jets. The most powerful of hydraulic turbines are reactive [1].

According to their embodiment hydraulic turbines can be divided into direct-flow and radial-axial.

Hydraulic units which equipped with direct-flow tube hydraulic turbines are designed for installation on flat water courses with a pressure of 3 to 15 m. The maximum capacity of units depending on the existing pressures and flow rates changes in the range of 30 to 300 kW. These units can produce sustainable energy for independent consumers and as a part of energy system.

Hydraulic units which are equipped with radial-axial turbines are designed for installation on the mountain and foothill streams with a pressure of 35 to 165 m. The maximum power capacity of the unit depending on the existing pressures and flow rates changes in the range of 250 to 630 kW [2].

Operation of hydraulic turbines is characterized by the following basic parameters: pressure of water before entering into turbine, efficiency and water flow.

In the world hydraulic turbines are installed at hydroelectric power stations. Hydroelectric power plants are usually built at or by natural water bodies (rivers), i.e. at open water channels with construction of dams and reservoirs. For efficient production of electricity hydroelectric power stations require two main factors: a guaranteed supply of water throughout the year and possibly steep slopes of the river.

In order to follow the world trends in energy saving and search for alternative ways of energy it was offered to use hydraulic turbines on the main oil pipeline, i.e. in a closed oil channel of the technology object.

Taking into account that hydraulic turbine at its operating process requires the constant presence of fluid flow and the large slope of the stream (pipeline) it is the most rational and expedient to locate hydraulic turbine at the end gravity section of the main pipeline.

A gravity section presents the part of pipeline in which fluid moves filling the tube partially partial section under influence of gravity force. The pressure in the gas space above the free surface of the oil remains constant; therefore oil flow in pipeline is called pressureless. At the same time the difference in pressure between the beginning of the gravity section and the end section exists and equals to the difference of geodesic heights of these points. Stationary gravity areas can only exist in the downstream directions.

The hill on the route from which oil flows to the end point of the pipeline by gravity called a saddle point. There may be several points.

The distance from the initial point of the pipeline to the nearest saddle point is called the gauge length of the pipeline. In hydraulic calculations the length of the pipeline is considered as gauge length. If the line of hydraulic gradient drawn from the end point of the route never intersects the profile of pipeline it can be concluded that there is no saddle point and the estimated length is equal to the total length of the pipeline.

The line of hydraulic gradient on gravity section runs parallel to the profile of the pipeline at a distance  $p_0/\rho g$  over it ( $p_0$  – the gas pressure in the area above the liquid). The slope of the line of hydraulic gradient on the

gravity section is characterized by the tangent of the angle formed by the profile of the pipeline and the horizon.

After saddle point the oil moves partially filling pipeline. The pressure on this area is lower than at any other point in the pipeline: it is equal to the saturated oil vapor pressure [3].

The energy lost by movement of oil after saddle point is used inefficiently. Installation of hydraulic turbine at the end of gravity section will allow using this energy of oil movement.

In the oil pipeline system of our country a gravity section exists on the route of the main oil pipeline «Druzhba Polotsktransneft». It was formed by exceeding the geodesic heights of saddle point over the rest of the points in the course of the movement of oil to the end station.

For the selection of hydraulic turbine it is necessary to have data on the disposable flow  $Q$  and pressure  $H$  at the end of gravity section. The consumption in the pipeline is  $1640 \text{ m}^3/\text{h}$ , the geodesic difference in height between the pump stations is 68 m, and the pressure before the final station is 46m.

As a result of comparison of the known values of pressure and consumptions to the areas of working fields of hydraulic turbines it became clear that the turbine could generate 100 kW of electricity. The installation of this unit will provide electricity from the energy of oil flow and will solve the problem of the partial energy supply of the station, i.e. makes it possible to reduce the consumption of electricity from third-party suppliers. The received electric power from the hydraulic turbine can be consumed by electric pumps or other processing units at the station.

In terms of operation of the main pipeline installation of hydraulic turbine before the final station requires solving several engineering and operational tasks.

Mounting of hydraulic turbine into the main pipeline will restrict the square of oil flow that will cause the inability to launch the treatment devices and intelligent inspection equipment. The location of the turbine at the bypass line causes the fluid flow separation and twice flow reduction that affects the corresponding decrease in power generation by hydraulic turbine generator.

The placement of hydraulic turbine in pipeline, filled incompletely, will decelerate fluid layers and ingoing of oil saturated vapors into a liquid. This results in cavitations that will trigger cavitations' corrosion and destruction of the metal pipe.

The location of hydraulic turbine at the end of the gravity section at a considerable distance from the terminal station raises the question of the method of power transmission to the final station. As a consequence the final pressure may not be enough for the processes within the end station.

Despite these operational tasks we have proposed the idea of installing hydraulic turbine at the end of gravity section of the main pipeline because it is innovative and has its own advantages as it allows to consume unused energy of oil flow.

#### REFERENCES

1. Modern engineering [Electronic source]. – 2016. – Access mode: <http://www.magi.ru>. – Date of access: 20.10.2016.
2. Enegy. [Electronic source]. – 2017. – Access mode: <http://www.energetika.in.ua/ru>. – Date of access: 15.01.2017.
3. Main pipeline transport / S.M. Vainshtok [et al.]. – M. : JSC «Nedra-biznescentr», 2004. – 624 p.

UDC 62.501.502

**OPTIMIZATION OF THE SERVING AND REPAIR CYCLE DURING  
THE LIFETIME OF THE BUS****ELENA KULAKOVA, VLADIMIR IVANOV**  
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*The problem of maintenance and repair of the bus cycle in the service for his life, which indicates the possibility of improvement and development of subjects " maintenance and repair of vehicles".*

Urban public transport in Belarus is represented by buses, trolleybuses, trams, subways and taxis. Bus routes exist in all cities of the country. Trolleybus opened in seven cities: Minsk, Gomel, Mogilev, Vitebsk, Grodno, Brest and Bobruisk. Tram lines are routed through the streets: Vitebsk, Minsk, Mozyr and Novopolotsk. Two subway lines operate in the capital of the Republic – Minsk.

These statistics suggest that the buses for the modern life of urban residents are of great importance, since they are the most common of all vehicle traffic. Currently, the largest number of buses carrying passengers.

Continuous operation of the bus and its operation modes are directly dependent on their technical condition. From conditionality implies the purpose of work.

Purpose - to provide the minimum cost of maintaining the bus fleet model MAZ 103 in good condition for normative life. Maintenance and repair should ensure a better result for the entire life cycle of the bus.

Maintenance of the reduced model in the basic operation period is divided into the following types: daily maintenance, maintenance after the first 1000-1300 kilometers, the first maintenance (maintenance -1, produced every 10,000 kilometers), the second maintenance (maintenance -2, produced by every 30,000 kilometers, but at least twice a year) and seasonal service [1].

However, provided repair and service cycle is not fully perfected, breakdowns, as failures and lack of timely maintenance leads to not exit the line, which provides the discomfort of passengers and increased car park to replace them in case of failure.

The first step will be to optimize the planning of the experiment.

Experimental Design - is a procedure for selecting the number and conditions of the experiments, necessary and sufficient for the task with the required accuracy.

This substantially as follows:

- the desire to minimize the total number of experiments;
- simultaneous variation of all the variables that determine the process by special rules - algorithms;
- the use of mathematical apparatus formalizing many of the actions of the experimenter;
- choice of a clear strategy to make informed decisions after each series of experiments.

For the work performed will be the selection of an extreme experiment.

Planning an extreme experiment - a method of selecting the amount and conditions of the experiments, the minimum required in order to find optimal conditions, that is, to solve the problem [2].

To solve the optimization problem of the most important use of simulation, which will enable to process statistical data and to obtain the necessary pattern-maintenance and repair.

Simulation is increasingly gaining popularity in the scientific field, as the solution to any problem you can bring it to this method.

The simulation model - a computer program that describes the structure and reproduces the behavior of a real time system. The simulation model allows to obtain more detail by sub-statistics on the various aspects of functioning of the system depending on the input data.

The use of simulation models has many advantages in comparison with the performance of experiments of the real system and the use of other criteria: cost, time, repeatability, accuracy, clarity, flexibility.

Simulation stages are as follows:

1. Forming the basic questions about the behavior of a complex system, the answers to which we get together. Many of these questions allows you to define a set of parameters that characterize the state of the system - the state vector (here, in addition to art researcher, requires a deep knowledge of the real system).

2. Implemented by decomposition of the system into simpler parts – blocks domains. In one domain together "related", ie. E. Close or transform according to the same rules of components of the state vector and the processes they convert (it requires knowledge of the real system).

3. Formulated laws and "plausible" hypotheses about the behavior of both systems, we as a whole and its individual parts. It is very important to note that in each domain to describe it-Sania usually used their mathematical formalism (algebraic and differential equations, mathematical programming, etc.). The most suitable for the respective domain. That blast principle enables the construction of a simulation model to

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establish the necessary proportions between the accuracy of the description of each domain block, its security information, and the need for simulation purpose.

4. Depending on the issues assigned to the researcher introduced the so-called system time, simulating the passage of time in a real system. Although it is not the physical time, but not a mathematical reversible and irreversible unidirectional present time, in which the principle of causality can be implemented.

5. Formalized way are given the necessary phenomenological properties of the system and its individual parts. Often, these properties generally can not be justified at the present level of knowledge, and based on long-term monitoring of the system. Sometimes, however, in terms of getting answers to our questions one phenomenological property is equivalent to the set of complex mathematical relationships and successfully replaces them. (At this stage it requires a profound knowledge of the simulated physical system, of course, if we want to achieve a high degree of adequacy of the model to the real object).

6. Randomly parameters appearing in the model, compared some of their implementation, continuing for one or more cycles of the system (model) of the time. Next discover new implementation.

The simulation model of the problem being solved.

This process includes the following steps:

1. The exact formulation of the research objectives;
2. Gather information and data;
3. Development of a conceptual model. To test the components of the model used quantitative methods - graphics, fit tests, test Kruskal-Uolisa;
4. Verification of the adequacy of the conceptual model to the task and execute the critical structural analysis;
5. Transfer the conceptual model using the software in the machine representation-tion;
6. Verification of the programmed pattern. At this stage, a sensitivity analysis-telnosti and validation of the output data of the simulation model;
7. If the adequacy of the model is not supported, depending on the detected error, not necessary to return to the first, second and third step;
8. Development, execution and analysis of experiments;
9. Documentation and presentation of the results.

One of the most common tools are the Arena, Extended, AnyLogic, AutoMod, Promodel.

To solve this problem the most suitable medium of AnyLogic is, it has a number of advantages: high flexibility to choose an approach, a comprehensive approach has all your stvami-to develop a simulation model [3].

Thus, the more it becomes necessary to research topics of "technical, maintenance and repair of vehicles": keeping them in good condition during their use-NII as intended within the specified service life. This suggests that the optimization serve-repair cycle-linking has relevance in scientific research and study.

#### REFERENCES

1. Руководство по эксплуатации 103003-0000020 РЭ. Автобусы МАЗ 103, МАЗ107. – Минск : ОАО «Минский автомобильный завод», 2015.
2. Адлер, Ю.П. Планирование эксперимента при поиске оптимальных условий / Ю.П. Адлер, Е.В. Маркова, Ю.В. Грановский. – М. : Наука, 1976. – 279 с.
3. Куприяшкин, А.Г. Основы моделирования систем [Текст] : учеб. пособие / А.Г. Куприяшкин ; Норил. индустр. ин-т. – Норильск : НИИ, 2015. – 135 с.

UDC 629.123:665.61

## THE RESEARCH OF INFLUENCE OF FUEL FRACTIONS ON EMULSION STABILITY OF OIL WASTE

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*The effect on the stability of the emulsion in the presence of the fuel fractions of oily waste, on which an emulsion was prepared. The analysis of the results. Observed negative effect on the stability of fuel fractions emulsion. The recommendations for the practical use of technology in the preparation of an emulsion based on oily areas of waste disassembly units and equipment with the help of shock waves that occur when operating a pneumatic transducer.*

During research, it was observed that the presence of the emulsion fuel fractions adversely affects the stability of the latter. This in turn may adversely affect the possibility of using the emulsion prepared on the basis of oil-containing waste as a commodity product introduction. In the production associated with the repair of equipment and machinery, liquid oily waste is generated, it contains the motor and gear oils, greases, fuel fractions, cutting fluids, technical detergents, cleaning fluids, and others. These wastes have a negative impact as on production workers and the environment. The largest share of liquid oily wastes is generated during dismantling of units. These include waste (% of total): 65–90 motor oil, transmission oil 6–10; fuel fractions 2–6, greases 1–2 [1].

Polotsk State University developed a fine emulsion preparation technology of oily exhaust products under the influence of shock waves that occur when operating a pneumatic transducer [1–4]. The emulsion which is prepared with the help of this technology may be used as an additive to fuels mainly for boiler installations or as release coating forms the working surfaces in the manufacture of concrete products [1–3]. due to insufficient stability.

**Objective** is to find the possible content of the emulsion fuel fractions, allowing an emulsion with the required stability.

**The methodology of the study.** Stability of the prepared emulsion was evaluated by the number of released water over a period of 1 to 30 days. The bundle of tubes is measured using the height of the liquid column. The technique which determines the effect of water content in its emulsion stability is described in [5].

Various oily wastes, which percentage of fuel fraction is 0, 10, 20%, were taken for the tests. Water was added in an amount of 20, 30 and 40% by volume of the emulsion.

The separation of water in emulsion 30 days did not exceed 2% by volume of the emulsion, and the emulsion used directly for the enterprise - less than 2% by volume of the emulsion for one week.

**Results and discussion.** The results of these studies are shown in Figures 1–3. Regression equations were formulated for various water content of the emulsion and the composition of the fractions.

The water content of the emulsion 40% (see Fig. 1):

without the presence of fuel fractions

$$y = -0,0069t^2 + 0,6197t - 1,2318; \quad (1)$$

when fuel fractions content 10%

$$y = -0,008t^2 + 0,859t - 1,1929; \quad (2)$$

when fuel fractions content 20%

$$y = -0,0435t^2 + 2,1022t + 2,2127. \quad (3)$$

The water content of the emulsion 30% (see Fig. 2):

without the presence of fuel fractions

$$y = -0,0065t^2 + 0,5105t + 0,5095; \quad (4)$$

when fuel fractions content 10%

$$y = -0,0075t^2 + 0,3538t + 0,001; \quad (5)$$

when fuel fractions content 20%

$$y = 0,0017t^2 - 0,006t + 0,0355. \quad (6)$$

The water content of the emulsion 20% (see Fig. 3):

without fuel fractions

$$y = -0,0056t^2 + 0,3488t - 0,0824; \quad (7)$$

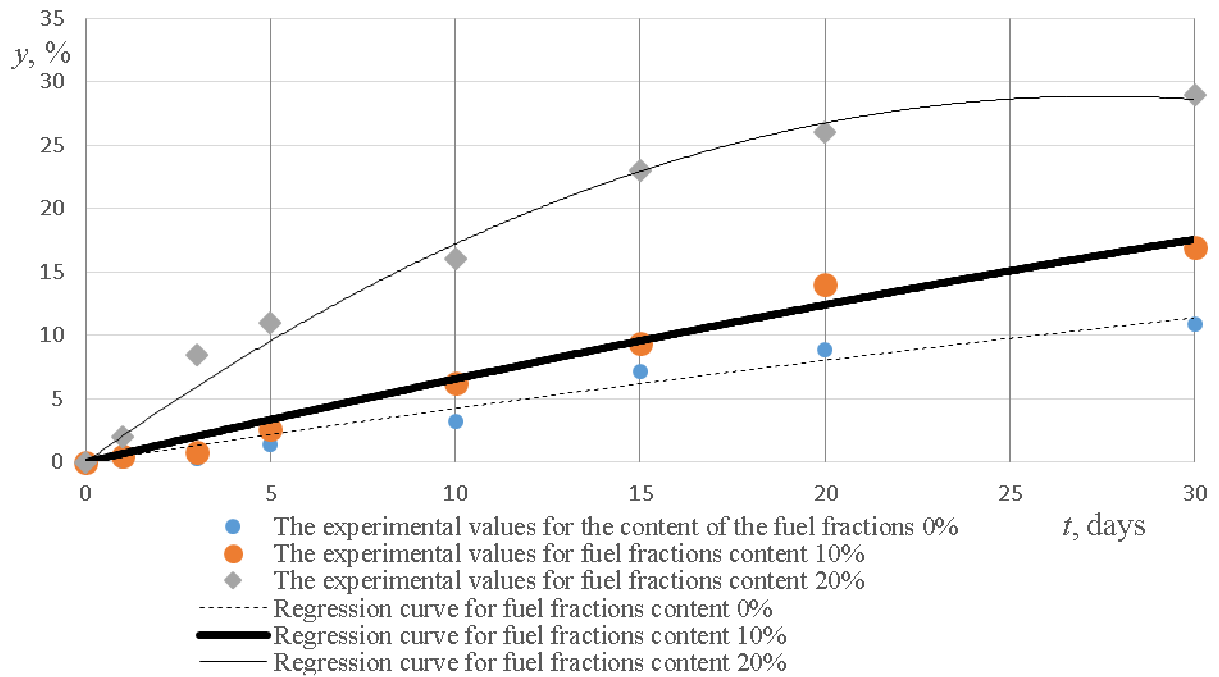


Fig. 1. The dependence of the evolved water  $y$  from the time  $t$  when the content of water in emulsion 40 %

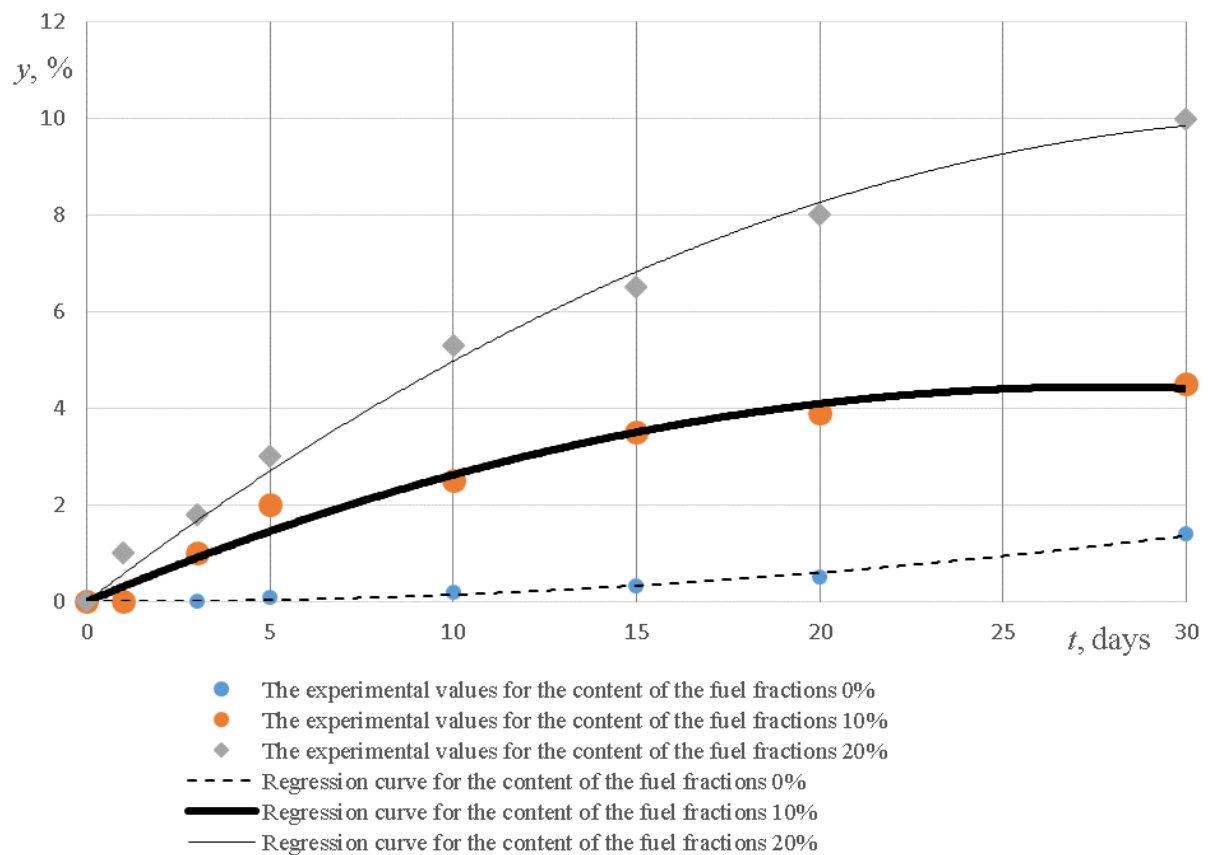


Fig. 2. The dependence of the evolved water  $y$  from the time  $t$  when the content of water in emulsion 30 %

when fuel fractions content 10%

$$y = 0,0013t^2 + 0,0149t - 0,0665; \tag{8}$$

when fuel fractions content 20%

$$y = 0,0013t^2 - 0,0243t + 0,0625. \quad (9)$$

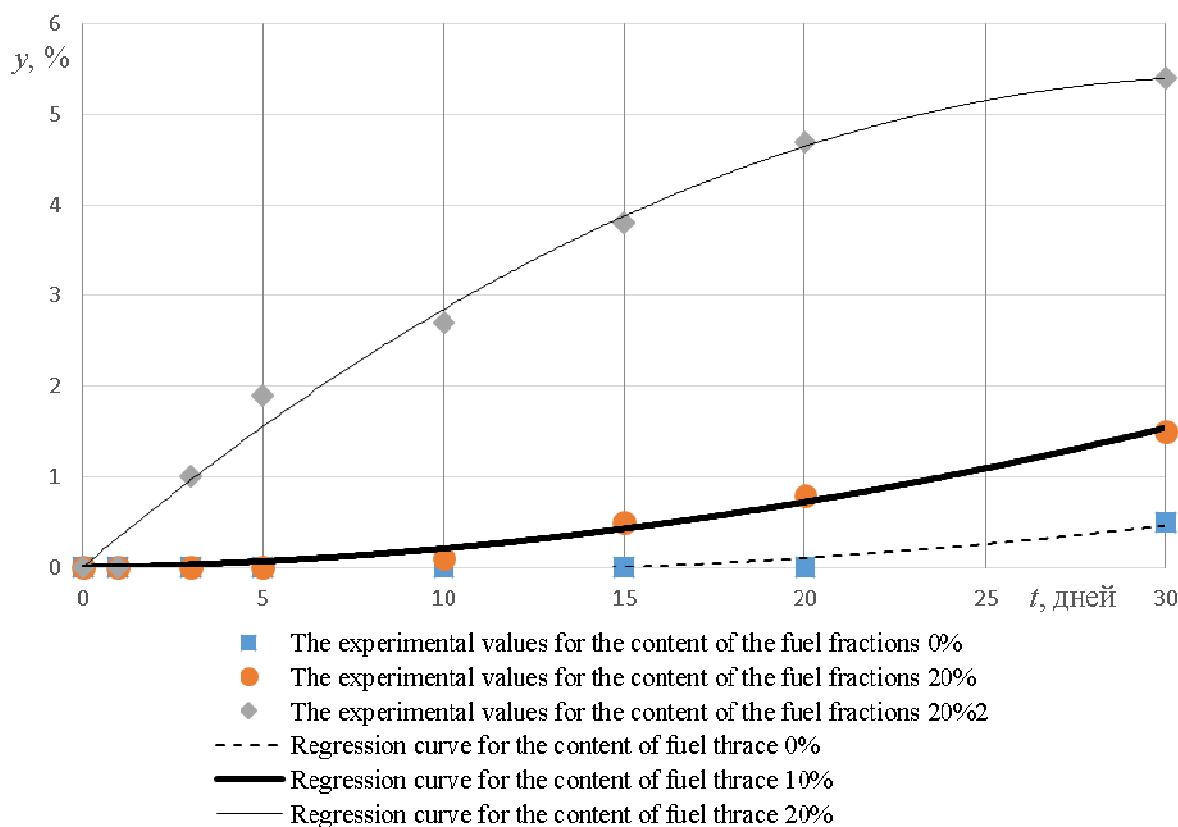


Fig. 3. The dependence of the evolved water  $y$  from the time  $t$  when the content of water in emulsion 20 %

The adequacy of the regression equations (1)–(9) was tested using Fisher's exact test with a significance level of 5% [6]. Design values of  $F_T$  criteria were calculated in the equations. Significance test was carried out for all the coefficients of the regression equations, which showed that all coefficients are significant. All equations are considered adequate and can be used for interpretation.

When the content of water in emulsion 40% (see. Fig. 1) 2% emulsion of water released without fuel fractions 7 days storage. The same amount of water released from the emulsion containing 10% of the fuel fractions, for 3 days. When the content of the emulsion fuel fractions 20% do not get a stable emulsion. The above leads to the conclusion that any number of fuel fractions at a water content in the emulsion of 40% does not allow to obtain an emulsion suitable for practical use.

When the content of water in emulsion 30% (see. Fig. 2) provides the required stability of the emulsion without fuel fractions. When the content of the fuel fraction 10% volume of emulsion precipitated in water for 30 days storage is 4.0%, which does not allow its use as a commercial product, but allows for the use of factory-emulsion. When the content of the fuel fractions of 20% in the emulsion after 4 days the amount of released water is more than 2%, calling into question the possibility of the practical use of such an emulsion.

Figure 3 shows that at a water content of 20% in the emulsion satisfy the required stability of the emulsion: 1 – no fractions of fuel (amount of released water for 30 days is 0.5%); 2 - fuel fractions content 10% (the amount of released water for 30 days of storage of the emulsion was 1.5%). 20% is not obtained with the required emulsion stability of the emulsion content of the fuel fractions. The closest result to the desired stability is obtained when the content of the fuel fractions in the emulsion close to 10%.

The storage time of the emulsion with the release of the normative amount of water can be calculated by using the regression equation (1)–(9). The resulting regression equations enable us to determine the amount of released water for a certain period of time at different water content in the emulsion, and fuel fractions in the emulsion and thus give an opinion on the suitability of the use of certain party emulsion without resorting to fractional analysis in the laboratory.

**Conclusion.** Research has shown that it is possible to obtain a stable emulsion even if fuel fractions. However, in order to more accurately determine the maximum possible fuel fractions content in the emulsion, wherein the amount of released water from a water emulsion does not exceed the permissible values, it is necessary to carry out pilot studies with the contents of the fuel fractions of 1-15% by weight of waste oil in 1% increments at a content and water 20 to 30%.

## REFERENCES

1. Иванов, В.П. Охрана труда рабочих и защита окружающей среды от вредного влияния нефтесодержащих отходов : моногр. / В.П. Иванов, В.А. Дронченко. – Новополоцк : ПГУ, 2016. – 248 с.
2. Иванов, В.П. Приготовление эмульсий на основе отработавших пластичных смазок / В.П. Иванов [и др.] // Проблемы трибології, – 2016. – Т. 80, № 2. – С. 63–68.
3. Семенов, В.И. Снижение выбросов оксидов азота при работе котельных установок / В.И. Семенов, В.А. Дронченко // Вестник Полоцкого государственного университета. Сер. В, Промышленность. Прикладные науки. – 2016. – № 3. – С. 186–190.
4. Sirota, A. Upgrading of the utilization method of the used oil-containing products / A. Sirota, V. Dronchenko // European and National dimension in research : materials of VIII junior researches' conf., Novopolotsk, 27-28 apr. 2016 : in 3 parts / Polotsk State University. – Novopolotsk, 2016. – P. 3 : Technology. – P. 124–127.
5. Дронченко, В.А. Влияние содержания воды на стабильность эмульсии на основе отработавших нефтесодержащих продуктов / В.А. Дронченко // Вестник Полоцкого государственного университета. Сер. В, Промышленность. Прикладные науки. – 2015. – № 11. – С. 82–86.
6. Клименко, Е.Т. Регрессионный анализ и введение в планирование эксперимента : учеб.-метод. пособие / Е.Т. Клименко ; РГУ им. И.М. Губкина ; каф. промышленной экологии. – М. : ИЦ РГУ нефти и газа, 2013. – 52 с.



UDC621.89.09

## GTL AS A MODERN PROCESS FOR OBTAINING HIGH QUALITY OILS

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*In this article theoretical and practical aspects of the GTL technology were overviewed. Proofs that motor oils obtained by GTL are the best on the market were provided and prospects for the development of this technology in the near future were exposed.*

### Introduction

Gas to liquid (GTL) – is a process of converting natural gas or other gaseous hydrocarbons into long chain hydrocarbons such as gasoline and diesel fuel.

In 1902, The French chemist Paul Sabatier with Jean Baptiste obtained methane from a mixture of carbon monoxide and hydrogen in the presence of powdered nickel. A few years later the Russian chemist Egor Orlov obtained from the same mixture in the presence of nickel and palladium - ethylene, thereby showing the possibility of the synthesis of higher hydrocarbons. But the first who used this technology in a commercial way were Franz Fischer and Hans Tropsch. The process described was called Fischer-Tropsch process.

Main natural gas reserves are concentrated in the Asian part of Russia and the Middle East, and the main consumers are in the US and Europe. It is necessary to transport gas over thousands of kilometers, which represents a technical challenge. For European customers shipping is mostly realized through pipelines. Asian region uses LNG tankers transporting refrigerated liquefied gas [1]. Both options are very expensive. There is a third way - the construction of GTL plant. Subsequent transport and storage of liquid natural gas conversion products can use infrastructure (tankers, oil storage) that is much cheaper.

In recent years, all over the world research aimed at the use of natural gas for the production of motor fuel, design and construction of a number of objects have been intensively developing. From an environmental point of view, natural gas has great potential not only as an energy source, but also as a raw material for the chemical and petrochemical industries: obtained motor fuels meet current and future standards of the industrialized countries in their content of olefins, benzene and other aromatic hydrocarbons, and sulfur impurities. [2]

Nowadays there are two existing plants for processing natural gas into synthetic liquid fuel Sasol companies in Mossel Bay (South Africa) with a capacity of 1.15 million t/year, and Shell in Bintulu (Malaysia) with a capacity of 625 thousand t/year.

### The synthesis of liquid hydrocarbons from natural gas

Shell is the leading company - licensee synthesis of hydrocarbons from natural gas.

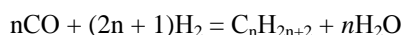
At the first stage from a mixture of natural gas and oxygen at a temperature of about 1500 °C syngas is produced - a mixture of carbon monoxide and hydrogen. In the process of manufacturing a synthesis gas emits a lot of heat and produces a lot of steam, which is used to rotate the turbine generators and produce electricity.

At the second stage the syn-gas is fed to the synthesis reactor, where the molecules are combined into a long chain hydrocarbon with a catalyst. The main product is long saturates - paraffins.

At the third stage paraffins are subjected to hydrocracking, during which the long molecules break into shorter and isomerization. Depending on the reaction conditions (temperature, pressure) a variety of hydrocarbon fractions can be obtained.

The formation of hydrocarbons from CO and H<sub>2</sub> is a complex catalytic process including a large number of series and parallel transformations. The process operates at high pressures and in the presence of catalysts based on group VIII transition metal (mainly Fe, Co, Ru) [3].

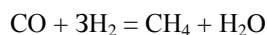
The most promising catalysts for hydrocarbon synthesis from carbon monoxide and hydrogen is cobalt system which at a pressure of 0.1-3 MPa and at a temperature of 120-130 °C makes it possible to obtain selectively allow linear alkanes [4]:



The maximum yield of liquid hydrocarbons is 208.5 g of a mixture of 1 nm<sup>3</sup> CO + 2H<sub>2</sub>.

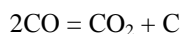
Side reactions for synthesis of hydrocarbons from CO and H<sub>2</sub> are:

a) hydrogenation of carbon monoxide to methane:

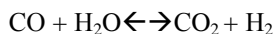


Technology, Machine-building, Geodesy

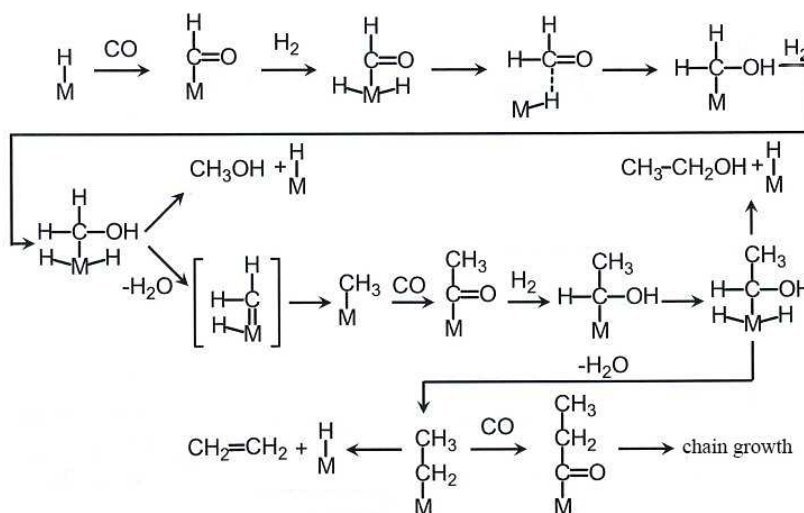
b) disproportionation of CO (Bell-Boudoir reaction):



c) the balance of water gas:



Mechanism according Henritsi-Olive [2]:



**Selectivity**

The Fischer-Tropsch synthesis is considered as hydropolymerizationreaction CO in which a wide hydrocarbon fraction is formed [5, 6, 7, 8].

Distribution of products is subject to polymerization kinetics, and the part of individual hydrocarbons distribution satisfies the Anderson-Schulz-Flory (Fig. 1).

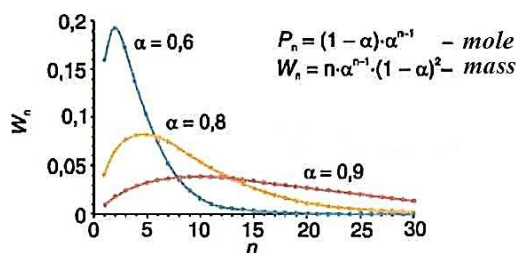


Fig. 1 The distribution of the Anderson-Schulz-Flory (ASF)

In this constant growth and chain termination  $k_1$  and  $k_2$  do not depend on the length of the intermediate chain (Flory, hypothesis). According to this model, the molecular weight distribution of products is determined by the growth of speed constants and chain termination, i.e. the value of the probability of chain growth:

$$\alpha = \frac{k_1}{k_1 + k_2}$$

The mass fraction of product with carbon number  $n$  is set by the Flory formula [5, 6]

$$W_n = n \cdot \alpha^{n-1} \cdot (1 - \alpha)^2$$

The value  $a$  is the probability of chain growth. The value  $a$  is determined by the nature of catalyst, the process temperature and pressure. For each class of products, simultaneously formed on one and the same contact of catalyst (paraffins, olefins, alcohols), the value  $a$  may be different.

ASF distribution restricts the selectivity of the process with regard to individual hydrocarbons and their narrow fractions. Thus, the yield of the gasoline fraction C<sub>5</sub> to C<sub>10</sub> can't exceed 45%, diesel fraction C<sub>11</sub> to C<sub>18</sub> - 30%. However, selectivity for paraffin wax increases monotonically with a rise and asymptotically approaches 100%. If obtained paraffins are subjected to soft hydrocracked gas-oil fraction yield can be increased to 60% for the reacted feed [9]. The practical maximum for a published data for cobalt is 0.94 and for iron 0.94 [10]. By Shell report, their cobalt catalysts obtain a product with the value a «good for 0.9" at a pressure synthesis "slightly above 3 MPa" [11].

**Catalysts**

The reaction catalysts are group VIII metals. Ru, Fe, Co, Ni provide the highest catalytic activity. Ruthenium is already active at 100 ° C, in its presence at elevated pressure paraffins of very high molecular weight (polymethylene) are formed. However, this metal is too rare and expensive to be considered as an industrial catalyst. Nickel at atmospheric pressure provides mostly direct hydrogenation of CO to methane. With elevated pressure volatile Ni(CO)<sub>4</sub> is easily formed, so that the catalyst is washed out of the reactor. For these reasons, commercial uses only iron and cobalt catalyst systems.

Comparative analysis of iron and cobalt catalysts is shown in numerous monographs and reviews [5, 8, 12–19]. These data are summarized in Table 1.

Table 1 – Comparison of iron and cobalt catalysts for Fischer-Tropsch

Fe	Co
Cheap	Co is more expensive than Fe
Low yield of CH <sub>4</sub> even with high temperature	Yield of CH <sub>4</sub> rapidly increases with increasing of temperature
Low hydrogenating activity - products contain many olefins	High hydrogenation activity – products contain almost exclusively alkanes
Significant formation of oxygenates	Oxygenates hardly formed
Capable of operating at a low ratio of H <sub>2</sub> :CO	Requires close to the stoichiometric ratio H <sub>2</sub> :CO
Part of the CO is converted to CO <sub>2</sub> by water gas reaction	Doesn't catalyze the water gas reaction
Quickly oxidized H <sub>2</sub> O and CO <sub>2</sub>	Resistant to oxidation
H <sub>2</sub> O inhibits the synthesis of hydrocarbons	H <sub>2</sub> O has no effect on the kinetics
The short life time	The life time is limited mainly catalyst poisons in the syngas

**The block diagram and the hardware design of the reactor block**

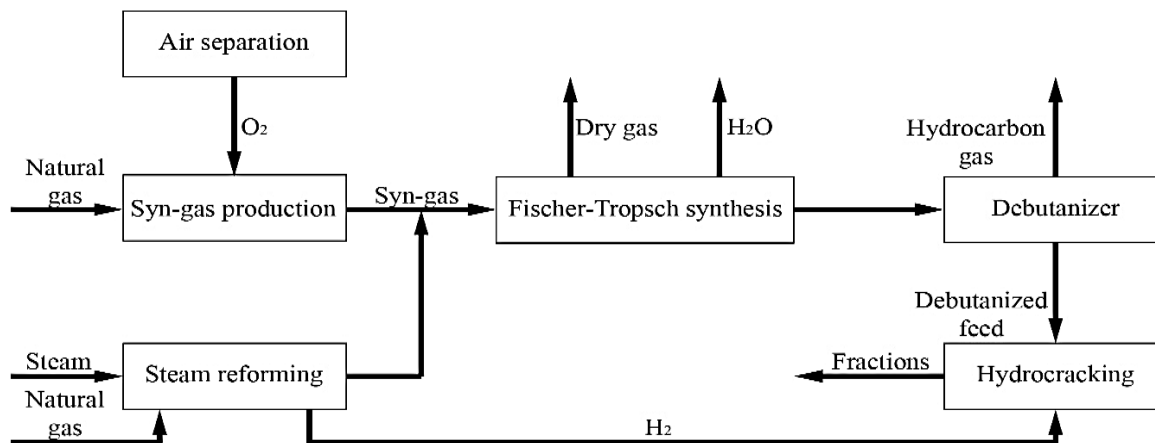


Fig. 2. The block diagram

The industrial FT synthesis reactor should provide a high rate of conversion of syngas, isothermality, effective heat dissipation, minimum loss of catalyst. Furthermore, the reactor should be structurally simple and reliable in operation. The most serious problem facing the designers is the need of a good heat removal. Local overheating is unacceptable because it leads to coking of the catalyst, and in the case of Co-catalyst - to an increased formation of methane. The reactor design is also determined by the kind of products, for which it is intended.

There are two common types of reactors for the conversion of this technology: the fixed bed type Arge reactor with tubes filled with catalyst and the liquid-based one, where the gas is blown through the movable base solid catalyst particles [20].

**Waste-free and environmentally friendly**

As known, the wide hydrocarbon fraction is obtained during the FT synthesis. Skilled use of products is possible after their separation into individual substances or narrow fractions. Separation scheme, and further processing depend on whether the plant operates the fuel or chemical route. Obviously, the relatively small production of FT is economically justified only if it is aimed at chemicals.

Because of low emissions of hydrocarbons, nitrogen oxides and sulfur, as well as less waste volume, the production of distillates plant using GTL technology is less polluting the air than refinery. Emissions do not lead to penalties for the contribution to the greenhouse effect, because they contain the same hydrocarbons, and emissions as traditional refineries.

Processed water and condensate can be reused in the plant. Gaseous light hydrocarbons collaterally displayed in small amounts of various technological installations return to the process used to generate energy. The flue gases are emitted into the atmosphere, almost without sulfur and meet the most stringent requirements in the world.

The catalyst is the only solid waste production - it returns to the manufacturer for further extraction of metals.

From the above it can be concluded that the production of hydrocarbons from carbon monoxide and hydrogen, is practically wasteless.

**The advantages of synthetic oils**

GTL technology allows a wide hydrocarbon fraction in the hydrocracking process which can obtain not only fuel, but also for the production of base oils, motor oils.

Synthetic oils obtained from GTL technology have several advantages over mineral ones.

1) Light start at low temperatures. This is possible because the base oil is made from natural gas, it has better stability on the molecular level than conventional base oils.

2) Save the properties for the entire life cycle. The base oil obtained by GTL technology has significantly greater resistance to oxidation than other base oils. Because of this it retains the original viscosity and fluidity, even after long runs.

3) Reduced cost for topping up. At high temperatures in the engine oil is vaporized, resulting in a decrease of its level in the lubrication system and reduce the engine protection. Synthetic oil has an extremely low evaporation under NOACK test results - 10% and below. This reduces its consumption, and significantly reduces the need for additional refilling.

**Conclusion.** It's obvious that the "gas to liquid" technology is a rapidly developing field of chemical industry and energy, although performance in absolute terms, is rather modest. According to forecasts, only about 2% of the world consumption of natural gas in 2015-2020 will fall on GTL-technologies. Thus, the GTL technology allows to use natural gas to produce motor fuels, basic chemicals, base oils and thereby weaken the dependence of these industries on the oil market fluctuations. In the future, it becomes possible to diversify the raw material base of energy and chemicals, more complete utilization of carbon-containing minerals of our planet.

## REFERENCES

1. Hafner M. Presentation for Technology Center of the EU-Russia Energy Dialogue / M. Hafner. Moscow, April 2004.
2. Sie S. Stud. Surf. Sci. Catal., 1994, v. 85, p. 627.
3. Davies P. Proc. of the 11th World Clean Air Congress, Durban, South Africa, September 1998.
4. Davies P. Proc. of the 11th World Clean Air Congress, Durban, South Africa, September 1998.
5. Репер, М. Катализ в С1-химии / М. Репер ; под ред. В. Кайма. – Л. : Химия, 1987.
6. Udaya, V. Catal. Today / V. Udaya, S. Rao, R.J. Gormley. – 1990. – V. 6. – P. 207.
7. Лapidус, А.Л. / Изв. АН СССР, Сер. Химия. – 1991. – № 12. – с. 2681—2698.
8. Adesina, A.A. / Appl. Catal. A: General, 1996. – V. 138. – p. 345.
9. Арутюнов, В.С. Успехи химии / В.С. Арутюнов, О.В. Крылов. – 2005. – т. 74. – С. 1216—1245.
10. Jager B., Espinoza R. // Catal. Today 1995. – V. 23. – P. 17.
11. Eilers J., Posthuma S. A., Sie S. Catal. Lett., 1990. – V. 7, P. 253—270.
12. Dry M.E. Appl. Catal. A: General, 1999. – V. 189. – P. 185.
13. Сторч, Г. Синтез углеводородов из окиси углерода и водорода / Г. Сторч, Н. Голамбик, Р. Андерсон. – М. : Изд-во ин. лит., 1954.
14. Agee, K. LNG & GTL: World and Russian Prospects : the conf., Moscow, May 26–27, 2004.
15. Yates I.C., Satterfield C.N. Energy and Fuels, 1991. – V. 5. – P. 168.
16. Davis B.H. Ind. Eng. Chem. Res., 2007. – V. 46. – P. 8938.
17. Anderson R.B. The Fischer-Tropsch synthesis / R.B. Anderson. – N.-Y. : Academic Press, 1984.

18. Fischer-Tropsch Technology. Eds. Steynberg A.P., Dry M.E. Elsevier. – Amsterdam, 2004.
19. Espinoza R.L., Steynberg A.P., Jager B., Vosloo A.C. Appl. Catal. A: General, 1999. – V. 186. – P. 13–26.
20. Zenarro R., Hugues F., Caprani E. Proc. of the DGMK/SCI-Conf. «Synthesis Gas Chemistry», Dresden, Germany, October 2006, P. 11–108.
21. Rahmin I.I. Oil and Gas / I.I. Rahmin ; J., 2005. – V. 103, № 10. – P. 2–8.

**THE ROLE OF THE HUMAN FACTOR IN INDUSTRIAL SAFETY*****SNIAZHANA LIAMACHKA, SVIATLANA HARUNOVA, NATALLIA KHARLASHOVA*****Polotsk State University, Belarus**

*The role of the human factor in industry as a result of providing a high degree of safety on dangerous industrial objects and potentially dangerous objects in current working conditions.*

The term "human factor" has been frequently used to express a new view on the role of a man in the production process.

This is an ambiguous term which describes a person who can make erroneous or illogical decisions in specific situations. The expression "human factor" is often used as an explanation of reasons for disasters and accidents, which have led to a variety of damages or casualties.

According to the World Health Organization, the death rate from industrial accidents in our time ranks third after cardiovascular diseases and cancer. It is possible to affirm that the problem of reducing injuries of various kinds in the Republic of Belarus, as well as worldwide, is extremely urgent and deserves the greatest attention.

The situation is extra dangerous when it comes to today's complex and multi-component equipment and technology. As a rule such industries use remote automatic control system which involves modern computer technology and numerical engineering. This system includes the receipt and processing of operating data about the options of all important (especially potentially dangerous) elements (devices) and the state of the production process as a whole. It quickly indicates faulty operations in the equipment.

In the result of introduction into software control systems the opportunities of modern technology, its potential has increased dramatically. Fundamentally new modern industries were set up – nuclear plants, laser settings, rockets, supersonic aircraft, new chemical and biochemical technology. However, sad consequences of huge technological disasters illustrate that even the existence of such warning devices could not allow to exclude the appearance and development of accidents.

Increase and concentration of controlled power in hands of one person makes the human factor a crucial component of industrial safety [1].

As a result, a high degree of safety on dangerous industrial objects and potentially dangerous objects is possible only if we join possibilities of modern technical warning systems, alarm systems and the systems of control to highly qualified personnel, psychologically prepared for fast and adequate response in the case of conditions that can lead to accidents. And if they still have any accident, they must be ready for actions to prevent its further development. There are no accidents without a fault of one of the "human factor" [2].

With the improvement of technology, technological skills of a human-operator (primarily psycho-physiological) also were growing (by improving the quality of general and vocational education, by increasing the amount of equipment of automated control and management system, by improving the system of medical and psycho-physiological selection). However, the possibility of a person was growing slower than technological development [3].

This was the result of the gap between personal comprehensive evaluation of new techniques and respect to their potential hazard. It is very difficult or almost impossible to foresee all types and variants of this threat on the stages of development and testing of new techniques and technologies.

Human errors can occur at all stages - from design and construction of objects to their reconstruction and decommissioning. This is due to the fact that complexity and perfection of technology, its quantitative growth, the appearance of new unknown technical failures, violations inevitably creates the preconditions for an increase in the probability (risk) of accidents.

The possibilities of a person to prevent accidents were also rising by improving education, training, the quality of the selection, the use of computer technology, computer-aided production management, improving the whole system of security tools. But never the less underdevelopment of these capabilities became increasingly noticeable in comparison to rapid development and expanding possibilities of modern technology.

Considering all the above, at present time in the Republic of Belarus there is a law which was adopted on January 5, 2016 № 354-Z "On industrial safety", approved by the Ministry of Emergency Situations of the Republic of Belarus of 06.07.2016g № 31 "On some issues of training and testing on industrial safety knowledge. "

This law regulates the issues connected with industrial safety of hazardous production facilities and (or) potential dangerous objects in the process of their usage in the field of industrial safety – their design, manufacture, construction, reconstruction, modernization and acceptance, commissioning, installation, maintenance, repair and diagnostics, technical certification, testing, maintenance, technical re-equipment, conservation, liquidation, temporary suspension, decommissioning, including the manufacture, renovation, modernization, installation, commissioning, maintenance, repair and diagnostics, technical certification, testing of technical devices (unless otherwise specified, – activities in the field of industrial safety), as well as the localization and liquidation of accidents and incidents and their consequences, and other relations in the field of industrial safety.

Thus the process of human factor control is a diverse problem, which includes complex processes of formation of moral values, physical health of society, preservation of cultural traditions, human resources and social policy and education.

#### REFERENCES

1. Либерман, А.Н. Техногенная безопасность: человеческий фактор / А.Н. Либерман // СПб., 2006. – 278 с.
2. Шаталов, А.А. Основные направления повышения противоаварийной устойчивости производств и совершенствования управления промышленной безопасностью / Шаталов А.А. // Берг-Коллегия. – 2002. – № 1. – С. 15–17.
3. Шкруднев, С.А. Задействовать все факторы влияния / Шкруднев С.А. // Охрана труда и социальная защита. – 2010. – № 10. – С. 17–20.

## THE ALLOCATION OF ANTHOCYANIDIN DYES FROM FOREST WASTES

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*The article presents experimental study of excretion of natural anthocyanidin dyes from waste of wood industry. Total mass fraction of anthocyanidin compounds in bark in the bound state are determined. Kinetic parameters of the process of obtaining anthocyanidin chlorides from tree bark are indicated.*

**Introduction.** In order to broaden the raw material basis and ensure reasonable consumption of plant raw material, much attention is paid within the recent years to processing of various plant wastes. One of large-scale wastes of wood processing is bark. Bark is rich in valuable biologically active compounds. Coniferous bark contains large amount of phenolic compounds of various classes possessing biological activity. The best studied and most widely used in Pharmacia, perfume and cosmetics manufacture, food and other industrial branches are flavo-noid compounds and flavilium salts. Anthocyanidin dyes, one of the groups of flavylum salts, are widely used in food industry. Anthocyanidin dyes for food industry are obtained from flowers, seeds, berries, vegetables, and wastes of their processing, the so-called mill cakes [1]. Each type of raw material gives both anthocyanes (dyes containing saccharide residues) and anthocyanidins (aglycones, or pigments containing no saccharides).

Anthocyanidins occur in nature usually as glycosides with one or two glucose residues or groups of other simple saccharides attached to the hydroxyl in 3, or 3 and 5 positions, as well as in the form of leucoanthocyanidins (reduced anthocyanidins) [2]. Oxidation of catechins gives Anthocyanidins, too [3]. Because of this, it is possible to obtain anthocyanidin dyes from plant raw material by several methods, including acid hydrolysis of the corresponding glycosides, treatment of colourless leucoanthocyanidins with acids, and oxidation of catechins in acid medium.

At present, the conditions and methods of quantitative determination of anthocyanidin dyes in fruit and vegetable raw materials are mastered best of all [3]. The most widely used method of obtaining anthocyanidins from the fruit and vegetable raw material is hydrolysis of anthocyanes (glycosides) by hydrochloric acid (2 M) at 100 °C for 40 min, or by 6 M hydrochloric acid at the same temperature for several minutes.

However, the same compounds can be obtained by the appropriate treatment of coniferous bark or its extracts. Anthocyanidins can be present in bark of different species both in the free state and bound in lignocarbhydrate complex. For example, the major part of leucoanthocyanidins is present in the free state in the bark of leaf-bearing trees, for example, in birch [4]. Leucoanthocyanidins of birch bark are analyzed by transferring them into the corresponding coloured anthocyanidin chlorides; the concentration of hydrochloric acid is 6–7 %, and exposure is 30 min. The processes involved in obtaining anthocyanidin dyes from the bark of Siberian coniferous trees are insufficiently investigated.

Anthocyanidins are natural colorants which occur in a wide variety of flowers and fruits [5–7]. The general structure of anthocyanidins is displayed in Figure 1.

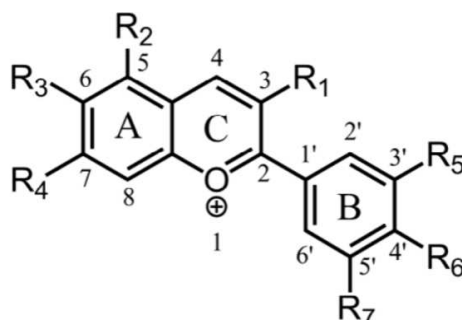


Fig. 1. General structure of anthocyanidins

Up to now, 23 different anthocyanidins were identified. The most common of them are pelargonidin, cyanidin, peonidin, delphinidin, petunidin and malvidin which differ in the substitution pattern of the B-ring including the number of hydroxyl and methoxy groups.

In the present work, the optimal conditions for obtaining anthocyanidins from the tree bark were selected.



**Methodology.** The initial raw material was the bark of freshly cut tree bark (birch *Betula pendula*, pine *Pinus silvestris*, spruce *Picea abies*, chestnut *Castanea sativa*, Cedar Lebanese *Cedrus libani*, Siberian fir *Abies sibirica* Ledeb, Siberian larch (*Larix sibirica*)) selected in the vicinity of Novopolotsk. The tree bark was sampled at a distance of 1-2 m from the base. Bark was dried in a drying chamber at a temperature of 105 °C for 5-6 h, ground, sieved. Tar substances were extracted from the larch and fir bark using the Soxhlet apparatus. A weighed portion of bark was extracted with hexane in Soxhlet apparatus.

Total mass fraction of anthocyanidins present in tree bark was determined using the following procedure. A weighed portion of bark, extracted preliminarily with hexane (to remove tar), ethanol was added, then hydrochloric acid. Then volumetric flasks were filled till the volume mark with ethanol, closed with reflux condensers and heated in thermostat at 70–75 °C. After the necessary time interval, the flasks were cooled to 20°C, the solution was filtered through the Schott filter.

**Results, discussion and conclusion.** The output of the dye and the content of resinous substances are given in table 1.

The extraction of alcohol in the presence of mineral acid (HCl) contributes to the conversion of related dyes in free state, cleavage of sugars and oxidation of substances that are in leuco form, to colored anthocyanidins.

Table 1. – The content of resinous substances and the output of dyes

Kind of bark	The output of dyes, % wt.	The content of resinous substances, % wt.
The bark of the chestnut	8,6	0,5
The bark of the cedar of Lebanon	9,8	4,9
The bark of the silver birch	10,1	1,6
Pine bark	10,5	5,9
Spruce bark	13,3	6,0
The bark of the Siberian fir	16,2	9,5
The bark of Siberian larch	18,7	5,1



Fig. 2. An aqueous solution of anthocyanidin dyes from wood waste processing

The output of natural anthocyanidin dyes from the bark of different wood species can be 8,6...18,7% wt. for raw materials. Minimum output of the dyes is characteristic of hardwood timber, and the maximum is characteristic for conifers.

Thus, a promising direction of utilization of wood waste from wood debarking of various species is getting from the bark anthocyanidin dyes.

#### REFERENCES

1. Kharlamova, O.A. *Naturalnye pishchevye krasiteli* / O.A. Kharlamova, B.V. Kafka, Pishchevaya apromst, Moscow, 1979.
2. Tanchev, S.S., *Antotiany v plodakh i ovoshchakh*, Pishchevaya promst, Moscow, 1980.
3. Vetchinkin, A.R., *Yestestvennye organicheskiye krasyashchiye veshchestva*, Privolzhskoye knizhnoye izd-vo, Saratov, 1966.
4. Bondarenko, S. M., Dolgodvorova S. Ya., Chernyaeva G.N., *Izv. SO AN SSSR. Ser.*, 1 (1989) 86.
5. Flavonols, flavones and anthocyanins as native antioxidants and their possible role in the prevention of chronic diseases / Bohm, H. [et al.] // *European Journal of Nutrition*. – 1998. – V. 37, № 2. – P. 147–163.
6. Yoshida, K. Blue Flower Color Development by Anthocyanidins: From Chemical Structure to Cell Physiology / K. Yoshida, M. Mori, T. Kondo // *Nature Product Reports*. – 2009. – Vol. 26, No. 7. – P. 884–915.
7. Chemical Studies of Anthocyanins : A Review / A. Castaneda-Ovando [et al.] // *Food Chemistry*. – 2009. – Vol. 113, No. 4. – P. 859–871.

**ANALYSIS OF OBTAINING NORMAL HEIGHTS POINTS OF THE EARTH'S SURFACE  
USING DATA FROM SATELLITE MEASUREMENTS AND MODELS OF THE GEOID**

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*The paper presents the analysis of opportunities for normal heights points of the earth's surface using satellite data and global models of the Earth's gravity. The estimation accuracy of the geoid models EGM2008, EIGEN-6C4 on different height anomalies is calculated for points of geodesic network of educational and scientific polygon «Polotsk State University» on instrumental data and data models.*

The final results of satellite measurements are spatial rectangular coordinates of the defined point in geocentric common terrestrial system of coordinates WGS-84. These coordinates are known formulas strictly converted to geodetic coordinates WGS-84 system: latitude B, longitude L, geodetic height H. Further transformation of the spatial coordinates of the common terrestrial WGS-84 coordinate system into other systems (SC-42, SC-95) is performed using seven transition options:  $\Delta X$ ,  $\Delta Y$ ,  $\Delta Z$ -linear parameters shift systems;  $\omega X$ ,  $\omega Y$ ,  $\omega Z$ -angle settings turn systems; m-scaling factor.

However, flat rectangular coordinates projected Gauss-Kruger and normal heights are common in the practice of topographic and geodesic works. Today the possibility of obtaining normal heights according to GNSS-measurements with an accuracy satisfying to large-scale surveys and other types of geodetic works is urgent for Belarus.

According to the theory of Molodensky geodetic height H is the sum of terms: the distance from the reference ellipsoid to the surface quasigeoid (height anomalies  $\zeta$ ) and the distance from the surface quasigeoid to the corresponding point on the Earth's surface (normal height  $H^y$ ) [1]

$$H = H^y + \zeta, \quad (1)$$

Currently, the most accurate for practical application are geoid models EGM2008, EIGEN-6C4, by the National Geospatial-Intelligence Agency – NGA and International Centre for Global Earth Models – ICGEM respectively. These geoid models have a full set of harmonic coefficients of the geopotential up to 2190-th degree [2].

It is known that the normal height assigned to the surface quasigeoid and gravity model of Earth carry information about the geoid. Therefore the translation of geodetic heights into the normal height using data from a geoid model contains an error. This error is the deviation from the geoid quasigeoid at this point. Strictly speaking, the geoid models provide orthometric heights instead of the normal. However, the practical interest is the possibility of normal height according to the GNSS-measurements and gravity models.

In this article the analysis of a possibility of obtaining normal heights according to satellite measurements and models of geoids of EGM2008 and EIGEN-6C4 is made. The study was performed according to the differences of height anomalies calculated for the ten points of scientific-training polygon "Polotsk State University."

For obtaining anomalies of heights GNSS measurement using dual frequency satellite receivers Trimble R7 Zephyr Geodesic and geometric levelling of class III were performed by the authors.

Anomalies of heights on geodesic points are received on gravitational models of Earth EGM2008, EIGEN-6C4 with the use of Calculation Service International Centre for Global Earth Models – ICGEM) [2]. The values of anomalies of heights obtained by the gravity model are shown in Table 1. Location scheme of geodesic points on the scientific-training polygon is shown in Figure 1.

Table 1 – The values of anomalies of heights obtained by the gravity model

Point ID	EGM2008	EIGEN-6C4 (2014)
	2190	2190
1	2	3
1001	20,525	20,565
1002	20,522	20,562
1004	20,520	20,560
1005	20,520	20,560
1005	20,521	20,561
1006	20,512	20,552

Table 1 Conclusion

1	2	3
101	20,528	20,568
102	20,487	20,527
103	20,547	20,587
104	20,539	20,580
105	20,540	20,580

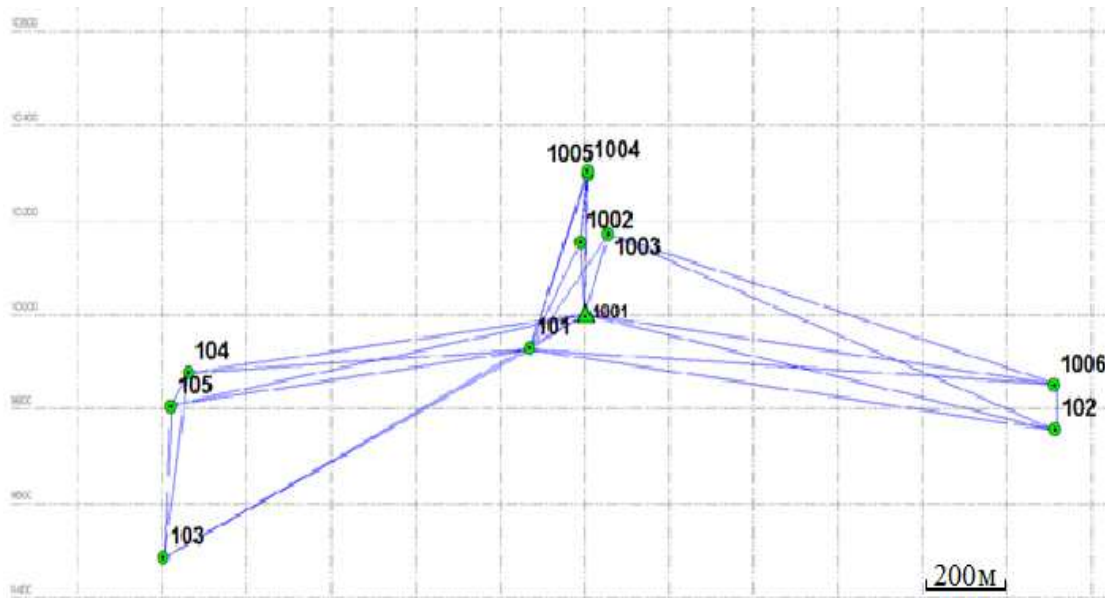


Fig. 1. Scheme of geodesic points on the scientific-training polygon

Information about anomalies heights using GNSS-measurement results (2015) was derived by comparing the difference in the geodesic height between reference points and datum profile № 1001, with elevations between the same reference points found from the geometrical levelling of class III. Excess should be regarded as the difference between normal heights and reference points. Thus, the anomaly height was determined according to formula (2) [3]:

$$\zeta_l = (H_l - H_{\text{№1001}}) - \sum_{\text{№1001}}^l h, \tag{2}$$

where  $\zeta_l$  – is the anomaly of height in the current reference frame relative to reference point № 1001;

$H_l$  and  $H_{1001}$  – is the geodesic height respectively of the current reference point and the profile of frame №1001, obtained from satellite data;

$\Sigma h$  – is the total excess between bench mark №1001 to the current bench mark, obtained from geometric height measurement.

The values of the height anomalies a relatively point №1001, obtained by the results of GNSS measurements and geometric levelling, and also according to the data of gravitational models of the Earth presented in Table 2.

Table 2 – Values of height anomalies at relative point №1001

Names of points	1001	1002	1004	1005	1006	1006	101	102	103	104	105
EGM2008, m	0	-0,003	-0,005	-0,005	-0,004	-0,013	0,003	-0,038	0,022	0,014	0,015
EIGEN-6C4, m	0	-0,003	-0,005	-0,005	-0,004	-0,013	0,003	-0,038	0,022	0,015	0,015
GPS-geometric levelling, m	0	-0,015	-0,009	-0,001	-0,011	-0,071	0,012	-0,036	0,019	0,051	0,021

Based on the values of the anomalies of height, it can be noted that the models of the geoid EGM2008 and EIGEN-6C4 have the same shape in this part of the surface and the systematic displacement relative to each other.

For these geodesic points statistical processing of the different values of height anomaly was conducted, derived from models EGM2008, EIGEN-6C4 and height anomaly, obtained according to data instrumental researches. Results of processing are presented in Table 3.

Table 3 – Statistical processing of the different values anomalies of height

Deviations	EGM2008 model in comparison with GPS measurements and geometric leveling	EIGEN-6C4 model in comparison with GPS measurements and geometric leveling
$[\Delta]/n$ , m	0,0026	0,0027
+ $\Delta$ , max, m	0,058	0,058
- $\Delta$ , max, m	-0,037	-0,036
RMS, m	<b>0,0225</b>	<b>0,0223</b>

Based on the statistical analysis of the data it can be noted that the law of distribution of the differences of the anomalies of height is close to normal. RMS error getting altitude anomalies does not exceed the values given by the creators of the models [2]. It should be noted that gravitational models have a systematic displacement relative to each other by the absolute values of the anomalies of heights ( $\sigma \approx 40\text{mm}$ ), however the forms of the geoid surface on the area are the same. The presence of systematic displacement models relative to each other causes difficulty in choosing a geoid model, if necessary, obtaining the absolute elevations of points in the system of normal heights. However, this error can be completely eliminated in the presence of at least one point from the level in the system of normal heights determined by using geometrical levelling.

Figure 2 presents the isolines of deviations of geoid model anomaly height EIGEN-6C4 on instrumental data results (relative to geodetic points №1001).

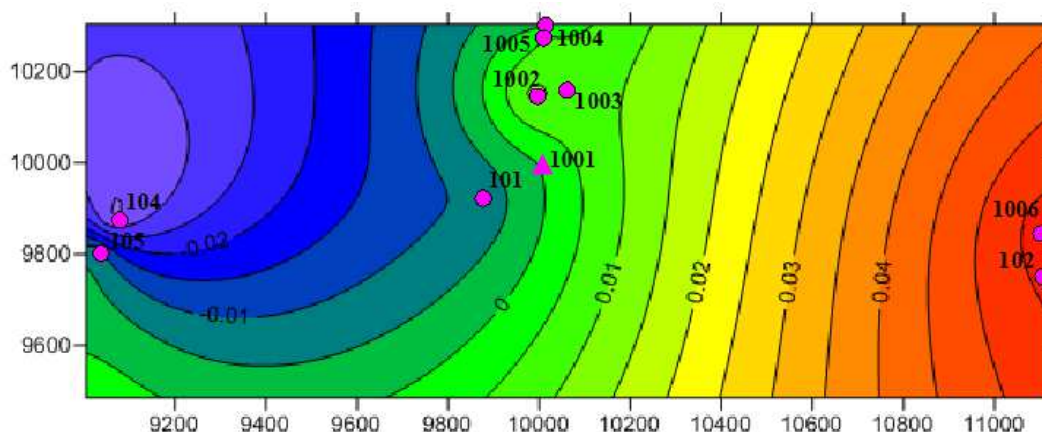


Fig. 2. Scheme of deviations height anomalies of geoid EIGEN-6C4 by anomalies obtained according to the data of GNSS measurements and the results of geometric levelling (isoline interval of 0.005 m)

Comparing the height anomalies, obtained both by using gravity models, and using the combination of GNSS measurements and geometric levelling can be argued that the data of the model have good convergence with the results of instrumental data, which is confirmed by other studies [4,5,6]. In addition, a small area geoid models EGM2008 and EIGEN-6C4 have the same shape, the same is confirmed by the difference in anomalies of height. Evaluation of the accuracy of the normal heights using geoid model EGM-2008, EIGEN-6C4 has shown that the use of these models of geoid heights in the territory for the determination of normal heights is only possible when creating a shooting justification to perform surveys with contour interval of at least 1 m [7].

#### REFERENCES

1. Закатов, П.С. Курс высшей геодезии / П.С. Закатов. – М. : Недра, 1976. – 510 с.
2. Global Gravity Field Models // International Centre for Global Earth Models (ICGEM) [Электронный ресурс]. – 2016. – Режим доступа: <http://icgem.gfz-potsdam.de/ICGEM/> International Centre for Global Earth Models (ICGEM).
3. Диагностика современных движений земной коры Беларуси по результатам геодезических и геолого-геофизических исследований ГБ-4026 : отчет о НИР ГПОФИ “Недра Беларуси 13” за 2006–2010 гг. / Полоцкий государственный университет ; рук. Г.А. Шароглазова ; исполн.: В.Н. Коровкин [и др.]. – Новополоцк, 2010.

4. Маркович, К.И. Анализ новейшей глобальной гравитационной модели Земли EIGEN-6C4 по геодезическим и гравиметрическим данным применительно к Полоцкому геодинамическому профилю / К.И. Маркович // Вестник Полоцкого государственного университета. Серия F, Строительство. Прикладные науки. – 2015.
5. Маркович, К.И. Оценка точности глобальной гравитационной модели EIGEN-6C2 в сравнении с моделью EGM2008 применительно к Полоцкому геодинамическому профилю / К.И. Маркович // Труды молодых специалистов Полоцкого государственного университета. Строительство. – 2013. – № 67 – С. 168–171.
6. Пигин, А.П. Глобальная модель геоида EGM2008. Предварительный анализ / А.П. Пигин, С.В. Березина // Инженерные изыскания. – 2009. – №2. – С. 44–47.
7. Инженерные изыскания для строительства : СНБ 1.02.01-96.

## ADJUSTMENT ACCURACY PARAMETERS OF FACE MILLS

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*The variants of customization mechanisms design for setting adjustable face mills in the radial and face directions are presented.*

The use of modular face mills on machine-building enterprises reaches 25% of the total amount of the assembly cutting tool. At the same time the most common are assembly face mills, consisting of interchangeable modules, the use of which reduces the production costs. The use of assembly modular construction mills is due to their high reliability and precision surface machining of parts. The design of modular face mill has been developed [1] and on the basis of the mill structure a cutting block lays [2]. The reliability and accuracy of the mounting cutting block design in the body module and the cutting insert in the cutting block is considered in [3].

An assembly mill can be provided with the adjustment module [4], allowing more to expand technological capabilities of the cutting tool. The adjustment module allows [5]:

- firstly, to provide a turn of cutting insert at a front angle with simultaneous change of location vertices diameter of cutting inserts and its face layout,
- secondly, to adjust over a wide range the cutting blocks layout relative to each other,
- thirdly, to adjust cutting edge angle  $\lambda$  by rotation of cutting block around its axis.

Thus there can be implemented progressive schemes of flat surfaces parts cutting [5]:

1. With the machining allowance division between cutting edges of tool by the cutting edges step arrangement of insert, for example, «peakless» schemes of blades step arrangement along the tool rotation axis to increase the resistance; schemes with blade arrangement in a helical or curved line in the planes parallel and perpendicular to tool axis of rotation to increase productivity and quality of treatment;

2. With the machining allowance division between cutting edges by adjusting of diameter cutting inserts arrangement of vertices in a plane perpendicular to the tool axis of rotation;

3. Cutting with cutting block chaser, which allows the formation of high-quality surface of the part, both a plane parallel and perpendicular to the tool axis of rotation.

Milling cutter design allows you to adjust it to the optimum diameter to the required geometry. Fig.1 shows some variants milling cutter adjustment to the required diameter  $D$  and front angles  $\varphi$  и  $\varphi_1$  of cutting insert by rotation of the adjustment module in the body module, and changing cutting blocks layout  $H$  in adjusting module.

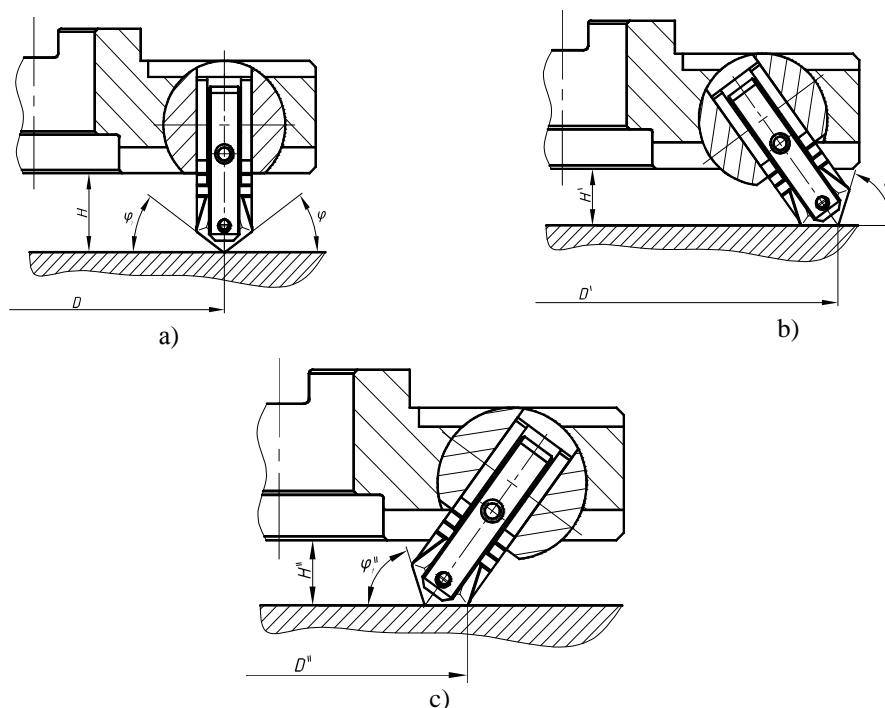


Fig. 1. Configuration variants of adjustable face mills in the radial direction

Fig. 1, *a* shows milling cutter design with arrangement the cutting block on the long side perpendicular to face of milling cutter body, wherein applying the different cutting inserts allows changing front angle  $\varphi$ .

Fig. 1, *b* shows the cutting block which unwrapped the outside of milling cutter body, and it enables the processing of greater width workpiece surface and adjusts the value of front angles  $\varphi$  и  $\varphi_1$ .

Fig. 1, *c* shows the cutting block which unwrapped the inside of milling cutter body, and its also allows you to adjust the size of the processed surface of the workpiece and the geometric parameters of the tool.

Fig. 2 shows some possible adjustments variants in the face direction of the cutting block.

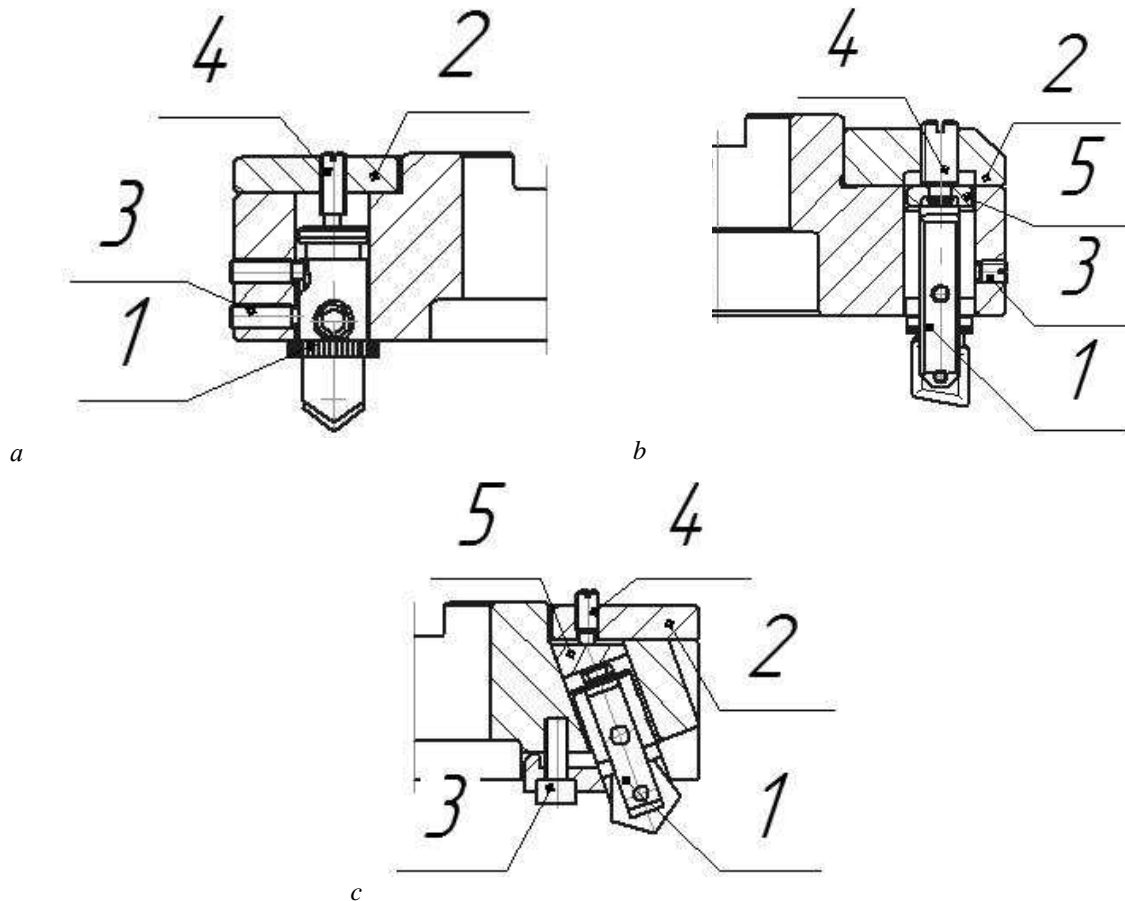


Fig. 2. Configuration variants of adjustable face mills in the face direction

Fig. 2, *a* shows the variant with screw 4 that is screwed into the body 2 of the cutting tool with the arrester in the end of cutting block 1.

Fig. 2, *b* shows the variant in which for the adjustment is used screw 4 screwed into the body 2 of the cutting tool and in contact with the cutting block 1 through the sleeve (washers) 5. Variants of this design may vary depending on the performance of screws and constructions of fixing and mounting cutting of blocks 3. The use of the sleeve 5 promotes the redistribution of load on the cutting block 1 and the smoothness of its movement.

Fig. 2, *c* shows the variant which involves moving blocks by screw 4 and the wedge 5. Variants of this design may vary depending on the constructions of wedges 5, adjusting screw 4 and fastening element of blocks 3. Using of the wedge 5 provides smooth movement of the cutting block 1.

Meanwhile, for all variants shown in Fig. 2, it is possible to change the adjustment accuracy for roughing, semi finishing and finishing milling. This can be achieved by the use of screws with thread corresponding accuracy. The usage of the combinations of the adjustment mechanisms which have been shown in Fig. 1 and 2, leads to an expansion of technological capabilities of modular mills and reduce the overall range of cutting tools.

#### REFERENCES

1. . Режущий инструмент : пат. по заявке № a2011026 / Н.Н. Попок, В.А. Терентьев, Р.С. Хмельницкий, А.В. Сидикевич, И.Я. Сопиков. – Оpubл. 12.12.2014.

---

Technology, Machine-building, Geodesy

2. Способ установки сменной режущей пластины в режущем инструменте : пат. по заявке № а2011025 / Н.Н. Попок, В.А. Терентьев, Р.С. Хмельницкий, А.В. Сидикевич, И.Я. Сопиков. – Оpubл. 12.12.2014.
3. Попок, Н. Совершенствование системы закрепления пластин режущих и блоков резцовых в блочно-модульных режущих инструментах / Н. Попок, А. Максимчук, С. Портянко / Вестник Полоцкого государственного университета. Сер. В, Промышленность. Прикладные науки. – 2015. – № 3, с. 16–22.
4. Многолезвийный блочно-модульный режущий инструмент : патент ВУ 3127 / Н.Н. Попок, В.А. Терентьев, Р.С. Хмельницкий, А.В. Сидикевич, И.Я. Сопиков. – Оpubл. 2006.
5. Русецкий, А.М. Конструирование и оснащение технологических комплексов / А.М. Русецкий [и др.] ; под общ. ред. А.М. Русецкого. – Минск : Беларуская навука, 2014. – 316 с.



UDC 665.75:665.7.03

**FEASIBILITY APPLICATION OF DEPRESSANT-DISPERSANT ADDITIVES OF DIFFERENT MANUFACTURERS IN THE PREPARATION OF WAXY DIESEL FUELS***YULIYA PIATROUSKAYA, LIZAVETA SYCHOVA, YULIYA BULAUKA*

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*The article presents the results of the analysis of depressant - dispersant additives of different manufacturers in terms of reflecting the technical and economic feasibility of its using in the preparation of waxy diesel fuels. Results of the analysis of depressant-dispersant additives of different manufacturers on indicators displaying feasibility expediency in the preparation of waxy diesel fuels are reflected in this article. It is shown that for each diesel fuel it is necessary to select the corresponding additive. The result of this work is the assessment of domestic depressant production expediency for the operating capacities of petrochemical production, which satisfies physical and chemical requirements. It is simple on a way of synthesis and it is low-cost in production as basic components of an additive are products of industrial petrochemical production, i.e. low molecular weight polyethylene, which hasn't found any appropriate application so far.*

**Introduction.** In many industrial applications additives are incorporated in compositions of interest. The additives are generally incorporated to provide a functional effect to the composition. For example, an additive may modify the physical properties of the composition, for example, the additive may modify the viscosity, or melting/boiling point, of the composition. The many different additives can be categorized in different ways based on the chemistry, purpose, etc. One convenient way of categorizing them is to group them as additives used to Aid Handling and Distribution, to Improve Fuel Stability, to Protect Engines and Fuel Systems and additives to Influence the Combustion Process. Some additives may influence more than one category and of course additives can be combined to produce multi-functional additive packages [1].

To increase the yield of diesel fuel the refiner must cut deeper into the crude feedstock, necessitating the use of flow improvers to restore the low temperature performance of the fuel. In cold regions the diesel fuels generally become more viscous than at the normal temperature and this leads to formation of wax crystals.

Of all the ways of improving low temperature properties of fuels and obtaining winter grades of diesel fuels, the most cost effective is the addition of depressant additives which provides the required improvement in the low temperature properties of fuels and increase in the rational use of resources for the winter grades of fuels. Hence, these pour point depressants are added to certain chemicals to prevent the fuel from forming this wax crystal structure. Wax crystals formed at low temperature can block fuel filters. Pipes and hoses can cut off the supply of fuel to the diesel engine. Wax crystals before and after using depressant additives are shown in Figure 1 [2].

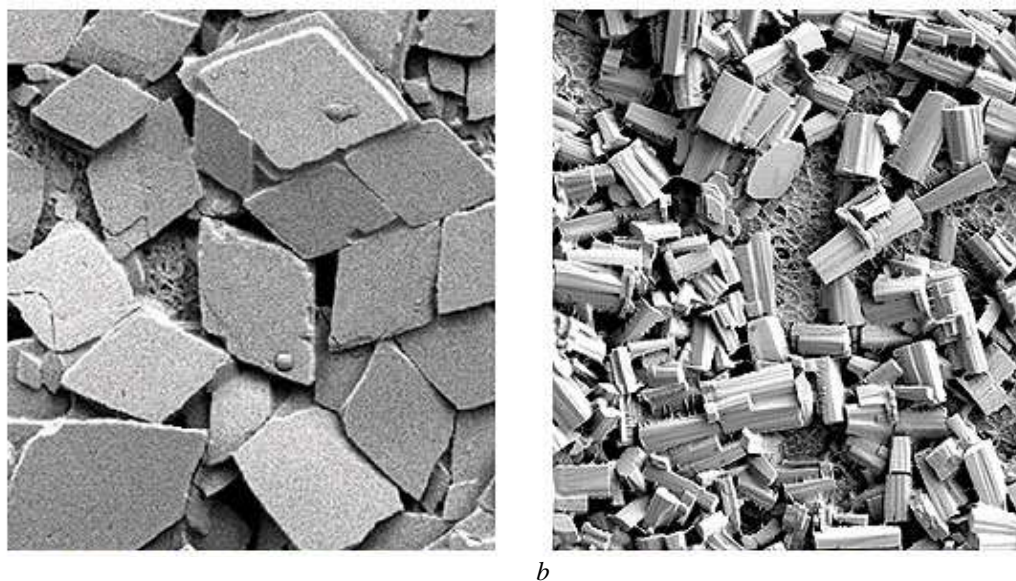


Fig. 1. Wax crystals: *a* – before using depressant additives; *b* – after using depressant additives

## Technology, Machine-building, Geodesy

The low temperature operability additives can be categorized as follows:

- Flow improvers;
- Wax anti-settling additives;
- Cloud point depressants;
- De-icing additives.

Depressant-dispersant additives in the preparation of diesel fuels enable to:

- Treat discounted, high paraffin crudes & resids;
- Reduce cost associated with blending cutter stock with high paraffin oils;
- Improve pipeline flexibility by allowing transportation of highly paraffinic oils;
- Reduce heating in fuel distribution system;
- Avoid removal costs of solidified paraffin waxes;
- Reduce pumping costs;
- Upgrade value of resids / heavy fuels.

Clariant Chemicals (Switzerland), BASF SE (Germany), Evonik Industries (Germany), Afton Chemical Corporation (U.S.), Croda International (U.K.), Chevron oronite company LLC (U.S.), Croda International PLC (U.K.), Messina Chemicals (U.S.), Sanyo Chemicals Industries Limited(Japan), Lubrizol Corporation (U.S.), Infineum International Ltd (U.K.), Akzonobel (The Netherlands), and Innospec Inc. (U.S.), etc. are the biggest flow improver producing companies worldwide with a broad product range of fuel additives. Domestic and Russian depressant additives are unfortunately still not used consistently despite the fact that some of them have been widely tested confirming their high efficiency.

**Methodology.** Depressant additives contribute to the formation of small wax crystals and prevent the formation of spatial framework upon cooling of diesel fuel, which reduces its temperature filterable limit and cloud point The latter are surfactants having in its structure long aliphatic radicals and polar groups [3–7].

In order to identify the most effective additives the analysis of technical and economic indicators (Pour Point, Cold Filter Plugging Point, Cloud Point, Price at the optimum concentration of the account) most well-known and used in the practice of pour-point depressants is made.

Cloud Point (CP) is the temperature at which first crystallization is observed as a haze in a diesel fuel sample. Pour point (PP) is the temperature at which the fuel stops flowing and becomes solid. Cold Filter Plugging Point (CFPP) is the temperature at which the fuel stops flowing through a standard fuel filter. Reaching this temperature will cause handling problems with the fuel through the fuel system.

**Results, discussion and conclusion.** Table 1 shows the results of analysis of the technical and economic indicators (Pour Point, Cold Filter Plugging Point, Cloud Point, Price at the optimum concentration of the account) best-known and used in domestic refineries of depressants.

Table 1. – The technical and economic indicators most known and used in domestic refineries of depressants

Additive names	Cloud Point, °C	Pour Point, °C	Cold Filter Plugging Point, °C	Optimum concentration, wt. %	Price of 1 liter, USD	Price at the optimum concentration of the account
Dodiflow 8055	-22	-39	-32	0,5	6	3,00
Keroflux 5695	-22	-33	-28	0,3	3,5	1,05
Gunk M2216	-5	-23	-35	0,1	7,8	0,78
Total Stopogel	-5	-23	-39	0,4	5,5	2,20
Jetgo	-5	-14	-27	0,5	4,7	2,35

On the Belarusian refineries they use additives of a series Dodiflow (Clariant) and Keroflux (BASF) in the production of commercial diesel fuel. The main drawback of imported depressants used today in industrial environments is their high cost. According to the table 1 the most effective and economically advantageous depressants are Keroflux 5695 (BASF) with their low cost. These additives have excellent physical and chemical properties.

Research has established the fact that depressant and dispersant additives for diesel fuel may be produced using the polymers of waste products (for example, low molecular weight polyethylene as a pour point

depressant [8]) and dispersing additive (e.g., C-5A). Dispersing additives contribute to the retention of small crystals in the solid phase suspension and facilitate their uniform distribution throughout the volume of fuel.

## REFERENCES

1. Nigel, R. Cuthbert. Auto and oil industries improving quality, efficiency of EU fuels / R. Nigel // *Oil & Gas Journal*. – 1999. – Vol. 97, No. 28. – P. 40–45.
2. Erkina, L.I. Basic problems in production of winter types of diesel fuel / L.I. Erkina, S.A. Feigin, E.D. Radchenko // *Chemistry and Technology of Fuels and Oils*. – 1978. – V. 14. – № 7. – P. 34–36.
3. Улучшение низкотемпературных свойств дизельных топлив : моногр. / С.Г. Агаев [и др.]. – Тюмень : ТюмГНГУ, 2009. – 145 с.
4. Таранов, Л.В. Механизм действия депрессорных присадок и оценка их эффективности / Л.В. Таранов, Ю.П. Гуров, В.Г. Агаев // *Современные наукоемкие технологии*. – 2008. – №4. – С. 90–91.
5. Данилов, А.М. Отечественные присадки к дизельным топливам / А.М. Данилов // *Мир нефтепродуктов*. – 2010. – № 1. – С. 9–13.
6. Васильев, Г.Г. Применение депрессорно-диспергирующих присадок при производстве дизельных топлив ЕВРО / Г.Г. Васильев, Н.В. Наврилов, М.М. Лобашова // *Мир нефтепродуктов*. – 2013. – № 1. – С. 5–11.
7. Тертерян, Р.А. Депрессорные присадки к нефтям, топливам и маслам / Р.А. Тертерян. – М. : Химия, 1990. – 238 с.
8. Павлов, А.В. Основные направления использования низкомолекулярного полиэтилена и его влияние на свойства нефтепродуктов / А.В. Павлов, А.А. Ермак // *Вестник Полоцкого государственного университета. Серия В, Прикладные науки*. – 2007. – № 8. – С. 123–127.

## BLEND COMPOSITION OF HEAVY PYROLYSIS GAS OIL

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The paper presents the experimental study of possibility of heavy pyrolysis tar refining to get a naphthalene fraction. According to the experimental data which was got with the help of the gas-liquid (GLC) chromatographic method of component composition of the heavier cut of pyrolysis gas oil of plant "Polymir" JSC "NAFTAN" is determined.

**Introduction.** In order to maintain competitiveness in the ethylene business for European steam crackers, more emphasis must be placed on upgrading all of the byproducts that are generated by liquid crackers. Producers who do not upgrade these by-products will face increasing pressure on plant margins due to competition from the low-cost regions of the world.

Naphthalene is produced commercially from either coal tar or petroleum [1, 2].

In the heavier cut of pyrolysis gas oil (PGO), naphthalene can be recovered. When a cracker size crosses the 1000 KTA mark, naphthalene recovery is economically feasible. The method of choice is a static-melt crystallisation process, such as that used at the largest North American producer's site. This operation produces refined naphthalene with a MP of 80°C, along with aromatic solvents and speciality fuel products. Various product derivatives can further increase the profitability of naphthalene recovery. The generic flow scheme of heartcut fractionation followed by crystallisation is shown in Figure 1 [3].

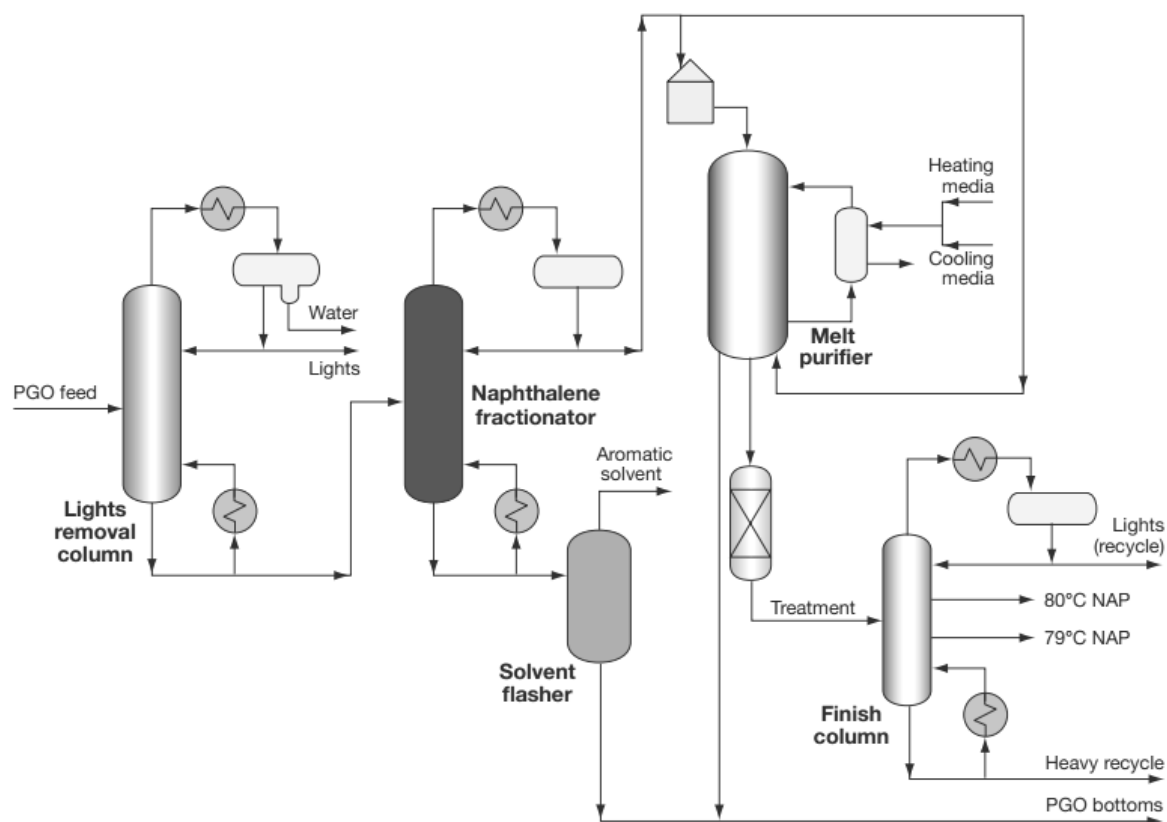


Fig. 1. Naphthalene separation process

**Methodology.** The PGO of the plant «Polymir» of JSC «Naftan» was distilled into three liquid fractions of b.b. –180 °C, 180–210°C, 210–230°C, and the solid residue – pitch. The research of three liquid fractions of heavy pyrolysis gas oil was carried with the gas-liquid chromatography method. NAS UniChrom gas chromatograph with a computing integrator was used.

**Results, discussion and conclusion.** Fractional yield b.b. –180 °C was 1.89 wt%, fr .. 180–210 °C – 18.76% by weight .. fr 210–230 °C – 14.45% by weight. and semi-solid residue of polymer nature – pitch – 64.9

wt%. Thus, the PGO of the plant «Polymir» of JSC «Naftan» contains about 35% liquid concentrate. In Table 1 there are data about the group hydrocarbon composition of separate fractions of heavy pyrolysis gas oil of the plant «Polymir» of JSC «Naftan». The data are obtained with the result analysis of each fraction gas-liquid chromatography.

Table 1. – Group hydrocarbon composition of PGO fractions

Hydrocarbon groups	Fractions, % Wt.			
	b.b.–180°C	180–210°C	210–230°C	total fraction (b.b.–230°C),
Paraffin	2,04	0,94	0,43	0,79
Isoparaffins	10,96	13,29	14,04	13,47
Aromatics	62,82	66,30	70,47	67,82
Naphthenes	7,30	5,26	1,94	4,00
Olefins	13,09	5,26	3,43	6,70
Unknown	3,79	5,64	9,69	7,22

Thus, the PGO liquid concentrate is a mixture of different hydrocarbon groups, first, aromatic ones, such as monocyclic or polycyclic groups. Also there are isoparaffins, unsaturated, naphthenic and paraffinic hydrocarbons in all fractions. More than 225 individual substances are identified in the PGO liquid concentrate of the plant "Polymir" of JSC "Naftan". The aromatic hydrocarbons with a compound chemical structure take first place by being in the PGO liquid concentrate (about 68 wt.%) among the hydrocarbon groups. More than 75 members of this group have been discovered and their being is increasing with the weighting of the PGO fractional composition. The main component of the product is a liquid PGO naphthalene and its alkyl derivatives (methylnaphthalenes and dimethylnaphthalenes), which have the total content of 27.3 wt%.

Naphthalene is a valuable raw material for the chemical industry. It is used for the synthesis of mono- and polysulfonic, nitro and numerous further processing products, in the production of phthalic anhydride and for the preparation of explosives and dyes, in medicine and etc. Methylnaphthalene is used as insecticides, solvents and initial products in the synthesis of dyes, for sulphonic acids and mono- dimethylnaphthalenes, used in surfactants. Besides, 2-methylnaphthalene is a valuable raw material for the synthetic vitamin K3 production; 1-methylnaphthalene is the standard in determining a cetane number of diesel fuel; 1,4-dimethylnaphthalene is used to inhibit a vegetable germination; 2,6-dimethylnaphthalene are oxidized to 2,6-naphthalene dicarboxylic acid, using in the polyesters and polyamides production. We should also pay attention to the cymene PGO liquid product (1-methyl-2-isopropylbenzene, 1-methyl-3-isopropylbenzene, 1-methyl-4-isopropylbenzene), which can be widely used for the synthesis of cresols, highly efficient antioxidants, phthalic acids (preferably isophthalic and terephthalic acid), flavors, etc. The PGO distillation residue is expedient to use as a raw material for the carbon fibers and pitches production.

The results of the chromatographic analysis reveals that the PGO concentrate is a mixture of different hydrocarbon groups, preferably aromatic ones, and there are various ways of rational and effective ways to its subsequent efficient usage.

#### REFERENCES

1. Mason, R.T. Naphthalene / R.T. Mason // Kirk-Othmer Encyclopedia of Chemical Technology / eds : J.I. Kroschwitz, M. Howe-Grant. – 4th ed. – New York : John Wiley & Sons, 1995. – Vol. 16. – P. 963–979.
2. Kazak, Y. The analysis of simultaneous solubility of naphthalene in alcohols and hydrocarbons / Y. Kazak, S. Yakubowski // European and National dimension in research : materials of VIII junior researchers' conference Polotsk State University, Novopolotsk, April 27–28, 2016 : in 3 p. – Novopolotsk : PSU, 2016. – P. 3 : Technology. – P. 84–85.
3. Joseph, G. Pygas upgrading for European steam crackers / G. Joseph, Z. Meijuan // Refining OAS processing petrochemicals. – 2009. – P. 103–108.

### USING OF 3D-MODELLING AND RAPID PROTORYPING TECHNOLOGIES DURING THE DESIGN OF CONSTRUCTIONS OF BLOCK-MODULE SURFACE CUTTINGS

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*The results of the development of constructions of block-modular surface cuttings based on the results of 3D-modeling and rapid prototyping application are introduced.*

Usage of the latest technologies of 3D-modeling and rapid prototyping as well as usage of modern photopolymer materials during the production of prototypes of cutting tools is getting a popular topic in machine building.

The proposed constructions of block-module surface cuttings consist of 80% common parts [1]. They include holders, clamps, pins, dentils, binders, etc.

Using 3D parameter-oriented models of master parts of the construction is an essential reserve for increase of construction effectiveness in CAD systems environment.

The interest to the study of these technologies and materials can be described as a possibility of «growing» of 3D-model constructions of block-module surface cuttings developed in different graphic software products such as SolidWorks (Autodesk), SolidEdge (Autodesk), Inventor (Autodesk), Pro/Engineer (Autodesk), Catia (Dassault Systemes) with further overall conducting researches and their production in machine building industry.

The task to construct a modification of block-module surface cutting for processing at high cutting speeds was set. It requires the systematization of its shape for the improvement of aerodynamic properties and balancing possibility.

To analyze the functionality of block-module surface cutting construction of a streamline shape is possible through 3D-model building and its prototype production. As a final stage of 3D-modelling it is necessary to export the model to a «.stl» format using software.

The specified format is recognized by high-tech devices of 3D-printer Mojo which supports high standards of FDM technology [2].

Using the rapid prototyping technology leads to decrease of the process engineering duration; increase of manufacturing flexibility; cross-cutting use of the technologies, integration with CADD or CAD.

The main stages of creating block-module surface cutting of a rational shape are introduced in Figure 1.

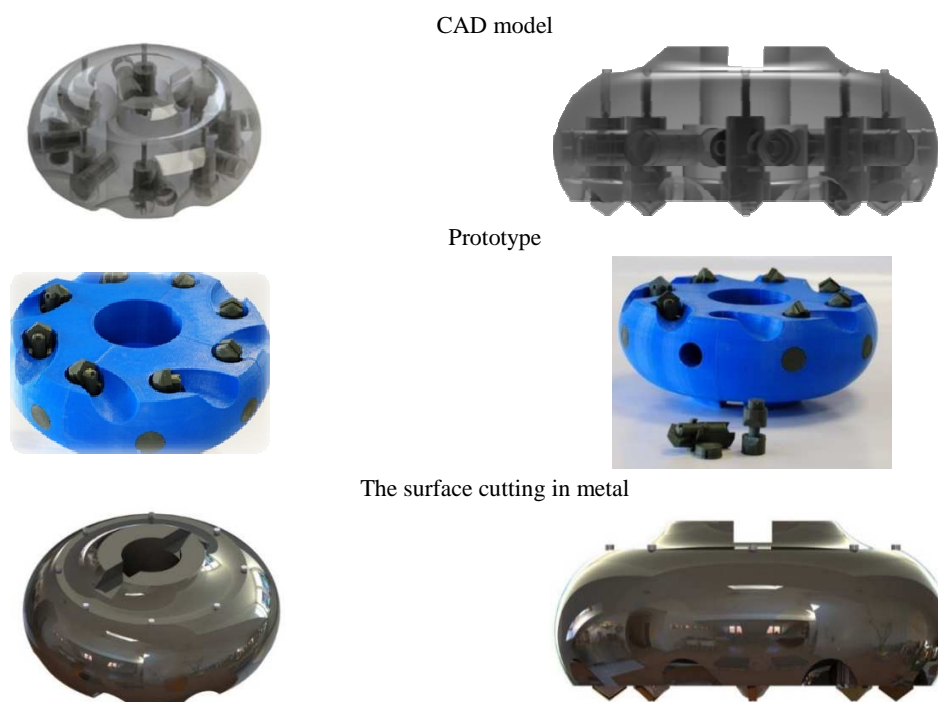


Fig. 1. Main stages of creating block-module surface cutting construction of a rational shape

The prototyping of constructions and basic elements of block-modular surface cutting has a broad scope of application. First of all, 3D-printing technology is used for experimental models of different elements which are included in the structure of assembly work. Also the rapid prototyping is necessary during the change of detail form, modernization and restyling; for exclusive developments; experimental models. In this case 3D-printing makes it possible to avoid financial and economic expenditures for production tooling.

The received prototype gives the opportunity to see what the model looks like in real life. Thus, it is possible to evaluate all advantages and disadvantages during the design stage, to decrease the probability of the production of low-quality or defective detail.

#### REFERENCES

1. Конструирование и оснащение технологических комплексов / А.М. Русецкий [и др.] ; под общ. ред. А.М. Русецкого. – Минск : Бел. наука, 2014. – 316 с.
2. Технология проектирования блочно-модульных режущих инструментов с использованием 3D-принтера / Н.Н. Попок [и др.] // Современные проблемы машиноведения : материалы XI междунар. науч.-техн. конф. – Гомель, 2016. –С. 34–35.

## USE OF ULTRA-WIDEBAND SIGNALS IN NONLINEAR RADAR

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*The analysis is given of the ways to improve the sensitivity of nonlinear radar to eavesdropping devices having small dimensions and having in its composition nonlinear objects. We investigated the method to increase the sensitivity by using, as the probe signal ultra-wideband pulses together with the harmonic signal of microwave frequency, which could result in intermodulation effect, through which run the identification nonlinear objects among the plurality of reflectors, which do not apply to non-linear objects.*

**Introduction:** from the variety of possible methods of searching objects, the nonlinear radar is one of the most important ones and has been actively developing since the 70-ies of the last century. The nonlinear radar (NRL) detects nonlinear objects (NO), not only in the active mode (transmission signal), but also in the passive (accumulation operation) one and being turned off.

Currently sensitivity plays an important role in NRL. Conclusions transistors diodes and other nonlinear elements, as well as the conductors of the PCB laying device serve as an antenna to broadcast a re-emitted signal on the air. The rapid development of micro- and nano-electronics sets the task of improving the sensitivity of the NRL to mortgages devices having small dimensions, such as GSM bug N9 Nero Apple 40x30x10mm size [1]. The sensitivity of a conventional radar is improved in several ways: to increase the sensing frequency of use sophisticated signal as a probe, to reduce the duration of a probing signal pulse, increase the power of the probe signal. Increasing the operating frequency of NRL causes complication of the radar receiver path and leads to deterioration of the penetrating power of the radio signal.

The traditional use of complex radar signals allows to resolve the contradiction between energy potential and sensitivity [2]. The use of complex nonlinear radar signal has a different character [3]: the use of complex signals leads to the deterioration of the sensitivity and accuracy of the range measurement.

Of interest is the use of ultra-wideband signals for probing nonlinear objects. Midget duration of such signals provides a high level of resolution (up to mm units).

**The goal:** to explore the sensitization method using ultra-wideband pulse as a probing signal together with the ultra-high frequency harmonic signal

**Objectives:** to increase sensitivity of the mortgage nonlinear radar devices having small dimensions and having in its composition nonlinear objects.

It is proposed to use the effect of intermodulation as the foundation of such a method [4]. At the same time NO should be irradiated with a powerful harmonic signal  $E_0(t)$  and ultra-wideband pulses  $E_r(t)$ . Reradiated signal from the NO is determined by (1):

$$E_r(t) = E_0(t) + g[E_0(t)], \quad (1)$$

where  $g(x)$  – the form of nonlinearity.

When the powerful high-frequency harmonic  $E_1(t)$  signal, given by the expression (2), rescattered signal from the NO will be determined by the expression (3):

$$E_1(t) = A \sin(\omega t + \phi), \quad (2)$$

$$\begin{aligned} E_r(t) &= E_0(t) + E_1(t) + g[E_0(t) + E_1(t)] = \\ &= E_0(t) + A \sin(\omega t + \phi) + g[E_0(t) + A \sin(\omega t + \phi)]. \end{aligned} \quad (3)$$

To analyze the efficiency of this method, the simulation scheme «Matlab» program (Fig. 1) is synthesized. In the simulation, the case of the presence of eavesdropping devices in an environment that does not have shielding and absorbing properties of radio waves is considered.

Ultra-wideband pulses formed «Pulse Generator» blocks and «Digital Filter Design». The harmonic signal is generated by «Sine Wave» block. With the help of these two signals combiner is formed and sent to the NO «Fcn», the current-voltage characteristic of which is given by a polynomial of the third degree. Blocks



«AWGN Channel» simulate communication channel with noise. The simulation results are presented in the form of spectrograms of the control points scheme: «Spectrum Analyser», «Spectrum Analyser1», «Spectrum Analyser2».

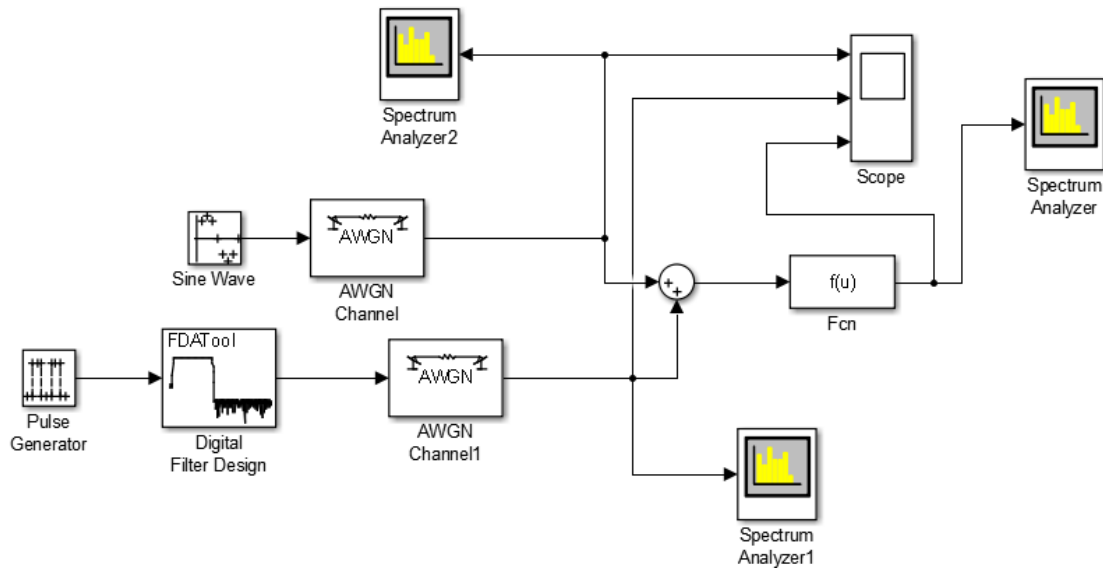


Fig. 1. Driving simulation

The spectrum ultra-wideband signal of the probe is shown in Figure 2, *a*. Signal to noise ratio in the simulation is set to + 20dBm. The spectrum ultra-wideband signal is limited to a band pass filter at the level of the main lobe. Pulse takes the form of the second derivative of a Gaussian pulse. The width of the spectrum in this case is on the level of 0.833GHz –3dB relative to the maximum power level, which is equal to –10 dBm. The spectrum of a harmonic signal (Fig. 2, *b*) has a single spectral component power 27 dBm in the 1.4 GHz frequency, which is higher than the maximum frequency of UWB signal spectrum at 600 MHz.

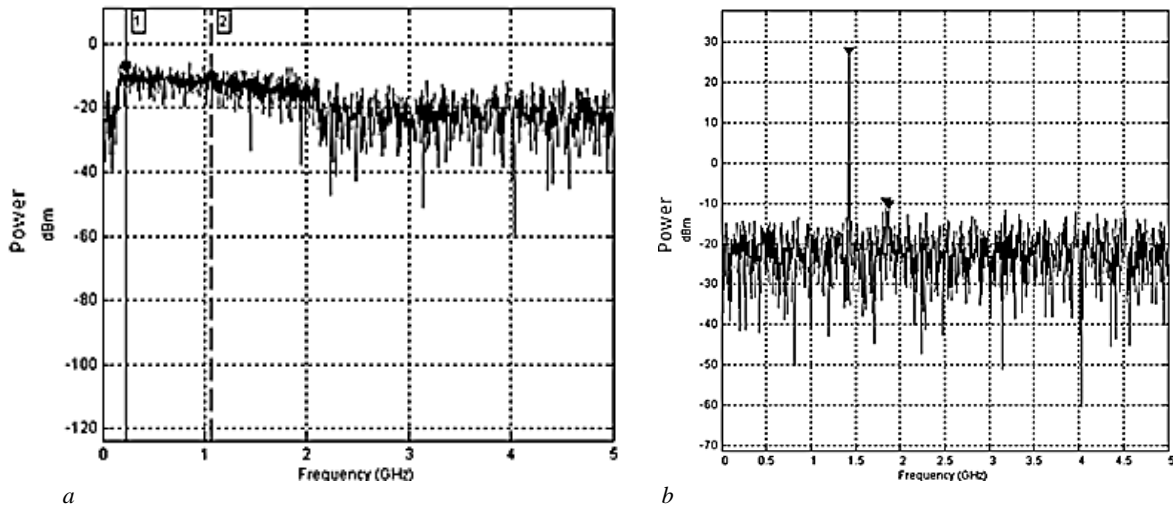


Fig. 2. Spectrograms probing signals:  
*a* – UWB signal spectrum, *b* – the harmonic spectrum signal

Output signals by converting NO described by a polynomial of the third degree is shown in Figure 3, *a*. As seen in the spectrogram, the reradiated signal is composed of harmonic signal emitted at the speed of 1.4 GHz 35 dBm level, twice the level of 25 dBm and three times the level of 15 dBm. In addition, there is cross modulation between the harmonic and UWB signals. And the range is similar to the amplitude-modulated signal, which serves as a carrier wave signal. When the quadratic nonlinearity (Fig. 3, *b*) is also present, and the double but not three times harmonic modulation of the radiated harmonic signal.

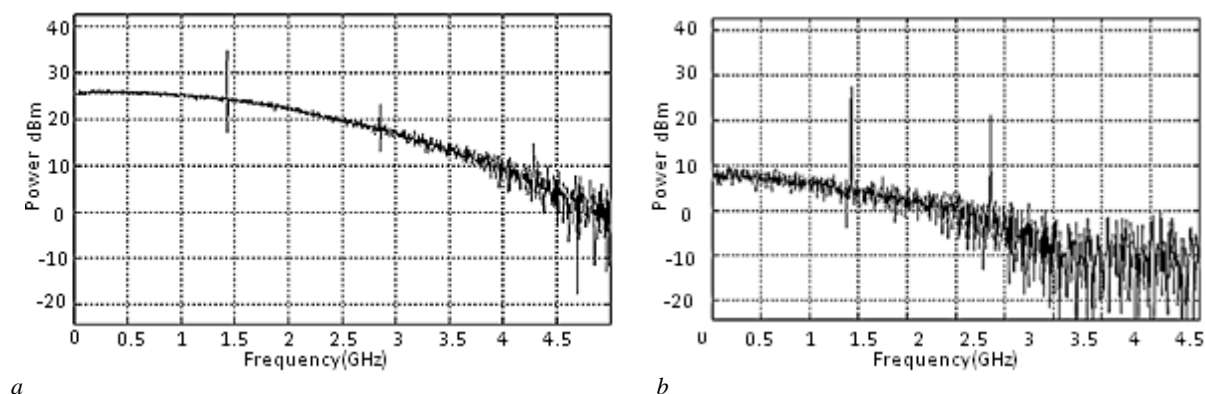


Fig. 3. The spectrum of the signal after the nonlinear transformation:  
*a* – for NO, described by a polynomial of the third degree; *b* – for the quadratic NO

**Conclusion.** Based on these results it is clear that irradiation as well as the harmonic signal and UWB pulses observed the effect of intermodulation. With NRL receiver tuned to a sideband of the modulated signal obtained as the result of the nonlinear transformation, NO is detected. Furthermore, the use of ultra-wideband signal can improve the sensitivity to NRL mortgage devices having dimensions of approximately a few centimeters. The programming model confirms the possibility of use in nonlinear radar the method of detecting eavesdropping devices having small dimensions and having in its composition NO. The model is the basis for practical tests in order to obtain more detailed studies.

#### REFERENCES

1. GSM жучок N9 [Электронный ресурс]. – Режим доступа: <http://www.spytome.net/manuals/Nero-Apple.pdf>. – Дата доступа: 02.04.2016.
2. Лезин, Ю.С. Оптимальные фильтры и накопители импульсных сигналов / Ю.С. Лезин. – М. : Сов. радио, 1969.
3. Горбачев, А.А. Особенности зондирования электромагнитными волнами сред с нелинейными включателями / А.А. Горбачев // Нелинейная радиолокация : сб. ст. №2. – М. : Радиотехника, 2006.
4. Дистанционная сверхширокополосная томография нелинейных радиоэлектронных элементов / В.П. Якубов [и др.] // Журнал технической физики. – 2015. – Т. 85, Вып. 2. – С. 122–125.

UDC 621.643.004:502.3

**DEVELOPMENT OF THE STANDARD TO ORGANIZE ENVIRONMENTAL PROTECTION DURING EMERGENCY OIL SPILLS****MIKALAI ROZUM, LUDMILA SPIRIDENOK**  
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*In the republic of Belarus the economic sector associated with oil and the products of its processing is well developed. It includes all the stages of the process of oil redistribution from production to the final delivery of the product to the consumer.*

The following steps can be distinguished in the back of oil: oil production, its preparation for transportation, transportation, processing, storage, and distribution.

One of the potential risks associated with the operation of oil technical objects is that contingency situations which can appear in the course of operation may be accompanied by depressurization of the equipment. And it leads to the emergency oil spills (EOS). Emergency oil spills bring backlash that may occur in the social, economic and environmental spheres. The EOS one way or another causes negative impact on all of the elements of the environment: land, water, air, flora, and fauna.

The scale and nature of the environmental backlash, such as pollution of water, land and marsh as well as the conditions that should minimize and eliminate these effects and their effectiveness, depend on the amount of oil spilled, the landscape characteristics in the areas adjacent to the site of the EOS. A necessary condition for the success of the activities aimed at minimizing the consequences of oil spills is using the procedures of technical regulation on the basis of the developed technical regulations (TR) in the field of environmental protection.

The standard establishes general rules for the organization and order of works to protect the environment (water bodies, land, marsh landscapes) in case of accidents on the main oil pipelines and oil-products pipelines. Also this standard is used in the development of emergency response plans and the development of training sessions, ABC units plans the main oil pipelines and oil-products pipelines.

Implementing the standard minimizes the biological influence of oil or oil-product on organisms. Harmful effects are divided into 5 categories: direct poisoning fatalities, serious violations of the physiological activity, the effect of the direct encapsulation of living organism with oil, painful changes caused by the introduction of hydrocarbons into the body, as well as changes in biological features of the environment.

The most significant factor that affects the spread and impact of pollution on the natural environments is the type of environments (water bodies, land, marsh landscape). Taking this into account industrial classification of natural objects has been developed in the standard, and the classification of accidents on main oil and oil-product pipelines (MOPP) associated with leakage of the pumped product has also been provided.

Water bodies are classified according to the following criteria:

- a) type of WB according to [2];
- b) the hydrographical characteristics of WB;
- d) the relief of the terrain;
- d) the characteristics of the soil near the WB;
- e) the nature of the flora;
- g) the ecological and economic importance of the WB according to [3].

Lands are classified by the following features:

a) the purpose according to the STB 943-93, it is necessary to take into account the quantitative and qualitative impact of vegetation;

- b) the humidity of the lands in accordance with [4];
- g) soil porosity in accordance with State Standard (GOST) 25100.

Marshes are classified according to the following criteria:

- a) the occurrence of the conditions regarding the relief, according to [5, p. 38];
- b) cross-country equipment in accordance with construction rules and regulations (SNIP) III-42.

Typical technical processes to liquidate emergency oil and oil-product spills have been developed on the basis of the worked out classifications for each natural environment. Technical processes include both the organization of work on the oil or oil-product spill and production of technology works. All the works to localize and liquidate emergencies at MOPP are made with possible emergencies plans. These plans include typical scenarios of technological processes. The water protection provides measures to prevent the ingress of oil and petroleum products in the water body, the construction of protective structures, localization of spilled oil, floating oil collection and reclamation, shoreline restoration, etc. Liquidation of land pollution consists of three stages: the localization of oil or oil-product spill, oil gathering from the ground and land reclamation. To

liquidate pollution of marsh lands following operations are performed: preparation work, digging ditches to gather oil or oil-product in the marshes of I and II category SNiP (construction rules and regulations) III-42, flushing the oil from the marsh surface in the ditch, oil collecting from water surfaces swamp category III SNIP III-42 and ditches in the marshes of I and II category with the help of oil skimmer, collecting and disinfection vegetation polluted with oil.

Implementation of the developed standard is not intended to obtain a direct economic benefit. However using the standard statements establishes rules and procedures for the liquidation of oil-polluted environments (land, water bodies and wetland landscapes) during the accidents on main oil and oil-product pipelines. So it minimizes environmental pollution in case of emergency oil spills.

#### REFERENCES

1. Защита окружающей среды при аварийных разливах нефти и нефтепродуктов. Основные правила и порядок выполнения работ : СТП 09100. 20001.004-2014.
2. Водный кодекс Республики Беларуси. [Электронный ресурс]. – Режим доступа: <http://www.newsby.org/kodeks/vodk/20131015/index.htm>.
3. Кадастр использования водных ресурсов (методы и практика ведения) / под общ. ред. А.Н. Колобаева. – Минск : 1997. – 209 с.
4. Кодекс Республики Беларусь о земле : 23 июля 2008 г., № 425-3.
5. Иванов, К.Е. Гидрология болот / К.Е. Иванов. – Л. : Гидрометеиздат, 1953. – 296 с.
6. Грунты. Классификация : СТБ 943-93.
7. ГОСТ 25100-2011 Грунты. Классификация.
8. Магистральные трубопроводы. Правила производства и приемки работ : СНиП III-42-80.

UDC 661.2/6=111

**SULPHUR GRANULATING ROTOFORM PROCESS**

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*Environmental regulatory agencies continue to promulgate more stringent standards for sulphur emissions from industrial sources. Many plants are still allowed to emit large quantities of SO<sub>2</sub> because of their remote locations and the high cost of mitigation, but those exemptions are running out as governments become more environmentally responsible.*

With the renewed interest in high sulphur coal for power production and increased activity in the mining and metals sectors, it is necessary to develop and implement reliable and cost-effective technologies to cope with the changing requirements.

Sulphur dioxide is found in a many industrial gases emanating from plants involved in roasting, smelting and sintering sulfide ores, or gases from power plants burning high sulphur coal or fuel oils or other sulphurous ores or other industrial operations involved in the combustion of sulphur-bearing fuels, such as fuel oil. One of the most difficult environmental problems industry faces is how to control SO<sub>2</sub> emissions from these sources economically [1].

Sulphur is a basic chemical element widely distributed in nature. It's found in small amounts in all living creatures, including humans. Sulphur makes up 0.05 percent of the earth's crust and often accumulates in large amounts near volcanoes. Sulphur is also found, in varying amounts, in crude oil and natural gas. The crude oil contains "sour gas" that has a hydrogen sulfide content of about 14 percent. Oil refinery plant removes this hydrogen sulfide from the crude oil and associated gas and converts it into elemental sulfur. Elemental sulphur is a yellow solid substance that is not hazardous.

Sulphur has many uses. It's a key element in the production of paper, rubber and textiles and to make cosmetics, plastics and paints. It's used by the pharmaceuticals, mining and food industries and in the production of cement, asphalt, glass and steel. Its largest use is in making fertilizers and soil conditioners [2].

As further processing very often requires liquid sulphur (e.g. for the production of sulphuric acid and fertilizer), it is advantageous to transport and store sulphur in liquid form. However, temperatures of between 124–145°C mean that handling, transportation and storage could pose a problem from the point of view of safety and economics, so liquid sulphur is handled only if one or more of the following factors apply:

- Short distances.
- Short storage cycles.
- Availability of adequate storage system.
- Availability of adequate infrastructure for transport, be it road, ship or railway transport.

More often, for easier handling, storage and transportation, sulphur is formed into pastilles/semispherical granules. The pastilles are globally accepted as a premium quality product, delivering the following significant benefits:

- High purity (bright yellow colour).
- Low friability and high impact abrasion resistance (low visual dust generation).
- Good flow characteristics.
- Easy remelt (no agglomeration).
- Low moisture content.
- Stable properties over time.
- Consistent quality.

Based on steel belt technology, world company has developed an efficient and environmentally friendly process for the cooling and solidification of molten sulphur. The basic principle consists of a continuously running steel belt, which is cooled from the underside by spraying water through nozzles. A specially developed feeding system – the Rotoformer – deposits liquid sulphur in form of droplets onto the steel belt. These are cooled as they run with the steel belt and discharged in form of solid pastilles / semispherical granules at the end of the system [3].

**Integration of the Rotoform in the complete system**

The product is manufactured in a reactor or a mixing container and kept at the ready in an intermediate container, pumped via a filter and placed onto the steel belt cooler in droplet form. The high-quality pastilles produced by the cooling and solidification are transported to the finished product warehouse and subsequently packed (Fig. 1).

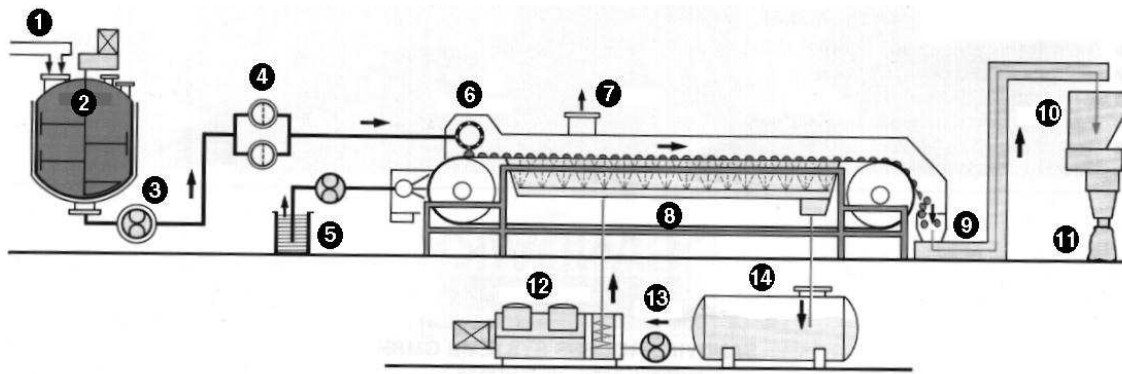


Fig. 1. Functional diagram of the Rotoform system:

1 – Additive raw materials; 2 – Mixer; 3 – Pump; 4 – Filter; 5 – Release agent applicator; 6 – Rotoform; 7 – Gas out; 8 – Steel belt cooler; 9 – Conveyor; 10 – Weigher; 11 – Packing; 12 – Chiller; 13 – Pump; 14 – Water tank

The sulphur pastillation unit consists of:

### 1. Sulphur Feeding Circulation Equipment

The liquid sulphur will be supplied from an existing sulphur pit by pumps via heated pipelines through liquid sulphur filters to the Pastillation Lines.

The liquid sulphur which is not used by the Rotoform system circulates back to the sulphur tank.

The sulphur feeding circulation equipment allows by constant pressure a flexible production performance (33...100%), and is consisting of:

- steam jacketed pipes and valves
- pressure control valve and pressure transmitter for control the sulphur pressure in circulating piping on constant value.
- liquid sulphur filter with pressure transmitter for estimation of pressure drop (dP) across filter. The filter consists of 2 bucket filter; one in operating the other one as stand by. By pressure drop High alarm (approx. 0,5bar) the operator should manually switch the bags and clean by steam the dirty filter (possible during production).

The sulphur pressure and temperature in circulation line have relevant influence on production capacity and pastilles quality.

### 2. Pastillation Lines

With Steel Belt Cooler and Rotoform unit.

The liquid sulphur is transported via a steam heated product pipe through a filter station to the Rotoform. The flow rate to the Rotoform unit can be adjusted by means of a manual needle valve on Rotoform or by supply pressure. On/Off-valve with steam heated jacket cuts sulphur feed to Rotoform by disturbances or malfunctions.

To avoid the solidification of sulphur in the Rotoform and the sulphur piping, these units are also heated by steam. Rotoformer temperature is monitored by temperature transmitter. The rotation speed of the Rotoform unit can be adjusted. According to the speed of the Rotoform unit the steel belt velocity must be adjusted for the steel belt cooler drive accordingly.

Cooling water is sprayed on the underside of the steel belt in order to solidify the sulphur pastilles along their way on the steel belt cooler. Cooling water flow is monitored by flow transmitter. The steel belt cooler is equipped with a rotation "zero" protection via zero speed sensor (fig. 2).

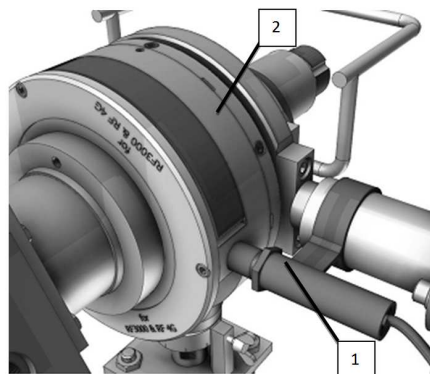


Fig. 2. Zero speed sensor

This provides a stop of the belt drive in case of a broken steel belt or chain. During operation a zero speed sensor constantly checks that the outer shell is rotating. The zero speed sensor is positioned in front of the service side bearing unit. A proximity sensor (1) detects a segment (2), installed in one of the three openings of the service side bearing unit. The zero speed sensor is a proximity switch. The proximity switch is adjusted so that it switches once per revolution of the bearing housing. This alternating signal is evaluated as a rotation signal by a separate controller and indicates that the outer shell is rotating.

Also two emergency pull rope switches are installed in case of emergency stop of the pastillation line is required. On the discharge and of the steel belt cooler a pneumatic discharge device disposes the pastilles from the belt. Pneumatic spray unit sprays release agent on the steel belt before RF in order to improve pastilles shape and discharging from the steel belt.

### **3. Cooling water system**

The internal cooling water circuit for all pastillation lines consists of:

- Cooling Water Pit;
- Cooling Water Pumps.

The cooling water spray on the underside of the steel belt then flows from the collecting pans below steel belt back to the Cooling Water Pit by gravity.

The cooling water is cooling down by heat exchanger.

### **4. Release Agent System**

The release agent system consists of a release agent tank with Mixer, Release Agent Pumps and circulation piping. This equipment is common for all pastillation lines.

The release agent tank is filled up with a mixture of 12% Tegopren and water. This mixture is put on the steel belt by means of spraying unit. The release system is required to easier remove the pastilles from the belt after solidification and improve pastilles quality.

### **5. Exhaust Fans**

The pastillation lines are equipped with Exhaust Fans which transports the sulphur vapors from the Rotoform area out of the stainless steel hood outside of the shelter. It has to be in operation during the solidification to avoid dangerous concentration of poisoning gases.

### **6. Downstream**

The Downstream (down to Pastillation Lines) performs the transport of produced sulphur pastilles via conveyor system to one of silos.

### **7. Railcar Loading**

Loading of Railcars from Silo consists of:

- Pneumatic gate valve;
- Movable & Reversible Conveyor;
- Discharge Chutes fixed at both ends of conveyor.

### **8. Truck Loading**

Loading of Trucks from Silo consists of:

- Pneumatic gate valve;
- Movable & Reversible Conveyor;
- Discharge Chutes fixed at both ends of conveyor [4].

### **Conclusion**

This process is the ideal solution for oil refineries, something that is clearly demonstrated by the fact that all major oil refineries in the world, where sulphur production has increased substantially over the last years, are equipped with this system. This versatile process – which is supported by an efficient and global service network – provides a reliable and environmentally friendly solution to the issue of handling sulphur in the most efficient way possible.

### **REFERENCES**

1. Production of Elemental Sulphur from SO<sub>2</sub> RSR (Rameshni SO<sub>2</sub> Reduction) [Electronic resource] / M. Rameshni, S. Santo, 2008. – Mode of access: [http://www.worleyparsons.com/CSG/Hydrocarbons/SpecialtyCapabilities/Documents/Production\\_of\\_Elemental\\_Sulphur\\_from\\_SO2.pdf](http://www.worleyparsons.com/CSG/Hydrocarbons/SpecialtyCapabilities/Documents/Production_of_Elemental_Sulphur_from_SO2.pdf). – Date of access: 08.01.2017.
2. Sulfur production and sales [Electronic resource] / Tengizchevroil, 2007. – Mode of access: [http://s3.amazonaws.com/zanran\\_storage/www.eco.gov.kz/ContentPages/2468512466.pdf](http://s3.amazonaws.com/zanran_storage/www.eco.gov.kz/ContentPages/2468512466.pdf). – Date of access: 10.01.2017.
3. Sulphur solidification and handling systems [Electronic resource] / Sandvik, 2008. – Mode of access : [http://www2.sandvik.com/sandvik/0140/internet/s002582.nsf/0/BC7D901D03D8DE7CC12574E4004A6B70/\\$file/Sulphur%20saleskit%208.7.2008.pdf?OpenElement](http://www2.sandvik.com/sandvik/0140/internet/s002582.nsf/0/BC7D901D03D8DE7CC12574E4004A6B70/$file/Sulphur%20saleskit%208.7.2008.pdf?OpenElement). – Date of access : 14.01.2017.
4. Operator manual Rotoform 4G [Electronic resource] / Sandvik Materials Technology Deutschland GmbH 2009. – Program (15M6). – 1 optical disk (CD-ROM).

**THE ULTRASONIC SOUND IN ADSORPTIVE PROCESSES**

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*This article deals with the implementation of the ultrasonic sound which is essential for the improvement of the quality of oil refining adsorption processes. The ultrasonic sound is used particularly for the process effectivization, it means, for the intensification of the speed in adsorption processes as well as duration reduction.*

It was stated that acoustic vibrations effect on the processes of mass exchange greatly. For example, in most research papers [1, 2] it is shown that heterogeneous processes that exist in the diffused area, in the acoustic area are much more intensive than if these processes are mixed with the help of the blender [3].

Mass exchange processes (crystallization, extraction, absorption, adsorption, distillation, drying) which play the great role in the chemical industry, are characterized by long duration. The speeding of these processes, in particular their ultra super sonic intensification, has a very important meaning for the oil refining industry.

Still, not much is known about the impact of the acoustic vibrations on the adsorption process, which is, on all counts, is very important.

Adsorption is the division process, which is based on the elective absorption of gases, vapors or of the substances dissolved in liquids. This adsorption is carried out by the solid porous absorption vessel which is capable to adsorb one or few substances or mixtures [4].

There exist lots of experiments where the process of ultrasonic adsorption has been carried out on different laboratory facilities. But one must know that the greater part of these experiments is empiric, that means, the experiments analyze mostly the mechanisms of ultrasonic adsorption and the main problems that can emerge during these processes.

For example, in the research work made by O. Rochmanov [5], it is shown that the implementation of ultrasonic sound during the adsorption process allows improving greatly the quality of purification paraffin hydrocarbon, in comparison with non-ultrasonic sound actions.

As the sorbing agent one uses increasingly the sorbents of natural origin (such as clay materials, zeolite, sand), as they are not so expensive and are generally available [6].

It is well known that depending on its mineralogical and chemical structure, clay adsorbents have different size and void content; that is why their stuffing needs the right selection of the ultrasonic vibration rational frequency.

Achromatize ability of the clay adsorbents depends on the conditions of their contacting with the paraffin hydrocarbon. In this respect the vibration frequency of ultrasonic sound during the process of paraffin hydrocarbon's purification has not the least role. Thus, O. Rochmanov analyzed the influence of the ultrasonic sound vibrational frequency on the degree of conformity at 80–85 °C. Herewith the length of the experiments was about 60 minutes and the number of the added clay adsorbents was equal to 4% of the paraffin hydrocarbon's bulk.

The results of this research have made it possible to state that the ultrasonic sound implementation helps to improve and advance the efficiency of the processes of paraffin hydrocarbon purification.

It is a well known fact that the implementation of the ultrasonic vibration leads to the development of the cavitation process. That means to the formation of microscopical explosions (cavities) in the liquid (paraffin hydrocarbon), these explosions are closed during the compression phase, thus leading to the local impulsive pressure which comprises hundreds and thousands of atmospheres. These short large hydraulic impacts drive to the demolition of the solid surface, their dispergating, etc.

Melted paraffin hydrocarbons, used in chemical industry, are purified with the help of galvanic method on the basis of polar and non-polar adsorbents. These adsorbents, as it has been stated above, have different size and void content and are filled more intensively in the presence of ultrasonic sound cavitation, in comparison to the common phase mixture [7].

The ultrasonic sound implementation helps to improve the quality of real-time existing paraffin hydrocarbons and to increase the speed of their filtration. It can be added that the implementation of ultrasonic effect while adsorption purification process improves the purification quality as well [8].

The mechanisms of the ultrasonic sound vibration on the implied adsorbents can be explained with the help of the penetration effect, it means, the sorption of the fluctuating bubbles (sorbates) into holes and splits of solid particles. "The Sound Wind" causes intensive mixture of adsorbents thus leading to the increase of the sorbate activity [9].



The experiments carried out by A. Chmutov and I. Alekseev show that the speed of fat acids adsorption in the finely porous coal improves greatly if the ultrasonic range is frequented by 2 MHz [10].

To sum up, we would like to say that it is evident that the thorough investigation of the theories of elastic vibration actions during the adsorption process gives many opportunities for their further intensification in the chemical industry.

## REFERENCES

1. ДАН, СССР / Н.Н. Домополов, В.М. Фридман, И.М. Караваяев. – № 1. – С. 93 ; № 2. – С. 305.
2. Tarcnozy, T. *Communic Congres Internat Traitements par les ultra-sons* / T. Tarcnozy, 1956. – С. 156.
3. Глистринг, А.М. Ультразвук в процессах химической технологии / А.М. Глистринг, А.А. Бараш. – Ленинград : Гос. науч.-техн. изд-во хим. лит., 1960. – 92 с.
4. Теряева, З.С. Процессы и аппараты химической технологии : в 2 ч. / З.С. Теряева, В.Б. Халил, Е.В. Сафронова. – Новополюк : ПГУ, 2004. – Ч. 2 : Массообменные процессы и аппараты. – 236 с.
5. Рахманов, О.К. Оценка влияния ультразвукового воздействия на качество очистки парафина местными адсорбентами / О.К. Рахманов, С.А. Абдурахимов. – ФарПИ Илмит-техника : журнал Фаргона. – 2009. – № 4. – С. 52–54.
6. Щуклин, П.В. Анализ основных направлений очистки производственных сточных вод от ионов тяжёлых металлов / П.В. Щуклин, Е.Ю. Ромахина. – Вестник ПГТУ : Урбанистика, 2011. – № 3. – С. 108–109.
7. Рахманов, О.К. Ультразвуковая очистка сернистого парафина / О.К. Рахманов, С.А. Абдурахимов, С.Р. Мирсалимова // ФарПИ Илмит-техническая конференция, 2009. – С. 116–117.
8. Рахманов, О.К. Интенсификация процесса адсорбционной очистки парафина контактным способом с наложением ультразвука / О.К. Рахманов. – Технолог. журн. – 2010. – № 1. – С. 58-59.
9. Рахманов, О.К. Механизм ультразвукового воздействия на расплавленный парафин при его очистке композиций адсорбентов / О.К. Рахманов, С.А. Абдурахимов, С.Р. Мирсалимова // Композиционные материалы. – 2009. – № 4. – С. 34-36.

## LUBRICANT COMPOSITIONS BASED ON WASTE PRODUCTS

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*The article presents the pilot study results on lubricant compositions based on waste oil refining and petrochemistry. Dropping point, penetration test, copper strip corrosion test and other metrics were performed. The results reveal that the lubricating grease from waste oil refining and petrochemistry can be used for general machines where extreme pressure is not required. The application of wastes in industries is a wise way to decrease pollution from industries as well as to preserve the environment.*

**Introduction.** Grease is a semi-solid lubricant. Lubricating grease consists of base oil, thickener agents and additives and its main application is to reduce friction and wear between moving parts of machineries that results in improvement in efficiency and saving of energy.

Greases are semi-solid lubricants used to reduce friction between two solid surfaces. Lubricating grease is defined by American Society of Testing and Materials as semi fluid to solid product of a dispersion of a thickener in a liquid lubricant. Greases are made by dispersing thickening agent into carrying lubricant (oil) in a controlled mixing temperature [1–3].

Lubricating grease has been used for plenty of application, involving machinery and moving part for efficiency and to prolong the life-time of the machinery [4]. Grease can perform additionally, more than lubricant oil does for the reason that grease can act as a seal, provide protection against corrosion and at the same time reduce noise and shock.

The grease formulation, which is currently used, is made from petroleum and its derivatives.

There is a great need for the reutilization of waste oil refining and petrochemistry into useful recycled products. Recycling is considered to be beneficial to environment and to economic development since it mitigates resource scarcity, decreases demand for landfill space and generally involves savings in energy.

The objective of this research is to produce lubricating grease from waste oil refining and petrochemistry.

**Methodology.** Grease was prepared by mixing the low molecular weight polyethylene (thickener) and different dispersion media: dewaxed oil (DM-1), residual solvent refined extract (DM-2), waste petroleum oil (DM-3) and waste synthetic oil (DM-4). Different ratios of thickener and dispersion media were used. Dropping point, penetration test and copper strip corrosion test were performed. The copper strip corrosion test indicates that corrosive nature of the grease samples was low under specific condition. The colour of the lubricating oil was brown and black is shown in Figure 1.



Fig. 1. The colour of prepared the lubricating oils

**Results, discussion and conclusion.** A number of samples of lubricant compositions have been obtained in the laboratory. The lubricant compositions are on the basis of high-density polyethylene (HDPE) that is the waste production of The Low Density Polyethylene Plant “Polymir” OJSC “Naftan”. The melting temperature of selected HDPE, that has low mass fraction of volatiles, is over 95°C. HDPE consists of a mixture of saturated hydrocarbons, predominantly with a normal structure, therefore is resistant to corrosion and chemically aggressive environments, has a high flash point (over 250 °C), and low ash content (less than 0.1%), is thermally reversible (it restores the structure and its properties after remelting) and a hydrophobic substance, has a high adhesion to various materials, i.e. it has properties of greases.

It was found that the synthetic lubricant compositions based on HDPE bear analogy to the existing industrially produced hydrocarbon greases as CPG (corrosion protection grease), CIAFAO-205 (Central Institute

of Aviation Fuels and Oils) according to their physico-chemical and service properties. However the source components for their production are cheaper than the ones for commercially produced lubricants. The formulation of lubricant compositions based on HDPE comprising dispersion media was developed: DM-1 – 27 ... 30% wt.; DM-2 – 27% wt.; DM-3 – 26 ... 27% wt.; DM-4 – 26 ... 27% wt.. They have the service properties that are similar to the CPG lubricant type.

On the basis of research results (Table 1), it was concluded that IV dewaxed oil vacuum distillate, waste petroleum oil and waste of synthetic oil can be used as dispersion media for production of lubricants based on HDPE. However it is recommended to use petroleum and synthetic oils after special refining.

Table 1 – Properties of synthesized lubricant compositions based on HDPE

Indicators	Lubricant compositions based on High Density Polyethylene having different dispersion medium			
	DM-1	DM-2	DM-3	DM-4
Appearance	smooth homogeneous ointment			
Colour	light brown	dark brown	black	dark brown
Dropping Point, ° C	60	57	57	56
Penetration at 25 ° C, 0.1 mm for 5 sec	102	106	142	153
Sliding temperature, °C	54...55	52...53	50...51	52...53
Acid value mg KOH/g	absence	absence	0,303	0,408
Volatility, for 1 hour at 100 °C; 150 °C	0,704 1,562	0,235 1,510	0,371 1,582	0,289 0,289
Colloid stability,% wt.	0,307	2,925	3,372	3,095
Oxidation at 120 ° C for 10 h, mg KOH / g	0,022	0,136	0,077	0,093

The results reveal that the lubricating grease from waste oil refining and petrochemistry have soft appearance and can be used for general machines where extreme pressure is not required. This shows that waste oil refining and petrochemistry have better potential in the lubricating market and also helpful in reducing the pollution problem as well as to preserve the environment and cost of the grease produced. Also this will helpful in further utilization of wastes into useful products and reduce the burden on the conventional sources. So this novel idea can bring the most effective solution to convert the industrial wastage to the usable form.

#### REFERENCES

1. Barriga, J.A. Sunflower based grease for heavyduty applications / J.A. Barriga // *Mecânica Exp.*, 13: 2006. – P. 129–133.
2. Akpan, K.F. Classification of lubricants using neutron Slowing-down technique / K.F. Akpan, M.Y. Onimisi, S.A. Jonah // *Pure Appl. Chem.* – 2011. – № 5(7). – P. 194–197.
3. Udonne, J.D. Comparative study of recycling of used lubrication Oils using distillation, acid and activated charcoal with clay methods / J.D. Udonne // *Petroleum Gas Eng.* – 2011. – № 2(2). – P. 12–19.
4. Pogosian, A., Impact of surfactant structure on the tribological properties of bentonite-based greases / A. Pogosian, T. Martirosyan // *Tribol.* – 2007. – № 129(4). – P. 920–924.

## COOLING TOWERS

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*This article deals with the process of water cooling in cooling towers. It also gives the classification of adverse water supply cooling systems at industrial enterprises. Having analyzed the peculiarities of cooling tower exploitation in different conditions, the authors give the initial data for the estimation of their reliability and their technical-economic assessment as well as the ecologico-economical liability of the cooling towers and their separate constructions.*

Cooling towers are constructions (devices) applied for the process of water cooling with the help of free air. Nowadays the cooling towers are applied in systems of adverse water supply while cooling heat-exchange apparatus. The importance of such systems is really high especially in power, chemical, oil-refining and other industries due to the fact that even today the outlet of the low grade heat source from the industrial apparatus with the help of cooling towers is still considered to be the cheapest and helps to economize not less than 95% of fresh water [1].

The most productive cooling tower in the world is the cooling tower for the Atomic Power Station – ISAR II in Germany [2]. It cools 216 000 cubic meters of water per an hour. Its height is 165 meters and the base diameter is 153 m.

The systems of industrial water-supply are designed to establish water delivery to the plant of needed quantity and of appropriate quality. After the cooling process, mostly with the help of cooling towers, and after its purification (if needed) the bulk of water returns to the system, some part of backwater is lost during the evaporation, the drop priming, the leak flow and the dumping as the form of system expulsion.

**Technical-and-economic as well as ecological aspects of the cooling tower appliance in industrial water-supply systems are the following.** The temperature requirements of the drop priming at the enterprise are established by the technological process and by the running ability of the equipment. When choosing the type of the cooling tower for the temperature maintenance one should consider the water contamination possibilities by the industrial products during the water rotation cycle.

The cooling process takes place with the help of some water masses evaporation while the water drains in a thin film or in drops along the special irrigator, where the air stream is brought in the opposite direction from water (*ventilator cooling tower*). In *ejection cooling towers* the cooling process is achieved with the help of the formed environment which is very close to the vacuum environment that is established by special jets. During the evaporation of 1% of water, the temperature of the remained water mass is lowered by 5,48 °C, and in ejection cooling towers – by 7,23 °C. As a rule, the cooling tower is applied when there is no opportunity to use big reservoirs of water for the cooling process.

#### **Specifications**

The main parameter of the cooling tower is the *irrigation density rate*. It means the specific value of water consumption for 1 m<sup>2</sup> of the irrigated surface. The main part specifications of the cooling tower are defined with the help of the technical and economic assessments depending on the volume and the temperature of the cooled water and the atmospheric parameters (temperature, humidity, etc.) in the place where the cooling tower is erected.

#### **Classification**

Depending on the type of the irrigator, the cooling towers are divided into filmy, dripping, spraying, dry.

By means of air feed they are divided into ventilating (the draft is caused by the fan kit); tower-shaped (the draft is caused with the help of the high stack); opened (atmospheric) – it means they use the wind power and the natural convention when the air is fed through the irrigator; ejected – they use natural catch of the air during the water irrigation through special openings.

*Under the direction of the environment flow (cooled water and air)* they are divided into those with the backflow (the highest temperature step, the strongest aerodynamic resistance); with the crossflow (the weakest aerodynamic resistance, lower droplet entrainment); with the mixed current (the construction of the cooling tower has both the backflow and the crossflow).

The operation mechanism is based on the spillage of hot water through the jets (nozzles), thereby the cooling process takes place. Very often the ambient airflow is added to this process with the help of the axle fan

kit. The essential area for the cooling process, the surface of its air-contacting, is set up in the cooling tower on its irrigating systems (irrigators), they can be dripping, filmy, complex.

There exist non-irrigating cooling towers where high-head irrigating nozzles are adjusted inside the tower under the drainage. These so called irrigating cooling towers are less effective than the cooling towers with spraying or filmy irrigators as the square of the water contact surface is relatively less.

*Cooling towers* are used for cooling the bulk amount of water, they exceed the amount of water used at works in several times. These cooling towers are used mainly at heat power or at nuclear power plants. The height of big Cooling towers, manufactured from monolithic concrete, can reach up to 90 m and have irrigating square up to 90 3200 m<sup>2</sup>.

*Opened cooling towers* can be of two types: spraying and dripping. The first represents a small spraying pool which is protected on all sides with louvre boards. They protect bulk water splashes from coming out of the pool in great amounts. In the dripping cooling tower there exist the irrigator, unlike in the spraying one. The application area of opened cooling towers is found out on the basis of the following conditions: irrigated density 0,8...1,4 kg/(m<sup>2</sup> sec); temperature step of hot and cooled water 5...10 °C.

By means of heat disposal of the atmospheric air the cooling towers are classified into *evaporative* (heat disposal from water to the air is carried out mostly by means of the evaporation), *Radiator* or *dry* (heat disposal from water to the air is carried out through the cooling wall (side) due to the thermal conductance and the convection), *Complex* (where heat disposal is carried out due to the evaporation and the thermal conductance or convection).

**Maintenance of cooling towers during a winter time.** During a winter time the maintenance of cooling towers can be complicated due to the freezing process of their structures (frame), especially this happens in severe climate conditions. Freezing of the cooling towers can lead to the critical condition with the following deformation and collapsing of the sprinkler due to additional strain from ice that can be formed on its surface. Freezing of the tower usually begins at the external air temperature below 10° C and happens in places where cold air contacts with small amount of warm water when coming into the tower. Internal freezing of the tower is dangerous because of intensive fog formation which can be found only after the sprinkler had collapsed. To avoid freezing, water is being sent only to several towers, sometimes with decreasing consumption of circulating water.

**Energy conservation in cooling towers.** Specific hydraulic loading on the cooling towers is estimated by the technology calculations. It depends on the parameter estimations of the atmospheric air with the specified percentage of the frequency, on the required water temperature step, on the estimated cooling water temperature, on the chosen type and the construction of the cooling tower.

In order to prevent cooling tower frosting and its breakdown one must facilitate equal distribution of the cooled water on the surface of the irrigator and look after the equal density of the irrigating process on the single part of the cooling tower (only necessary for the spray cooling towers). The forcing fan is also forced to freeze, it happens so due to the incorrect or inaccurate usage of the cooling tower (for ventilating cooling towers). While using ejection cooling towers, the biggest part of these problems fades away due to the absence of either a ventilator or a spray [3].

The choice of the cooling tower's type is brought out with the help of the technological estimations taking into account many factors. For example, the water consumption rate and the heat amount, taken from the product; machineries and the cooling fittings; weather, geologic and hydrolic conditions of a building spot; placing the constructions and development of surrounding territory; chemical composure of water.

Splash type cooling tower should be used if there are suspensions combined with oils and petrochemicals in the circulating water and if there is a possibility of allocation of calcium carbonate (chalk) as a scum.

**The environment protection.** Nowadays the demands for the environmental protection have been risen above. The cooling tower as the source of the environmental damage should be considered by using two following factors: as the noise source and as the source of the harmful substances emission during the process of their outlet to the atmosphere. That is why all cooling towers should meet the existing norms of the environmental protection. Especially those that concern the noise reduction.

When choosing the place for the cooling tower one must follow some special rules: cooling towers should be erected on the open air, where there exists fast wind flow of hot and humid air; cooling tower orientation should be chosen relying on the wind streamline of the town; the air entrance into the cooling tower and its coming out should not have any obstacles.

**Conclusion.** The cooling tower, chosen for water cooling of any industrial objects, must provide the water cooling process at normal or even highest thermal load in any, even the most uncomfortable conditions of the environment, determined by the climatic data of the region. Only the correct and right choice of the cooling

tower type, of the spray and the ventilator will benefit in the workable system which will react correctly on the changes both of environmental conditions and of thermal load of the industrial processes.

## REFERENCES

1. Градирни промышленных и энергетических предприятий : справ. пособие / под общ. ред. В.С. Пономаренко. – М. : Энергоатомиздат: 1998. – 376 с.
2. [Электронный ресурс]. – Режим доступа: <http://ru.wikipedia.org/wiki>. – Дата доступа: 15.10.2016.
3. Защита от шума : СНиП 23-03-2003. – Взамен СНиП II-12-77 ; введен : 01.07.82. – М. : Гос. комитет СССР по стандартам, 1981.

UDC 665.765

**ON THE QUESTION OF IMPROVING THE QUALITY OF LOW SAPS MOTOR OILS**

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*The article describes a promising direction for improving the quality of motor oil aiming to reduce the ash content, while maintaining the performance and environmental characteristics. It is proposed to expand the range of action of functional ashless dispersant additives that will reduce the involvement of the metal detergents.*

**Introduction.** Motor oils are obtained by compounding the basic oil and package of additives which improves the properties of the original base or adds some new properties, which the original oil does not have [1]. As regards purpose, additives are combined into several groups:

1. Viscosity additives which improve the viscosity index and other properties (viscosity index modifiers).
2. Additives which improve lubricity (antiwear, extreme pressure, etc.).
3. Anti-corrosion additives (corrosion inhibitors).
4. The antioxidant additives which reduce oil consumption and increase the life oil operation (anti-oxidants).
5. Detergents, dispersing additives.
6. Additional (defoamers, etc.).

In recent times more and more attention is paid to maintenance of road vehicles from an environmental point of view. Over the past thirty years seven environmental standards have been developed (Euro 0 – Euro-6), controlling the content of harmful substances in exhaust gases of vehicles with diesel and gasoline engines.

Promising directions for improving the quality of motor oils are developing Low Saps motor oils with improved properties. One way to solve this problem is to expand the functional action ashless dispersants, which reduce the involvement of metal additives in the component structure of commercial oil [2].

**Formulation of research tasks:**

The major source of ash in engine oil is the metal-containing additives: sulfonates (Ca, Mg, Ba) and dithiophosphates (Zn). Under high temperatures in the process of oil operation metal-containing additives can be oxidized, and by reacting with the sulfur contained in the fuel or additives form metal phosphates and sulfates, also known as sulphated and phosphated ash [3]. These compounds are first-class abrasives, i.e. they are hard, which leads to accelerated wear of engine parts in friction zones. If any oil hit in the running engine due to incomplete sealing it burns away and combustion gases are removed through the exhaust system. However, diesel cars that were released after the introduction of Euro 5 standard in 2011 and some modern models with petrol engines are equipped with a particulate filter. When injected into the filter, ash settles and accumulates in it, which significantly reduces the service life of the diesel particulate filter [4].

Nowadays the engine oil classification ACEA (Association of European car manufacturers) at the same time with the classic division into oil for gasoline (A) and diesel (B) engines added a separate category of oil that is compatible with diesel particulate filters and catalytic converters (C).

Thus, due to the stiffening of operational and environmental requirements for motor oil, the maximum improvement of its properties is required, which is mainly achieved by the addition of additives, and at the same time it is necessary to decrease the ash content that requires a reduction of ash additives quantity.

The solution is made possible by the use of ashless additives. Ashless dispersants are: succinimides, high molecular Mannichbases, polyethers. These additives are multifunctional, that means, they don't have only a function of dispersing but also neutralizing.

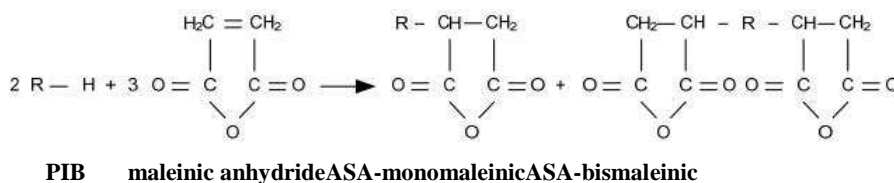
In Full SAPS engine oil neutralizing function is assigned to the cleaning additives (detergents) and is defined by total base number. Total Base Number - ability index to neutralize corrosive acidic products formed in the oxidation of oil, expressed in mg KOH/g. The ashless dispersants have high alkalinity, therefore they partially offset the neutralizing function, thereby reducing the involvement of detergents and reducing ash content in the engine oil [5].

It is known that succinimids neutralizing ability is conferred by imide structures =NR. The more nitrogen atoms contains an aminating agent, the higher will be total base number of the received additive. For this purpose, there was suggested in this study to substituted diethylenetriamine ( $C_4N_3H_{13}$ ) to pentaethylenehexamine ( $C_{10}N_6H_{29}$ ).

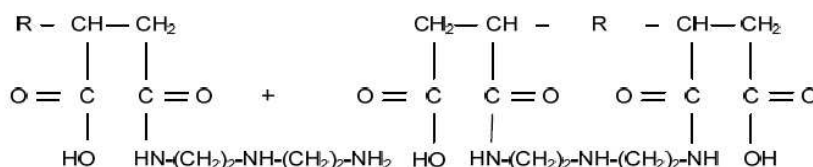
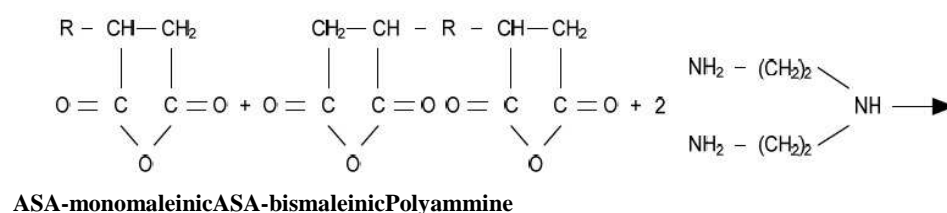
Technology, Machine-building, Geodesy

The technology of producing such ashless dispersants as succinimide includes 3 stages:

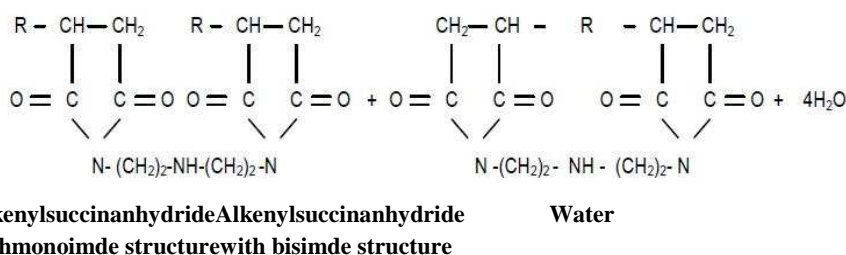
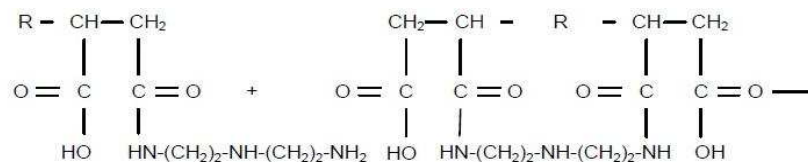
1) The reaction of polyisobutylene with maleic anhydride to obtain polyisobutenylsuccinimidid:



2) Neutralization of the resulting polyethylene polyamine product in a hydrocarbon solvent to give the corresponding amide:



3) Thermal treatment with resulting a polyisobutenylsuccinimide amide



By comparison the total base number of synthesized high-alkaline additive with industrial C5 additive A (EI 38.101146-77), neutralizing capacity increased almost in 2.5 times (from 35 mg KOH / g to 82). Such a high neutralizing capacity of dispersant additive allow reducing the involvement of highly alkaline detergent, which has a positive effect on the ash content of the commercial oil (Table 1).

Table 1 – Ash comparison of Full SAPS and received Low SAPS engine oils

	Units	Full SAPS oil	Low SAPS oil
Sulphated ash	% m/m.	1,4	0,75

Thus, the received engine oil corresponds categories C2<sub>.12</sub> and C3<sub>.12</sub> by ACEA engine oil classification by content of sulphate ash for the Low SAPS motor oils.



**Results and perspectives**

Reduced ash in engine oil allows improvinfg the following characteristics:

- 1) reduce engine wear by reducing the quantity of abrasive ash;
- 2) extend the operation of the engine oil;
- 3) reduce the fuel consumption by reducing friction of moving parts;
- 4) extend the service life of the vehicle exhaust system.

At present, ina CIS territory the production of Low SAPS oils is still developing. Motor oil, corresponding to category C on the ACEA classification is obtained by adding additives, which are produced by foreign firms. Using the above method of producing Low SAPS oil could be implemented the import substitution in the business.

**REFERENCES**

1. Специальные технологии переработки природных энергоносителей : учеб.-метод. Комплекс / С.В. Покровская [и др.]. – Новополоцк : ПГУ, 2014. – 132 с.
2. Кулиев, А.М. Химия и технология присадок к маслам и топливам / А.М. Кулиев. – 2-е изд., перераб. – Л. : Химия, 1985 – 312 с., ил.
3. Фукс, И.Г. Основы химмотологии. Химмотология в нефтегазовом деле : учеб. пособие / И.Г. Фукс, В.Г. Спиркин, Т.Н. Шабалина ; ФГУП РГУ нефти и газа им. И.М. Губкина. – М. : Нефть и газ, 2004. – 280 с.
4. Венцель, С.В. Применение смазочных масел в двигателях внутреннего сгорания / С.В. Венцель. – М. : Химия, 1979. – 240 с., ил.
5. Химмотология. Свойства и применение топлив, смазочных и специальных материалов : учеб. пособие : в 2 ч. / В.Г. Спиркин [и др.] ; под ред.: В.Г. Спиркина, В.Л. Лашхи. – М. : Рос. гос. ун-т нефти и газа им. И.М. Губкина, 2014. – Часть II. – 271 с.

## RESEARCH IN DEWAXING OF THE RAFFINATE 3RD OIL CHASE AND DEOILING OF GATCH WITH PURPOSE OF GETTING TECHNICAL PARAFFIN

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*The article describes a method of processing the third raffinate oil distillate followed by using intermediate gatch, for the purpose of obtaining technical paraffin.*

It is well known that the lube oil unit of a modern refinery plant is one of the most expensive units at the refinery on costs of manufacturing and operational costs. One of the problems of lube units is efficient use of by-products of the dewaxing (slack wax and petrolatum), which are not often used as a commercial product due to the poor quality and low profitability.

The application of slack wax of dewaxing process and petrolatum (petroleum waxes) in production processes of paraffins and ceresin allows to get special composition, which find wide application in various industries and agriculture.

Paraffins and microcrystalline wax are used as coating and impregnation of various materials such as paper, cardboard, particle board, ceramic products, in the processing of crops and foods and so on. They give surfaces smoothness and sheen, water repellent and waterproof properties. Paraffins are widely used in medicine and cosmetics; they are also valuable products in the oil refinery. Price per tonne of paraffin increases depending on the content of the oil in it, which makes it profitable to produce this product in the manufacture [1].

Selection of the method. For obtaining technical paraffin mark T-3 was chosen method of solvent deparaffination by using solvents MEK (methylene ketone) and toluene with subsequent gatch slack wax obtained by de-oiling. The installation of solvent dewaxing is functioning at the plant OJSC (Open Joint-stock Company) "Naftan" with use of MEK and toluene as solvents

As raw-material the third raffinate oil distillate after selective purification has been selected.

Carrying out the dewaxing. For obtaining slack wax, raw material for production of paraffin, it is required to conduct solvent dewaxing using toluene and MEK. At first the necessary amount of raw material is taken, after that the raw material is mixed with solvent in a ratio of 1: 3 (vol.). The obtained mixture is heated up to a predetermined temperature to remove the "germ" of high melting crystals, then the mixture is cooled down to filtration temperature [2].

The mixture is filtered through a vacuum filter. On the filter a "flapjack" remains, it is a slack wax, which is the raw material for producing the paraffin. The "flapjack" is washed with solvents and sent to deoiling.

After the filtration obtained the filtrate is sent to solvent recovery, where dewaxed oil is also obtained.

Carrying out deoiling. Deoiling process is not different from the dewaxing process either by equipment design or process flowsheet, although the process of deoiling has some differences, for example, heating and cooling temperatures are lower than the dewaxing, multiplicity solvent: feed 6 (8): 1 (vol.).

The product of deoiling is crude wax, which is sent to hydrofining.

Analysis of results. After the deoiling it is necessary to determine the oil content in paraffin and its melting point for assigning a certain class clearing and mark of the paraffin.

The results obtained in the course of the analysis are shown in the table 1.

Table 1

Parameters	Values
Appearance	White crystalline mass, shades of gray or yellow are acceptable
Melting point, °C	53
Oil content,% wt.	2,8

We see from these results that this paraffin gratifies a technical paraffin mark T-3 [4]. The obtained paraffin is valuable for the petrochemical and chemical industries as a necessary component for manufacturing of various products, is a part of anti-corrosion and impregnating coating.

### **Conclusion.**

During the analysis of the literature and results of the study research the following was established:

- The obtained paraffin complies with and conforms to the technical paraffin mark T-3;
- The resulting paraffin meets the requirements of the petrochemical and chemical industry;
- This research has a practical orientation as it may be realized in practice.

Industrial installation of the dewaxing includes: heating units of raw-material, filtration, solvent recovery from dewaxed oil solution, the regeneration solution slack solvent, separation of water from the solvent [5]. For production of technical paraffin modernization of solvent recovery unit is offered, namely:

- 1) an extra stripper for technical paraffin;
- 2) an extra column for evaporating technical paraffin [6].

#### REFERENCES

1. Ахметов, С.А. Технология глубокой переработки нефти и газа : учеб. пособие / С.А. Ахметов. – Уфа : Гилем, 2002. – 672 с.
2. Покровская, С.В. Технология переработки нефти и газа. Производство нефтяных масел : учеб.-метод. комплекс / С.В. Покровская. – Новополюцк : ПГУ, 2008. – 320 с.
3. Практикум по технологии переработки нефти : учеб. пособие для студентов химико-технологических специ-альностей вузов / Е.В. Смидович [и др.] ; под ред.: Е.В. Смидович, И.П. Лукашевич. – М. : Химия, 1978. – 285 с.
4. Парафины нефтяные твердые. Технические условия : ГОСТ 23683-89. – Введ. 1998-01-01. – М. : Изд-во стандартов, 1998. – 14 с.
5. Ходикова, Е.А. Исследование депарафинизации рафината 3-го вакуумного погона и обезмасливания гача с целью получения технического парафина / Е.А. Ходикова // Труды молодых специалистов Полоцкого государственного университета. – 2016.– № 72 : Технические науки. – С. 200.
6. Ходикова, Е.А. Интенсификация процессов депарафинизации и обезмасливания / Е.А. Ходикова // Труды молодых специалистов Полоцкого государственного университета. – 2016. – № 72 : Технические науки. – С. 202.

## PETROLEUM ROAD BITUMEN MODIFIED BY WASTE OF PETROCHEMICAL INDUSTRY

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We conducted studies on modification of petroleum bitumen with low a molecular weight polyethylene (LMPE) and residue of the heavier cut of pyrolysis gas oil (residue of PGO) of production plant «Polymir» of JSC «Naftan» to improve the quality indicators of the produced road binder. We measured physical and mechanical properties of asphalt mixture. It was found that adding of polymer- aromatic binder to the resulting asphalt concrete improves its physical and mechanical characteristics. The use of waste of petrochemical industry reduces cost of bitumen in comparison with its analogues.

**Introduction.** Bitumen is a very complex combination of organic compounds containing a high proportion of hydrocarbons with high carbon numbers. This family of molecules can be found in many heavy crude oils. In its simplest form bitumen manufacturing separates the lighter fractions from the residuum, the required molecules being already present in the crude oil. For other types of bitumen, for example oxidized bitumens, the only way to achieve the desired properties is to produce new molecules through chemical reactions. Several manufacturing methods are available to produce specification bitumens depending on the crude source(s) and processing capabilities available. Often a combination of processes is selected. The schematic in Figure 1 provides a compilation of refinery processes related to the production of bitumen [1–4].

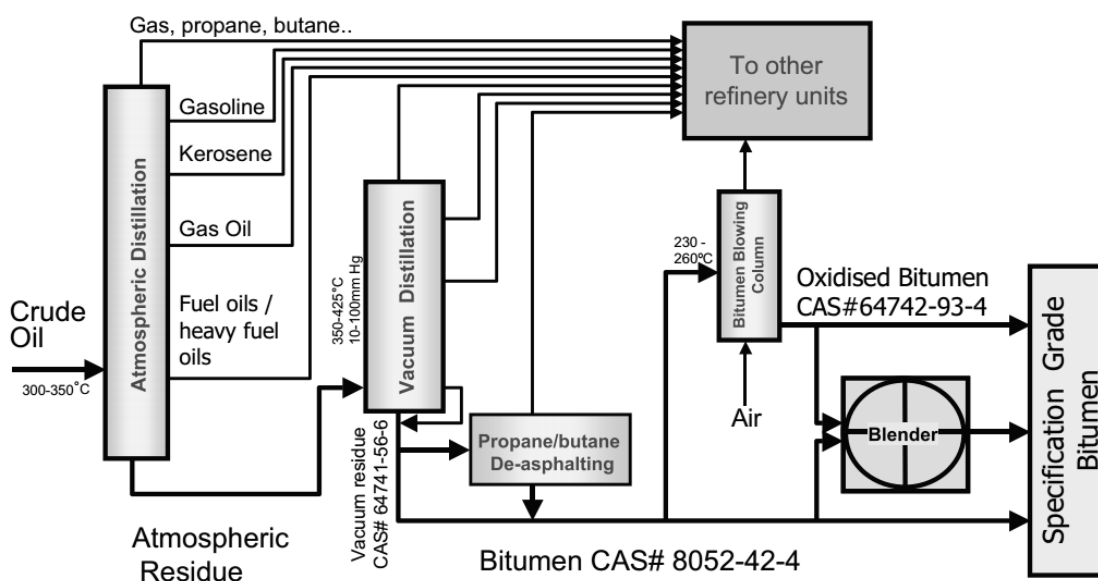


Fig. 1. Schematic diagram of bitumen manufacturing

Bitumen fume is a complex mixture having a broad boiling point range. The molecular composition can include hydrocarbons covering the range from naphtha through to long branched chain aliphatic hydrocarbons, cycloalkanes aromatics and hetero-molecules containing sulphur, oxygen, occasionally nitrogen, and low levels of polynuclear aromatic compounds (PAC), including of Polynuclear Aromatic Hydrocarbons (PAH).

The chemical characterization of bitumens is based on their separation into four broad classes of compounds – asphaltenes, saturates, cyclics and resins. The relative content of these groups of compounds varies. Examples of the typical structures of the fractions are given in figure 2 [4].

Nomenclature and grading in Europe is based on the penetration range of the product [a measure of consistency at 25°C (77°F)]. Paving bitumen specifications include EN 12591 (paving grades), EN 13924 (hard grade paving bitumens) and EN14023 (Polymer Modified Bitumens), the latter specification being bitumen products comprising bitumen plus other materials including polymers. These are based on the various existing (empirical) test methods and former national standards, which were in common use for many years.

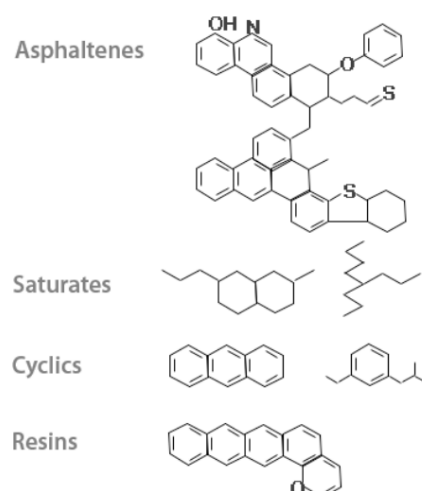


Fig. 2. Example of the broad chemical types present in bitumen

The specified properties relate to rheology (penetration, softening point, viscosity), resistance to hardening/ageing, flash point (for safety reasons) and solubility to indicate absence of contaminants. Paving grade bitumens are produced by vacuum distillation and air-rectification. Polymer modified bitumens, which are blends of bitumen with polymers and other additives, are also categorized as paving bitumens.

**Methodology.** For the device of pavings for low-temperature conditions of application it is necessary to increase plasticity in initial bitumen, to lower a temperature of fragility and to increase coupling with stone material at preservation up to standard of other physic and mechanical properties [5,6,7]. In this connection it is interestingly to modification of the specified properties of bitumen of low-molecular polyethylene and the pitch of heavy pitch of pyrolysis of production of the Polimir plant of JSC Naftan capable to be dissolved in bitumen.

In work used bitumen oil road, the BND 40/60 brands (Technical Conditions BY 400091131.009-2011) of production of JSC «Naftan».

Modification of bitumen was carried out by hashing of components in metal capacity at a temperature of receiving asphalt concrete of 130–160 °C within 30 min. an anchor mixer with a speed of rotation of 60 rpm.

At a research of compositions of the BND 40/60 initial bitumen and the modified knitting standard methods of definition were used:

- softening temperatures on a ring and a sphere in accordance with GOST 11506-73;
- tensile properties at + 25 °C according to GOST 11505-75;
- a penetration according to GOST 11501-78;

**Results, discussion and conclusion.** Results of influence of the modifying LMPE and residue of PGO additives on properties of road bitumen of brand 40/60 are presented in figures 3 and 4.

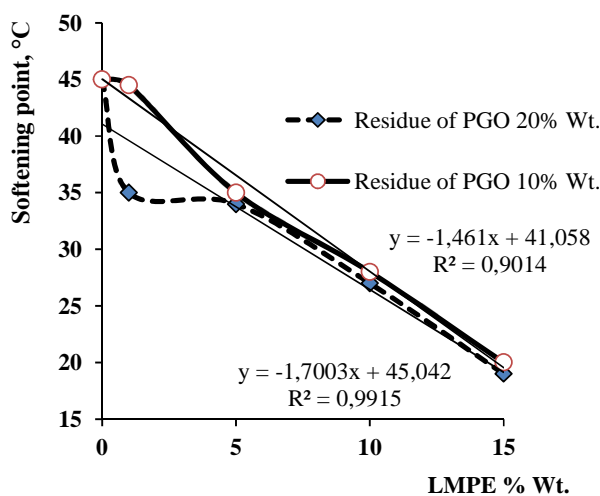


Fig. 3. Softening temperature change dependence on bitumen ring and ball concentration of LMPE and Residue of PGO

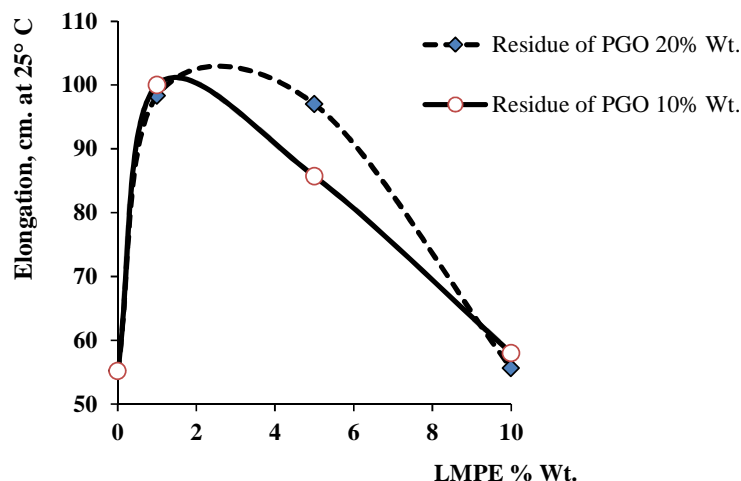


Fig. 4. Dependence of change elongation of bitumen on the ring and ball on the concentration LMPE and Residue of PGO

From the figure 3 it is visible that bitumen softening temperature linearly decreases with increase in concentration both LMPE, and Residue of PGO.

From the figure 4 it is visible that the tensile properties (ductility) of bitumen change not linearly, and passes through a maximum at concentration of LMPE 1.5% of wt. Thus, for ensuring high plasticity of bitumen in the presence of Residue of PGO, concentration of LMPE shouldn't exceed 5% of wt.

It is established that modifying of Residue of PGO bitumen gives to sharp increase in a penetration of bitumen (decrease in hardness), for example, bituminous mix of 20% wt. Residue of PGO and 1% of wt. LMPE reduces a bitumen penetration more than twice (depth of penetration of a needle has made 99 x 0,1 mm: at 25 °C). Proceeding from the studied indicators, it will allow to receive from bitumen of brand 40/60 bitumen oil road corresponding GOST 22245-90 of brand 90/130. The modified bitumen can be applied under more low-temperature service conditions.

Introduction to bitumen of the modifying LMPE and residue of PGO additives makes the plasticizing impact on its structure [8]. Besides, use of waste of petro chemistry provides decrease in prime cost of bitumen in comparison with analogs.

#### REFERENCES

1. Gary, J.H. Petroleum Refining : Technology and Economics / J.H. Gary, G.E. Handwerk. – New York : Marcel Dekker, INC., 1975.
2. McKetta J.L. Petroleum Processing Handbook / J.L. McKetta, – New York : Marcel Dekker, INC., 1992.
3. Zakar, P. Bitumen / P. Zakar (American Edition) ; Chemical Publishing Company, Inc. // Library Catalogue Card Number: 73-122761. – 1971.
4. Hot Mix Asphalt Materials, Mixture Design, and Construction, / F.L. Roberts [et al.]. – National Asphalt Pavement Association Publication TB-1, 1991.
5. Improving Energy Efficiency of Bitumen Modification with Reclaimed Crumb Rubber / V. P. Belyaev [et al.] // Components of Scientific and Technological Progress. – 2013. – №1 (16). – С. 75 – 77.
6. Belyaev, V.P. On the Prospects of Integrated Solutions to Problems of Ecology and Improving the Quality of Road Surfacing / V.P. Belyaev, P.S. Belyaev, D.L. Polushkin // Перспективы науки. – 2012. – №5 (32). – С. 186–189.
7. Bitumen Modification with Recycled Polymeric Materials / V.P. Belyaev [et al.] // Глобал. науч. потенциал. – 2013. – №9 (30). – С. 29–33.
8. Павлов, А.В. Основные направления использования низкомолекулярного полиэтилена и его влияние на свойства нефтепродуктов / А.В. Павлов, А.А. Ермак // Вестник Полоцкого государственного университета. Сер. В, Прикладные науки. – 2007. – № 8. – С. 123–127.

UDC 665.633

**THE PROCESS OF PENEX COMPANY UOP**

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*This article deals with the process of low temperature isomerization in the light part of gasoline cut, as one of the ways of improvement of the commercial gasoline quality.*

The evolution of engine-building, the improvement of its construction, the reinforcement of ecological requirements have made it essential to use better quality benzene. Right in this article we will try to describe the process of obtaining ecologically pure components of the commercial gasoline.

The most suitable isomers, needed for the improvement of starting qualities of benzene, are ethyl-methyl ethane and caproyl hydride. These isomers can be obtained from straight-run gasoline fractions. These fractions are characterized by the low disquisitive octane level, which usually fluctuates from 60 to 70. This fraction, which is used to constitute 10 per cents of the gasoline blending fleet in the USA and even more in Europe, was just added into benzene without any farther refinement, not taking into account the removing of alkyl hydrosulphide.

But it has been shown that one must invert paraffin hydrocarbons C<sub>5</sub> and C<sub>6</sub> of normal pattern into the correspond branched isomers, in order to improve their disquisitive octane level. One of the variants of such an improvement is the suggested UOP process Penex, where highly active low temperature hydroisomerization catalyst (industrial aluminum platinum catalyst, promoted chlorine) is employed [1]. The platinum catalyst with aluminium oxide when employed into Al<sub>2</sub>O<sub>3</sub> 7 – 10 per cents of haloid, has very high acid activity that is why the process of isomerization is successfully carried out under 100 – 130 ° C [2].

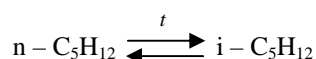
Since the fraction which takes up 10 per cents of gasoline distillation is responsible for the starting process, the strategic implementation of Penex process appears in evidence. That is – the purification of the benzene quality with intent to improve the benzene starting process by means of improving knock characteristics of gasoline light particle (the increase of octane number). The startability is characterized by: the pressure of startup steam and the octane level. During the isomerization process these two factors are regulated simultaneously: the improvement of the octane level due to the migration of methyl group(s) and due to the lowering of the isomerizate boiling temperature. That results in better evaporation and, accordingly, in the increase of prime steams pressure. The main characteristics of octane hydrocarbons and their isomers are shown in Table 1.

Table 1. The main characteristics of the octane hydrocarbons C<sub>5</sub>–C<sub>7</sub>

Hydrocarbons	Octane number (MON)	Octane number (RON)
n-C <sub>5</sub>	61,9	61,7
i-C <sub>5</sub>	90,3	92,3
n-C <sub>6</sub>	26	24,8
2-methylpentane	73,5	73,4
3-methylpentane	74,3	74,5
2,3-dimethylbutane	94,3	101,7
n-C <sub>7</sub>	0	0

One can see from the Table 1 that it is highly efficient to use hydrocarbons upto C<sub>7</sub>. The products of isomerization have low sensibility (the common difference between the researched and the engine octane levels). And this is highly important for the operational qualities of the commercial gasoline. It is also seen from the Table 1 that caproyl hydride should be well recycled.

The reactions of the paraffine hydrocarbon's isomerization are balanced:



They are carried out almost without any changes in its volume, that is why the thermodynamic equilibrium depends only on the temperature; low temperatures contribute to the formation of the isoparaffin hydrocarbons. The thermal effect of the isomerization reaction is not rather big – from 2 to 20 kJ/mole and changes very little during the temperature vibrations. The reaction's mechanisms are carbocationic [3].

## Technology, Machine-building, Geodesy

The reactions act in attendance to the hydrogen in the fixed layer of the catalyst under the operating conditions, contributing to the isomerization and preventing hydrogen cracking. These operation conditions are far not tough, as evidenced by the moderate operating pressure, low temperature and high partial pressure of the hydrogen [1].

On the Table 2 you can see the operating conditions of "Penex".

Table 2. The operating conditions of "Penex"

Conditions	Range
$t, ^\circ\text{C}$	120–180
$P, \text{MPa}$	3–4
Content of $\text{H}_2$ in hydrogen-rich recycle gas, % w.	$\geq 95$
Content of benzol in raw material, % mass.	1–5

One of the important characteristics of raw material is the content of benzol in it. The content should usually not exceed 5 per cent, as benzol is hydrogenated easily, respectively, it raises the operating temperature and lowers considerably the octane number of the isomerizate (see Table 1).

In summary: The process of low temperature of isomerization "Penex" allows getting a high quality component of the commercial grade fuel, which meets ecological requirements as well as the usage conditions, as the main component of the commercial gasoline in modern engines.

## REFERENCES

1. Основные процессы нефтепереработки : справ. : пер. с англ. / Р.А. Мейерс [и др.] ; под ред.: О.Ф. Глаголевой, О.П. Лыкова. – 3-е изд. – СПб. : ЦОП «Профессия», 2011. – 944 с.
2. Химия нефти и газа : учеб.-метод. комплекс для студентов специальности 1-48 01 03 и слушателей ИПК УО «ПГУ» по специальности 1–48 01 72 / сост. и общ. ред. С.В. Покровской. – 2-е изд., доп. – Новополоцк : УО «ПГУ», 2007. – 268 с.
3. Технология переработки нефти и газа. Процессы глубокой переработки нефти и нефтяных фракций : учеб.-метод. комплекс для студентов специальности 1-48 01 03 : в 2 ч. /сост.: С.М. Ткачев. – Новополоцк : ПГУ, 2006. – Ч. 1 : Курс лекций. – 345 с.



## ***ITC, ELECTRONICS, PROGRAMMING***

**UDC 004.457**

### **APPROACHES TO THE DESIGN OF GRAPHIC WEB INTERFACE ON THE EXAMPLE OF A WEB APPLICATION**

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*The article analyses the technologies used for implementation of web applications interfaces. Examples of web interface implementation within the page of an application are given.*

**Introduction.** With the development of Internet technologies more and more web applications with various subjects began to appear.

Web application is a client-server application in which the client is a browser, and server is a web server. The logic of the web application is distributed between the server and the client, data storage is carried out, preferentially, on the server, information exchange happens on a network.

The web application consists of client and server parts, thereby realizing client-server technology. A client part realizes the user interface, creates server requests and processes responses from it [1].

Development of web applications is a powerful tool which allows to realize business ideas and to create successful software products. Web applications help to automate process of operation with large information streams (a client basis, a directory of goods, a branch network, documents and so on).

Front-end and back-end are terms in program engineering which are distinguished according to the principle of division of the responsibility between external representation and internal implementation respectively. Front-end is an abstraction which provides the user interface. For example, in the design of software, the architecture provides to Model-View-Controller front-end and back-end between the database, components of data handling and users [1].

Development of web applications on the front-end and back-end system implies hierarchical division of a resource creation process into two parts, into development of the user interface (frontend) and its programme and administrative part (back-end).

Now web applications are already comparable by their advantages to classical applications. But at the same time they can be available in any place and at any time on a computer, a pad or a mobile device and often have smaller cumulative possession costs. These features make web technologies very attractive to the solution of a wide range of tasks.

**Main part.** Main techniques of implementing a web application front-end are considered on the basis of noncommercial passengers transportation.

Front-end development is an operation of creating a public part of an application which a user contacts with, and functions which can be used directly (in the browser). The front-end is a component of the application which is responsible for the output of certain information to the user and for user's actions in the web application, for its interpretation in a clear way to the programmes relating to a back-end.

In operation Bootstrap – CSS/HTML is a framework for creating web applications. A number of advantages makes it the most popular framework among the similar ones. In other words, it is a tool kit for imposition.

Primary benefits of Bootstrap are considered as following:

- operation speed – due to a set of ready elements imposition with bootstrap takes much less time;
- scalability – new elements adding doesn't break the general structure;
- easy adjustability – editing styles are made by creating new css-rules which are executed instead of standard ones;
- large number of templates;
- huge community of developers;
- wide scope of application – Bootstrap is used for creating subjects for almost any CMS (OpenCart, Prestashop, Magento, Joomla, Bitrix, WordPress and many other), including one-page appendices [3].

Bootstrap uses the modern practices in the field of CSS and HTML therefore it is necessary to be attentive with assistance of old browsers.

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The main Bootstrap tools include the following:

– grids – the sizes of columns are given in advance, which can be used at once. For example, the width of a column of 140px belongs to the class `.span2` (`.col-md-2` in the third version of a framework) which can be used in CSS document description;

– templates – the fixed or rubber document template;

– typographies – fonts descriptions, determining of some classes for fonts, such as a code, quotes and so on;

– media – are represented by some control of images and video;

– tables – means of tables designing, including addition of sorting functions;

– forms – classes for forms designing and some events happening to them;

– navigation – design classes for tab, tabs, pageness, the menu and a toolbar;

– alert – dialog boxes designing, hints and pop-up windows [1].

Also in case of implementing a web application JSP (JavaServerPages) – the technology allowing to create contents with both static and dynamic components was used. The JSP page contains texts of two types: static basic data which can be issued in one of the text HTML formats, SVG, WML, or XML, and JSP elements which construct dynamic contents. Besides libraries of JSP tags, and also EL (ExpressionLanguage), for implementation of Java code in static contents of JSP pages can be used [1].

JSP platform is an independent, portable and easily expanded technology for developing web applications. The main idea of JSP is very simple – the page is a template with already prepared HTML tags between which it is necessary to insert the necessary data.

JSP pages have extension of `.jsp` and are placed with normal web pages. The structure of such pages can consist of five constructions: HTML, comment, scripting elements, directives and actions. The JSP page in case of compilation will be transformed to a servlet with static contents which go to the output stream connected to the service method. Therefore in case of the first request this process can cause a small time delay. Scripting elements allow to specify a code in the Java language which afterwards will become a part of a finite servlet, directives give the chance to control the whole structure of a servlet, and actions are used for existing components functioning, and also for controlling the performance of the JSP engine. To simplify scripts functioning there are variables defined in advance, such as request, response, page context, session, out, application, config, page, exception [1, 2].

The code of the JSP page is broadcast in servlet Java code by means of JSP pages compiler Jasper, and then compiled in byte code of the virtual machine Java (JVM). The containers of servlets capable to execute JSP pages are written in the Java language. JSP pages boot on the server and cope from structure of special Java server pack which is called Java EE WebApplication. Usually pages are packed into file archives `.war` and `.ear`.

**Conclusion.** Nowadays web technologies are quickly developing, they are giving more and more opportunities to developers, and their productivity is growing. As a result, advantages of native applications are decreasing, and development is going to the web environment more and more. Web applications have become part of our life, and we use many of them even without thinking – for example, Google search or a Gmail mail service.

Developing web interfaces, it is necessary to pay attention not only to a good design which helps to concentrate on user's tasks, but also to consider that any interface should be intuitively clear for the user – he is supposed understand instantly which following step he is to take. The web interface should have such qualities as a cross platform, adaptivity for different screen sizes, dynamism and correct operation in different browsers.

It is obvious that the use of web applications has a lot of advantages, and the use of different frameworks and technologies allows to reduce considerably the time of web applications implementation without their quality loss.

#### REFERENCES

1. Wikipedia – the free encyclopedia [Electronic resource]. – Mode of access: <https://ru.wikipedia.org/wiki/>. – Date of access: 23.09.2016.
2. Metanit – the website about programming [Electronic resource]. – Mode of access: <http://metanit.com>. – Date of access: 23.09.2016.
3. Hinex – the company specializing in a web development and Internet advertising [Electronic resource]. – Mode of access: <http://hinex.ru/>. – Date of access: 23.09.2016.

UDC 546.28:621.315.592

## MICROINDENTATION AND MECHANICAL PROPERTIES OF SILICON

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*The paper presents results of the research concerning microindentation of physical and mechanical properties of materials, which are used in modern production technology of electronic devices. On the basis of measurements, the analysis of microhardness, micro-fragility and fracture toughness of silicon, grown according to the Czochralski method (Cz-Si), was carried out, when the combined magnetic fields were applied to the melt.*

**Introduction.** Modern economic conditions of microelectronic techniques production require reduction of material consumption and material production, and the percentage output increase of effective devices. However, the basic microelectronic materials (silicon and structure on its basis) are fragile and because of that they are prone to mechanical damages. This causes necessity of additional researches of physico-mechanical characteristics of the semiconductors, which are used in the microelectronics [1–7].

**Features of microindentation of semiconductors.** Researches in the field of semiconductor materials should be carried out and based on a number of features of these materials in comparison with metals.

Defect-impurity composition of covalent materials (which include semiconductors) is very mobile. Its change in semiconductors structures occurs during the growth of single crystals, and their technological processing (doping, irradiation, heat treatment) and exploitation of finished products. Formation of strong internal stress in a crystal at all stages leads to the appearance of micro-defects and as a result to brittle fracture of the material.

Basic semiconductor materials (silicon and germanium) are high purity materials, which do not have any dislocations. The predominant mechanism of deformation in semiconductor single crystals and structures (at least in initial stages) is displacement (offset) of the material by movement of the individual (interstitial) atoms, point defects.

Microindentation was selected as a method of research due to several reasons:

- Microindentation is a method of non-destructive control. This allows to use it at different stages of technological chain of semiconductor devices production;
- This method does not require complex technical devices for measurements and processing results;
- Microindentation method in conjunction with methods of mathematical statistics allows to get results with an error of no more than 5-7%;
- Microindentation allows to calculate some strength characteristics and evaluate physical and mechanical properties of material comprehensively according to one imprint;
- In this paper, by applying indentation (figure 1), three strength characteristics were calculated: microhardness ( $H$ ), micro-fragility ( $Z$ ) and first-order critical stress intensity factor (fracture toughness,  $K_{IC}$ ).

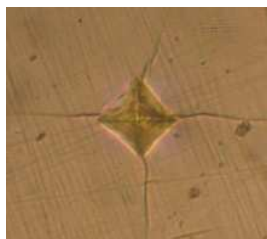


Fig. 1. Micrograph of the imprint after indentation of silicon by the Vickers pyramid

Microhardness used for Vickers pyramid indentation is calculated by the formula

$$H = \frac{1,854P}{d^2},$$

where  $P$  – the load on the indenter;  $d$  – diagonal imprint.

Measurement results were used in evaluating of silicon micro-fragility statistical methods of processing. A score of fragility was assigned to each of the applied imprints, which was determined by the arbitrary scale, which takes into account the number of cracks and chips near the imprint and the nature of their evolution [1].

During the measurements the number of imprints, which was corresponding to each score of fragility, was fixed. According to the results of measurements histograms were plotted. The total average score of fragility of the material was calculated by the formula

$$Z = \sum_{i=0}^5 i \cdot n_i,$$

where  $n_i$  – the relative number of imprints that have the mark of fragility  $i = 0, 1, 2, 3, 4, 5$ .

The propensity of the material to crack formation was evaluated by the value of the critical coefficient of stress intensity of the first kind (crack resistance):

$$K_{1c} = k(E/H)^{1/2} P/l^{3/2},$$

where  $k$  – empirical calibration coefficient;  $E$  – Young's modulus;  $l$  – length of the crack.

**Experimental results and discussion.** Consider the possibility of obtaining information on the strength properties of semiconductor materials concerning microindentation on the example of silicon single crystals, grown by Czochralski method (Cz-Si), when combined magnetic fields were applied to the melt. Overlay of magnetic fields on the melt allows to manage the processes of convection in the melt and to vary the defect-impurity composition of the grown single crystal [8].

Silicon plates 2 mm thick were cut from the upper and lower parts of the plate. They were subjected to the same treatment in the process of growing and passed identical chemical-mechanical polishing. Indentation was performed on a PMT-3 using the Vickers pyramid by a standard technique with loads of 50–200 g.

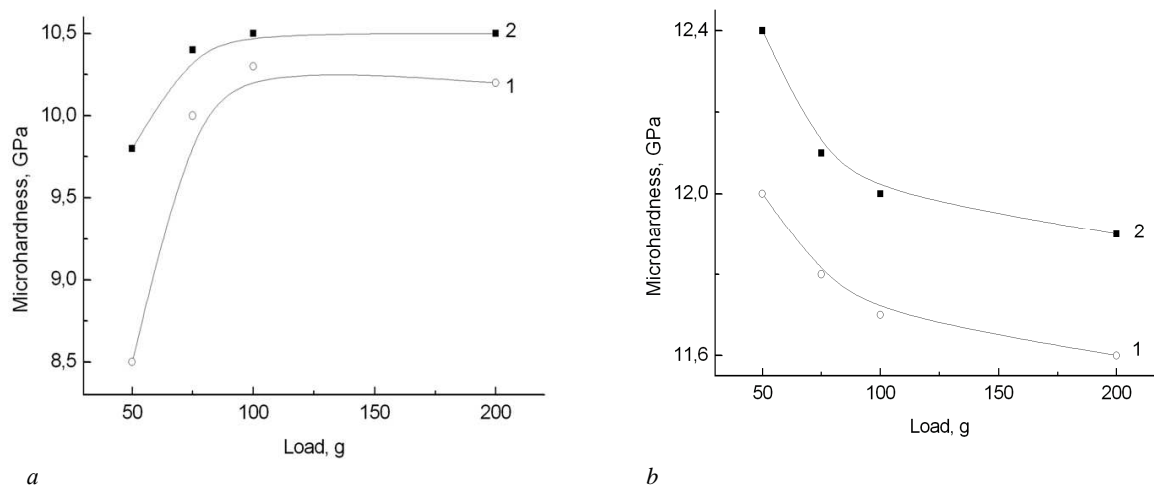


Fig. 2. Dependence of the microhardness on the load for plates cut from the upper (1) and lower (2) parts of the ingot to the orientation of  $a - \langle 100 \rangle$  and  $b - \langle 111 \rangle$

Dependence of the silicon microhardness on the load **on the indenter** is presented in figure 2. Analysis of these dependencies leads to the following conclusions:

- A strong dependence of the microhardness of single crystal orientation was detected. The microhardness of plates cut from single crystals with the orientation  $\langle 100 \rangle$  was lower by 10–15% than the plates with the orientation  $\langle 111 \rangle$ .
- It was found that the microhardness of samples which were cut from the lower part of the ingot, was slightly higher than  $H$  samples which were cut from the upper part the same ingot.
- For samples from the lower part of the ingot the effect of the surface hardening was observed, comprising in the microhardness decrease by 10–20% as the load increases from 50 to 100 g. This effect is typical

for the traditional (Cz-Si). However, the microhardness for samples cut from the upper parts of the ingot, measured under a load of 50 g, was close or lower than the microhardness that measured with a load of 100 g.

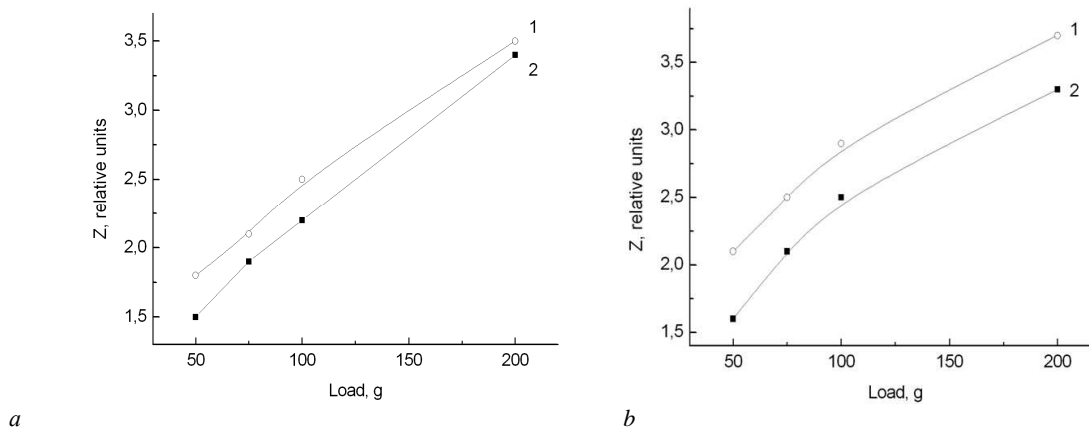


Fig. 3. Dependence of micro-fragility of the load for plates cut from the upper (1) and lower (2) parts of the ingot to the orientation of  $a - \langle 100 \rangle$  and  $b - \langle 111 \rangle$ .

Analysis of micro-fragility dependence on the load (fig. 3) shows:

- Micro-fragility of single crystals increases with increasing of the load.
- Values of micro-fragility of investigated single crystals are close to the values which are typical for traditional Cz-Si [9-11].
- Values of micro-fragility of the plates cut from the lower part of ingot were slightly lower than of the plates cut from the upper part of the same ingot regardless of the ingot orientation.
- When applying magnetic fields to the melt, the amount of oxygen-containing growth defects increases. The increase of micro-fragility of the silicon single crystals in comparison with the traditional Cz-Si was observed [9-11].

Studies of tendency of silicon single crystals to crack formation (figure 4) showed the following results:

- Crack resistance was decreasing with the load increasing (for all samples).
- Values of  $K_{IC}$  of investigated single crystals were close to the values that are typical for traditional Cz-Si [9-11].
- The critical coefficient of stress intensity of the first kind  $K_{IC}$  was slightly higher in ingots with orientation  $\langle 100 \rangle$ , especially under heavy loads of 100-200 g.
- $K_{IC}$  from the ingot to ingot increases with decreasing the load.
- $K_{IC}$  is lightly higher in plates, cut from the lower parts of ingots, for both investigated orientations of ingots.
- The presence of oxygen-containing growth defects formed during the growth of a single crystal in complex magnetic fields led to some reduction in silicon crack resistance compared with traditional Cz-Si [9-11].

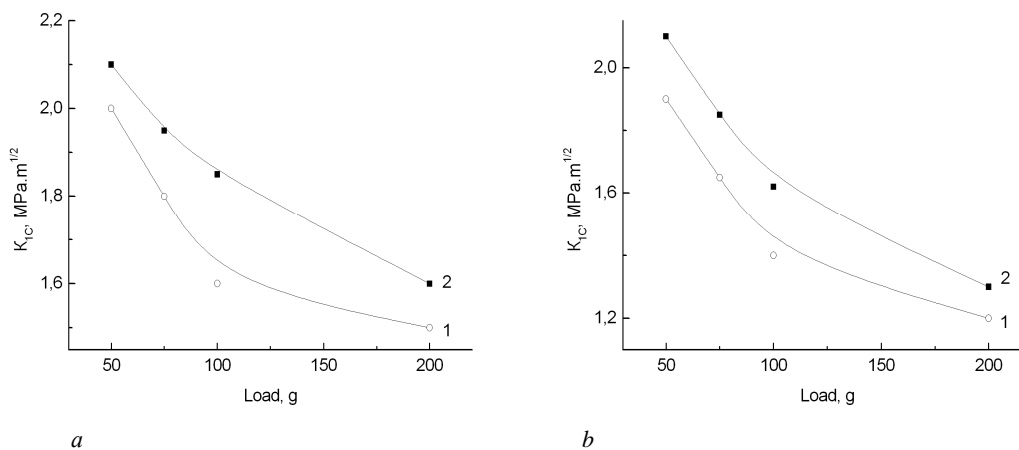


Fig. 4. The dependence of the critical stress intensity factor  $K_{IC}$  from the load for plates cut from the upper (1) and lower (2) parts of the ingot to the orientation  $a - \langle 100 \rangle$  and  $b - \langle 111 \rangle$

Increasing of the microhardness and fracture toughness  $K_{IC}$  of plates, cut from the lower parts of the ingots, due to the fact that in the lower parts the ingots technological impurities concentration is substantially higher, due to the effect of impurities pushing into the melt during the growth process.

**Conclusion.** Using the example of silicon which was grown overlaid with magnetic fields on the melt, it was found that all the strength characteristics of silicon substantially depend on growing conditions. Variation of crystal growing conditions allows us to manage physical and mechanical properties of the material. Microindentation is a method that allows us to assess the range of the strength characteristics of the semiconductor material. This method also allows us to choose material with the most optimal physical and mechanical properties for the production of microelectronics and electrical devices.

## REFERENCES

1. Brinkevich, D.I. Microhardness of silicon grown by the czochralski technique in nitrogen atmosphere / D.I. Brinkevich [et al.] // *Inorganic Materials*. – 1999. – V. 35, № 12. – P. 1207–1208.
2. Brinkevich, D.I. The effect of group III<sup>B</sup> and group IV dopants on the microhardness of single-crystal silicon / D.I. Brinkevich, S.A. Vabishchevich, V.V. Petrov // *Russian Microelectronics*. – 1997. – V. 26, № 4, – P. 254–257.
3. Vabishchevich, S.A. Microhardness of silicon sheets, subjected to gettering treatment / S.A. Vabishchevich, N.V. Vabishchevich, D.I. Brinkevich // *Advanced Materials*. – 2005. – V. 12, № 2. – P. 125–128.
4. Brinkevich, D.I. Strength degradation of silicon diffusion-doped with gold / D.I. Brinkevich [et al.] // *Inorganic Materials*. – 2009. – V. 45, № 4. – P. 343–346.
5. Vabishchevich, S.A. Defect formation in silicon implanted with ~1MeV/nucleon ions / S.A. Vabishchevich [et al.] // *Inorganic materials*. – 2010. – V. 46, № 12. – P. 1281–1284.
6. Surface hardening of silicon wafers implanted by high energy boron ions / S.A. Vabishchevich [et al.] // *Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques*. – 2010. – № 1. – P. 78–81.
7. Physical and mechanical properties of silicon near the SiO<sub>2</sub>/Si interface / D.I. Brinkevich [et al.] // *Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques*. – 2013. – V. 7, № 6. – P. 1217–1220.
8. Бринкевич, Д.И. Микропрочностные свойства монокристаллического кремния, выращенного при наложении на расплав сложных электромагнитных полей / Д.И. Бринкевич, Н.В. Вабищевич, С.А. Вабищевич // *Вестник Полоцкого государственного университета. Серия С, Фундаментальные науки*. – 2012. – № 4. – С. 77–82.
9. Глазов, В.М. Микротвердость металлов и полупроводников / В.М. Глазов, В.Н. Вигдорович. – М. : *Металлургия*, 1969. – 247 с.
10. Физическая природа изменения микротвердости по глубине образца / А.Б. Герасимов [и др.] // *Физика и химия обработки материалов*. – 2004. – № 3. – С. 71–74.
11. Обратимое изменение микротвердости кристаллов Si, вызванное малыми дозами облучения электронами / Ю.И. Головин [и др.] // *Физика твердого тела*. – 2004. – Т. 46, № 10. – С. 1790–1792.

UDC 621.891:539.217.1

**PHYSICAL INTERACTION OF POINT DEFECTS WITH CRACKS IN THE SOLID**

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*The problem of vacancy during healing of cracks in metal is considered as a part of the structural and diffusion mechanism of interaction between defects and cracks in the solid state. Dependence of the diffusion coefficient of defects on temperature is noted. It has been shown that the activation energy of the diffusion pores in metal significantly affects the rate of fractures healing.*

**Introduction.** Defects in solids, particularly in metals, may be of various types and origins. The defect structure of solids is formed at the stage of producing material. In the manufacturing process of products and during the operation of finished products, the defect structure can be transformed. This may change the number of the defects and may cause their reformation with the formation of new types of violations. The most typical defects in the crystal structure are [1]:

- point defects (vacancies, interstitial atoms);
- linear defects or dislocations which can exist both separately and combined into the loop, that leads to distortion of the crystal lattice;
- surface defects (grain and twins boundaries, stacking faults);
- volume defects (voids and inclusions).

During the machining processing of the material such defects as cracks, voids, inclusions can be seen. The destruction process begins with the formation of cracks, their increasing and ends with the macroscopic destruction of the material into separate parts. In materials science of metals the surface state and the emergence of cracks in many ways determines resistance to deformation and destruction of materials. Under certain conditions cracks in metals can heal (decrease its volume), which leads to improved performance characteristics of the material.

In this paper, the possible outcome of cracks healing within the model of structure-diffusion mechanism is considered which was proposed by the authors [2].

**The model of pores and cracks interactions.** Cracks are sinks for point defects and micropores in the solid. The process of healing (overgrowing) is connected with the flow of the micropores (vacancies) from the crack (to the crack). It was established [2] that the vacancy concentration near the surface of small cracks (pores) higher than the vacancy concentration of large cracks, and therefore the flow of vacancies comes from small cracks to large cracks. There is the healing of small cracks. The flow of micropores on the surface of cracks of unit length is calculated by the formula [2]:

$$f = \frac{\gamma n_1}{R} \sqrt{\frac{D}{n_2}} \frac{K_1(z)}{K_0(z)}, \text{ where } \gamma = \frac{2\alpha\Omega}{kT}, \quad z = R\sqrt{\frac{n_2}{D}},$$

$R$  – radius of the crack;

$D$  – the effective diffusion coefficient for this type of defect;

$n_1, n_2$  – constants;

$\alpha$  – specific surface energy;

$\Omega$  – typical volume of micropores (defect);

$T$  – absolute temperature;

$K_i(z)$  – MacDonal'd's cylindrical functions of the  $i$ -th order.

Take into account that the temperature dependence of the diffusion coefficient of the defects can be described as well-known ratio:

$$D = D_0 e^{-\frac{E_a}{kT}},$$

where  $E_a$  – activation energy for diffusion of the defect;

$D_0$  – constant;

$k$  – Boltzmann constant.

In this way the flow of micropores is a complex function of many parameters: temperature, diffusion coefficient, surface energy, crack radius.

Consider the diffusion of micropores in volume adjacent to the open crack of cylindrical shape. Then the change of volume of crack  $\Delta V$  (length  $h$  in a time  $t$ ) is defined by the formula:

$$\Delta V = 2\pi R h f t \Omega.$$

In assessing crack healing process it's necessary to determine the relative change of crack volume (relative rate of crack healing):  $\varepsilon = \Delta V/V$ .

**Results, their discussion and perspectives.** Figure 1 shows the dependence of the relative change in the volume of crack on the temperature for different values of activation energy of micropores diffusion. It is known [3, 4] that activation energy for the vacancies in metals is in the range 0,9–2,0 eV.

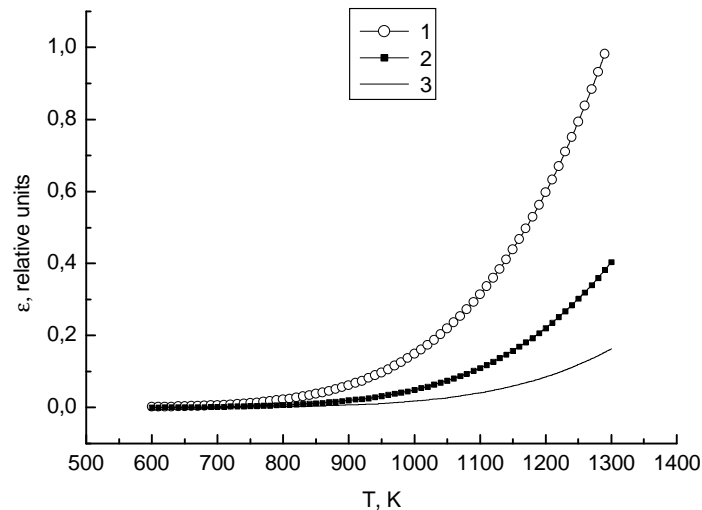


Fig. 1. The dependence of the relative change in the volume of crack on the temperature at different activation energies of pores, eV: 1 – 1, 2 – 1,13, 3 – 1,25.  $D_0 = 5 \cdot 10^{-6} \text{ m}^2/\text{s}$ ,  $t = 20 \text{ h}$ .

As we can see from the fig. 1, changes of activation energy of pores in a small range of 1-1,25 eV significantly affect the healing option. Additionally, the rate of the healing process depends on the temperature. As the temperature rises the difference in the healing rate in the studied energy range sharply increases.

It is supposed that the flow of impurity atoms in the healing process has to be an order less than the vacancy mechanism since the migration energy for impurities  $E_a$  lies in a wide range from 1 to 5 eV. In this way, the main influence of pores on cracks healing is connected with the low value of the activation energy of the diffusion pores. The surface energy of metal has a value on the value of pore flow (fig. 2).

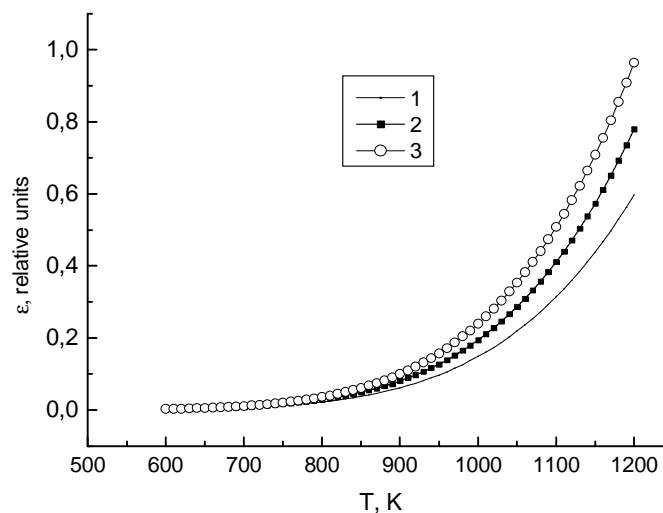


Fig. 2. The dependence of the relative change of crack volume on the temperature at different values of surface energy,  $\text{J}/\text{m}^2$ : 1 – 1,3; 2 – 1,7; 3 – 2,1.  $D_0 = 5 \cdot 10^{-6} \text{ m}^2/\text{s}$ ,  $t = 20 \text{ h}$ .



Figure 3 shows the dependence of time of the total healing of cracks on the temperature. It can be seen, the shortest time of healing is typical for high temperatures 900–1000 K.

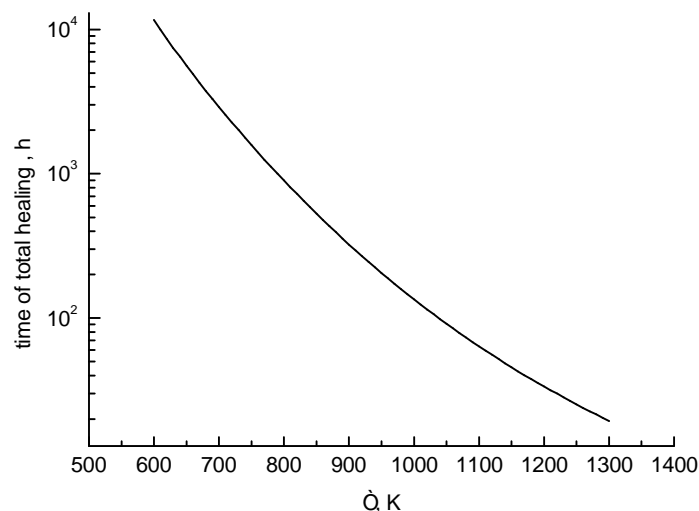


Fig. 3. The dependence of time of the total healing of cracks on the temperature.

$$E_a = 1 \text{ eV}, D_0 = 5 \cdot 10^{-6} \text{ m}^2/\text{s}.$$

**Conclusion.** Within the vacancy mechanism of the cracks healing it was demonstrated that diffusion parameters of micropores significantly affect the rate of the healing of cracks in metal. 25% reduction in the diffusion coefficient leads to a 10-fold decrease in the rate of healing. The time of complete healing at temperatures of 900-1000 K is 100-200 hours.

#### REFERENCES

1. Завистовский, В.Э. Механика разрушения и прочность материалов с покрытиями / В.Э. Завистовский. – Новополоцк : Полоцкий государственный университет, – 1999. – 144 с.
2. Zavistovskiy, V. On interaction between cracks and particles in coated materials / V. Zavistovskiy, E. Bogdanova, S. Zavistovskiy // Fracture mechanics and physics of construction materials and structures : materials of II international symposium, 7-10.11.1996. – Lviv-Dubliany. – P. 45–48.
3. Фистуль, В.И. Физика и химия твердого тела : учеб. для вузов : 2 т. / В.И. Фистуль – М. : Металлургия, 1995. – 486 + 325 с.
4. Физика твердого тела : учеб. пособие для вузов / И.К. Верещагин [и др.]. – М. : Высш. шк., – 2001. – 237 с.

## PRINCIPLES OF WORK AND BASIC POSSIBILITY OF USE PROXY SERVERS FOR BUSINESS AND EVERYDAY LIFE

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*The article reveals the meaning of the concept "proxy server" on a simple example, describes classification of proxy, capabilities and features of each type of proxy, as well as interaction between servers of different types.*

**Introduction.** Nowadays, the proxy servers are becoming more and more popular. They are used in large firms, small businesses, and even by housewives. Proxy has a number of ways and reasons for applying. We will enclose what a proxy server is, its work principle and features of its application.

**The notion of a proxy server.** A proxy server - a server (set of programs), computer networks, allowing customers to perform indirect requests to other network services. Firstly, a client connects to the proxy server and requests a resource (e.g., e-mail), located on another server. Then the proxy server either connects to a specified server and obtains the resource from it, or returns the resource from its own cache (in case if the proxy has its own cache). In some cases, a client's request or a server's response can be modified by the proxy server for specific purposes. The proxy server helps to protect a client computer from some network attacks, and helps to maintain the anonymity of a client [1].

In other words, the proxy is a resource, which intentionally intercepts all traffic between a recipient and a source itself, sends it to a recipient by specifying his/her ip-address as a source. Between the stage of intercepting and the stage of forwarding can appear an intermediate stage, such as filtration. At the stage of filtering, a part of traffic is removed or is made unavailable. Thanks to filtering, computer users are protected from viruses, spam and advertising, as well as it also limits user's access to some resources. For example, most companies treat communication in social networks by the staff during working hours badly, so the resources of such a plan are blocked. In its turn, computer classes of educational institutions are blocked with the limit rating 18+, as well as most entertainment and game resources.

To better visualization of the proxy server operating principle, consider the diagram in Figure 1. It gives the opportunity to analyze desires of a computer user in order to get data from a remote resource. If the proxy server is not used, information will be sent between points a and b directly, that is represented by a dotted line. If a computer A previously connected to the proxy server S, the request will be sent to the proxy firstly, and ip-address of this computer in the query will be changed to ip-address of the proxy server S. Then, a changed request will be sent to a computer B. When the computer B sends the answer, this answer will be received by the proxy server and, after filtration, it will sent it to the computer A.

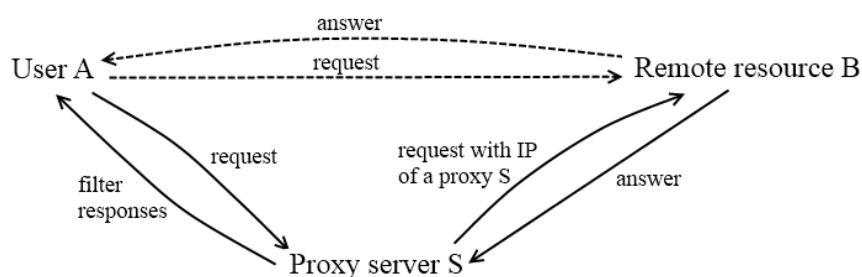


Fig. 1. Scheme work of Proxy

**Possibilities and use of proxy servers.** Proxy servers are divided into few categories according to their appointment. Basic types of proxy servers:

- proxy servers for speeding of the Internet work;
- proxy servers for making anonymous access;
- proxy for getting access to restricted resources (for example, restrictions which exist in specific countries and regions);
- proxy for restrictions of access to specified resources (often it is used on business and in public networks);
- proxy for defending from viruses and banners;
- proxy for work around other proxy servers.

Speeding of the Internet work with the help of proxy servers is reached with the help of redistribution streams of sending data. If a user needs access to foreign resources, he/she finds the closest proxy for connection, and only then sends a query to a specific address. The main factor influencing the speed of data transfer is a network bandwidth. If the proxy is not used, then the data will be forwarded through many routers until they reach the destination. In this case, the speed of those routers is limited and the path through which data is sent, is not always the shortest. In its turn, the proxy server has more powerful communication channels with other servers and sites than a user's computer, so data transmission occurs faster and only bandwidth between your computer and the proxy server is severely restricted. In addition, the server can cache data, and if a large number of users require accessing to one site, then the proxy server can give the answer to a client with data from cache.

Testers often use the proxy anonymizer for reliability testing of the developed software. In addition, ordinary users can use the proxy anonymizer if they do not want their internet activity to be tracked from any software or by the computer service. And also, some sites do not allow you to run multiple versions of their pages on one computer. Proxy anonymizers are used to circumvent such restrictions. With their help, a user can log in from multiple computer accounts, which is very useful for developers and testers of such systems, as well as administrators, already working with systems of this type.

The proxy, for access-restricted resources, works on the same principle as the proxy for anonymity. Their idea is - the ip-address of a user is changed to the ip of another country or another region. In this case, blocking installed on the territorial principle, is not applied. In the same way, users can access to a site even if they were in "black list".

The proxy for access restrictions, usually simultaneously perform the protecting function from viruses and ads. Usually, this kind of software is installed on a primary server. This proxy server performs several functions: organizes work of a local area network of a company, distributes employees' access to official data that are stored on the server, and also provides access from a local network to the Internet. Given peculiarities of such process organization of data transmission and processing, as well as the use of proxy servers for access restriction and protection from viruses and ads is a very profitable decision. The proxy server provides security of a primary server and a local network of organization. In addition, system administrators can control external traffic, block access to malicious and banned sites in this company (very often the list of sites includes social sites and the remote proxy server for bypassing locks). Also, if the proxy server is configured well, it may present the activity log of each user of the system. It helps to manage and determine how effectively employees spend their working time. Also, based on log records, the system sifts the most useless, resource-intensive, as well as dangerous in terms of virus infection sites. Log entries may even lead to dismissal of an employee, if he spends most part of his working hours on entertainment, gaming or suspicious sites. It is worth to mention that all parental control systems that provide the Internet access to children, also include local proxy for limiting and filtering of traffic.

The proxy server for crawling other proxies are typically used by employees of businesses that need to get access to the restricted resources. The most popular sites of this kind are blocked by administrators, but every day there are new "mirrors" websites with not employed earlier ip-addresses. Because of this close access to such resources, administrators have to update the "black list" regularly, or rely on the conscientiousness of the organization's staff.

**Conclusion.** In conclusion it is worth saying that the proxy server is a very powerful tool that can either open a user's access to all information on the Internet, regardless of its territorial or personal qualities, which sometimes provoke moderators of sites to block certain ip-addresses, or vice versa, severely restrict the ability of users; the proxy server helps in organization of total control over their activities. The same can be said about computer security system in conjunction with a proxy. On the one hand, if the proxy filters out at least half of the malware, antivirus can "catch" the rest from the half easier. On the other hand, attackers often use connection through the chain of multiple remote proxy servers in different parts of the world in order to hide their whereabouts.

## REFERENCES

1. Википедия – свободная энциклопедия [Electronic resource] / Прокси-сервер – М., 2016. – Mode of access: [https://ru.wikipedia.org/wiki/Прокси\\_сервер](https://ru.wikipedia.org/wiki/Прокси_сервер). – Date of access: 15.12.2016.
2. CITForum [Electronic resource] / Часто задаваемые вопросы о proxy (proxy FAQ) – М., 2005. – Mode of access: [http://citforum.ru/internet/webservers/proxy\\_faq/#1](http://citforum.ru/internet/webservers/proxy_faq/#1). – Date of access: 10.01.2017.

**THE USE OF E-LEARNING SYSTEMS FOR KNOWLEDGE ASSESSMENT**

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*The article deals with modern electronic systems for knowledge assessment, their characteristics and possibilities of applying in the education system. The process of using systems in practice is described in detail, their main advantages and disadvantages are presented.*

**Introduction.** In the age of widespread variety of information and technical resources, principles of knowledge control developed many decades ago are still often used. However, in recent years information systems have been developed. New systems are becoming increasingly popular and more suitable for the modern education system. One of the most common innovations is electronic testing which allows making a transition from paper to electronic learning systems.

Typically, e-learning systems are implemented in educational institutions for remote learning realization, but in recent years these systems have increasingly been used for classroom knowledge testing. These systems have a number of obvious advantages: mobility (portability), variability, ease for check, assessment impartiality.

**Mobility (portability).** Most knowledge control systems allow performing not only testing in computer rooms during lessons, but also extracurricular and regular testing. For example, an account for a student or learner can be created in systems such as x-TLS[1], INDIGO[2], Let's test[3] or USATIK (Universal system for automation of testing and control) [4, 5]. Access permission for entering the system is given to a student or learner. Next, a teacher uploads educational materials for preparing a test, creates the test based on these materials, and then makes the test available for students, sets the due date and time as well as the maximum number of attempts. Furthermore, in some systems a calendar allows to set not only due time, but also the time when the test will be available for students. Thus deferred testing is organized.

A possibility of setting the due time and the time the test is available allows students to carry out tasks in the most comfortable environment for them, in the most appropriate time. Since remote systems work around the clock, you can take the test in the early morning or in the late evening. In addition, students who have problems with health or other personal difficulties, may take a test on their home computers or even on their mobile phones at a the most convenient time. Among other things, if a student knows in advance when new tests are available and the due time, they become more organized. It helps to properly allocate their time for study and for leisure, and also students can prepare for testing better and without haste.

A possibility to set the number of attempts for passing a test does not exist in every system, but it is very useful. Thus, student can try to pass the test again after revising the studied material, if the test result was bad. Firstly, weak students can get at least minimum positive score. Secondly, it encourages students to re-read the new and revise previously learned material. And thirdly, in this case there is no need for a teacher to make additional setting for the students who failed the test, because afterwards they will be able to pass the test once again.

In addition to these systems, there are also programmes for carrying out testing in computer rooms. Such programmes have a server with questions and computers for students, where they can pass a test (the connection between them is carried out via LAN), or for each test a separate module is generated, which is copied to the student's computers (modules are not linked to each other). These programmes include Iren [6], OpenTEST 2.0 [7] and MyTestXPro [8]. All of these programmes can only be used for classroom tests, which is not a big disadvantage, as these systems have all the advantages of automated testing systems, and implementation of knowledge control can take place in the classroom under the teacher's supervision.

**Variability.** As a general rule, tests comprise a set of standard questions, and preparing several variants of tasks is a very hard work. On the other hand, if all students have the same set of tasks the possibility of cheating and using cheat sheets increases, and with each new attempt the efficiency of passing a test reduces. After all, if students know what questions they answered correctly, they can simply repeat their answers, without thinking about the meaning of the question and not analyzing it. At the same time, if students know exactly what questions will be in the test, they focus on the educational material connected with these issues, and ignore other, often equally important issues. Because of this, often a small gaps in knowledge that can then become disastrous.

The solution for this problem is a property of automated knowledge testing systems, such as variability. The teacher creates a set of questions covering the whole subject area of the topic, and the system in turn, chooses from a given set of a specific number of questions and offers them to students at random to answer. This approach makes students learn all the theoretical material, provokes understanding of topics, rather than memorizing numbers of correct answers, and also ensures adequate assessment of students' real knowledge.

**Ease for check.** As a rule, checking test results is becoming quite a big challenge for a teacher. If a small number of people passes the test, checking out all the tests manually is not difficult, but if the group consists of 20-30 people, and the test contain at least 10-15 questions of different variants of tasks, checking all solutions becomes a very long and tiring process with a high percentage of errors on the part of the teacher, because eventually people get tired and their attention is scattered. In the case of automated knowledge control systems, correct answer to the question is checked automatically and the results of a test are available for the learner as well as for the teacher. Thanks to this system students can independently monitor progress of their knowledge on the subject and receive information about the tests which they have already passed. The systems operate automatically so failures in detecting errors are avoided, in contrast to manual checking.

**Impartiality of assessment.** Often, process of grading becomes quite a big problem for teachers. In the case of oral or written examination it is difficult to assess students' knowledge, in fact, there are many criteria for grading, and all of them should be used. Tests are a great solution to this problem. If a teacher has a sufficient set of tests on the topic and a well thought out system of evaluation of each question, then the only task is to properly distribute range of grading, and the system will place them automatically. Some systems allow you to put a different "value" of questions, such as: easy question - 1 point, medium - 2 points, complicated - 3 points.

The system also solves the problem of personal relationships influence between students and teachers on the result of examination. The system has no personal qualities and does not include third-party factors during assessment.

**Conclusion.** Considering the above material, it is possible to say that automated knowledge assessment system is very convenient and effective means for intermediate and final knowledge assessment. Their use greatly simplifies and accelerates the work of the teacher and, at the same time, encourages students to study in the most detailed and comprehensive way, it pushes them to further develop self-discipline and self-organization.

The only drawback of these systems is the lack of a creativity in checking tasks, such as drawings, compositions, writing, etc., but for this purpose special testing procedures are developed. There cannot be any clear sets of rules, because if creative tasks were evaluated by a system (even using neural networks) the results would be unpredictable.

#### REFERENCES

- 1 Автоматизированная система обучения и контроля знаний на основе расширенных тестовых заданий x-TLS [Electronic resource] / О программе для тестирования знаний и конструкторе тестов x-TLS – Киев, 2016. – Mode of access: <http://xtls.org.ua/about.php.html>. – Date of access: 27.12.2016.
- 2 INDIGO [Electronic resource] / Программа для создания тестов и онлайн тестирования. – Ставрополь, 2016. – Mode of access: <http://indigotech.ru>. –Date of access: 27.12.2016.
- 3 Система тестирования Let's test [Electronic resource] / Конструктор для создания тестов.Онлайн сервис для проверки знаний учащихся и аттестации работников. – Воронеж, 2016. – Mode of access: <https://letstest.ru>. –Date of access: 27.12.2016.
- 4 Компьютерная газета A-Z [Electronic resource] / УСАТИК — система тестирования знаний. – Минск, 2016. – Mode of access: <http://www.nestor.minsk.by/kg/2006/29/kg62917.html>. – Date of access: 28.12.2016.
- 5 УСАТИК [Electronic resource] / Описание пакета УСАТИК. – Ульяновск, 2001. – Mode of access: <http://www.usatic.narod.ru>. – Date of access: 28.12.2016.
- 6 Айрен [Electronic resource] / Программа тестирования знаний. – Москва, 2009. – Mode of access: <http://irenproject.ru>. – Date of access: 05.01.2017.
- 7 Программа тестирования [Electronic resource] / Компьютерное тестирование студентов OpenTEST 2. – Киев, 2013. – Mode of access: <http://opentest.com.ua/kompyuternaya-programma-testirovaniya-znaniy-opentest-2>. – Date of access: 05.01.2017.
- 8 Компьютерное тестирование знаний и компьютерные педагогические тесты [Electronic resource] / MyTestXPro – система программ для создания и проведения компьютерного тестирования, сбора и анализа их результатов.– Москва, 2016. – Mode of access: <http://mytest.klyaksa.net>. –Date of access: 05.01.2017.

**MARKETING EFFICIENCY EVALUATION PROBLEMS IN SOCIAL MEDIA*****KATSIRYNA HATSIKHA, OKSANA GOLUBEVA, GENNADIY AVERIN*****Polotsk State University, Belarus**

*The main problems connected with creation of the software for marketing efficiency evaluation in social media are enclosed in this article. The main features of external and internal use of software products are described.*

There is a large number of various social networks on the Internet now, blogs and forums which serve not only for communication of users, but also are platforms for promotion of goods and services. Many modern entities and companies choose promotion in social media as one of the instruments of marketing.

Marketing researches are the main channel of receiving information, necessary for acceptance of management decisions. As well as any marketing activity, promotion in social media does not make a sense without performance indicators expressed in specific figures. Manually it is very difficult to be engaged in efficiency evaluation of marketing activity in social media because of large volumes and high speed of information distribution on the Internet.

Being engaged in promotion assessment in social media, it is possible to use numerous quantitative and qualitative indexes of efficiency. Each of them has both benefits, and shortcomings. In particular, the formalization characteristic of quantitative researches allows to receive exact and reliable estimates which consider a set of factors influence on a marketing activity of a company. On the other hand, carrying out quantitative researches is rather labor-consuming, requires collection of information, use of special application programs for its handling. Thanks to qualitative indexes, it is possible to receive quite reliable estimates, unexpected opinions, descriptive characteristics, however not always objective. Therefore, it is optimum to use a combination of different types and methods of marketing researches [1].

As a rule, the unique system of assessment, adapted under solvable tasks is developed for each specific marketing software product. Speaking about the simplest classification of the software products used for marketing efficiency evaluation in social media, it is possible to allocate two types of programs: internal and external. For measurement of rather internal statistics indicators of the used service, possible to apply the software of internal type. Special tools, such as systems of web analytics and services for social networks monitoring, relating to software products of external type will be necessary for measurement of other indicators. As many social networks, blogs and forums have no full-fledged program modules for marketing efficiency evaluation, often together with the software of internal type, it is necessary to use programs of external type. The usage of numerous indicators from different sources is rather inconvenient, and for resulting effect, it is necessary to consider features of assessment systems of each software product.

Many external web services often provide to users more extensive list of opportunities for analytics, than software products of internal type. Developers of such external multipurpose web services try to create the universal tool for marketing efficiency evaluation directly for several social networks, forums or blogs. The usage of one service for several accounts in various social media is convenient only in theory. However, in practice it leads to the problems connected with high complexity of work with multipurpose external web services. Developers, instead of planning and working according to needs of those users who will purchase and use the created products, are pretty often concentrated on technology and as a result generate decisions, poorly governed and inconvenient in application. In general, many programs look excessively difficult and tangled, that complicates navigation and understanding of many events [2]. A user needs some time for training in order to work with multipurpose web service for marketing efficiency evaluation.

Many social web services have similar structure, however each social network, a blog or a forum has the distinctive components and architectural features. Developers of social media constantly finish and create new functionality of own web services, including tools for promotion of goods and services. Therefore, application of the external software is not always possible, and the modifications of social web service with obtained later data, can be not correct and not urgent.

Besides, you should not forget about the amount of data, which must be processed in case of marketing efficiency evaluation in social media. Handling of large data standard program volumes and hardware seems extremely difficult. It is possible to tell that "Big Data" is a problem of storage and handling of huge amounts of data. As a rule, when the term "Big Data" is used, it means three "V", that means "Volume" – amount of data,

"Velocity" – need to process information with high speed and "Variety" – variety and often insufficient structure of data.

Storage of large volumes of information requires special conditions, and it is a question of space and opportunities. Speed is connected not only with possible delay and "braking" caused by obsolete methods of information processing, it is also a question of interactivity: the quicker process, the more return, the more productive result. The problem of heterogeneity and the absence of structure arises because of sources separation, formats and quality. To unite data and to process them effectively, it is required to bring them into a type, suitable for work.

The analysis of big data was also successfully applied long ago to determination: target audience, interests, demand, and activity of consumers. For example, the analysis of big data allows to remove advertising only for those consumers who are interested in goods or services [3].

Thus, during creation of the web service for marketing efficiency evaluation in social media it is necessary to solve the problems connected with the large volume of the processed information, convenience of use and modification, high performance level and functional suitability.

#### REFERENCES

1. Маркетинг в социальных медиа. Интернет-маркетинговые коммуникации : учеб. пособие / под ред. Л.А. Данченко. — СПб. : Питер, 2013. — 288 с.
2. Купер А. Алан Купер об интерфейсе. Основы проектирования взаимодействия : пер.с англ. / А. Купер, Р. Рейман, Д. Кронин. — СПб. : Символ-Плюс, 2009. — 688 с.
3. Что такое BigData (большие данные) в маркетинге: проблемы, алгоритмы, методы анализа [Электронный ресурс]. – Режим доступа: <http://lpgenerator.ru/blog/2015/11/17/что-такое-big-data-bolshie-dannye-v-marketinge-problemy-algoritmy-metody-analiza>. – Дата доступа: 09.12.2016.

**ARTIFICIAL INTELLIGENCE, DECISION-MAKING AND PRINCIPLES OF JUSTICE****LUBOV URYVSKAIA****Baltic Federal University of Immanuel Kant, Russia****LEV GOVOR****Artistic Industrial College, Russia**

*The authors report is on the opening of the world of programming and jurisprudence: the creation of artificial intelligence, the ability to make judgments. It discloses the relevant actions of artificial intelligence and principles of applicable proceedings.*

**Introduction.** A combined team of specialists from Pennsylvania University and the University of Sheffield created a weak form of artificial intelligence that is able to predict decisions of the European Court of Human Rights (European Court of Human Rights, ECtHR, ECHR) with an accuracy of 79%. The system predicts the court's decision after reviewing the case file, and on the basis of these data the AI is concluded [1].

Analyzing hundreds of texts of ECHR cases, scientists have found that judges of this court, first of all, pay attention neither to the legal terms in the text of appeal nor to a simple description of the facts. In other words, judges, according to the authors of the project, are most realists and pay attention to a moral side of the matter, not formalists, who strictly follow every letter of the law.

It is possible that in a few years the decision of Judicial Affairs will not take a judge but a robot. The idea sounds great, because the artificial intelligence will be deprived of a number of drawbacks in judgment of a human: addiction to bribes and the influence of emotions on decision-making [2].

**Main part.** "The Court may use this method to prioritize hearings on the basis of having a high probability of a violation of the article", - said in an interview with the Athens-Macedonian News Agency head study, Dr. Nikolaos Aletras (Faculty of Computer Science, University College London) [3].

The majority of Russian population relates to the court with suspicion and without respect, believing that the court in Russia is inefficient, unreliable or simply corrupt. Nearly 80% of respondents do not expect to find justice in Russian courts [4]. This belief is based mainly on the ideas expressed by the two versions of statements: "Our courts often win the case, the highest bidder" and "Many do not want to go to a court, because the road has too informal costs". For about 15% of respondents appeal to the courts during a year. And more than 27% say that have faced with the need to go to a court, but have not done so for the last two years [5].

Artificial Intelligence as a mediator of the judiciary could improve the efficiency and fairness of the judicial decision, and at the same time the level of citizens' trust to the judicial system, and as a consequence, to the government as a whole. It would increase the level of legal awareness and legal status of the state.

It becomes interesting to match the application of artificial intelligence to the principles of judicial proceedings.

1. The principle of legality. Continued compliance of the law requirements will not be violated due to the fact that the program was originally based on the norms of law and case-law in countries with Anglo-Saxon legal system. Additionally, you can admit the impossibility of deviation from the rule of law, which often leads to miscarriages of justice and the revision of cases on appeal.

2. The principle of justice. Artificial intelligence comprehensively processes facts of the case, including the nature and degree of public danger, the circumstances of the crime and the identity of the perpetrator. It guarantees no bias in the decision.

3. The principle of justice only by the courts. "No one can be convicted of a crime and subjected to criminal punishment except by the verdict of the court and in accordance with the procedure established by the Criminal Code." The circle of bodies authorized to administer justice is clearly restricted by the law [6]. Artificial intelligence is not an independent body of state authority or local government, and acts as a subsidiary subject in deciding some intermediary.

4. The principle of judicial independence. It controls a judge in deciding cases under its production. Artificial Intelligence is based only on the laws of conscience and their inner conviction and on the study in the court of admissible evidence. Artificial Intelligence creates an absolute impossibility of interference in the administration of justice due to the lack of methods and means of physical or mental pressure on it.

5. The principle of equality before the court. Artificial intelligence does not mean the individual classification according to sex, race, nationality, language, origin, property and official status, place of residence, attitude to religion, beliefs, membership of voluntary organizations. In solving the case, it relies only on the exist-



tence of offenses, administrative offenses, previously committed crimes, as well as mitigating and aggravating circumstances, which were crucial for the outcome of the case.

6. The principle of the right to appeal to the court. Everyone is guaranteed judicial protection of his rights and freedoms. Artificial intelligence implies a change in the stage of immediate trial without affecting the Complaint resolution of conflicts, as well as the process for submitting and receiving the application for judicial review [7].

7. The principle of the rights of the suspect and the accused to defense. The right to have a lawyer in order to collect information and provide evidence base remains essential in the court. Artificial intelligence is only concluded on the basis of evidence presented by both sides.

8. National judicial language. Presentation of evidence and publication of decisions is made in the national language of the State in which the proceedings are conducted. In the absence of language recognition, the software may attract a special translator in that field of law attributable to a dispute.

9. The principle of adversarial proceedings and equality of arms. The software system does not provide declination of a decision in favor of one side. Facts are analyzed without reference to their source. The possibility of an unlimited number of evidence by both sides fully implements the principle of adversarial proceedings.

10. The principle of citizen participation in administration of justice. Does not exclude the possibility of a jury, whose dissenting opinions may also be included in the program of the decision, but the statements have to be built in a logical way (based on templates created in the framework of the program laid down in the AD), based on the facts, excepting emotional and personal side.

11. The principle of the open court. If artificial intelligence assumes the correspondence form of the court hearing, the principle of the open court will find itself in a public proclamation and publication of the judgment and operative part of motivation.

12. The presumption of innocence principle. The decision is made after full analysis of the facts of a particular case, based on the evidence provided, including the prosecution, which function is to prove the defendant's guilt. The impossibility of adopting a program of conviction in the absence of sufficient evidence of claimed elements of a crime once again reinforces this principle.

13. The principle of legality, competence and impartiality of the court. The court, which is entrusted to hear and determine civil, criminal and other cases, is able to administer true justice if it is legitimate, competent, independent and impartial. Artificial intelligence relies on the law, has the ability only to correct and direct interpretation of the law, is independent of other authorities, and other kinds of influence, and has no sense of prejudice and forms its own positions on certain categories of cases.

14. The principle of respect of the rights and freedoms of a man and a citizen. It have been read 584 court rulings on the suit of citizens to the ECHR while analyzing artificial intelligence algorithms. The researchers chose those decisions, which related to the three articles of the Convention on Human Rights. These are the prohibition of torture and degrading treatment, the right to a fair trial and the right to respect private and family life. According to these articles, the court makes the most decisions. Analyzing the text of the appeal, artificial intelligence makes its own verdict of "violation" or "no violation". The computer, using a number of precedents to analyze each particular case, brings along its verdict based on phrases found in the text of the case, the facts, and circumstances. "Before, our system can predict the court's decision only on the basis of a crime or opinions of each judge. We were able to predict the decisions of referees on the basis of the documents analysis, which were prepared by the court ", - said one of the study participants.

15. The principle of binding judicial decision. The court ruling, created with the help of artificial intelligence, will be imposed on behalf of the State, and the obligation of execution is equal to any other judicial acts. This foundation has a character of legal presumption, that the court decision is considered to be true as long as it is not canceled in the manner prescribed by the law.

**Conclusion.** According to the given above analysis, we can conclude that introduction of artificial intelligence, as a subsidiary subject to the judicial system will not infringe existing principles of the trial, but, on the contrary, increase the speed, efficiency, trial openness, as well as literacy and complete impartiality of adjudication that in its turn will lead to the increase of quality of justice and the level of trust of citizens to acting judicial system.

## REFERENCES

1. Искусственный интеллект научили предсказывать судебные решения в делах по нарушению прав человека [Электронный ресурс]. – 2016. – Режим доступа: <https://geektimes.ru/post/281830>. – Дата доступа: 02.10.2016.

## ITC, Electronics, Programming

2. Искусственный интеллект по правам человека [Электронный ресурс]. – 2016. – Режим доступа: [https://www.gazeta.ru/science/2016/10/24\\_a\\_10267349.shtml](https://www.gazeta.ru/science/2016/10/24_a_10267349.shtml). – Дата доступа: 22.11.2016.
3. Греческие ученые разработали инновационный искусственный интеллект [Электронный ресурс]. – 2016. – Режим доступа: <http://1gr.tv/ot-partnerov/kultura/category/grechskie-uchenyie-razrabotali-innovatsionnyiy-iskusstvennyiy-intellekt>. – Дата доступа: 29.11.2016.
4. Соломон-мл, П. Судебная реформа в России: движение сквозь вакуум [Электронный ресурс] / Питер Соломон-мл. – 2003. – Режим доступа: <http://magazines.russ.ru/oz/2003/2/solomon.html>. – Дата доступа: 30.11.2016.
5. Сатаров, Г. Проржавевшее правосудие [Электронный ресурс] / Георгий Сатаров. – 2003. – Режим доступа: <http://www.strana-oz.ru/2003/2/prorzhavevshee-pravosudie>. – Дата доступа: 03.12.2016.
6. Уголовно-процессуальный кодекс Российской Федерации [Электронный ресурс] от 18.12.2001, N 174-ФЗ (ред. от 19.12.2016) (с изм. и доп., вступ. в силу с 01.01.2017) // Консультант Плюс: Версия Проф. Технология 3000 / ООО «ЮрСпектр». – М., 2006.
7. Принципы правосудия [Электронный ресурс]. – 2016. – Режим доступа: [https://ru.wikipedia.org/wiki/%D0%9F%D1%80%D0%B8%D0%BD%D1%86%D0%B8%D0%BF%D1%8B\\_%D0%BF%D1%80%D0%B0%D0%B2%D0%BE%D1%81%D1%83%D0%B4%D0%B8%D1%8F](https://ru.wikipedia.org/wiki/%D0%9F%D1%80%D0%B8%D0%BD%D1%86%D0%B8%D0%BF%D1%8B_%D0%BF%D1%80%D0%B0%D0%B2%D0%BE%D1%81%D1%83%D0%B4%D0%B8%D1%8F) – Дата доступа: 08.12.2016.

UDC 004.056.2

**INFORMATION INTEGRITY MONITORING AS A PART  
OF HOST INTRUSION DETECTION SYSTEM****KANSTANTSIN HALAVAN, EVGENIJ SUHAREV**  
**Polotsk State University, Belarus**

*The article describes the concept of the information integrity, control information integrity and the relevance of integrity. Providing classification and comparison of modern information integrity software.*

In the context of the deep distribution of information technology in all human activity fields, the reliability of the identification information and the control of its integrity become important issues, all scientific, technological, and social. The scientific and technological problems include creating mathematical approaches, algorithms, software and hardware to solve these problems. The social aspect of the problem is the need to create a public accessible, convenient and secure system with the reliable data identification, an adequate level of development of information technologies.

Information integrity control has significant impact in various fields of human activity. In the financial area a large number of financial transactions is carried out every day on the Internet in which integrity control of the processed, transmitted and stored information is an important part.

Creating a secure system is a complex problem, and it is solved by using of software and hardware, as well as organizational measures. The real protection system is built based on possible threats and the chosen security policy.

The main information security threats depend on the aspects on which these threats are directed. They are:

- privacy threats;
- integrity threats;
- availability threats;
- authenticity threats;
- safety threats.

Information protection system ensures the information integrity, if it provides the accuracy, completeness and security of information from unintentional and intentional distortions in storage, transmission and processing.

One way to ensure the information integrity is to use software (file) integrity monitor tools and to process information, including its recovery.

The main objective of information integrity monitoring tools is to provide such a state of the system when it is impossible to hide the fact any unauthorized modification of information.

File integrity monitor (FIM) is one of the security tools that can be implemented in a host environment as a part of a host based intrusion detection system (HIDS). Information integrity monitor plays a big role in monitoring the integrity of the files in the event of any changes to the files or their content, access control, privilege, group and other properties either by authorized or unauthorized users. The main goal of related integrity tools is to notify system administrator if any changes have been made, deleted, or added on the monitored system. Basically, file integrity tools measure the current checksum or hash value of the monitored.

As part of the HIDS functions, file integrity monitoring can be classified as off-line (on request) and on-line (on real time) integrity monitoring [1].

Tripwire [2] is a well known file integrity monitoring tool that motivates other researchers to develop more powerful IIM tools. Tripwire works are based on four processes: init, check, update and test. Comparison of the current hash values of the files with the baseline values is the main principle of the FIM tools like Tripwire.

Inspection frequency and the modification detection effectiveness is the main issue in the off-line FIM. In order to maintain the effectiveness of the FIM, high frequency inspection is needed at the cost of system performance, and vice versa. In order to overcome this issue by proposing a dynamic inspection schedule by classifying related files to certain groups and the inspection frequency will vary between the groups of files [1].

On-line FIM is proposed to overcome the delay detection in off-line IIM approach by monitoring the security event involving system files in real-time. However, in order to work in real-time, it requires the access of low level (kernel) activities which require kernel modification. When kernel modification is involved, the solution is kernel and platform-dependent, and therefore incompatible with other kernels and platforms.

As an example, I3FS [3] proposed a real-time checking mechanism using system call interception and working in the kernel mode. However this work also requires some modifications in protected machine's kernel.

In addition, whole checksum monitoring in real time affects performance degradation. I3FS offers a policy setup and update for customizing the frequency of integrity check.

There are various on-line FIM and other security tools using the virtual machine introspection (VMI) technique to monitor and analyze a virtual machine state from the hypervisor level.

On the other side, virtualization based file integrity tools (FIT) has been proposed by XenFIT [4] to overcome the privileged issue on the previous user mode FIT. XenFIT works by intercepting system call in monitored virtual machine (MVM) and sent to the privileged virtual machine (PVM). However, XenFIT requires a hardware virtualization support and only can fit with the Xen virtual machine, not other virtualization software. Another Xen based FIT is XenRIM [5] which does not require a baseline database. NOPFIT [6] also utilized the virtualization technology for their FIT using undefined opcode exception as a new debugging technique. However, all those real-time FIT only works on the Linux based OS [1].

Centralized management of the file integrity monitoring is the main concern of those tools, and in order to develop this need one should take it as the fundamental features for this type of system and need to focus more on the checking scheduling concern on the multi-platform host. The other security tools also implement a centralized management for their tools, such as anti-malware and firewalls, FIM as part of HIDS also needs that kind of approaches to ensure the ease of administration and maintenance.

FIM tools, Samhain [7], and OSSEC[8] come with centralized management of the FIT component in their host based intrusion detection system which allow multiple monitored systems to be managed more effectively. Monitoring the integrity of files and registry keys by scanning the system periodically is a common practice of the OSSEC.

Combining the on-line and off-line integrity monitoring with centralized management is to maintain the effectiveness of the FIM and to reduce the performance overhead.

**Conclusion.** The integrity threat is one of the main information security threats. Unauthorized changes of the information may be caused by accidental or premeditated actions. One way to ensure the information integrity is the use of software integrity controls and processes information, including its recovery.

In general, data integrity control is provided by pre-determining characteristics of the information integrity, called a message authentication code [9].

Among the considered software should note the client / server structure of the program with a centralized management, including the administrative console to collect information, the set up time of the integrity check for each agent and configuration. As a method for the modification detection used hashes comparison method.

## REFERENCES

1. Towards a Dynamic File Integrity Monitor through a Security Classification / Zul Hilmi Abdullah [et al.] // International Journal on New Computer Architectures and Their Applications (IJNCAA). – 2011. – Vol. 1, № 3. – P. 766–779.
2. Kim, G.H. and E.H. Spafford, The design and implementation of tripwire: a file system integrity checker, in Proceedings of the 2nd ACM Conference on Computer and communications security. - 1994, ACM.
3. Patil, S. I3FS: An In-Kernel Integrity Checker and Intrusion Detection File System, in Proceedings of the 18th USENIX conference on System administration / S. Patil. – USENIX Association: Atlanta, GA, 2004.
4. Junghan, K. NOPFIT: File System Integrity Tool for Virtual Machine Using Multi-byte NOP Injection. in 2010 International Conference on Computational Science and Its Applications / K. Junghan. – Fukuoka, Japan, 2010.
5. Quynh, N.A. A novel approach for a file-system integrity monitor tool of Xen virtual machine, in Proceedings of the 2nd ACM symposium on Information, computer and communications security / N.A. Quynh, Y. Takefuji. – ACM: Singapore, 2007.
6. Quynh, N.A. A Real-time Integrity Monitor for Xen Virtual Machine, in Proceedings of the International conference on Networking and Services / N.A. Quynh, Y. Takefuji. – IEEE Computer Society, 2006.
7. Wotring, B. Samhain, in Host Integrity Monitoring Using Osiris and Samhain / B. Wotring, B. Potter. – Syngress: Burlington, 2005. – P. 241–305.
8. System Integrity Check and Rootkit Detection, in OSSEC Host-Based Intrusion Detection Guide / A. Hay, [et al.]. – Syngress: Burlington, 2008. – P. 149–174.
9. Петров А.А. Компьютерная безопасность. Криптографические методы защиты информации / А.А. Петров. – М. : ДМК, 2000. – 448 с.

UDC 004.9+004.021

**GEOLOCATION-RELATED DATA CLUSTERING METHODS****ARTUR DRYOMOV, ARKADY OSKIN****Polotsk State University, Belarus**

*Displaying various points on a map it is possible to get high points density in certain areas of the map. This kind of behaviour is not desired for an end user of the map, mostly because it is not trivial for a person to manipulate points in such environments. The issue can be solved by grouping points using clustering methods.*

Maps in all their variety are essential for proper interpretation and representation of overwhelming amount of geographical data. This kind of data surrounds us every day in any form imaginable. One of the first things we do in the morning is the commute from home to work and, as a consequence, vice versa action in the evening. This can sound like a common sense, but it requires deep geolocation-related information knowledge about at least two points: source and destination. Fortunately enough with the current informational technology integration level in our everyday lives we have more or less reliable online mapping solutions like Google Maps, Yandex Maps, Apple Maps and so on, all of them are quite popular. Their users use them as they please to perform various tasks: search for a location and a route to that location, view location details and reviews, plan complex routes for a set of locations and much more than that. Soon enough a complex issue arises — what to do if there is a large amount of locations needed to be displayed on a map. The straightforward solution is just to put them as it is without any preprocessing. The final result can be kind of disappointing — a lot of markers, associated with locations, on a limited in size will look like a tightly filled with markers field without any option to take a look or select a single one among them, visually overloading the map and its interaction. There are some solutions to deal with such sort of situations.

Clustering or Cluster analysis is a specific operation of transforming a set of various objects into groups. Resulting groups can be characterized and are different one from another. Grouped objects in a single picked group are more similar to one another than other ones in different groups. These groups of objects are called as clusters. The clustering task is one of primary areas of exploratory data mining. The operation itself has a wide appliance: from machine learning and image analysis to data compression and computer graphics. It is important to notice that clustering is not an algorithm, but a general task. Analysis and cluster grouping can be performed using various methods, ways and notions about what constitutes a cluster itself and how to differentiate one cluster from another. Most known notions are distance-related metrics, dense areas of data space, statistical distributions or intervals. This way clustering can be characterized as a multi-objective optimization issue. Cluster analysis is not a fixed-steps issue for most of the data, it is an iterative process of trial and failure involved in the knowledge discovery. Sometimes it is necessary to change algorithms and its parameters until the result is available. Depending on specific data set and desired results form distance function, density threshold and number of resulting clusters can and should be changed in the process of analysis itself [1].

Geomapping data, as it was noticed before, requires clustering when working with a large amount of location-related data. Most of all the issue relates to map markers — map objects associated with specific locations. Such objects can be represented as pins, location dots and signs. The issue of representing an overwhelming amount of pins on a fixed map area will lead to a field filled with pins without any underlying context. At the same time, another digital map-related parameter should be considered called zoom. While observing a map area using maximum and minimum zoom results will be different. For example, when placing a million pins on a single street, maximum zoom (a house-level one) will lead to observing a spread of pins, while minimum zoom (a planetary-level one) will show a dot of highly dense area of pins.

The proposed solution is to use clustering to group pins based on their location and current zoom level. The desired behaviour will replace pins with pin clusters and vice versa while zooming out and in respectively. The proper implementation will use clustering to optimize displayed pins count to exclude results with overwhelming data displayed on the map [2].

There are two solutions related to geographical-related data clustering.

- Square based clustering.
- Distance based clustering.

Square based clustering, as the name says, does the clustering via dividing a map to squares. The square size depends on a current map zoom level. Map markers appearing in the calculated square are grouped into a cluster. The technique is quite simple.

## ITC, Electronics, Programming

1. Choose a coordinate system on a map and split it to squares of a chosen size.
2. Start iterating over all locations available in a set.
  - a. Find out which square hosts the location.
  - b. Put location into a square-related subset.
3. Finish iterating over all locations available in the set.
4. Start iterating over all resulting square subsets.
  - a. Calculate a centre of the square.
  - b. Put a cluster marker into a calculated centre.
5. Finish iterating over all resulting square subsets.

The similar approach is based on administrative units clustering. This way a map is not divided into squares and markers are tested against fitting into specific predetermined geographical regions, most likely being equivalent to real units of the selected country [3].

The technique has some limitations.

– Because splitting a map to squares is mostly artificial the resulting markers set looks artificial as well, basically being a perfectly aligned markers on the same size one from another. In this way the geographical data context can be lost.

– Two or more markers can be very close to one another but be in separate squares. As a result, clustering will not work properly.

Distance based clustering is a smarter but less efficient way of grouping markers into clusters. Instead of splitting the map into squares or regions markers are grouped by their respective distance to one another. For example, it is possible to combine locations into a cluster inside 10 kilometres radius. There is one issue though. Kilometres, meters and such metric units have different meaning based on the current zoom level. A zoomed in map displays a distance unit differently than a zoomed out map. This needs to be considered while implementing the algorithm. Even more — the clustering operation should be redone on each zoom level change [4].

1. Choose a random location from a location set.
2. Form a current cluster.
3. Remove the chosen location from the location set.
4. Start iterating over all locations available in the set.
  - a. If a current location fits the desired distance criteria regarding the chosen location:
  - b. include it into a current cluster;
  - c. remove it from a location set.
5. Finish iterating over all locations available in a set.
6. Repeat from the beginning until the set is empty.
7. Start iterating over resulting clusters.
  - a. Calculate a geographical centre of locations in the cluster.
  - b. Put a cluster marker into a calculated centre.
8. Finish iterating over resulting clusters.

This approach gives better results, but is not as efficient as the square-based clustering — it is required to pass through all locations multiple times instead of a single pass with the square-based method.

There are other, more complex, methods, that can be researched and benchmarked in the future developments, but it clearly seems that the issue is real and has practical applications in the current state of the world.

## REFERENCES

1. Dudek, A. Dynamic Classification of Geographic Points on Google Maps / A. Dudek ; University of Lodz. – Lodz, 2014. — 10 p.
2. Meert, W. Clustering Maps / W. Meert ; Katholieke Universiteit Leuven. — Leuven, 2006. — 62 p.
3. Hot, E. Soil data clustering / E. Hot, V. Popovic-Bugarin // Telfor Journal. — 2016. — 6 p.
4. Chen, X. Efficient Filtering and Clustering Mechanism for Google Maps / X. Chen // Journal of Advanced Management Science. — 2013. — 5 p.

UDC 331.108.3+00.9=111

**EXPERT SYSTEMS DEVELOPMENT  
APPROACH IN MODERN INDUSTRIAL APPLICATIONS****VITAL DRAZDOU, ARKADZI OSKIN****Polotsk State University, Belarus**

*The article represents the overview of expert system approach in modern industrial applications. Shows base advantages and disadvantages of using this approach, performance comparison. The inference contains issues, which need to solutions.*

As networking and mobile technologies develop, modern software solves a wide range of tasks.

As a result, software products include components realizing its complicated business logic. Software specifications are constantly changing, importance of new solutions and techniques of new, more effective products design appear.

Methods of qualitative software writing have been known for 30 years already. In spite of considerable achievements, the software field does not use its whole potential for different reasons [2].

The issues of implementation application logic with the approach used in expert systems on the stack of Java virtual machine technologies are analysed in the article.

Java-code writing is the most widespread way of business logic components, i.e. J2EE and J2SE, design. The drawback of the code is its complexity and entanglement, which cause a problem to experienced developers as well. Moreover, any changes of logic, even the simplest ones, require recompilation and unwinding of the application.

Nowadays, there are a few software processors with commercial and open source codes. Commercial processors allow define the regulations in special languages similar to English. In other cases, the regulations are defined by means of scripting languages, such as Groovy or Python [3].

Drools is a rules processor with an open source code, Java written and implementing the rules according to the Rete algorithm. Business-rules application can be characterized in declarative form due to Drools, using a language simple for learning and understanding and not connected with XML. Patterns of Java code can be implemented in file rules, thus Drools becomes more convenient and favourable for use [4, 5].

Among Drools advantage the following can be named.

- Public support;
- Easy utilization;
- High speed of rules obeying;
- Correspondence to API specifications for Java (JavaRuleEngine API – JSR 94);

The main purpose of Drools rules use is processes description and solution making. The example of a discount making and potential clients searching is analysed in two different variant: with and without of Drools rules.

Rules of the discount calculation:

- Payment in cash does not mean the discount;
- Debit card payment means a 5 per cent discount of the total amount paid;
- Credit card payment means a 10 per cent discount of the total amount paid.

These are the rules of potential clients searching:

- Possibility for a potential client to get a loan of 80 per cent of the purchase total cost;
- To send the loan proposal by e-mail if it does not exceed 500 units;
- To call a potential client if the loan exceeds 500 units.

The application is represented as web service to make test process more convenient.

Four rules are used to characterize the implementation of the Drools rules. Each of the rules defines a discount detection and search for a potential client.

Following applications were developed to realize an abovenamed logic:

- Rule for finding loan amount to the debit card owners;
- Rule for finding loan amount to the credit card owners;
- Rule of the e-mail to the client with a loan proposal;
- Rule for a loan proposal call to the client.

The example of using the discount rule is shown in Fig. 1.

```

Package com.my.rules;
import      com.my.domain.Client
rule       "Creditcarddiscount"
when $client : Client(paymentType.equals("CREDIT_CARD"))
then      Float discount = $client.getSpentedSum() * 0.1f;
          $client.setSpentedSum($client.getSpentedSum() - discount);
end
    
```

Fig. 1. Example of drools rule for the client's discount

From example we can see that the rule works only in case of the debit card payment, and a new sum is credited adjusted for a 10 per cent discount.

Behavioral pattern strategy was used in classical realization for discounts and potential clients search. This approach makes the process ultimately flexible. In the Fig.2. we can see the architecture of the classical implementation.

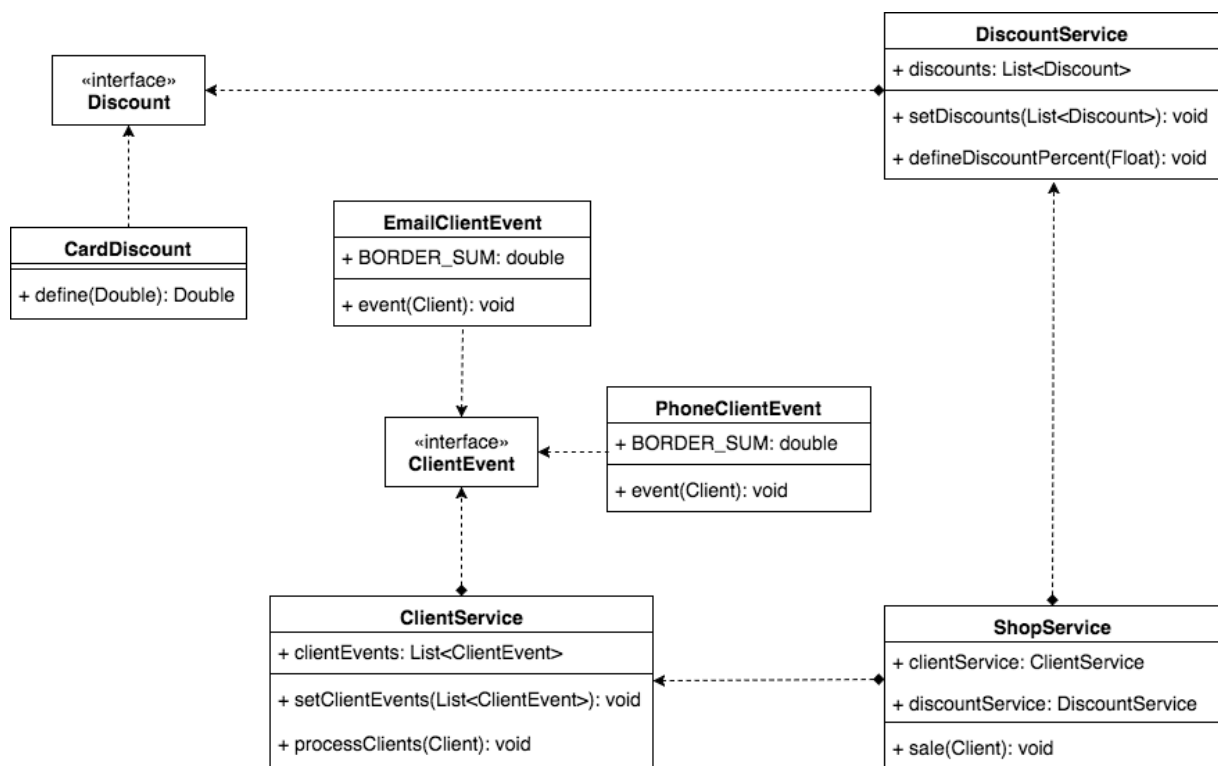


Fig. 2. Class diagram for the application.

The aspects of the program work, in the context of the research, are analyzed further.

Efficiency and SFT are key specification at the stage of its running.

System performance is a key criterion of the running and usually it crucial for the choice of this or that technique [2]. Due to Rete Algorithm Drools rules have a rather effective performance, thus becoming competitive in the market [6].

Rete algorithm provides it with higher efficiency. Using Rete, the expert system draws a special graph or a prefix tree, which nodes are parts of the rules. The way from the root to the leaf makes the whole condition to certain products. Each node contains a list of factors meeting the rule. Adding or changing of a factor causes its running over the net; the nodes, containing corresponding rules, are marked. The rule is met, when rule's conditions are satisfied, and the system reaches the graph leaf [7].

The application imitates a web site. So two web sites, having equal input characteristics and result, but different in the mechanism of a business component operation, are tested. To test application is used Apache JMeter tool [8].

Characteristics tested:

- REQs: 10000.
- Flows referring to the service simultaneously: 100.



The tables below provide the test result.

Aggregated results of tests for the Drools implementation

Total REQs	Average time (ms)	Median (ms)	REQ maximum time (ms)	Errors (%)
10000	31	27	880	0

Aggregated results of tests for the classical implementation

Total REQs	Average time (ms)	Median (ms)	REQ maximum time (ms)	Errors (%)
10000	12	8	885	0

The data above prove a greater effectiveness of Java in implementation, which, consecutively, limits a rules approach in the system, where high efficiency is required. It is important to mention high SFT in both cases.

Thus, the rules approach is suitable in cases not requiring an immediate reply and delays are unimportant. On the other hand, systems, based on the rule processor, are complicated and need an expert for a knowledge base update.

Having analysed the data, the ways for further study can be pointed: alternative approaches to decision making and business logic description, optimization of the actual approach to the rules and the search for algorithms of its automatic training.

#### REFERENCES

1. Аппаратные и программные средства информационных технологий и систем // Информационные технологии в бизнесе / под ред. Милана Желена. – СПб, 2002.
2. Steve McConnell. Professional Software Development // Publisher Addison-Wesley, 2007.
3. Flow-managed persistence in Spring Web Flow 2 [Electronic resource] // IBM developerworks journal, 2010. – Mode of access: <http://www.ibm.com/developerworks>. – Date of access: 31.10.2016.
4. Lucas Amador. Drools Developer's Cookbook // Packt Publishing, 2012.
5. Use Drools and JPA for continuous, real-time data profiling [Electronic resource] // IBM developerworks journal, 2012. – Mode of <http://www.ibm.com/developerworks>. – Date of access: 20.10.2016.
6. World's fastest rules engine [Electronic resource] // Infoworld, 2010. – Mode of access: <http://www.infoworld.com>. – Date of access: 20.10.2016.
7. Robert, B. Doorenbos Production Matching for Large Learning Systems / B. Robert ; Computer Science Department. Carnegie Mellon University. – Pittsburgh, PA, 1995.
8. Sandeep Bhatti, Raj Kumari. Comparative Study of Load Testing Tools / Sandeep Bhatti, Raj Kumari // International Journal of Innovative Research in Computer and Communication Engineering. – 2015.

## SEMANTIC NETWORKS AND FRAMES: KNOWLEDGE REPRESENTATION PROBLEMS. THOUGHTS ON SEMANTIC FRAMES

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*This article describes two major knowledge representation models – semantic nets and frames, points out their flaws, shows the possibilities to combine both formalisms into a more powerful one, providing this notation with necessary extensions, and recommends how to do it using Lisp and UML as fundamental technologies.*

### Foreword

Semantic networks and frames are two formalisms, used to capture information about the world and represent knowledge in forms that allow utilizing computer systems to deal with information from different problem domains and solve complex tasks.

Some sources blindly claim both to be powerful and universal solutions for knowledge representation. This isn't just a bold statement, but a completely false one. Each has its own conceptual flaws and practical limitations, which narrow down a range of their possible applications.

### Semantic networks

*Semantic network* (SN) has a form of directed or undirected graph consisting of *vertices*, which denote entities or conceptions, and *edges*, which specify relations between them. The number of all possible relations is finite – less than 300. Any other type of relationship can be represented as their combination.

Semantic nets are good only for one thing – expressing relations. Period. Any attempt to use them for other purposes immediately draws their apparent disadvantages:

- 1) SN can't describe complex *procedural knowledge*, only very simple – linear – algorithms. In fact, there are much better notations for this task out there – *activity diagrams* and *flow-chart diagrams*;
- 2) SN can express only binary relations, which means a lot of redundancy;
- 3) even when it comes to relations, *entity-relationship diagram* is a much more intuitive and expressive tool (especially for depicting complex structures);
- 4) there is no standard definition of link names;
- 5) it's impossible to describe all aspects of problem domain without using special extensions (like qualifiers);
- 6) loads of vertices with the same name make it hard to search for a specific node.

### Frames

Frames were originally derived from semantic networks and are a part of structure-based knowledge representations. The basic idea behind frames relates to the human psychology: people tend to see real world as a set of composite objects, where each one can be classified as a member of a concrete group (type).

A *frame* is a minimally possible description of some object, event, situation or process – a part of a knowledge base, which can be analyzed independently from other fragments. Frames have solid structure and are composed of standard elements called *slots*. Every slot has a name and contains a value.

While the frame model is a major improvement over semantic networks, it closely based on the concepts from *object-oriented programming* (OOP) paradigm and, therefore, inherits of lot of its problems:

1) There is a huge difference between “real” objects and “knowledge” about them, so any class, which encapsulates the information about some entity, can't be simply modeled after it. Here's an example: suppose we have two real people – a male and a female. To produce a new human both need to have an intercourse and give birth to a baby. However, when we deal (on the “knowledge level”) with two frames, which represent those people (*Male* and *Female* – both subclasses of *HumanBeing*), there is no need to describe any special procedures (like “*make\_ove()*” and “*give\_birth()*”) to make a new frame. Actually, nothing stops the processing system (whether it's a natural mind or artificial intelligence) from involving into the creative cognitive process – imagination – and generating fake knowledge, e.g. creating an instance of human frame without a real counterpart in existence.

2) Incorrect or incomplete information leads to shallow knowledge. Perceptual blindness and other factors (like expectations, emotional state) can have significant impact on the whole perception process and result in frames with empty or ambiguous slots. For example, when a perceiver is being exposed to something for the first time or for a short period, its consciousness creates a frame for this distal stimulus, but this frame may be not fully-constructed, because all properties of the stimulus are not known yet.

3) Uncertainty and difficulties with classification. Let's imagine a man driving a car. It is evident that technically the driver is not a component of the car itself, so he can't be a member of the *Car* frame. At the same

time when we view this system as a physical object that moves in space it can be represented as a single entity: man's and car's masses sum and, along with the speed, define how much kinetic energy this object possesses. In this case both CAN be organized as some virtual composite frame, containing all parts of the system.

4) It's difficult (and sometimes impossible) to make changes in the core hierarchy and hard to handle exceptions.

5) Different pieces of information, combined in a single frame, can't be represented as a sequence of definitions.

6) There is no way to control the inference process. *Attached procedures* is a lousy way.

7) In OOP there are three techniques used to express behavioral aspect of classes (procedural knowledge): *methods*, *messages* and *generic methods*. None of them is universal. They all is just a convenience for programmers and not always correspond to how real objects act. If you decide to have a class for a cup – it will have no methods, because the cup can't do anything on it's own. Also, it won't react to any messages. Yet the cup can be a participant of many activities: you can fill it with coffee, drink from it, throw it into your stupid boss etc. So anything you can do with the cup should be described via generic methods. Now if you consider yourself as a human – you can respond to messages, but it's not possible to define a finite set of instance methods on *Human-Being* class, because everything you're capable of and how you behave was learned during your whole life (like realizing that making your chief angry can get you fired). Besides, as for exceptions again, – objects of the same class can act differently (just like people do).

### The problem

Semantic networks and frames were the most promising and intensively developed models for knowledge representation. Despite their conceptual simplicity, these formalisms have serious weaknesses and can't cover all possible use cases. So, clearly, there is a need for a new form of knowledge representation.

Let's summarize all apparent requirements, which that model must satisfy:

- 1) Support for full declarative and procedural knowledge representation.
- 2) It should be possible to express all kinds of relations, including N-ary (multiple).
- 3) Support for fuzzy logic (there must be a way to assign "certainty" level to attributes and relations).
- 4) Multiple inheritance.
- 5) Prototypes and incomplete types (objects can be constructed even if full class specification isn't known yet).
- 6) It should be possible to specify value ranges and restrictions for slots.
- 7) The notation must be serializable and, if possible, have a graphical form.

### Semantic frames

When it comes down to practical realization there is almost no difference between semantic nets and frames, because both are usually implemented using the same technique – via hash tables or associative arrays. From this perspective relations and slots are just annotated references (pointers) to other nodes (entities or frames). So, following this logic we can conclude that it's possible to merge both formalisms into one – *semantic frames*, combining their advantages and overcoming limitations by using needed extensions.

There's no need to design the semantic frame model from ground up. In fact, it would be much more easier and cleverer to adapt some already existing technology. The most obvious way is to utilize the power of S-expressions and use one of Lisp dialects to implement a classifier and an inference engine.

From this perspective there can be several approaches to do frames in Lisp programming language:

- 1) Build frames entirely on top of CLOS (Common Lisp Object System) using macros if necessary.
- 2) Build frames using associative arrays:

```
frame = '(, frame name, frame type, slots, ');
frame name = identifier;
frame type = identifier | reference;
identifier = symbol | string | keyword;
slots = '(, { slot }, ');
slot = '(, { pair }, ');
pair = '(, attribute name, '.', attribute data, ');
attribute name = 'name' | 'range' | 'default-value' | 'allowed-types' | ... .
```

- 3) Combined solution: use associative lists for basic frame structure and specialized objects for holding values (references) and specifying their attributes:

```
frame = '(, frame name, frame type, slots, ');
frame name = identifier;
frame type = identifier | reference;
```

## ITC, Electronics, Programming

```
identifier = symbol | string | keyword;  
slots = '(', { slot }, ')';  
slot = '(', slot name, ',', slot data, ')';  
slot name = identifier;  
slot data = Value class instance | Range class instance | ... .
```

As for graphical notation – it is best to use class diagrams from UML, extending them with additional sections for events and messages.

**Conclusion**

The progress in AI department heavily relies on achievements from cognitive psychology, which studies mental processes such as attention, language use, memory, perception, problem solving, creativity, and thinking, as well as other fields of science (like quantum physics) and philosophy.

Knowledge is the fundamental and the most important component in AI systems; it has specific characteristics that clearly distinguish it from pure information. There are many knowledge representation models, each has its own advantages and disadvantages, so none of them fully satisfies a well-established set of requirements of AI community.

## REFERENCES

1. Башмаков, А.И. Интеллектуальные информационные технологии / А.И. Башмаков, И.А. Башмаков. – М. : Изд-во МГТУ им. Н.Э. Баумана, 2005. – 304 с.
2. Макаренко, С.И. Интеллектуальные информационные системы / С.И. Макаренко. – Стврополь : СФ ММГУ им. М.А. Шолохова, 2009. – 207 с.
3. Information [Electronic resource] / Wikipedia – The Free Encyclopedia. – Mode of access: <https://en.wikipedia.org/wiki/Information>. – Date of access: 20.11.2016.
4. Perception [Electronic resource] / Wikipedia – The Free Encyclopedia. – Mode of access: <https://en.wikipedia.org/wiki/Perception>. – Date of access: 21.11.2016.
5. Knowledge [Electronic resource] / Wikipedia – The Free Encyclopedia. – Mode of access: <https://en.wikipedia.org/wiki/Knowledge>. – Date of access: 24.11.2016.
6. Knowledge representation and reasoning [Electronic resource] / Wikipedia – The Free Encyclopedia. – Mode of access: [https://en.wikipedia.org/wiki/Knowledge\\_representation\\_and\\_reasoning](https://en.wikipedia.org/wiki/Knowledge_representation_and_reasoning). – Date of access: 25.11.2016.
7. Semantic network [Electronic resource] / Wikipedia – The Free Encyclopedia. – Mode of access: [https://en.wikipedia.org/wiki/Semantic\\_network](https://en.wikipedia.org/wiki/Semantic_network). – Date of access: 27.11.2016.
8. Frame (artificial intelligence) [Electronic resource] / Wikipedia – The Free Encyclopedia. – Mode of access: [https://en.wikipedia.org/wiki/Frame\\_\(artificial\\_intelligence\)](https://en.wikipedia.org/wiki/Frame_(artificial_intelligence)). – Date of access: 28.11.2016.

UDC 004.415.2.031.43

**APPROACH TO THE DESIGN PATTERNS OF MULTICOMPONENT SYSTEM  
FOR DETECTING NETWORK ATTACKS****PAVEL ZHURAUKOU, EUGENIY SUKCHAREV**  
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*The article touches upon the concepts of design services for collection and processing of network packets received by corporate systems, along with the principles of modern web applications development.*

**Introduction.** Due to the fact that new network technologies penetrate into various spheres of human activities the questions regarding protection of computer networks from outside interference are becoming more relevant nowadays. The leading world IT-companies are developing various solutions for protection of cloud-based computing. The relevance of such investigations comes from two factors: firstly the modern features to connect computing resources to the Internet networks and secondly cloud services users, who pose a real threat to security. In this article two components of Intrusion Detection System will be considered, such as agent that collects and processes network packets (that is a Windows Service) that works on corporate system nodes and web application client.

**Agents for collecting and processing network packets.** The main purpose of the agent is to collect and analyze the quantity, type, IP address, from which the packet was sent, as well as the size of the received and transmitted packets to the host. The developed component should be implemented as a Windows Service, that is automatically started after loading the operating system.

The fundamental task of the developed service is 24/7 uninterrupted operation of the main components responsible for data collection and analysis. Otherwise, the system will stop to analyze the data, which may result in serious losses for the company, containing the attacked site. According to the statistics from Kaspersky Lab covering 2015 year, loss of the companies affected by network attacks based on unlimited amounts of targeted system resources amounts to approximately \$400 thousand. On average, 61% of victims temporarily lost access to very important information, 38% were unable to perform usual actions, and 33% of companies reported about transactions and contracts losses. Due to these facts, analysis and monitoring of systems is required to be available at any time.

To achieve this goal it is necessary to consider and implement the mechanism that checks whether the agent is working all the time. Based on one of the items in the settings, the service should send a similar to ping query to the database, thereby informing that the DB is functioning correctly [2].

It is necessary to develop the infrastructure that would allow to continue the work of a subsystem even after an error in it. It is necessary to take a Task based approach when a separate Task is created for a particular event in the operating system as a basis for such a system. Tasks in the operating system allow to abstract from the current sequential execution of the program. A unit of work is being executed in a separate thread that allows to move away from the main context of the program. The main advantage of this solution in this situation is that if there is a runtime thread error, it will not affect the operation of the rest of the system. The system will continue working as if nothing has happened.

In the situation when any subsystem service has failed (an error occurred in the program), the same subsystem must correctly handle the error that occurred and continue to work correctly. One of the design patterns of programming with threads is the realization of the so-called task managers that are responsible for creation, running and error handling in these tasks. Task manager takes over the whole process of creating a task automatically wrapping the unit of work in the thread. This implementation can significantly reduce the amount of code, as well as to improve its readability. After the thread is created, it has to be run in a separate thread. The manager automatically launches the task after it is created. Finally, if the runtime thread error occurs, manager handles this error to prevent the crash of the entire system [4].

One of the aims for designing an agent is the ability to configure the service remotely. This functionality must be implemented as a part of the client web application. Moreover there is one more requirement. That is imperceptible change of the current settings of the agent while it is running. The service should automatically load the required settings from the database and apply them without breaking or stopping its work. This functionality must be implemented using cache mechanism that has to check the current settings over some period of time. The main criterion for choosing this approach is to reduce the load on the database.

As far as the requirements are concerned, the main task of the agent is to collect data for later analysis. The unit of data transmitted over the network is a packet network i.e. a block of data which is formed in a certain way. The main task of the attacker who wants to disrupt any node in the system is a multiple increase in the transmitted packet node, so the node is not able to cope with the large amount of information. As a result, legal

users cannot partially or fully use the corporate system. Collecting information about the number of packets, as well as their content is the paramount task.

Capturing of packets must be implemented on the network card driver level, which uses the NDIS packet to read what the network card receives. There is the Pcap library that has all the low-level logic to work with these drivers implemented. It allows programmers to avoid the work directly with the driver. The mentioned above library is written in the C programming language. It is not always convenient when working with higher-level languages, such as Java and C#. Therefore it is good to use the wrapper Pcap on the SharpPcap language. SharpPcap implements all the functionality of the Pcap library, complementing it with the specific to the C# language features namely an event processing model of incoming packets. It is also needed to consider the size and type of packages while developing. Low-level library Pcap implements the processing of the following packet types: ARP, IPv4, IPv6, ICMP, ICMPv6, IGMP, UDP, TCP. All of the mentioned packages types should collected and counted by the developed system. For this purpose, a separate thread (task) performs quantification of each packet, as well as its size and the type in real time [4].

Filter subsystem should filter all the packages types. At the design stage, the concept of reuse of filters should be considered. The so-called reusable filters that can be applied to different devices in different network nodes in the enterprise system will allow to control the process of filter setting process. On the basis of the cache mechanism of additional upload settings agent, it is needed to implement cached upload of filters from the database to the network devices on the node where the agent is running.

**Web Application.** The main purpose of the client Web part is the ability to configure the agents as well as display information on their current load. Setting agents includes displaying information about the work at the sites of agents, output of agent errors allowing information security professionals to monitor the correctness of the agents, output of operations of different filter units. Besides, web application must show the real time data collected by the collection and processing agents, as well as to build a clear schedule.

Web application should be developed using the MVC pattern. MVC is a design pattern where application model, user interface and interaction with the user are divided into three separate components so that the change of one of the components brings about a minimal effect on the work of the other. The controller captures the event from the outside and in accordance with the logic it responds to this event with changing the model by calling the appropriate action. After that the model uses the event that it has changed, and when all the relevant to this event updates become available, they turn to the model and update the data that is displayed after that. Thus, adhering to this approach throughout the software development cycle makes the code scalable and easy to read. The scheme of the MVC approach is shown in Figure 1.

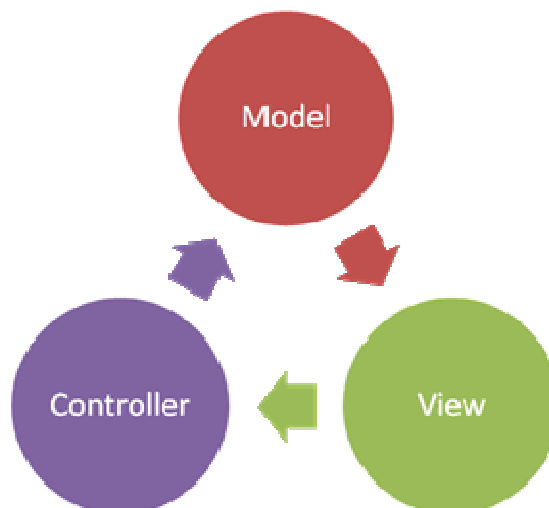


Fig. 1. The scheme of the MVC design pattern

Let's consider the implementation of the user interface. The total summary statistics for all the nodes should be displayed on the main page. The diagrams with load nodes, packet types percentage, the number of packets on all nodes and the traffic amount should be displayed on the page for clearer perception. The model of the described page is displayed in Figure 2.

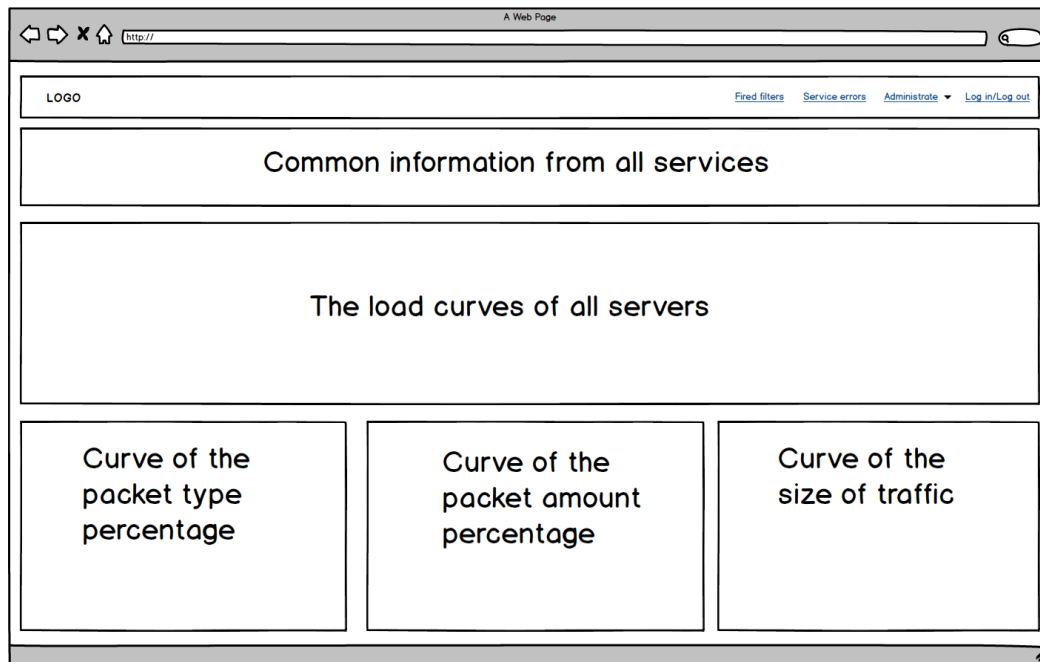


Fig. 2. The mock of the Web application home page

#### REFERENCES

1. Система обнаружения вторжений – Викиучебник [Электронный ресурс] / Wikimedia Foundation Inc.. – 2017. – Режим доступа: [https://ru.wikibooks.org/wiki/Система\\_обнаружения\\_вторжений](https://ru.wikibooks.org/wiki/Система_обнаружения_вторжений). – Дата доступа: 23.01.2017.
2. ping – Викиучебник [Электронный ресурс] / Wikimedia Foundation Inc. – 2017. – Режим доступа: <https://ru.wikibooks.org/wiki/Ping>. – Дата доступа: 20.01.2017.
3. Обработка исключений (библиотека параллельных задач) – MSDN – сеть разработчиков Microsoft [Электронный ресурс]. – 2017. – Режим доступа: [https://msdn.microsoft.com/ru-ru/library/dd321409\(v=vs.110\).aspx](https://msdn.microsoft.com/ru-ru/library/dd321409(v=vs.110).aspx). – Дата доступа: 21.01.2017.
4. Рсар – Викиучебник / Wikimedia Foundation Inc. [Электронный ресурс]. – 2017. – Режим доступа: <https://ru.wikibooks.org/wiki/Рсар> – Дата доступа: 21.01.2017.
5. Model-View-Controller – Викиучебник / Wikimedia Foundation Inc. [Электронный ресурс]. – 2017. – Режим доступа: <https://ru.wikibooks.org/wiki/Model-View-Controller>. – Дата доступа: 21.01.2017.

## PRESENTATION OF REMOTE EARTH SENSING BY MEANS OF MATLAB IN COSAR FORMAT

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*Formats of the initial level data processing are considered. Radar image storage COSAR format and complete structure of its file are described. Examples of reading the COSAR file in MATLAB and ENVI software are given. The structure of the final product of the radar picture is considered. Features of presenting metadata obtained from radar images are shown. The article presents a flowchart of radiolocation image (RLI) conversion into COSAR radar data presentation format.*

The most important tasks in the development and pre-commissioning of remote sensing data processing systems are to increase performance of software systems, to automate the pre-treatment process and to select results presentation format.

RS data processing is divided into preliminary and thematic [1].

– Pre-treatment - is a complex operation with images aimed at removing various RLI distortions. The distortions are due to the influence of adverse factors such as: the effect of the atmosphere; interference in the communication channels; geometric distortion methods of space imagery; analog-to-digital conversion of images. Pre-processing includes radiometric calibration, geo referencing, geometric correction of images and others.

– Topical treatment - a complex of operations with images, which allows to extract information needed to solve different thematic problems.

Most of the satellite systems transmit a stream of untreated "raw" data, which are recorded by ground receiving centre. The transmitted signal is a bit sequence containing both an earth shoot results and the service information about the motion of the spacecraft and the orientation of its modes of imaging equipment, and time markers al. (Metadata) [1]. The received signal goes through several stages of pretreatment (demodulation, synchronization, decoding, and others), decompressing the received data stream, extracting images and associated service information, part of which is performed at the hardware level, with the help of the reception complex software. Processing results are presented in a variety of storage formats of the output product. The output product usually has the home directory, and a specific structure of subdirectories and files in which the data of the RLI supporting metadata are stored and.

The four formats that streamline data radar image (RLI) are usually used to provide a rough "raw" data corresponding to the processing level 0:

- Band Sequential, BSQ;
- Band Interleaved by Line, BIL;
- Interleaved by Pixel, BIP;
- The sequence of the zones compressed data to a file group coding method (for example, in jpg format).

In order to correctly reproduce the image of the data file formats it is necessary to know the structure, i.e., recording format and the number of lines and columns. The image files are usually provided with additional information related to the images: the description of the data file (the format, the number of rows and columns, resolution, etc.), statistics (distribution characteristics of brightness – minimum, maximum and mean, variance) and data on the map projection. Additional information can be found either in the header of the image file or in a separate text file with the same name as the image file name [2].

Remote sensing data processing, as a rule, is always carried out in a digital format, where the RLI is represented as a two-dimensional image. Data obtained in the same spectral region, i.e. using a radiolocating (RL) signal may be represented as a two-dimensional matrix of numbers  $A(i, j)$ , each of which represents the intensity of the radiation received by the sensor element of the Earth surface, which corresponds to one pixel of the image. The image consists of  $n \times m$  pixels, each pixel has coordinates  $(i, j)$  - line number and column number. The number placed in a matrix cell  $A(i, j)$  is an integer and is called the spectral brightness or gray level. If an image is obtained by multiple radio signals (several spectral bands) it is a three-dimensional table consisting of the numbers  $A(i, j, k)$ , where  $k$  - spectral channel [2].

One of the most flexible formats for the presentation of basic data and metadata of a radiolocating image is COSAR format. COSAR file contains a complex form of satellite data received from SAR, which are grouped for package transmission and store information about the received reflected radio signal. The file can be in multiple packages, depending on the mode of satellite photography. If the SAR system uses multiple radio signals for each channel of the polarization, the information for each reflected signal is recorded in a separate file.



Formed package keeps the additional data and RLI data. These RLI may be suitable or unsuitable for further processing. Information on suitable and unsuitable data is stored as auxiliary data. Both auxiliary data and RLI data are stored in a rectangular matrix, and arranged so that it is sufficient simply to visualize the RLI itself. Figure 1 shows the arrangement of several data packets in the file.

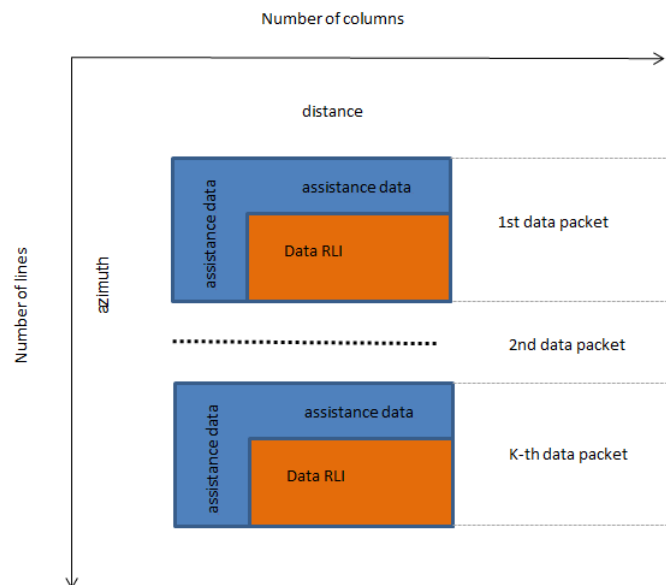


Fig. 1. Location of data packets in COSAR file

Since the data are arranged in a rectangular array, each column contains information about the range of the azimuth data, the division into cells occurs every 32 bits.

Auxiliary data are arranged in the first three rows of the range and at the beginning of each subsequent line. Auxiliary data of the first three lines are repeated in each formed package and contain information about the broadcast and general information about the generated file.

The following parameters are recorded in the first line of each packet: the number of bytes in current transfer; distance index, which reflects the relative location of the virtual raster of a first sample relative to the reference value range; the number of lines that store values in range; azimuthal number of columns; numbers radio code; total number of bytes in the line in the range direction; the total size of azimuth lines; sampling frequency of the first selection relative to the current selection range; COSAR file identifier and generated file version, two 32-bit numbers that define the file format; real variables of floating point (the order MSB) value is scaling back the speed of  $1 / K$  used in data processing; other remaining 32-bit numbers to the end of each packet line are reserved for auxiliary data and internal use, which may contain additional modes of forming dependent information useful for interferometric processing of complex data.

The data format in a COSAR file is 32-bit numbers. These radar images are written in complex form: 16 bits for the imaginary part and 16 bits on the actual part. Byte order is reverse (the most significant byte (MSB) is the first). All auxiliary data is stored in a 32 bit integer. Cell named COSAR identifier is a 32-bit integer with a constant value in hexadecimal notation being 7F7F7F7F, and in the decimal notation the number is 1129529682. Information is read line by line, 32 bits per symbol. Line size is determined by  $RS + 2$  or RTNB parameter [3].

Considering the structure and radar data presentation format in standard COSAR file, data representation MatLab algorithm in COSAR format was synthesized and implemented in the software, which is represented in block diagrams in Figure 4 and includes the following main steps: import of focused RLI with geometric correction; formation of the main auxiliary data based on imported RLI: raster size, COSAR ID file and its version. range index, number range of lines, the number of azimuth columns; number code of radio transmission; total number of bytes per line in the direction of range, the total size of azimuth lines, sampling frequency of the first selection relative to the current selection range; output in the first line of the file of the principal subsidiary, conversion of RLI, i.e. permutation of pixels for better adhesion to the 32-bit number of two 16-bit; the formation of auxiliary data skew, no warping in the default; conversion of all raster radar data into one-dimensional matrix, and in the resulting array of neighbouring glued two in one 32-bit number; the output of the auxiliary data and skew data in the RLI COSAR file.

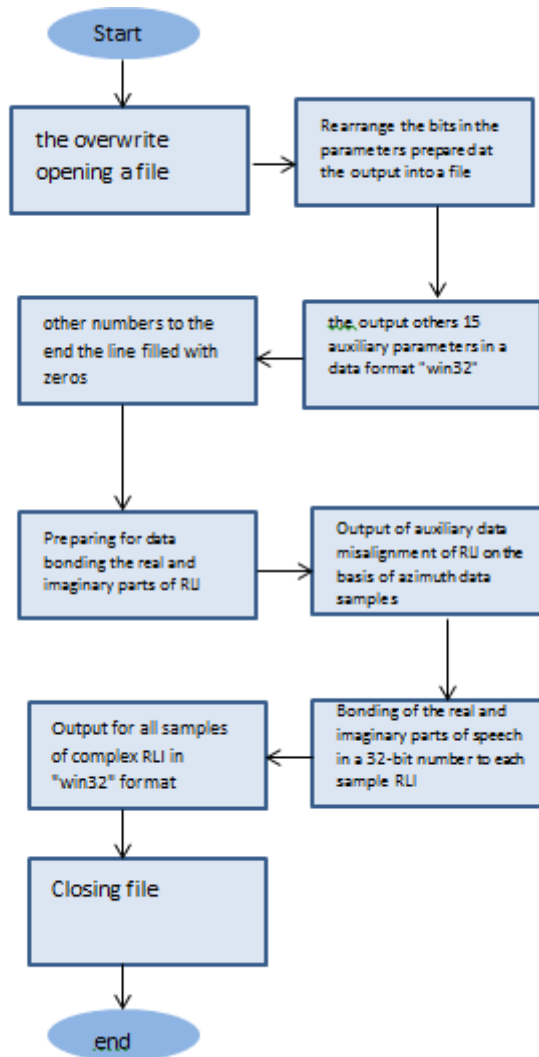


Fig. 2. A block diagram of a COSAR file formation algorithm

Figure 3 shows an example of the transformed algorithm developed by RLI in COSAR format.

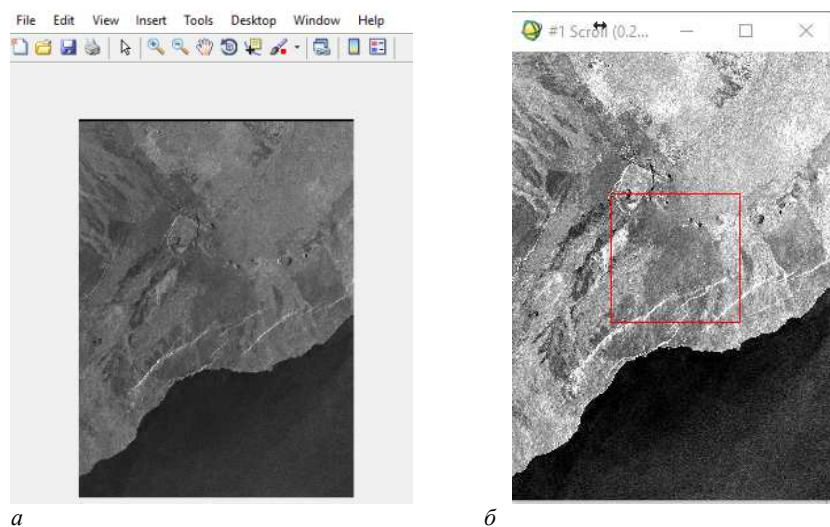


Fig. 3. Example of radar data format conversion:  
*a* – a focused image of the satellite ERS-1 converted to COSAR format;  
*b* – Open RLI COSAR synthetic format in ENVI

**Conclusion.** The algorithm is implemented in the Matlab software, it allows converting data into radio-location images of COSAR format. This significantly simplifies further processing of radar data for presentation in a form which corresponds to a standardized level data.

#### REFERENCES

1. Федоткин, Д.И. Технологии предварительной обработки данных ДЗЗ: опыт ИТЦ «СканЭкс» в создании программного обеспечения и организации обработки данных в составе приемных комплексов [Электронный ресурс] / Д.И. Федоткин // Пространственные данные. – № 1. – 2006. – Режим доступа: <http://www.gisa.ru/35154.html>. – Дата доступа: 10.09.2016.
2. Дистанционное зондирование Земли (ДЗЗ) [Электронный ресурс] // Журнал "Все о Космосе". – Режим доступа: <http://aboutsacejournal.net/космические-аппараты/искусственный-спутник-земли/дистанционное-зондирование-земли/>. – Дата доступа: 14.09.2016.
3. Беленов, А.В. Стандартные уровни обработки и форматы представления данных ДЗЗ из космоса. Мировой опыт / А.В. Беленов // Геоматика. – № 4. – 2009. – С. 18–20.

**SUFFICIENT CONDITIONS FOR THE SOLVABILITY OF THE PROBLEM OF SYNTHESIS  
OF NON-RESONANT SYSTEMS WITH LOCALLY INTEGRABLE COEFFICIENTS**

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*In this paper it is proved that the problem of synthesis of non-resonant linear non-stationary control system with locally integrable and integrally bounded coefficients and disturbance is solved if the upper general exponent of Bohl of the system (7) is globally controllable, i.e if this linear system has the property of uniform global quasi-attainability or the property of uniform full controllability.*

Consider the non-stationary control system with disturbance

$$\dot{x} = A(t)x + B(t)u + w(t), \quad x \in \mathbb{R}^n, \quad u \in \mathbb{R}^m, \quad w \in \mathbb{R}^n, \quad t \geq 0, \quad (1)$$

and locally integrable and integrally bounded [1, p. 252] matrix coefficients  $A$  and  $B$ . In this system  $u = u(t)$  is measurable and bounded control,  $w = w(t)$  is measurable and bounded vector-function with external disturbance.

For all  $t \geq 0$  denote

$$f(t) = B(t)u(t) + w(t).$$

Then the system (1) can be written as

$$\dot{x} = A(t)x + f(t), \quad x \in \mathbb{R}^n, \quad f \in \mathbb{R}^n, \quad t \geq 0. \quad (2)$$

**Definition 1** [2] Equation (2) is called a resonance, if there is an initial condition  $x(t_0) = x_0$  and bounded at  $t \geq t_0$  the function  $f(t)$ , that the solution of  $x(t)$  generated non-boundary on the half-line  $t \geq t_0$ ; equation is not a resonant or non-resonant called sustained in the sense of bounded input - bounded output.

It is known [2, p.295], that a necessary and sufficient condition for the stability of the equation (2) in the sense of bounded input - bounded output is the exponential stability of the system

$$\dot{x} = A(t)x, \quad x \in \mathbb{R}^n, \quad t \geq 0, \quad (3)$$

i.e. on valid

**Theorem 1** [2, p. 295] Equation (1) non-resonance then and only then, when the system (3) is exponentially stability.

**Definition 1** it follows that the resonant case there are initial conditions that the solutions generated by them are unbounded with bounded control actions. Therefore, the resonance system difficult to implement, resulting in the construction of control systems is usually primarily the problem of ensure non-resonance.

For the system (1) we take as a control  $u$  vector function

$$u(t) = U(t)x + v(t), \quad (4)$$

where  $U$  and  $v$  – some measurable ( $m \times n$ ) - matrix and ( $m \times 1$ ) - vector respectively.

Than system (1) can be written as

$$\dot{x} = (A(t)x + B(t)U(t))x + B(t)v + w(t), \quad x \in \mathbb{R}^n, \quad v \in \mathbb{R}^m, \quad w \in \mathbb{R}^n, \quad t \geq 0, \quad (5)$$

**Definition 2** [2, p. 293] The problem of finding a measurable and bounded ( $m \times n$ ) -matrix of function  $U(t)$ ,  $t \geq 0$ , at which the closed-loop system (5) with a control (4) is non-resonant (has only bounded solutions with measurable and bounded input actions in  $v(t)$  and external disturbances  $w(t)$ ) is the problem of synthesis of non-resonant system.

**Theorem 1** implies that this problem is solvable if there exists a measurable bounded control

$$U = U(t), \quad t \geq 0, \tag{6}$$

what system

$$\dot{x} = (A(t)x + B(t)U(t))x, \quad x \in \mathbb{R}^n, \quad t \geq 0, \tag{7}$$

is exponentially stability.

It is well known (see e.g. [3, p.61]), that for the exponential stability of linear non-stationary system (3) (and, therefore, (5)) corresponds to the upper special (general exponent)

$$\Omega^0(A) = \lim_{T \rightarrow +\infty} \frac{1}{T} \sup_{k \in \mathbb{N}} \ln \| X((k+1)T, kT) \|$$

(Here  $X(t, s)$ ,  $t, s \geq 0$ , is Cauchy matrix of system (3), and  $\|\cdot\|$  are in brackets to demonstrate how its operator matrix (spectral) norm), pioneered by P. Bohl [4], and, much later, but independently of it, K.P. Persidsky [5]. This exponent provides for Cauchy matrix of system (3) uniform bound

$$\| X(t, s) \| \leq D_\varepsilon \exp((\Omega^0(A) + \varepsilon)(t - s)),$$

where  $D_\varepsilon > 0$  constant depending on the  $\varepsilon$ , and therefore negativity means that there is a uniform asymptotic (exponent) stability [3, p. 61].

Upper general exponent Bohl  $\Omega^0(A)$  (also, e.g., as well as the characteristic exponents of Lyapunov  $\lambda_i = \lambda_i(A) \in \mathbb{R}$ ,  $i = \overline{1, n}$ , irregularities coefficients of Lyapunov, Grobman, Perron, correctness properties and reducibility of systems [3, p.46-80] and others) they represent many of the asymptotic invariants of linear differential systems (3), i.e. variables or properties that are saved under Lyapunov's transformations.

**Definition 3** [3, p. 57] *Transformation of Lyapunov of the system (3)* is called a linear transformation  $y = L(t)x$ , square  $(n \times n)$ -matrix is a matrix  $L(t)$  whose for every  $t \geq 0$  is reversible, piecewise continuously differentiable and thus satisfies the condition:

$$\sup_{t \geq 0} \| L(t) \| + \sup_{t \geq 0} \| L^{-1}(t) \| + \sup_{t \geq 0} \|\dot{L}(t)\| < +\infty.$$

**Definition 4** [3, p. 182-183] *The problem of global control of asymptotic invariant  $i(A+BU)$  of the system (7)* is to find such a measurable and bounded control (6), that the system (7) with the this control will have a pre-assigned value of this invariant. For example, considering this problem as an asymptotic invariant  $i(A+BU)$  the upper general exponent of Bohl  $\Omega^0(A+BU)$  system (7), we obtain a problem of global control of the upper general exponent of Bohl.

In the case of a positive decision of the latter problem, we have an opportunity with the help of some measurable and bounded control action (6) provides a negative exponent  $\Omega^0(A+BU)$  of the system (7) (moreover, can choose this exponent value itself), and, thus, the exponential stability of the system (7), which means that non-resonantly of the equation (5). Therefore, there is a sufficient condition for the solvability of the problem of synthesis of non-resonant system:

**Theorem 2** *If the upper general exponent of Bohl of the system (7) is globally controllable, then the problem of synthesis of non-resonant system (5) is solvable.*

Consider linear control system (1) without the presence of disturbance ( $w(t) \equiv 0$ ,  $t \geq 0$ )

$$\dot{x} = A(t)x + B(t)u, \quad x \in \mathbb{R}^n, \quad u \in \mathbb{R}^m, \quad t \geq 0. \tag{8}$$

**Definition 5** [6,7] *The system (8) is uniformly full controllable* if there are numbers  $\sigma > 0$  and  $\gamma > 0$ , that for any  $t_0 \geq 0$  and  $x_0 \in \mathbb{R}^n$  there is a measurable and bounded control  $u: [t_0, t_0 + \sigma] \rightarrow \mathbb{R}^m$ , for all  $t \in [t_0, t_0 + \sigma]$ , satisfying the inequality  $\|u(t)\| \leq \gamma \|x_0\|$  and carrying the vector of the initial position  $x(t_0) = x_0$  (8) to zero on this segment.

Initially V. A. Zaytsev systems (8) with piecewise continuous and bounded matrix coefficients  $A$  and  $B$  and piecewise continuous [8] and the bounded control (6) has been established following

**Theorem 3 [8]** *If the system (8) with piecewise continuous and bounded coefficients is uniformly full controllable, then the upper general exponent of Bohl of the system (7) is globally controllable.*

On the basis of this theorem, and **Theorem 2** we obtain

**Corollary 1** *If the system (8) with piecewise continuous and bounded coefficients is uniformly full controllable, then the problem of synthesis of non-resonant system (5) is solvable.*

For the same systems (8) with a locally integrable and integrally bounded coefficients, which are discussed in this article, A. A. Kozlov and I.V. Ints in [9] has been proved for the following two-dimensional case

**Theorem 4 [9]** *Let  $n = 2$ . If the system (8) is uniformly full controllable, then the upper general exponent of Bohl of the system (7) is globally controllable.*

From it follows from **Theorem 2**, as above, directly follows

**Corollary 2** *Let  $n = 2$ . If the system (8) with locally integrable and integrally bounded is uniformly full controllable, then the problem of synthesis of non-resonant system (5) is solvable.*

In the case of an arbitrary phase space dimension  $n > 2$ , for the systems (8) with a locally integrable and integrally bounded coefficients global controllability of the upper general exponent of Bohl succeeded in establishing [9] with a stronger than uniform full controllability, condition - the evenly global quasi-attainability of the system (7).

**Definition 6 [9].** *The system (7) has the property of uniform global quasi-attainability if for some  $T > 0$  whenever  $t_0 \geq 0$  and any  $r > 0$  and  $0 < \rho \leq 1$  there orthogonal  $(n \times n)$ -matrix  $F = F([t_0, t_0 + T]; r, \rho)$  and is independent of the  $t_0$  value of  $\theta = \theta(r, \rho) > 0$ , such that for any upper triangle  $(n \times n)$ -Matrix  $H$  with positive diagonal elements, satisfying the inequalities  $\|H - E\| \leq r$  and  $\det H \geq \rho$ , there is a measurable and bounded on the interval  $[t_0, t_0 + T]$  control  $U = U(t)$ , satisfying for all  $t \in [t_0, t_0 + T]$  assessment  $\|U(t)\| \leq \theta$  and guarantees for the Cauty  $X_U(t, s)$  matrix system (7) the equality  $X_U(t_0 + T, t_0) = X(t_0 + T, t_0)FHF^{-1}$ .*

There is a

**Theorem 5 [9].** *If the system (8) is uniformly globally quasi-attainable, then the upper general exponent of Bohl of the system (7) is globally controllable.*

Then, by **Theorem 2** and the last statement is executed

**Corollary 3.** *If the system (8) is uniformly globally quasi-attainable, the problem of synthesis of non-resonant system (5) is solvable.*

**Acknowledges.** This report has been performed with the financial support of State Program of Science Research («Convergence-2020», project 1.2.01).

## REFERENCES

1. Былов, Б.Ф. Теория показателей Ляпунова и её приложения к вопросам устойчивости / Б.Ф. Былов, Р.Э. Виноград, Д.М. Гробман. — М., 1966. — 576 с.
2. Гайшун, И.В. Введение в теорию линейных нестационарных систем / И.В. Гайшун. — Минск, 1999. — 409 с.
3. Макаров, Е.К. Управляемость асимптотических инвариантов нестационарных линейных систем / Е.К. Макаров, С.Н. Попова. — Минск : Беларус. навука, 2012. — 408 с.
4. Bohl, P. Über Differentialgleichungen / P. Bohl // J. reine und angew. Math. — 1913. — Bd.144. — S. 284–318.
5. Персидский, К.П. Об устойчивости движения по первому приближению / К.П. Персидский // Матем. сборник. — 1933. — Т. 40, № 3. — С. 284–292.
6. Тонков, Е.Л. Критерий равномерной управляемости и стабилизация линейной рекуррентной системы / Е.Л. Тонков // Дифференц. уравнения. — 1979. — Т.15, № 10. — С. 1804–1813.
7. Kalman, R.E. Contribution to the theory of optimal control / R.E. Kalman // Boletin de la Sociedad Matematica Mexicana. — 1960. — Vol.5, № 1. — P. 102–119.
8. Зайцев, В.А. Об управлении показателями Ляпунова и о  $\lambda$ -приводимости / В.А. Зайцев // Вестник Удмуртского ун-та. — 2000. — № 1. — С. 35–44.
9. Kozlov, A. A. On the global Lyapunov reducibility of two-dimensional linear systems with locally integrable coefficients / A.A Kozlov, I.V. Ints // Differential Equation. — V. 52. — 2016. — №. 6. — P. 699–721.

UDC [517.977+517.926]

**ON THE STABILIZABILITY OF TWO-DIMENSIONAL LINEAR SYSTEMS  
WITH LOCALLY INTEGRABLE COEFFICIENTS AND OBSERVER**

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*The system of the asymptotic measure of condition for the two-dimensional linear non-stationary control system and observer has been constructed in the assumption of Lebesgue locally integrability and integrally boundedness of its coefficients on a positive semi-axis, sufficient conditions of the uniform stabilizability of the asymptotic identifier and with it of the two-dimensional linear system with locally integrable and integrally bounded coefficients and observer has been obtained in this report.*

Let  $\mathbb{R}^n$  – a vector Euclidean space of dimension  $n$  with norm  $\|x\| = \sqrt{x^T x}$  for each  $x \in \mathbb{R}^n$  (the symbol  $^T$  means the operation of transposition);  $M_m$  – a space of real  $(m \times n)$ -matrix with the spectral operator norm

$$\|A\| = \max_{\|x\| \leq 1} \frac{\|Ax\|}{\|x\|},$$

i.e. with norm induced by the Euclidean norm in the spaces  $\mathbb{R}^m$  and  $\mathbb{R}^n$ ;  $M_n := M_m$ .

Let us consider a linear non-stationary control system

$$\dot{x} = A(t)x + B(t)u, \quad x \in \mathbb{R}^n, \quad u \in \mathbb{R}^m, \quad t \geq 0, \quad (1)$$

with observer

$$y = C^T(t)x, \quad y \in \mathbb{R}^n. \quad (2)$$

We will assume that matrix functions  $A(\cdot)$ ,  $B(\cdot)$  и  $C(\cdot)$  belong to the class of Lebesgue locally integrable and integrally bounded coefficients [1, c. 252] matrix function, i.e. such that inequalities

$$\sup_{t \geq 0} \int_t^{t+1} \|A(\tau)\| d\tau < a < \infty, \quad \sup_{t \geq 0} \int_t^{t+1} \|B(\tau)\| d\tau < b < \infty,$$

$$\sup_{t \geq 0} \int_t^{t+1} \|C(\tau)\| d\tau < c < \infty$$

are true. Also we will assume that system (1) has the property of uniform full controllability.

**Definition 1** [2]. *The system (1) is called uniformly fully controllable if numbers  $\sigma > 0$  and  $\gamma > 0$  exist such that for each  $t_0 \geq 0$  and  $x_0 \in \mathbb{R}^n$  measure and bounded control  $u: [t_0, t_0 + \sigma] \rightarrow \mathbb{R}^m$  exist for every  $t \in [t_0, t_0 + \sigma]$  such that satisfies the inequality  $\|u(t)\| \leq \gamma \|x_0\|$  and transfer the vector of the initial condition  $x(t_0) = x_0$  of the system (1) to the null on this time segment.*

Also let us consider the system (1), (2) with null-control, i.e system

$$\dot{x} = A(t)x, \quad y = C^T(t)x, \quad x \in \mathbb{R}^n, \quad y \in \mathbb{R}^k, \quad t \geq 0, \quad (3)$$

that has the property of uniform full observability.

**Definition 2** [3, p.304]. *The system (3) is called uniformly fully observable if number  $\sigma > 0$  exist such that for each  $t_0 \geq 0$  every vector of the initial condition  $x(t_0) = x_0 \in \mathbb{R}^n$  can be defined by observer by the only way on time segment  $t \in [t_0, t_0 + \sigma]$ .*

Let us construct a new system using the system (1), (2) and  $y$  (output of this system)

$$\dot{\hat{x}} = A(t)\hat{x} + V(t)(y(t) - C^T(t)\hat{x}) + B(t)u, \quad \hat{x} \in \mathbb{R}^n, \quad (4)$$

where  $\hat{x}(t)$  - measure of condition of the system (1), (2). System (4) is called the system of asymptotic measure of condition (asymptotic identifier). Let us take control  $u$  as a linear feedback

$$u = U(t)\hat{x}. \tag{5}$$

Rewriting the system (1), (2), (4) with the control (5) we get  $(2n)$ -dimensional system

$$\begin{pmatrix} \dot{x} \\ \dot{\hat{x}} \end{pmatrix} = \begin{pmatrix} A(t) & B(t)U(t) \\ V(t)C^T(t) & A(t) + B(t)U(t) - V(t)C^T(t) \end{pmatrix} \begin{pmatrix} x \\ \hat{x} \end{pmatrix}. \tag{6}$$

Let  $\tilde{x} := x - \hat{x}$ . With the non-degenerate transformation of variables

$$\begin{pmatrix} x \\ \tilde{x} \end{pmatrix} = \begin{pmatrix} E & 0 \\ E & E \end{pmatrix} \begin{pmatrix} x \\ \hat{x} \end{pmatrix}$$

let's reduce the system (6) to the form

$$\begin{pmatrix} \dot{x} \\ \dot{\tilde{x}} \end{pmatrix} = \begin{pmatrix} A(t) + B(t)U(t) & -B(t)U(t) \\ 0 & A(t) - V(t)C^T(t) \end{pmatrix} \begin{pmatrix} x \\ \tilde{x} \end{pmatrix}. \tag{7}$$

**Definition 3** [4, p. 61]. Upper general Bohl exponent  $\Omega^0$  of the homogenous system

$$\dot{x} = A(t)x, \quad t \geq 0 \tag{8}$$

is a number

$$\Omega^0(A) = \lim_{T \rightarrow +\infty} \frac{1}{T} \sup_{k \in \mathbb{N}} \ln \| X((k+1)T, kT) \|,$$

where  $X(t, s)$ ,  $t, s \geq 0$  is Cauchy matrix of the system (8).

**Definition 4** [2]. The system (7) is called uniformly stabilized if for each  $\alpha > 0$  measure and bounded controls  $U(\cdot)$  and  $V(\cdot)$  can be constructed such that relation  $\Omega_{U,V}^0 > -\alpha$ . is true.

**Definition 5** [4, p. 259]. The system (1) has the property of global Lyapunov reducibility if measure and bounded control (5) can be constructed as a linear feedback such that the corresponding closed-loop system

$$\dot{x} = (A(t) + B(t)U(t))x, \quad x \in \mathbb{R}^n, \quad t \geq 0 \tag{9}$$

is asymptotically equivalent (kinematic similar) [4, p. 56-57] to arbitrary preassigned system

$$\dot{z} = K(t)z, \quad z \in \mathbb{R}^n, \quad t \geq 0, \tag{10}$$

with locally integrable and integrally bounded matrix of coefficients  $K(t)$ ,  $t \geq 0$ .

Thus means [4, p. 57-58] that linear transformation

$$z = L(t)x, \quad t \geq 0,$$

which is called Lyapunov transformation exists and reduce system (9) into system (10). Here  $(n \times n)$ -matrix  $L(t)$  (Lyapunov matrix) for each  $t \geq 0$  is bouded, reversible, has integrally bounded and wherein satisfies the following

$$\sup_{t \geq 0} \|L(t)\| + \sup_{t \geq 0} \|L^{-1}(t)\| + \sup_{t \geq 0} \int_t^{t+1} \|\dot{L}(\tau)\| d\tau < +\infty.$$



Using the method had been proposed by V. Zaitsev [5], the problem of constructing control as a linear feedback for system (1), (2) of a small dimensions of phase space that assure uniform stabilization for system (7) is considered in this report. Thereby, main result of this report are

**Theorem 1.** *Let  $n = 2$ ,  $m \in \{1, 2\}$ . If system (1) with locally integrable and integrally bounded coefficients has the property of uniform full controlability, system (3) with the same coefficients has the property of uniform full observability, then system (7) is uniformly stabilized.*

In the report [6] the following theorem 2 was proved by A. Kozlov and I. Ints

**Theorem 2.** *Let  $n = 2$ ,  $m \in \{1, 2\}$ . If system (1) with locally integrable and integrally bounded coefficients has the property of uniform full controlability, system (3) with the same coefficients has the property of uniform full observability, then the corresponding closed-loop by feedback (5) system (9) has the property of global Lyapunov reducibility.*

Basing on thus, theorem 3 have been proved

**Theorem 3.** *Let  $n = 2$ ,  $m \in \{1, 2\}$ . If system (1) with locally integrable and integrally bounded coefficients has the property of uniform full controlability, system (3) with the same coefficients has the property of uniform full observability, then for each locally integrable and integrally bounded matrix functions  $P: [0, +\infty) \rightarrow M_n$  and  $Q: [0, +\infty) \rightarrow M_n$  measure and bounded controls  $U(\cdot)$  and  $V(\cdot)$  exist such that system (7) with these controls is reduced to the following system*

$$\begin{pmatrix} \dot{z} \\ \dot{\tilde{z}} \end{pmatrix} = \begin{pmatrix} P(t) & G(t) \\ 0 & Q(t) \end{pmatrix} \begin{pmatrix} z \\ \tilde{z} \end{pmatrix}, \quad z \in \mathbb{R}^n, \quad \tilde{z} \in \mathbb{R}^n, \quad t \geq 0$$

with some locally integrable and integrally bounded matrix  $G(t)$ .

Particularly if  $P(t) \equiv P$  and  $Q(t) \equiv Q$  for each  $t \geq 0$ ,  $P$  and  $Q$  are arbitrary preassigned real  $(n \times n)$ -matrix, the following is true

**Corollary 1.** *Let  $n = 2$ ,  $m \in \{1, 2\}$ . If system (1) with locally integrable and integrally bounded coefficients has the property of uniform full controlability, system (3) with the same coefficients has the property of uniform full observability, then for each preassigned real  $(n \times n)$ -matrix*

$$P \in M_n \quad \text{and} \quad Q \in M_n$$

measure and bounded controls  $U(\cdot)$  and  $V(\cdot)$  can be found such that the system (7) of asymptotic measure of condition with these controls can be reduced to the system

$$\begin{pmatrix} \dot{x} \\ \dot{\tilde{z}} \end{pmatrix} = \begin{pmatrix} P & G \\ 0 & Q \end{pmatrix} \begin{pmatrix} x \\ \tilde{z} \end{pmatrix} \quad (11)$$

with the some constant matrix  $G \in M_n$ .

Thence for the two-dimensional linear control system with locally integrable and integrally bounded coefficients (1) the following statement implies about stabilization:

**Corollary 2.** *Let  $n = 2$ ,  $m \in \{1, 2\}$ . If system (1) with locally integrable and integrally bounded coefficients has the property of uniform full controlability, system (3) with the same coefficients has the property of uniform full observability, then for each  $\kappa > 0$  measure and bounded controls  $U(\cdot)$  and  $V(\cdot)$  and Lyapunov transformation*

$$\begin{pmatrix} x \\ \dot{x} \end{pmatrix} = L(t) \begin{pmatrix} z \\ \dot{z} \end{pmatrix},$$

exist and reduce the system (7) of asymptotic measure of condition with these controls to the system (11) with constant matrix of coefficients  $D$  such that inequality  $\text{Re} \lambda_i(D) \leq -\kappa < 0$  is true for each eigenvalues  $\lambda_i(D)$ ,  $i = 1, \dots, 2n$ , of matrix  $D$ .

**Acknowledgment.** This report has been performed with the financial support of Belarusian Republican Foundation for Fundamental Research (Ф16М-006).

## REFERENCES

1. Теория показателей Ляпунова и ее приложения к вопросам устойчивости / Б.Ф. Былов [и др.]. – М., 1966.
2. Тонков, Е.Л. Критерий равномерной управляемости и стабилизации линейной рекуррентной системы / Е.Л. Тонков // Дифференц. уравнения. — 1979. – Т. 15, №10. – С. 1804–1813.
3. Красовский, Н. Н. Теория управления движением / Н.Н. Красовский. – М., 1968.
4. Макаров, Е.К., Управляемость асимптотических инвариантов нестационарных линейных систем / Е.К. Макаров, С.Н. Попова. – Минск : Беларус. навука, 2012. – 407 с.
5. Зайцев, В.А. Ляпуновская приводимость и стабилизация нестационарных систем с наблюдателем / В.А. Зайцев // Дифференц. уравнения. — 2010. – Т. 46, №3. – С. 432–442 .
6. Козлов, А.А. О глобальной ляпуновской приводимости двумерных линейных систем с локально интегрируемыми коэффициентами / А.А. Козлов, И.В. Инц // Дифференц. уравнения. — 2016. – Т. 52, №6. – С. 720–7422.

UDC 517.983

**SOLUTION OF ONE CLASS OF ONE-DIMENSIONAL INTEGRAL EQUATION  
WITH LEGENDRE FUNCTION OF THE FIRST KIND IN THE KERNEL**

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*This paper is devoted to the study of one class of one-dimensional integral equation*

$$\int_a^x (x^2 - t^2)^{-\mu/2} P_\nu^\mu\left(\frac{x}{t}\right) f(t) dt = g(x) \quad (x > a),$$

involving the Legendre function of the first kind  $P_\nu^\mu(z)$  with real  $\mu, \nu, 0 < \mu < 1$ , in the kernel. By Tamarkin's method the solution of the investigating equation in the closed form are obtained, and necessary and sufficient conditions for its solvability in the space of summable functions on a finite interval  $[a, b]$  of the real line are given.

**Introduction.**

We consider the integral equation

$$\int_a^x (x^2 - t^2)^{-\mu/2} P_\nu^\mu\left(\frac{x}{t}\right) f(t) dt = g(x) \quad (x > a), \quad (1)$$

containing the Legendre function of the first kind  $P_\nu^\mu\left(\frac{x}{t}\right)$  in the kernel, see [1, formulas 3.2(3) and 3.4(6)] and [2, Section 2.1];  $\mu \in \mathbb{R}, \nu \in \mathbb{R}, 0 < \mu < 1$ . By Tamarkin's method the solution of the equation (1) in the closed form are obtained, and necessary and sufficient conditions for its solvability in the space of summable functions on a finite interval  $[a, b]$  of the real line are given.

We need the generalization [1, 2.4(3)]:

$${}_2F_1(a, b, c, z) = \frac{\Gamma(c)}{\Gamma(s)\Gamma(c-s)} \int_0^1 \frac{x^{s-1}(1-x)^{c-s-1}}{(1-xz)^{a'}} {}_2F_1(a-a', b; s; xz) {}_2F_1\left(a', b-s; c-s; \frac{(1-x)z}{1-xz}\right) dx, \quad (2)$$

where  ${}_2F_1(a, b, c, z)$  is the Gauss hypergeometric function defined for complex  $a, b, c \in \mathbb{C}$  and  $|z| < 1$  by the

hypergeometric series  ${}_2F_1(a, b, c, z) = \sum_{k=0}^{\infty} \frac{(a)_k (b)_k}{(c)_k} \frac{z^k}{k!}$  with the corresponding analytic continuation

$${}_2F_1(a, b, c, z) = \frac{\Gamma(c)}{\Gamma(b)\Gamma(c-b)} \int_0^1 t^{b-1} (1-t)^{c-b-1} (1-zt)^{-a} dt,$$

for  $z \in \mathbb{C}, 0 < \operatorname{Re} b < \operatorname{Re} c, (|\arg(1-z)| < \pi, z \neq 1)$ , see [1, 2.1(2) and 2.1(10)], here  $(z)_n$  is the Pochhammer symbol, that is,  $(z)_0 \equiv 1, (z)_n = z(z+1)\dots(z+n-1) (z \in \mathbb{C}; n \in \mathbb{N})$ ;

the representation [1, 3.2(9.24)]:

$$P_\nu^\mu(z) = \frac{1}{\Gamma(1-\mu)} 2^\mu (z^2 - 1)^{-\frac{\mu}{2}} z^{\nu+\mu} F\left(-\frac{\nu}{2} - \frac{\mu}{2}, \frac{1}{2} - \frac{\nu}{2} - \frac{\mu}{2}; 1-\mu; 1 - \frac{1}{z^2}\right), \operatorname{Re}(z) > 0, \left|1 - \frac{1}{z^2}\right| < 1; \quad (3)$$

and the following formula [2, formula (1.32)]

$$\int_a^b dx \int_a^x f(x, y) dy = \int_a^b dy \int_a^y f(x, y) dx, \quad (4)$$

provided that one of the multiple integrals in (4) converges absolutely.

**Solution in the closed-form.**

First, we give a formal solution of the equation (1). Using the representation (3) for  $P_v^\mu\left(\frac{x}{t}\right)$ , we rewrite equation (1) in the form

$$\frac{2^\mu x^{v+\mu}}{\Gamma(1-\mu)} \int_0^x (x^2 - t^2)^{(1-\mu)-1} t^{-v} F\left(-\frac{v}{2} - \frac{\mu}{2}, \frac{1}{2} - \frac{v}{2} - \frac{\mu}{2}; 1 - \mu; \frac{(x^2 - t^2)}{x^2}\right) f(t) dt = g(x).$$

Replacing  $x$  by  $t$  and  $t$  by  $u$ , multiplying both sides of the resulting equality by

$$t(x^2 - t^2)^{\mu-1} F\left(\frac{v}{2} + \frac{\mu}{2}, \frac{1}{2} - \frac{v}{2} + \frac{\mu}{2}; \mu; \frac{(x^2 - t^2)}{x^2}\right),$$

integrating, and changing the order of integration according to the formula (4), we obtain:

$$\begin{aligned} & \frac{2^{\mu-1}}{\Gamma(1-\mu)} \int_a^x u^{-v} f(u) du \int_u^x t^{v+\mu} (x^2 - t^2)^{\mu-1} (t^2 - u^2)^{(1-\mu)-1} \\ & \times F\left(\frac{v}{2} + \frac{\mu}{2}, \frac{1}{2} - \frac{v}{2} + \frac{\mu}{2}; \mu; \frac{(x^2 - t^2)}{x^2}\right) F\left(-\frac{v}{2} - \frac{\mu}{2}, \frac{1}{2} - \frac{v}{2} - \frac{\mu}{2}; 1 - \mu; \frac{t^2 - u^2}{t^2}\right) 2t dt = \quad (5) \\ & = \int_a^x (x^2 - t^2)^{\mu-1} F\left(\frac{v}{2} + \frac{\mu}{2}, \frac{1}{2} - \frac{v}{2} + \frac{\mu}{2}; \mu; \frac{(x^2 - t^2)}{t^2}\right) t g(t) dt. \end{aligned}$$

To calculate the inner integral in (5), we introduce the new variables  $s = \frac{x^2 - t^2}{x^2 - u^2}$ . Using the formula (2),

we see that the inner integral in (5) equals  $x^{v+\mu} \Gamma(\mu)$ .

Thus, the equality (5) takes the form:

$$\int_a^x x^{-v} f(u) du = f^*(x), \quad (6)$$

$$f^*(x) = 2^{1-\mu} \frac{x^{-v-\mu}}{\Gamma(\mu)} \int_a^x (x^2 - t^2)^{\mu-1} F\left(\frac{v}{2} + \frac{\mu}{2}, \frac{1}{2} - \frac{v}{2} + \frac{\mu}{2}; \mu; \frac{(x^2 - t^2)}{x^2}\right) t g(t) dt.$$

Differentiating both sides of the (6), we come at the following form of the equation solution (1):

$$f(x) = x^v \frac{d}{dx} \left\{ 2^{1-\mu} \frac{x^{-v-\mu}}{\Gamma(\mu)} \int_a^x (x^2 - t^2)^{\mu-1} F\left(\frac{v}{2} + \frac{\mu}{2}, \frac{1}{2} - \frac{v}{2} + \frac{\mu}{2}; \mu; \frac{x^2 - t^2}{x^2}\right) t g(t) dt \right\}. \quad (7)$$

Thus, we have proved that if the equation (1) is solvable, then its solution has the form (7).

**Necessary and sufficient solvability conditions.**

Prove the theorem which gives necessary and sufficient conditions of solvability of equation (1) in the space  $L_1([a, b], t^{-v}) = \left\{ f(t) : t^{-v} f(t) \in L_1(a, b) \right\}$ , where  $L_1(a, b) = \left\{ f(x) : \int_a^b |f(t)| dt < \infty \right\}$ , in terms of auxiliary function  $f^*(x)$ . In the proof we use the fact that the space of absolutely continuous functions coincides with the class of primitive from the Lebesgue integrable functions [3, p. 338; 4, p. 368-369]:

$$g(x) \in AC([a, b]) \Leftrightarrow g(x) = c + \int_a^x f(t) dt, \int_a^b |f(t)| dt < \infty,$$

therefore, absolutely continuous functions are integrable almost everywhere derivative  $g'(x)$ .

**Theorem 1.** *The Abel-type integral equation (1) with  $\mu, \nu, 0 < \mu < 1$ , is solvable in the space  $L_1([a, b], t^{-\nu})$  if and only if*

$$f^*(x) = 2^{1-\mu} \frac{x^{-\nu-\mu}}{\Gamma(\mu)} \int_a^x (x^2 - t^2)^{\mu-1} F\left(\frac{\nu}{2} + \frac{\mu}{2}, \frac{1}{2} - \frac{\nu}{2} + \frac{\mu}{2}; \mu; \frac{(x^2 - t^2)}{x^2}\right) t g(t) dt \in AC([a, b]),$$

and  $f^*(a) = 0$ .

*Under these conditions, equation (1) is uniquely solvable in  $L_1([a, b], t^{-\nu})$  and its solution is given by (7).*

#### REFERENCES

1. Higher transcendental functions (Bateman Manuscript Project) / A. Erdelyi [et al.] // McGraw-Hill., New York, 1953 ; Nauka, Moscow, 1965. – Vol. 1.
2. Самко, С.Г. Интегралы и производные дробного порядка и некоторые их приложения / С.Г. Самко, А.А. Килбас, О.И. Маричев. – Минск : Наука и техника, 1987. – 688 с.
3. Колмогоров, А.Н. Элементы теории функций и функционального анализа / А.Н. Колмогоров, С.В. Фомин. – М. : Наука, 1968. – 496 с.
4. Никольский, С.М. Курс математического анализа / С.М. Никольский. – М. : Наука, 1983. – Т. 2. – 448 с.

## APPLICATION OF RADIO IMPULSE TO GEOELECTRICAL EXPLORATION OF A HYDROCARBONIC DEPOSIT

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*Geoelectrical exploration method of a hydrocarbonic deposit by means of radio impulse emission is suggested. This method allows to pinpoint overall boundaries and depth of a geological deposit with greater accuracy. Two examples of the method have been described in this paper.*

The methods of the hydrocarbonic deposit geoelectrical exploration have some drawbacks: its low accuracy is caused by the high level of interference in the range of used frequencies; limitation the distance between the receiver and the transmitter associated with the final sensitivity and transmitter power; large size antennas; low depth of measurement; low resolving ability; inaccurate detection of anomalies of the electric field of the hydrocarbon deposits.

The object is achieved by the use of radio signals. The investigated profile at the site of possible deposits location is scanned by radio signals following each other in a frequency range of 50 to 100 kHz, with high-frequency component in the range from 20 to 35 MHz and the low frequency envelope in the range of 1 to 5 MHz. Reflected signals are received, the electric field intensity is measured and the lag time of the reflected signals at each point in the scan, and then the location of boundaries and depth deposits are determined on the basis of the measurements.

When probing the signals [1] in layer with "d" thickness three signals are sent to the receiver: straight, the upper signal reflected from the upper boundary of the layer, and the lower the signal reflected from the lower boundary of the layer, as well as signals from intermediate boundaries between the top and the bottom. Geoelectrical exploration method is used to determine the boundaries and depth of hydrocarbon deposits. Periodic sequence of probing radio signals use allows measuring the time delay of the reflected radio signals relative to the emitted and measuring the depth of hydrocarbon deposits. The boundary is defined by the abnormal increase in the electric field intensity of the reflected signal radiopulse.

The selection of high-frequency component  $\langle f_1 \rangle$  in the range of 20–35 MHz is due to the required amount of attenuation radiopulse signal for measuring the depth of hydrocarbon deposits and achievement acceptable antenna size for probing deposits. The frequency  $f_2 = (1-5)$  MHz due to the achievement of high resolution identifying deposits. The value of  $f_3 = (50-100)$  kHz defines the range of unambiguous measurement of the depth of hydrocarbon deposits.

**Example of the method.** As the receiving and transmitting are used vibro antennas of 4.07 meter. The spacing  $L = 2$  m. The height  $H = 0.5$  m. The speed of propagation electromagnetic wave  $v = 7.5 \cdot 10^7$  meters per second.

### Example 1.

The profile of an electromagnetic wave was scanned at a fixed frequency  $f_1 = 25$  MHz in the low-frequency envelope  $f_2 = 5$  MHz repetition rate radio signal  $f_3 = 100$  kHz. The reflected signal was received and electric field intensity of the reflected signal was measured to the test points of measurement profile. The reference point was chosen against which the distance along the investigated profile was measured. The measuring points were selected with the discrete 10 m. along a straight line passing through the reference point and the anticipated border. In anomalous values of the electric field intensity of the reflected signal is determined by the border of hydrocarbon deposits. At the same time the delay time  $t_3$  of the reflected signal was measured relatively to the emitted and, according to the formula (1), the depth of hydrocarbon deposit was measured:

$$d = \frac{vt_3}{2}, \quad (1)$$

where  $v$  – speed of electromagnetic waves propagation,

$t_3$  – the reflected signal time delay relative to the emitted radiopulse.

### Example 2.

The process was performed as in Example 1, and  $f_1 = 20$  MHz at 1 MHz and the  $f_2 = f_3 = 100$  kHz.

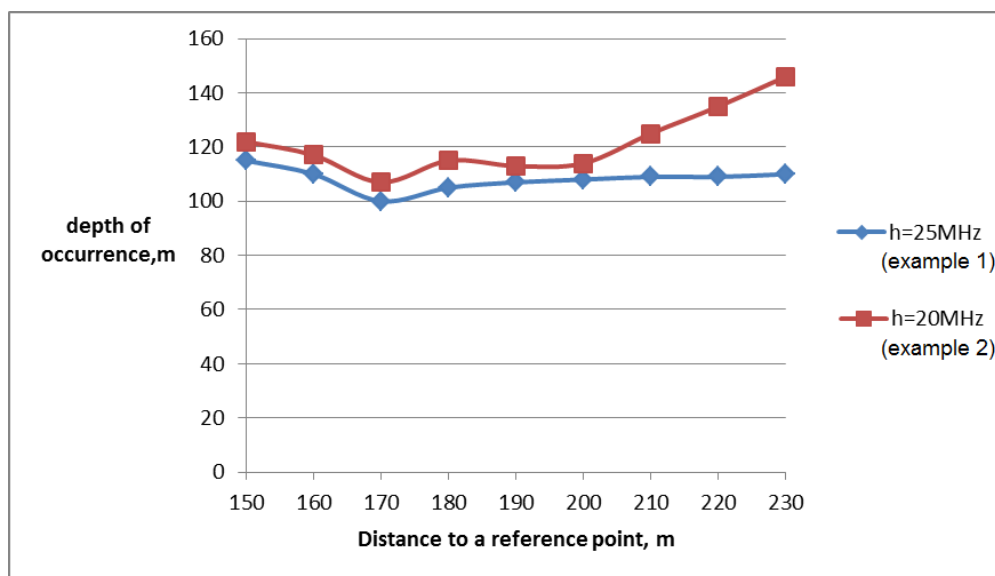


Fig. 1. The graphs of the depth of hydrocarbon deposits on the distance from a reference point, as examples 1 and 2

It can be seen from graphs in Figure 1 that the value of the field strength of the reflected signal radiopulse increases on the border of the deposit (reference point 170) at a depth of about 100 m., at a frequency of 25 MHz and at a depth of 107 m. at a frequency of 20 MHz, which allows you to determine the boundaries of hydrocarbon deposits with the added dimension of depth.

The advantages of the method in comparison with existing analogues are:

- Improving the accuracy of determining the boundaries of the deposit, by receiving radio signals reflected from deposits;
- The possibility of measuring the depth of 100–150 m;
- Increasing the resolution of the positioning of deposits, at the expense of used radial pulse.

#### REFERENCES

1. Финкельштейн, М.И. Применение радиолокационного подповерхностного зондирования в инженерной геологии / М.И. Финкельштейн, В.А. Кутев, В.П. Золоторёв. – М. : Недра. – 1986. – С. 42.

**SERVICE STACK FOR CREATING WEB APPLICATIONS AND WEB SERVICES**

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*Most of the .Net Developers use standard solutions by Microsoft to solve task for the development of web services and web applications, as a rule it's MFC or Asp.Net MVC / Web Apl. However, modern dot Net has a lot of non-standard technologies, just about one of them we discuss in this article.*

Service Stack [1] is a complete framework for creating web services and web applications. Creators of it excluded the worst, unnecessary and superfluous in Asp.Net and added a lot of new and useful functionality.

Service Stack appeared in the BBC in 2007 [2]. The company used the standard Enterprise solutions by Microsoft with Waterfall development methodologies. Due to the rapidly changing requirements of the functional BBC was face with a major problem. To make each small change was necessary to extend the cycle by UML to code, which took they until few days, use a variety of workarounds for compatibility formats between the old and new recordings that led to weekly downtime between releases. The team has had the question: "What is the service?" and identified basic principles of it:

- Service isn't necessarily has to use a predefined architecture which always determined before or follow a predetermined format.
- Service shouldn't impose a particular technology or a platform.
- Service shouldn't have pre-determined limit.
- Service has to encapsulate some possibilities for using it again, and it has to organized to be available.
- Access has to organize the most efficient and simple way, with the highest possible re-use and cost-effectively.

A list of these principles is what the definition of service. To this list we can add the fact that good service has to be ready for changes, and it needs to design so that the new changes won't be a problem.

A list of these principles led to the creature of Service Stack which let speeding up the development of several times. Now one half of the team can do more than the whole team did before.

ServiceStack [3] has more advantages than standard dot Net solutions:

- It's easier to use and intuitive.
- It works faster.
- Due to architecture of it, that allows to achieve a high level using of the code, even inexperienced developers.

We have to add in the last paragraph the fact that developers with great experience and high professionalism might to achieve code reuse and with using standard solutions by Microsoft. But it's necessary to understand that it takes the right approach and more time-consuming than using ServiceStack. Due to the flexible architecture and simplicity ServiceStack allows less-skilled developers to achieves better results and to brings a commitment to more effective approaches to the structuring code.

One of decisive arguments in using ServiceStack is that, that the projects can be deployed on Linux, without additional manipulation. This can significantly save on rent servers. You don't have to use the Windows Azure road or contain your Windows Server. Well-server usually approaches for medium-sized projects such as Debian or Ubuntu Server.

ServiceStack Asp.Net wasn't destroyed in developing and root IHttpHandler of it was leave. However, all the rest was put away and re-written with using lightweight alternatives which in some places were adapt specifically to meet the challenges of Web services development. Framework has its own session and authentication providers, a cache manager, the MQ-a broker who works on the basis of Redis. Also within the framework-Redis-own a client has been created that can be used either with or separately from the framework-and in different contexts. The standard IoS (Inversion of Control) containers used a slightly modified version of the popular and lightweight container Func. If desired, can be used instead of any other IoS- container.

The basis for ServiceStack are DTO (Data Transfer Objects, Data Transfer Objects), which are based on flat objects POCO. ISP authentication and sessions, as well as custom services based on the POCO, that allows you to use different backends for different implementations. Default available, for example, to store session typed directly into memory and Redis. Also available is an untyped and session speakers for the fans, but it is, unfortunately, a bit slower.

Consider creating a simple web service to ServiceStack. The first step in the project need to do three basic things:

1. Create a class for the DTO response service.



2. Create a class for the DTO request to the service.
3. Create a class of service, otnasledovav it from the base class, and overriding methods of the same name with the HTTP-methods that you need to implement.

First we need to create a project in Visual Studio or Xamarin Studio. Create an empty ASP.Net-project (Empty Web Application). The solution we call SSEExampleProject, and the project - SSEExampleAPI.

According to the project in the Solution Explorer (Solution Explorer) do right click, and select "Manage Packages NuGet" (Manage Nuget Packages).

After clicking on the Add button to connect our project downloaded dll ServiceStack'a. If after this step in the project is not Global.asax, you need to add it, and copy standard code ServiceStack site [3] (section Registering your web services and starting your application). There will also be missing web.config file, it must be filled with standard data ServiceStack site [3] (section Configuring Service Stack to run in your application).

After that you need to create ExampleService class, in which will be three classes:

– ExampleRequest - is responsible for the request to the service, and marked Route attribute. What reports for any inquiry that will meet the class. In this case it will be [Route ("/ hello")] and [Route ( "/ hello / {Name}")] . Where Name is the string property class.

– ExampleResponse - is responsible for receiving a response from the service. It has one string property Result.

– ExampleService - This service itself is inherited from the base class has a method and Service Any, which takes ExampleRequest and returns the object. The method is a simple code that creates and assigns an instance ExampleResponse Result string query name.

Next, you need to compile and run the project in the browser's address bar to enter after the hostname and port "/ hello / ExapleString". ServiceStack Title query itself determines the type of customer, and in this case will reveal the answer service in a html-wrapper. And in the Result field will be displayed ExampleString line.

Any method name indicates that we have identified the same logic for all HTTP-methods.

Also pay attention to the metadata page that opens instantly when the project starts. It contains the automatically generated documentation to the services. ServiceStack creates different endpoints, and we can work with our service with both RESTful-service or as a SOAP-service.

Also ServiceStack is good because it created the service is very convenient to use Windows Phone, Xamarin.Android or Xamarin.iOS. There are different ways, but the easiest is to select individual files in the classes of requests and responses, and to connect them through the binding of a mobile application project. Also from Nuget set assembly ServiceStack.Client.

## REFERENCES

1. Servicestack.net – официальный сайт ServiceStack [Электронный ресурс] / ServiceStack. – Режим доступа: <https://servicestack.net/>. – Дата доступа: 10.01.2016.
2. slideshare.net [Электронный ресурс] // Гитхаб. – Режим доступа: <https://github.com/ServiceStack/ServiceStack/wiki>. – Дата доступа: 10.01.2016.
3. GitHub.com [Электронный ресурс] // Сервис презентаций. – Режим доступа: <http://www.slideshare.net/newmovie>. – Дата доступа: 10.01.2016.

**AN ANALYSIS OF THE SUBJECT AREA AND FEATURES OF DATABASE DESIGN  
FOR THIS APPLICATION «VIRTUAL TOURS OF POLOTSK STATE UNIVERSITY»**

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*The object of development is an application for virtual tours of Polotsk State University. Objective - creation of information system of Polotsk State University with an emphasis on virtual walks step by step. Questions database design for virtual tours of Polotsk State University Information System.*

To create an application for virtual tours, you must first design the database itself. For the convenience of the subsequent development of the projected base should be as simple to understand and normalized.

The database design is necessary to highlight the essence of which will be used in the information system. During domain analysis, which is determined by the breadth of all the information about the university, which can be useful to anyone for review, the following major entities have been identified:

- university housing (housing);
- university hostel (hostel);
- the city in which there are hostels and housings (city);
- university faculties (faculty);
- university departments (department);
- general departments and university services (university services);
- NGOs of university (public organizations);
- the people standing at the head of the university, faculty, department, service or public organization (people);
- places for leisure activities of students, such as a dining room, a gym, a library and other (leisure);
- places of historical or cultural value (history culture places).

Accordingly, for such a database should be developed special software, with which will work administrator. From this perspective, you can list the administrator functions:

- add / delete / edit the information about the cities in which the buildings are located university;
- add / delete / edit the information about the hostels;
- add / delete / edit the information about the university buildings;
- add / delete / edit the information about the university faculties;
- add / delete / edit the information departments of the university;
- add / delete / edit the information of the general departments and services of the university;
- add / delete / edit information on public organizations of the university;
- add / delete / edit the information about the people connected with the university and its subdivisions;
- add / delete / edit the information about the places of leisure located in of the university;
- add / delete / edit the information about the places that have historical or cultural value, and associated with the university.

To construct the database schema must define a set of relations between entities to be used in the database. It is also important that the relationship between the entities were performed entity integrity of the condition and the condition of link integrity. Conditions integrity entity is as follows: each tuple of any relationship should be different from any other tuple of this relation, that is, any relationship should have a primary key and referential integrity condition as follows: for each foreign key value that appears in the child relation, the parent respect there must exist a tuple with the same primary key value [2].

Selecting the database is one of the most important phases of system development. Among the many available database choice was made in favor of the MS SQL Server - a powerful relational database as its capacity will be sufficient for the system being developed: there is a need to use a client-server DBMS, for the developed system is used as an online service. The main advantages of SQLite can be identified such as reliability, performance, ease of use, integration with other products Microsoft. [3]

For proper operation and preserve referential integrity for the entities in the database triggers were designed to add / delete / edit that prevents the addition of base identical records and organize cascade delete without leaving stale links (Fig. 1).

The purpose of development of administrative applications for virtual tours of Polotsk State University is to provide a user-friendly application with a compact interface, with which you can easily work with the database, process errors or avoid them altogether.

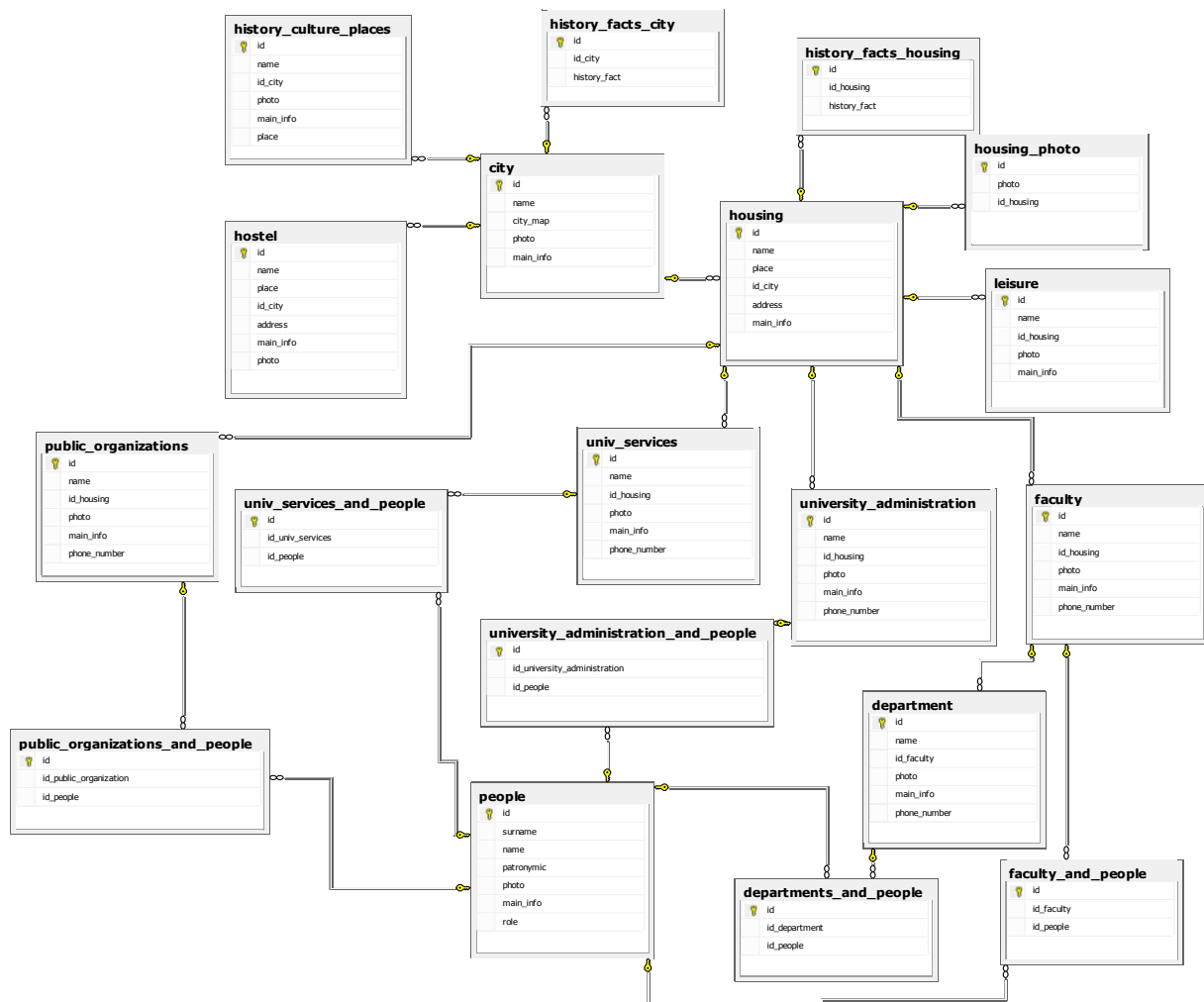


Fig. The scheme of designed database

For an application to write the .NET Framework version 4.5 was selected. This choice is conditioned by the fact that this platform is the main platform for Windows operating systems, the most widespread OS family in the world. In addition, most people are accustomed to the visual of Windows, and it will be easier to take an application written for this OS.

For direct application design was chosen integrated development environment Microsoft Visual Studio development. It allows you to create various types of applications, and apply a variety of modern technologies of the platform. Wednesday has a convenient code editor and visual environment for the development of graphical user interface.

Of all the programming languages was chosen the C # programming language. Selection was made on the basis of its advantages, namely:

- true object orientation;
- safe (as compared with the languages C and C ++ ) code;
- support for event - oriented programming;
- "native" language for the application on the .NET platform;
- bringing together the best ideas of modern languages [4].

As a result of this work an information database of PSU was designed . Designed database can create the basis for an information system for the virtual tours of Polotsk State University. There were also identified the starting point for the development of the application administrator, through which you can manage the database.

## REFERENCES

1. Википедия - свободная энциклопедия [Электронный ресурс] – Режим доступа: <http://ru.wikipedia.org>. – Дата доступа: 30.01.2017.

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**ITC, Electronics, Programming**

2. Сайт Мурманского государственного технического университета [Электронный ресурс]. – Режим доступа: [http://www.mstu.edu.ru/study/materials/zelenkov/ch\\_4\\_3.html](http://www.mstu.edu.ru/study/materials/zelenkov/ch_4_3.html). – Дата доступа: 30.01.2017.
3. Возможности и преимущества MSSQLServer [Электронный ресурс]. – Режим доступа: <http://users.freenet.am/~tank1873/Microsoft%20SQL%20Server/benefits.htm>. – Дата доступа: 30.01.2017.
4. Языки программирования [Электронный ресурс]. – Режим доступа: <http://www.uzluga.ru/potrd/Программа+последовательность+инструкцийd/part-7.html>. – Дата доступа: 30.01.2017.

UDC 628.9

**COMPARATIVE ANALYSIS OF CONSUMPTIONAL PROPERTIES FOR VARIOUS TYPES OF HOUSEHOLD LAMPS****VLADISLAV PYATNITSA, JAMAL FARRAN, DMITRY ANTANOVICH**  
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*This article examines the functions, profitability, economy, and characteristics of different types of household lamps.*

**Introduction.** The sunlight plays an important role in a human life. However, apart from the sunlight, man extensively uses artificial sources to make the environment more suitable for work and leisure. Properly designed and chosen lighting provides comfort and mood, increases brain's efficiency in work, and helps to preserve health. Selection of high-quality lighting is not only to achieve sufficient light, but also reliability, safety, profitability in practical life of people.

**Task formulation.** The study of different types of household lamps.

In modern lightening of domestic premises, five main types of artificial light sources are used: incandescent lamps, halogen incandescent lamps, fluorescent lamps, discharge lamps and LEDs.

The advantage of **incandescent lamps (IL)** is their familiarity, prevalence and low cost. However, the conventional incandescent light bulb (Fig 1, a), due to its design features, 6 - 8% of the electricity consumed is converted to light [1], whereas the rest is converted into thermal energy (heat). As for the disadvantage of incandescent lamps, we take into consideration that the emission spectrum is different from natural daylight which is dominated by the yellow and red lights, and complete the absence of UV light needed for normal functioning. The service life of incandescent lamps is short and usually does not function more than 1,000 hours. Organization of high technical level of lighting using these lamps is difficult. Therefore, despite the fact that incandescent lamps are the most common source of light, they gradually give away places to other types of lamps. Recently, incandescent lamps have become widely used with internal mirror coating that increases the light output. Mirrored lamps that emit directional light are the easiest way to create light accents. They are also designed for the use in embedded, pendant, ceiling and wall lamps.

The light of **halogen lamps (ILT)** - scattered from wide, soft, non-giving shadows to dramatically limited narrow beam - makes it possible to find countless lighting options [2]. ILT miniature cones (Fig. 1, b) are not formed from normal glass, but from refractory silica glass. Working conditions of ILT filament can be called "rehabilitation". Evaporation from its surface, tungsten particles connected with particles of halogen, form chemical complexes. Reflected from hot walls of the quartz cone, these convective chemical complexes move back to the filament. The thermal decomposition of complexes returns the tungsten particles back onto the surface of the filament. This return process takes place in a dynamic equilibrium with the evaporation process. Halogen lamps, in contrast to conventional incandescent lamps, provide light with a high color temperature (approximately 3000 K). Elevated values of the color temperature of the filament ILT provides a shift of the emission spectrum to shorter wavelengths. The maximum radiation of IL is in the yellow-green region. In ILT, this region is in the green area, where the sensitivity of the human naked eye is much higher. In other words, ILT light is tightly close to the sunlight. In comparison with IL, they are more durable, they provide more light if subjected to the same quantitative power, and maintain a constant value of flow during the entire period of operation. New generation of halogen lamps has a clear limitation of the beam, the presence of heat-reflective coating, superior color reproduction. The level of ultraviolet radiation emitted by halogen lamps is very little. Therefore, being in a room lit by halogen lamps for a period of 8 hours is equivalent to 10 minutes of being in the direct sunlight.

In **gas-discharge lamps** the light emitters are gases or sodium vapor, mercury, arising due to the passage of an electric current through them (Fig. 1, c). The emission spectrum is linear, where a large proportion (30%) is concentrated in the visible region [2]. The glow of gas has a higher profitability. However, the spectrum of gas sources consists of separate lines and is very different from the usual white light to the human eye. If this factor plays a minor role, so such sources successfully replace the incandescent lamps, for example, when illuminating highways. As a serious disadvantage for discharge lamps, we include its inability to adjust the luminous flux. The principle of operating gas discharge lamps is as follows. After turning on the discharge lamp, a current flows through the buffer gas in the burner. Due to thermal effects, there occurs the evaporation of mercury, sodium or halide, until their vapor pressure is stabilized, and reaches the pressure in the working condition. This so-called flare-up time, can be up to 1-4 minutes. The re-ignition time averages out to 10 minutes. Such lamps are usually used for continuous lighting in closed luminaries.

**Fluorescent lamps** - the world's second most common source of light, and, for example, in Japan, they even occupy the first place, overtaking incandescent lamps. Every year the world produces more than one billion

fluorescent lamps (Fig. 1, d). The first samples of the modern type fluorescent lamps have been shown by the American company General Electric at the World Fair in New York in 1938. Over the past 65 years of existence, they have become part of our lives, and now it is hard to imagine any large store or office, in which there would not be a single fluorescent lamp. The fluorescent lamps contain a light emitter substance - phosphor, the glow of which is due to any form of energy other than heat. This is commonly called "cold glow". In household fluorescent lamps, phosphor coated on the inner surface of the discharge lamp radiates band spectrum by ultraviolet radiation of the discharge. The phosphor is selected in such a way, that it compensates with the deficiency of the gas glow luminescence. In the standard bulb type LL halo phosphate is used. The result is a source of radiation which color is close to the Sun. Fluorescent lamps are characterized by their lumen maintenance, improved color and high luminous efficiency. There are also lamps with warm light close to the color of incandescent lamps, as well as the subdued light with a low dose of UV radiations. Small sized ones (up to 0.16 mm) are of high luminous flux and with exceptional design flexibility, easy installation of the light unit in modular ceiling systems, and effective in dealing with the redistribution of the luminous flux. Fluorescent lamps diffuse light much more than the "point" sources (incandescent, halogen or discharge lamps). They are ideal for illuminating open spaces such as an offices or industrial premises. It is recommended for them to be used where low initial costs are a priority. Compact fluorescent (decorative) lamps produce more light with virtually no heat, converting up to 25% of the electricity consumed in the world [3]. The service life of such lamps is 15 times longer than incandescent bulbs.

For the latest generation, light sources include **LED bulbs and lasers** - lasers in the optical range (Fig. 1, e). They emit light so-called excited active medium (gases, crystals, solutions), which creates an inverse population of quantum energy levels. At this stage, the LED technology is the most expensive of all the above options, but with an increase in their production, their price and value decreases. Besides, their use does not require recycling industry lamps containing mercury, as well as the fact that LED lamps are the closest to the solar spectrum [4].



Fig. 1. Different types of lamps:  
*a* - incandescent lamp; *b* - halogen lamp; *c* - gas-discharge lamp;  
*d* - fluorescent lamps; *e* - led-lamp

To apply a comparative analysis for the functions of different lamp types, we use the characteristics provided in Tab.1 IL3 lamps where used.

Table 1 – Characteristics of different lamps

Name	Power		Price (BYR)	Lifetime (hours)
	Consumption	Light output (equivalent incandescent lamp)		
Incandescent lamp	100	100	0,5-1	1 000
Halogen	40	100	2-3	4 000
Fluorescent (energy saving)	20	100	5-12	10 000
LED	5	100	1-60	100 000

The results of the comparative analysis of power consumption and the cost of replacing the failed lamps are shown in Table 2. It was assumed that the average daily lamp operating time is about 7 hours.

Tabl. 2 – Cost of operation

Name	Power consumption per year (kW·h)	Consumption per 1 year of service (BYN)	Consumption per 2 years of service (BYN)	Consumption per 5 years of service (BYN)
		Taking into account the cost of the lamp and its replacement		
Incandescent lamp	255,5	36,22	74,1	195,68
Halogen	76,65	15,79	32,24	83,07
Fluorescent (energy saving)	51,1	16,64	23,62	56,54
LED	12,78	41,66	43,41	49,14

Experimentally, the lighting characteristics of the two types of bulbs were analyzed: incandescent IL IL B100 and Lisma B. Experiments were carried out on the photometric bench FS-3, as well as for the measuring equipment, HN25/7 visual photometer, light meter U-116, a laboratory autotransformer LATR, voltmeter AC 50-250V (value of division 10V), ammeter with outside 100 - 500 mA (10 mA value of division) were used. The results are shown in Figure 2.

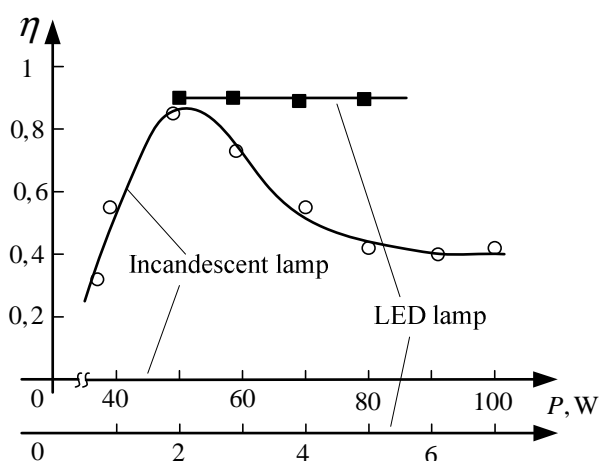


Fig. 2 Efficiency depending on the power consumption

It is evident that the application of light for a period of several years (1-3 years) the most efficient energy consumption and the price is the energy saving lamp. If we are talking about a longer period (over 4 years), the most efficient is LED lamp, because of its low consumption and long service life.

#### REFERENCES

1. Mode of access: <https://www.calc.ru/Lampa-Nakalivaniya-Kharakteristiki-Lamp-Nakalivaniya.html>.
2. Mode of access: <http://deal.by/Energoberegayuschie-lampy.html>.
3. Mode of access: <http://elektrik.info/main/lighting/482-vidy-galogennyh-lamp-i-ih-osobennosti.html>.
4. Mode of access: <http://lightenergy.by/category/svetodiodnie-lampi>.

## THE APPROACH TO THE INTERACTION OF ANDROID APPLICATIONS TO THE DATABASE WEBSITE DATA

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Internet technology has become an integral part of our daily lives. They are developing every day more and more, covering different aspects of our lives: social networks, a variety of applications, calendars, reminders, monitoring magazines, websites, etc. Previously, users could work with Internet resources only through personal computers or laptops, but with the development of smart phones and tablets, everything you need is at your fingertips 24 hours a day. Most devices based on the Android operating system.

Using the Internet, anyone can visit a variety of sites and register thereon request. And an important indicator of the "modern" web-site is the ability to support its mobile version or application. But from this raises the question, how to synchronize data base of website and mobile applications.

Most web sites are written in PHP and work with the MySQL database and a mobile application can be developed in Java development environment through Android Studio. And in order to synchronize the Web site data from a mobile application you can use a bundle of data: from MySQL through JSON objects in Android Studio.

The solution of the problem. Very often there is a situation when you need to create a mobile application for developed website. Basically, mobile applications, which synchronized with the web sites, need user's authentication and minimal, but sufficient data to work with, because characteristics of a smartphone is lower than personal computers or laptops. To do this, the designer needs to consider a functional part of the application, its interface and method of receiving data from the database. Therefore, this article describes how to connect MySQL database via PHP JSON file requests using Volley library .

RPHP (PHP: Hypertext Preprocessor - «PHP: Hypertext Preprocessor", originally Personal Home Page Tools - «Tools for creating personal web pages") - scripting general-purpose language, intensively used for web application development. Today it is supported by the overwhelming majority of hosting providers and it is one of the leaders among the languages that are used to create dynamic Web sites [1].

MySQL - free relational database management system. Development and support for MySQL, Oracle provides, won the right to the trademark, together with the absorbed Sun Microsystems, which had previously acquired the Swedish company MySQL AB. The product is distributed as under the GNU General Public License, as well as under its own commercial license [2].

JSON (English JavaScript Object Notation.) - Text format data exchange, based in JavaScript. Like many other text formats, JSON is easy for people to read. JSON format may be more appropriate for the serialization of complex structures because of its brevity, if we compare with XML. If we talk about Web applications, in this manner it is appropriate to the problems of data exchange both between the browser and the server (the AJAX), and between the servers themselves (program, the HTTP interface).

JSON format can be easily deserialized built-in function `eval()`, because it is a subset of JavaScript syntax. Beside it is possible to insert JavaScript-bodied functions. In the language of PHP since version 5.2.0, JSON support is included in the kernel as a function `json_decode()` and `json_encode()`, which are converted JSON data types themselves to the appropriate PHP type, and vice versa [3].

Volley is an HTTP library, which makes network sharing Android applications easier and, most importantly, faster. Volley is available for use through the open AOSP repository.

Volley Library offers the following advantages:

- Automatic planning of network requests.
- Multiple parallel network connections.
- Transparent caching on the disk and in memory of the responses using a standard HTTP cache coherency.
- Support requests priorities.
- API is for the cancellation request. You can cancel a single request, or you can set the block or region requests to cancel.
- Easy to configure, for example, to retry attempt and delays.
- A strict procedure that allows you to fill in the user interface of the data easily and correctly received from the network asynchronously.
- Tools for debugging and trace.

This library can be easily integrated with any protocols, and comes with support for raw strings, images and JSON [4].



To implement the interaction of the Android application and web site, you must connect com.mcxiao.ke.volley library: library: 1.0.19 in Android Studio in build.gradle file. After the library will be connected, there will be available two classes for work and RequestQueue Request and then you must connect use of the Internet in AndroidManifest.xml. RequestQueue is used to send network requests. This class can be created at any time, but usually it creates during startup and it is used as a Singleton. Request: contains all necessary parts to build a Web API call. For example: which method to use (GET or POST), the request data, response listener, error listener.

As an example we can take a way to authenticate of the website's user through mobile application to gain access to your account information.

First it is necessary to create a .php file to connect to a database. and we need to prescribe functional receiving data therein from the selected database and display them in a JSON format. Subsequently, the Android app will refer to this file to connect to the website, send and receive data via the URL registered in the Java application code.

When we fill out the entering fields of login/password and sending them by request method as a response user receives Json object with the notification of successful or erroneous jsonObject.get () authorization.

When we process POST-request it is necessary to remember that analysis of parameters is not automatic, as a result of clear exit method protected Map <String, String>getParams (throws AuthFailureError).

After successful authentication, the system refers to the database directly from the user ID in a similar way, providing access to the account. Beside, this library provides transparent disk cache, and cache memory.

Methods of solving problems. As a model of a mobile application architecture and web site it is better to use a model user-shell database administrator. In this architecture, one can make the conversion of parts of the model and changes of other parts are not so global.

Each part of the model has its own characteristics that define the subject area, which may be reflected in the GUI, i.e., in the shell.

The user implements some methods for sending and receiving data. Part of architecture as a database administrator manages the entire contents of the content.

Conclusion. As a conclusion we can say that for synchronization a website and mobile applications with Android system is convenient to use a bundle of operating system data: MySQL database, PHP file and Json objects. From the Android app as the connector is better to use Volley library. It will be able to directly connect to the .php file with the database connection settings and allows direct exchange of data between the mobile app and website. Beside, this method makes it easy to navigate in the program code, which significantly simplifies its further modernization, functional expansion and correction of errors appeared in the development.

Architecture of the applications user-shell-DB administrator will enable to make the modernization of one of the parts of the model, which in turn do not lead to the global changes in other parts.

#### REFERENCES

1. Wikipedia – the free encyclopedia [Electronic resource]. – Mode of access: <https://ru.wikipedia.org/wiki/PHP>. – Date of access: 22.09.2016.
2. Wikipedia - the free encyclopedia [Electronic resource]. - Mode of access: <https://ru.wikipedia.org/wiki/MySQL>. – Date of access: 22.09.2016.
3. Wikipedia - the free encyclopedia [Electronic resource]. - Mode of access: <https://ru.wikipedia.org/wiki/JSON>. – Date of access: 23.09.2016.
4. The operating system for multi-screen devices [Electronic resource]. – Mode of access: <http://developer-android.unlimited-translate.org/training/volley/index.html>. – Date of access: 23.09.2016.

## STANDALONE APPLICATION FOR AUDIOADDICT'S RADIO STATION WITH THE SUPPORT FOR SOUNDCLOUD

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*The object - a set of desktop software and website to play music from online radio stations: Digitally Imported, Rockradio, RadioTunes, ClassicalRadio and JazzRadio - with support for SoundCloud service. The goal - implementation of these programs and website. The above questions - subject area analysis, the choice of development tools and design techniques.*

There are five very popular online radio stations: Digitally Imported, Rockradio, RadioTunes, ClassicalRadio and JazzRadio - each under a certain style of music. Each radio station has a web application and a mobile application. However, there is no desktop application. In addition, these applications allow only listen to the music in real time, but you cannot save a single song for later listening offline. To solve these problems, a set of programs has been developed, consisting of three desktop software (for Windows, macOS, Linux) and website for the distribution of these programs.

To implement this set of programs is necessary to analyze the subject area. During the analysis, the following features of online radio stations have been identified:

- log in to your account;
- control music playback (start / stop, increase / decrease the volume);
- possibility of selecting the channel with the songs of a certain musical style;
- selecting the sound quality;
- possibility to vote for the song (like or dislike).

After the analysis of the subject area, you need to define a set of features that the program will perform. The following features have been identified:

- possibility to log in the application and get the possibility to use the saved favorite channels and see favorite songs;
- display the channel list for each radio station and get the possibility to select one of them for playback;
- possibility to control music playback (start / stop, increase / decrease the volume);
- possibility to add a channel to favorites, or delete it from there;
- possibility to select the sound quality;
- possibility to vote for the song (like or dislike).

In addition, the following unique features have been identified:

- select a radio station to listen to in one application;
- possibility to listen to your favorite songs through SoundCloud service;
- possibility to control the player using global hot keys.

It was also decided to develop a cross-platform application, so that users of different platforms (Windows, macOS or Linux) had a possibility to take advantage of a convenient application.

Next, you must determine the development tools. The selection is made among 2 frameworks: Qt and C++ or Java and Swing. Both frameworks provide a possibility to implement cross-platform applications, however, framework Qt and C++ was chosen because of the following advantages:

- C++ is faster and requires less computer resources;
- The QML markup language, included in Qt, more powerful than the Swing, and gives more flexibility in the design of the user interface;
- Qt Multimedia is built-in module for audio content management capabilities.

Next, you need to design the user interface of the program. The user interface must allow the user to perform all the functions inherent in the program, to be comfortable, clear and beautiful. The following two application forms have been identified:

- the login form;
- the main form.

The following controls of main form have been identified:

- player;
- tabs for radio stations, channels, songs and settings.

Figure 1 shows the main form of the application.

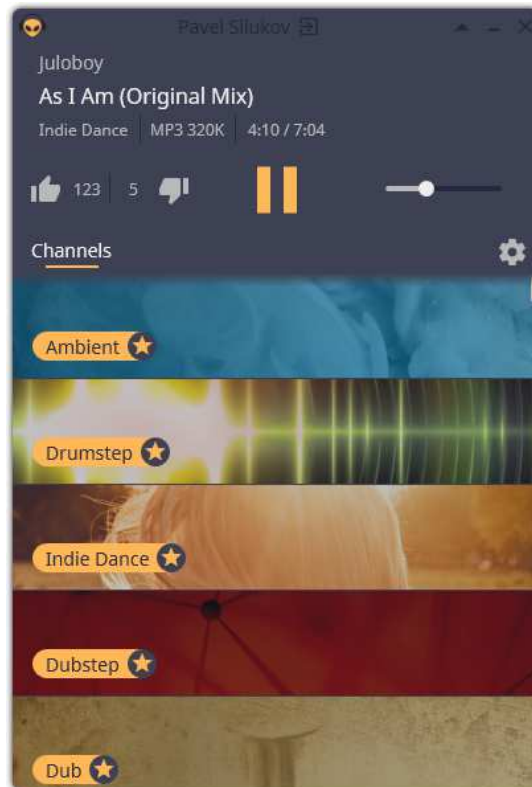


Fig. 1. The main form of the application

Next, you need to develop a website for distribution the program. The website should have the following functions:

- describe the features of the program to the user;
- give the possibility to download the latest version of the program;
- give the opportunity to connect with the developer via email.

Flask framework with Python was chosen to develop website. Homepage of the site is shown in Figure 2.

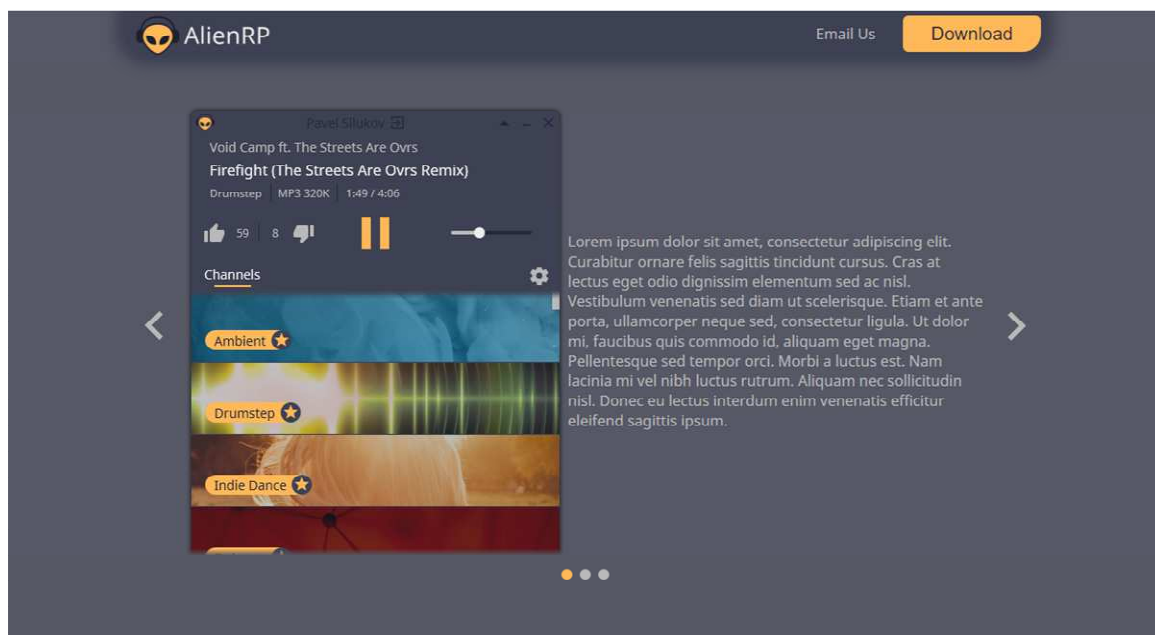


Fig. 2. Homepage of the site

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As a result, standalone application has been developed. It allows you to perform all the functions provided by online radio stations with the support for SoundCloud. In addition, the website has been developed for distribution of the application.

**REFERENCES**

1. Digitally Imported [Electronic resources]. – Mode of access: <http://www.di.fm/>. – Date of access: 30.01.2017.
2. ROCKRADIO [Electronic resources]. – Mode of access: <http://www.rockradio.com/>. – Date of access: 30.01.2017.
3. JAZZRADIO [Electronic resources]. – Mode of access: <http://www.jazzradio.com/>. – Date of access: 30.01.2017.
4. RadioTunes [Electronic resources]. – Mode of access: <http://www.radiotunes.com/>. – Date of access: 30.01.2017.
5. ClassicalRadio [Electronic resources]. – Mode of access: <http://www.classicalradio.com/http://www.di.fm/>. – Date of access: 30.01.2017.

UDC 004.054

**EVALUATION OF QUALITY WEB SITES FOR EXAMPLE INTERNET SHOP  
AND CORPORATE SITE USING A UNIVERSAL SCHEME OF TESTING****DIANA POPKOVA, OKSANA GOLUBEVA, TATYANA CHERNYAK**  
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*The complexity of the website usability evaluation of the quality has been considered. Basic functions of the websites, and also the elements which are subject to tests are selected. The universal scheme for automated testing of web sites on usability indicators has been represented.*

The assessment complexity of the web sites quality is in network users' variety of tastes and preferences. Nationality, geography, religion, accepted standards, subjective opinion: all this prevents from creating a universal scheme of process automation testing on usability indicators.

Developing the interfaces the term *usability* means general concept of convenience while using the software, logicity and simplicity in layout of controls [1]. Let's give the definition of this concept as a measure of quality of the user experience gained in case of interaction with web site.

Any website, whether it is the corporate website or an e-commerce shop, has certain tasks which can be divided into screens, each screen on units to subject units to testing.

A corporate website is the website - directory with the emphasis on the corporate style of the company [2]. The corporate website which is aimed at the successful development of the company includes the following elements: unique design, corporate style, management system website, call back, slide-show, location map, directory, mail.

Let's select basic functions for the corporate websites:

1. The main information about the company view.
2. Browsing the list of company's services.
3. Getting all possible contacts of the company.
4. Availability of service or product reviews\feedback [3].

An Internet shop – site trading in products by means of the Internet [4]. For successful functioning it must contain such sections as "About us", "The directory of goods", "Basket", "News", "Responses", "Contacts" and features in the form of unique design, management system, modules of a call back and slide-show, a component of online store.

The basic functions of the Internet shops:

1. Search for the right product.
2. Viewing the product.
3. Product purchase.
4. Sell screens (promotions, discounts, etc.) [5].

According to the listed functions and requirements certain pages are selected, for example, the purchase of the product or description of the company.

Having identified main pages, we will consider the blocks that will be tested. Data entry form when paying, a block with a description of competitive advantages, communication with social networks, menu, navigation, etc.

Let's consider basic elements which need to be tested: typographics, compatibility of colors, adaptivity to mobile screens, load time speed of the page, a semantic annotation (tel, mailto), existence of pictures in high resolution (in the description of goods).

As the tool for automation testing we will select WebDriver. It represents the browser driver that is the program library which doesn't have the user interface which allows other programs to interact with the browser, to control his behavior, to obtain data from the browser and to force the browser to execute different commands. WebDriver is suitable for several browsers was selected, has the specification for control of the browser, are a part a set of libraries in several programming languages [6].

Let's consider a usability element – ease of use. Auxiliary logic blocks are usually entered. For example, similar goods, button of back coupling, etc. These units simplify operation with web sites, but badly give in to test automation process.

Let's select the logic blocks (optional) that improve the quality:

- "Similar goods" (figure 1 point a).
- "Postpone on later" (figure 1 point b).
- The presence of "breadcrumbs" in the catalog (figure 1 point c).
- Callback button (figure 1 point e).

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- "Online consultant" (figure 1 point f).
- Possibility to compare products (figure 1 point g).
- Possibility to navigate quickly to the information on payment methods and delivery options (figure 1 point g).
- Possibility to leave feedback at the site, etc.

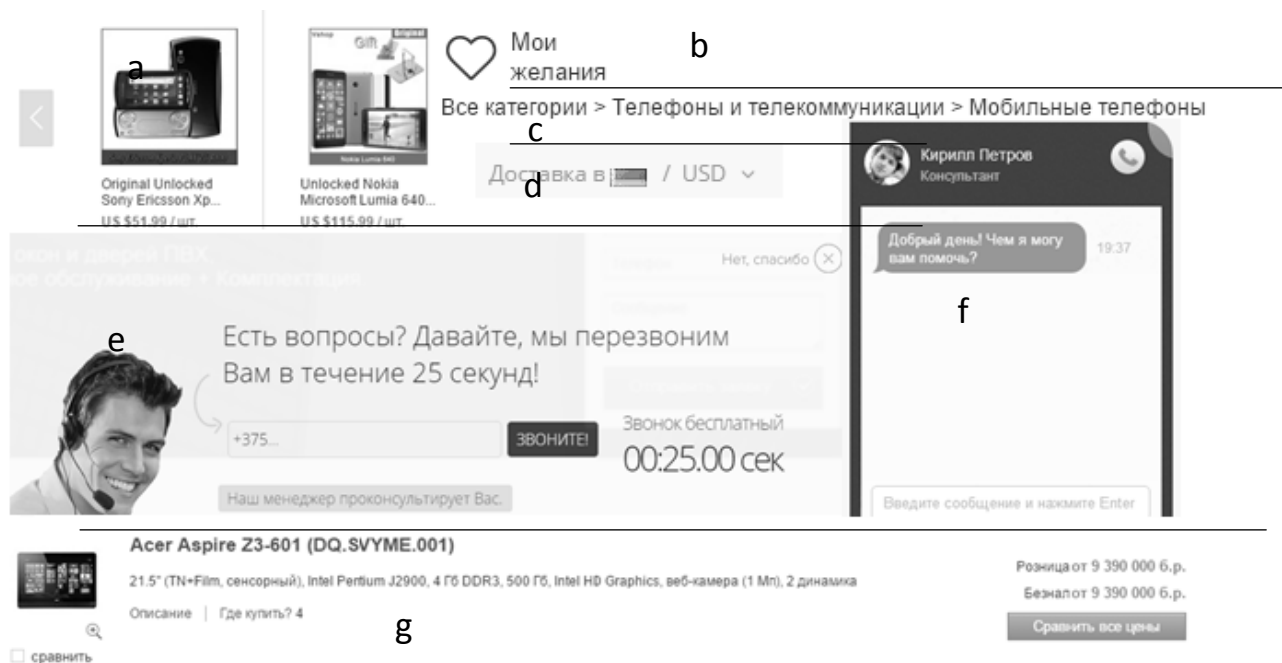


Fig. 1. Additional logic blocks

Let's develop the universal scheme of process automated testing. To improve the execution quality of tests we will turn on the main and additional units in process. In order to do that we need to involve the tester.

Let's divide the testing procedure into 3 stages.

1. Phase of manual testing of the functional pages of the site. The task is verification of presence of the main and auxiliary units. We will organize the execution process of testing in the form of installation of a tag about passing of test by the tester. The coefficient of quality of the first stage will be result.

2. Process of automated testing. WebDriver uses a script which contains a command set in a certain programming language for the browser. The tester develops a test set for each unit and transfers by parameter, input data in the form of the selector of the tested elements in WebDriver [7]. The coefficient of quality of the second stage will be the result.

3. Automated testing with of third-party means. The following assistants were selected: service of check contrast range (<http://www.checkmycolours.com/>), service of check readability of the text (<http://readable.com/>), service of check load time speed, adaptivity and convenience of the website (<https://developers.google.com/speed/>), service of check unique flowers and type sizes (<http://cssstats.com/>). At this stage we test the website entirely with attraction of third-party decisions. The coefficient quality of the third stage will be the result.

Thus, the provided scheme of assessment is the universal and more flexible. Further, taking into account three coefficients received earlier it is possible to calculate total assessment of quality.

The universal scheme of process automation testing, from the point of view a usability, looks as follows:

1. Receiving the application for testing.
2. Passing the request to the tester.
3. Marking the site on test pages, identification of blocks, preparing selectors.
4. Setting WebDriver tests for testing the selected blocks.
5. Manual testing of the main pages by the tester.
6. The tester starts the automated testing.
7. The tester starts testing with third-party tools.
8. Receive the detailed report with recommendations.
9. Transmission of the report to the user.

Basic functions of the websites are defined, units and elements for conducting testing are selected. Complexity of process of test automation on usability that web sites have no uniform structure and directivity. Each website has characteristic distinctive features only for it. The universal scheme automation of process testing of a usability sites is developed.

## REFERENCES

1. Юзабилити – Википедия [Электронный ресурс]. – Режим доступа: <http://ru.wikipedia.org/wiki/Юзабилити>. – Дата доступа: 20.04.2016.
2. Корпоративный сайт [Электронный ресурс]. – Режим доступа: <http://www.aliva.by/korporativnyj-sajt.html>. – Дата доступа: 29.04.2016.
3. Функции корпоративного сайта [Электронный ресурс]. – Режим доступа: <http://www.analzsaita.ru/funkcii-korporativnogo-sajta/>. – Дата доступа: 29.04.2016.
4. Интернет-магазин – Википедия [Электронный ресурс]. – Режим доступа: <https://ru.wikipedia.org/wiki/Интернет-магазин>. – Дата доступа: 29.04.2016.
5. Функции интернет-магазина [Электронный ресурс]. – Режим доступа: <http://www.itsait.com/statia/65-funkcii-i-magazina>. – Дата доступа: 29.04.2016.
6. Selenium WebDriver [Электронный ресурс]. – Режим доступа: <http://seleniumhq.org/projects/webdriver>. – Дата доступа: 03.05.2016.
7. Что такое Selenium WebDriver [Электронный ресурс]. – Режим доступа: <http://habrahabr.ru/post/152971/>. – Дата доступа: 03.05.2016.

## THE SOURCE OF CHARGED PARTICLE BEAMS FOR IMPLEMENTATION OF THE COMBINED EFFECTS ON MATERIALS

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*Presents some results of an experimental study of realization the combined ion-electron effects on the material surface using a single source.*

**Introduction.** Ion-plasma technologies are promising for the controlled modification of materials surface properties [1]. Moreover, for mechanical and corrosion modification of surface with ion beams are applied ions with energy typically lower than 1 keV and a flux density of about 1 mA/cm<sup>2</sup>. Since the electron beams with power density up to 10<sup>8</sup> W/m<sup>2</sup> in addition to the heat, can have modified (hardening) impact. The effectiveness of ion impact is dependent on the temperature of the modified material support which is not advisable around the product. The promising direction is submitted electron-beam assisting ion influence by plasma electron sources (PES) that can emit electrons and ions with the polarity of the accelerating voltage.

In this paper we present some results of an experimental study of realization the combined ion-electron effects on the material surface using a single PES.

**Results and discussion.** As an experimental PES used the structure shown in Figure 1. In this source the main gas ionization processes take place in the area bounded by external and internal cathodes 1 and 2 and the anode 3. The magnetic field is generated by using permanent magnets 6 disposed between the cathodes. The direction of the magnetic induction vector is a necessary condition for the structure. It should have a perpendicular direction relative to the working surface of the cathodes because this leads to restriction of the electrons mobility from the plasma to anode, resulting in increased plasma density in that area. Plasma penetrates the expander 9 through the upper hole in expander. The plasma-forming gas lets into the discharge structure through the channel 8 in the socket 5 and cathode 1. The construction of this gas-discharge structure provides the location of workpieces and the feeding mechanism in the volume of plasma expander 9 within the vacuum chamber which communicates with the discharge structure via the base flange 11. The use the additional electrode 7 located between the internal cathode and expander provides increased extraction efficiency and stability of the emission current [2].

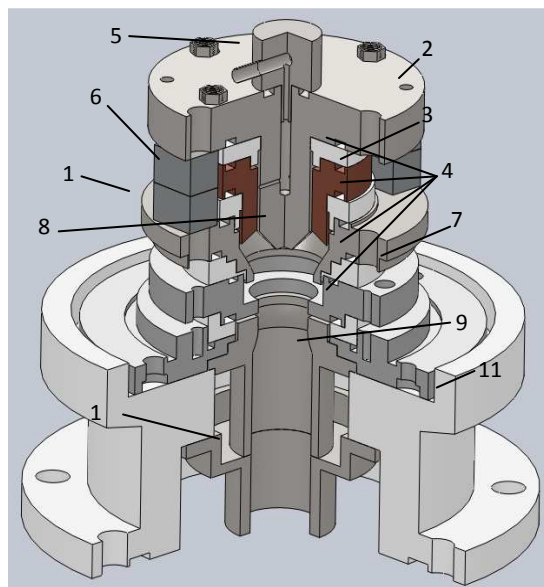


Fig. 1. Plasma electron source with crossed  $E \times H$  fields and the additional electrode: 1 – external cathode; 2 – internal cathode; 3 – anode; 4 – insulators; 5 – socket for inlet plasma-forming gas; 6 – permanent magnets; 7 – additional electrode; 8 – gas outlet; 9 – expander; 10 – accelerating electrode; 11 – flange

Besides the application of additional electrode, to control the source extraction efficiency is possible due to the magnitude of the magnetic field [2]. The presence of a magnetic field in the gas-discharge structure is due



to the conditions of the discharge formation and the order of 0.1 Tesla. However, since source structure elements (expander and accelerating electrode) is also made of a magnetic material (steel), the magnetic field goes from gap between cathodes, which provides additional mechanisms to improve emission efficiency in the expander by increasing the plasma concentration and the creation of conditions for the movement of electrons in the plasma along lines of the magnetic field in the area of emissions. Basic characteristics of the source and pictures of electron and ion beam are shown in Figures 2-3.

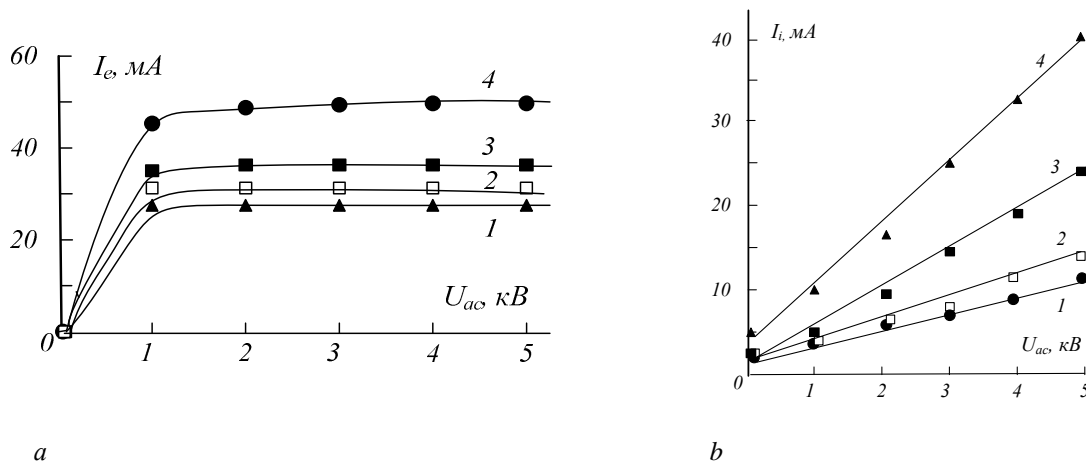


Fig. 2. Characteristics of electron extraction a) and ion extraction b) for different expander potentials: Expander potential: 1, 2 – anode, 3, 4– cathode; discharge current: 250 mA

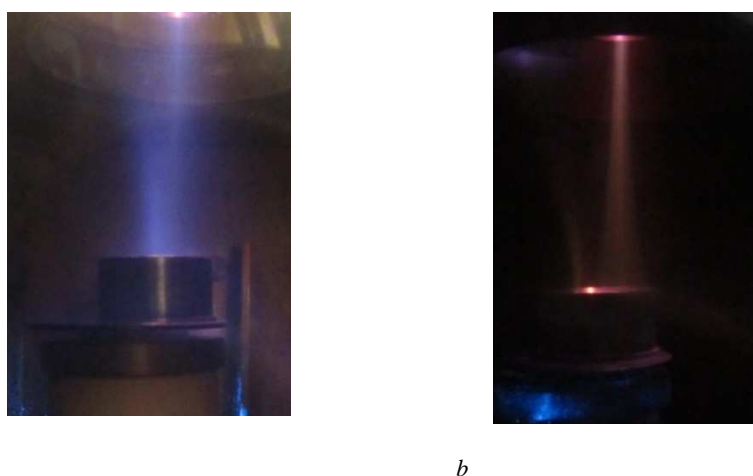


Fig. 3. Appearance of electron (a) and ion (b) beams if charged particles

To determine the most promising modes of operation provided gas-discharge construction were carried some experiments of the implementation of effects on the samples steel in various modes: electronic, ionic, combined. Research hardening process carried out by the example of tool steels (steel X12BM) used for the manufacture of die tooling. In this changed the current density in discharge structure and the temperature of the samples heating. The measurement results of the hardness (HV), and microhardness ( $H_{0,19}$ ) after different electron-ion treatment conditions shown in Table 1. Determination of HV is conducted on unimplanted the sample surface, and characterized the change in the hardness of steel during high temperature impact during ion implantation. Using the measurement  $H_{0,19}$  is estimated hardening implanted surface layers of steel.

Figure 4 is a graph of the distribution of microhardness depth of the modified layer. The implantation of nitrogen ions at 670 K leads to an increase in the depth of the modified layer to ~ 10-15 microns. The microhardness of the layer significantly increases and reaches a level  $H_{0,19} = 16000$  MPa.

Table 1 – The hardness HV and microhardness  $H_{0,19}$  X12BM treated steel before and after treatment with an electron-ion ( $j \approx 2 \text{ mA} \cdot \text{sm}^{-2}$ ) at different temperatures

X12BM steel					
Measured characteristics	Processing mode				
	The initial state	The temperature of electron-ion influence, K			
		620	670	720	770
Surface microhardness $H_{0,19}$ , МПа	6100	9600-10000	16000-16500	14000-15000	10500-11000
Steel hardness HV, МПа	5950	5800	5700	5300	4900

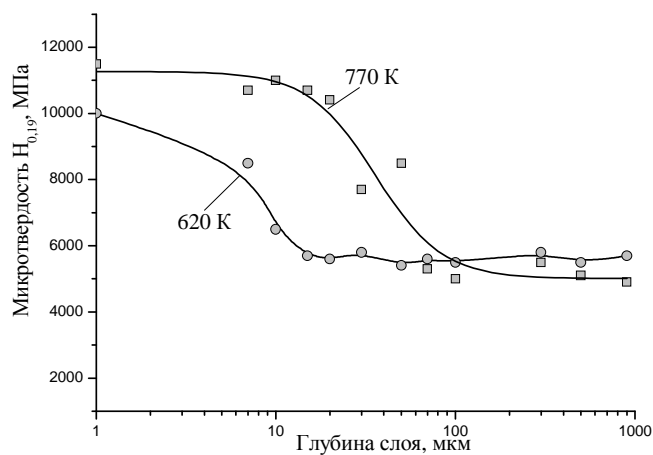


Fig. 4. Microhardness distribution in the depth of modified layers of steel X12BM

**Conclusion.** These results demonstrate the possibility of alternate electron and ion extraction from the gas discharge plasma and the combined implementation of the ion-electron impact onto the material surface using a single PES with parameters sufficient for a number of surface modification techniques.

## REFERENCES

1. Плазменные эмиссионные системы с ненакаливаемыми катодами для ионно-плазменных технологий / В.Т. Барченко [и др.] ; под общ. ред. В.Т. Барченко – СПб. : Изд-во СПбГЭТУ «ЛЭТИ», 2011. – 220 с.
2. Груздев, В.А. Плазменный ионно-электронный источник / В.Г. Залесский, П.Н. Солдатенко // Вестн. Полоцкого государственного университета. Сер. С, Фундаментальные науки. – 2013. – № 4. – С. 63–68.

UDC 537.533

## HIGH-PERVEANCE CHARGED PARTICLES SOURCE FOR IMPLEMENTATION OF E-BEAM TECHNOLOGY

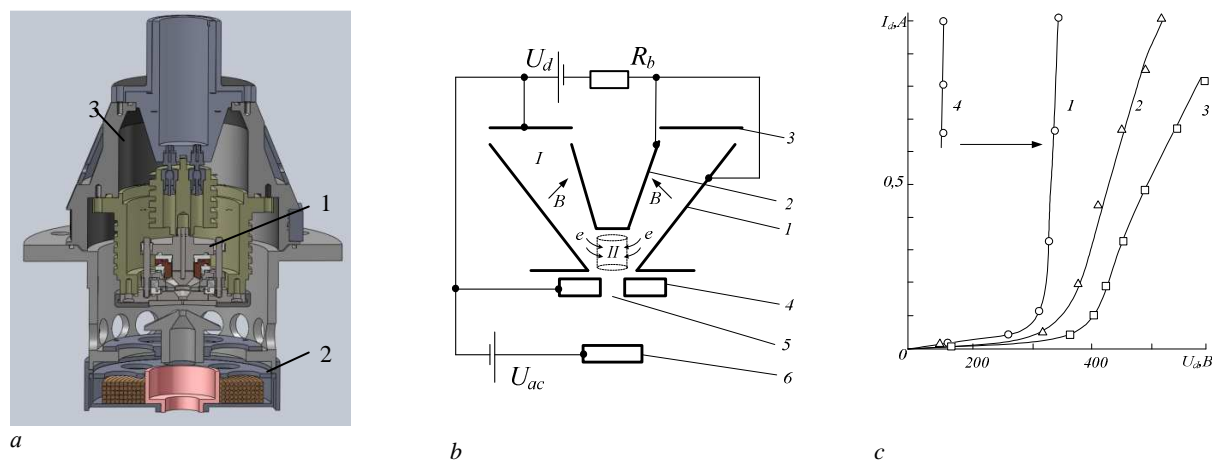
PAVEL SOLDATENKO, VITALY ZALESKI  
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*Presented a number of electron-beam technologies, it is possible to implement by high-perveanced plasma source of charged particles. A discharge structure of high-perveance source that can form electron and ion beams, with parameters satisfying presented technologies.*

**Introduction.** By now the electron-beam technologies found quite widely used in various industries. This has stimulated the development of electron sources, implementing a wide range of technological parameters that differ in power, current density, operating modes, gas-dynamic conditions. The variety of requirements to technological electron beam cannot be realized in the sources of the one type. The most widely used are three main types of electron beam sources – electron source with thermocathode, sources based on high-voltage glow discharge, and plasma electron sources [1]. This paper presents the construction of high-perveance plasma source of charged particles based on a discharge in crossed  $E \times H$  fields, to implement a wide range of electron beam technologies.

Fig. 1 shows the construction (a) and electrode structure (b) of plasma electron source that implements principles of the emission current due to creating conditions for the switching without axial plasma inhomogeneity restricted in extraction efficiency over the known electron sources based on the hollow cathode [1].

The discharge is excited in the space between the cathodes 1 and 2 (a) (region I, in Fig. 1, b). The plasma-forming gas is fed into the space between cathodes and the pressure differential, provided by geometry of the emission channel. The emerging in the discharge between the cathode plasma diffuses into the region of the emission channel. It is promoted by additional electrodes 3 and 4 (with anode or intermediate potential [2]), which serve as the emitter electrode (see. Fig.). Extracting electrons carried out of the emission channel in the emitter electrode with anode (or close to it) potential. The presence of a magnetic field almost all the volume of the discharge structure facilitates to efficient gas ionization. In this electrode structure excludes the initiation stage of the discharge, which is reflected in the form of current-voltage characteristics (see. Fig. 1, c).

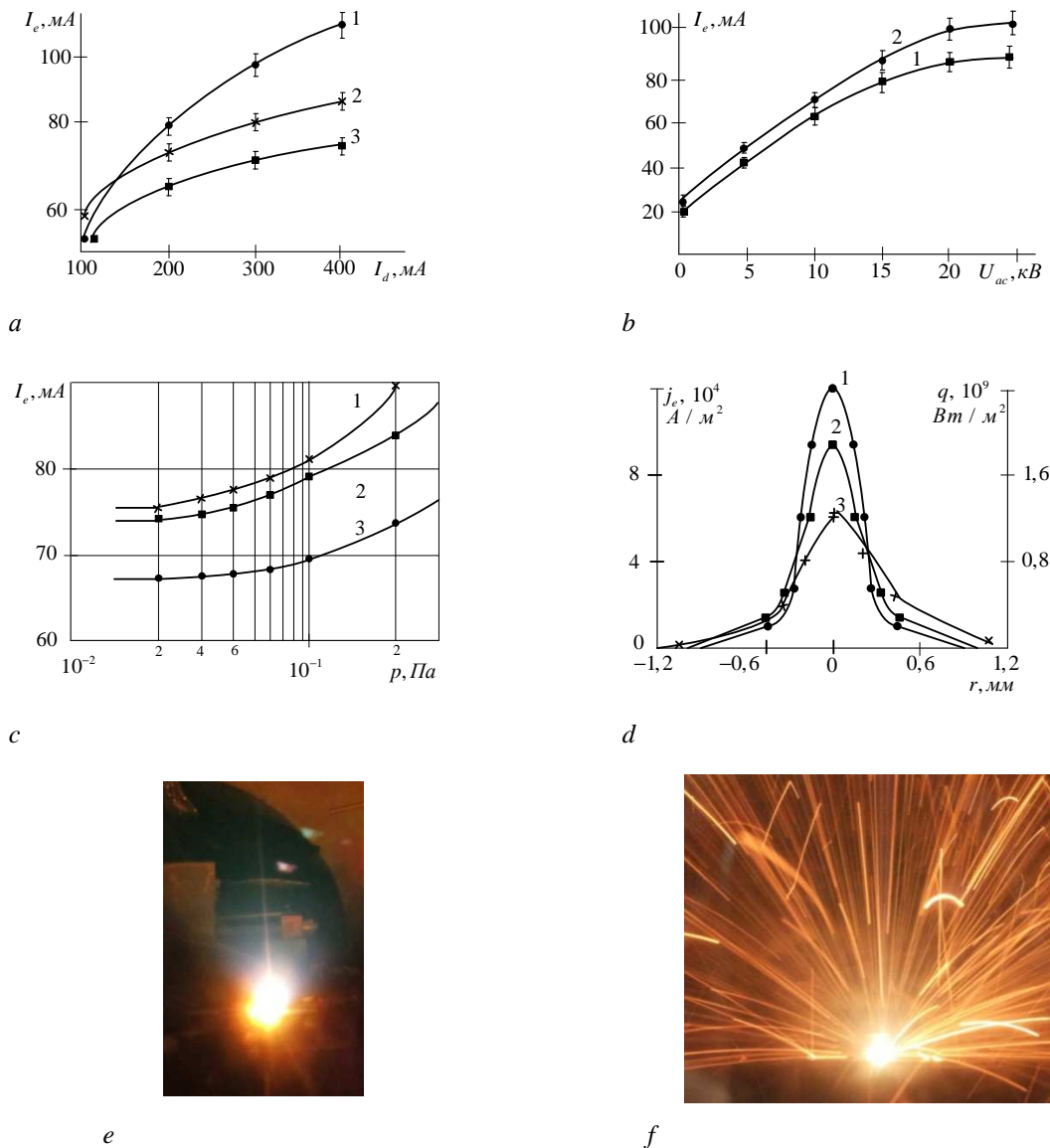


a – 1 – plasma source; 2 – magnetic lense; 3 – case  
b – 1 – outlet cathode; 2 – inlet cathode; 3 – anode; 4 – emitter electrode;  
5 – эмиссионный канал; 6 – ускоряющий электрод;  
 $U_d$  – discharge voltage;  $U_{ac}$  – accelerating voltage;  $R_b$  – ballast  
resistance;  $B$  – magnetic induction  
c – gas puffing,  $\text{mPa} \cdot \text{m}^3/\text{sec}$ : 1 – 2,8; 2, 4 – 1,7; 3 – 1,25

Fig. 1 – Plasma electron source:  
a – construction; b – electrode structure; c – current-voltage characteristics

Fig. 2 shows the typical characteristics of the source. The main advantage of this source is the weak dependence of the emission current from the pressure up to 0.3 Pa (fig. 2, c). This feature is implemented as due to

the special electrode configuration of the discharge chamber, and due to the additional self-stabilization of the electron beam parameters by inclusion resistance emitter electrode chain with respect to anode [2]. Figure 2, d, are presented current density distribution and power density of the electronic starting over the cross section. Analysis of distributions indicates that the maximum power densities  $q_{max} \approx 10^9 \text{ W/m}^2$  and the effective diameter of the electron beam (defined at  $0.1 q_{max}$ ) corresponds to typical values of the power density of the electron beams used for electron beam welding [3]. This fact and appearance of and the gas characteristics show the possibility of using this source for welding, including materials with high gas separation during heat treatment [3].



a – emission characteristic: accelerating voltage 18 kV; gas puffing  $1,5 \text{ mPa}\cdot\text{m}^3/\text{sec}$ ; pressure, Pa: 1, 2 – 0,04; 3 – 0,1;  $R_{CM2}$ , kOhm: 1 – 0; 2, 3 – 1;   
 b – current-voltage characteristic: gas puffing  $1,5 \text{ mPa}\cdot\text{m}^3/\text{sec}$ ; discharge current 0,2 A; gas pressure, Pa: 1 – 0,04; 2 – 0,1;   
 c – gas characteristic: accelerating voltage 16 kV; gas puffing  $1,5 \text{ mPa}\cdot\text{m}^3/\text{sec}$ ;  $R_{CM2}$ , kOhm: 1 – 0; 2 – 0,5; 3 – 1;

d – current density distribution and power density distribution over the beam cross-section: accelerating voltage 18 kV; gas puffing  $1,5 \text{ mPa}\cdot\text{m}^3/\text{sec}$ ; current discharge 0,2 A; emission current 0,08 A;  $R_{CM2}$ , kOhm: 1 – 1; 2 – 0,5; 3 – 0

Fig.2 – The main characteristics of plasma electron source (a, b, c, d) and beam appearance in process of welding different materials (e, f)

### Applications

Listed above characteristics suggest the possibility application presented the plasma source for the implementation of the "classical" welding technology. At the same time the traditional application of electron beam welding (EBW) usually involves getting deep keyhole penetration to great depths (up to hundreds of millimeters). However, there are many variants of products that are not necessarily getting keyhole welds, requiring a very high quality. It is a product with high quality and reliability of welded joints, as well as the details of the high-purity and high level metals. Here are some examples of possible use of presented electron source.

#### 1. An electron beam melting of highly active metals

One of the traditional electron beam technology is remelting of highly active metals, which are necessary to conduct in a vacuum. When this beam load factor reaches 90% [1]. When metals and alloys are remelting dirt and metal fumes removed out of them get into the EB gun, in the case of an incandescent cathodes they quickly fail. Practice has shown that for metallurgical processes associated with intense evaporation is advisable to hold guns with plasma source of electrons.

Because highly technological waste metals (zirconium, titanium, niobium, etc.) by remelting can obtain homogeneous casting structure, which are suitable for reuse, such as the target cathodes. As a material for the EB remelting zirconium turnings ( $T_m = 1855^\circ\text{C}$ ) and titanium ( $T_m = 1668^\circ\text{C}$ ) are used. Practiced manufacturing methods for creating new and regeneration of used cathodes by EB remelting - targets for magnetron and vacuum arc sputtering systems from pure Ti, Zr, Hf, Ti and Zr alloys with Cr, Al, B, Mo, etc., from scrap and turnings.

#### 2. Management of spent nuclear fuel (SNF)

Analysis of available data on the shelving structures for wet and containers for dry near-station storage of spent nuclear fuel says that for these purposes lengthy tube from stainless steel of thickness 4.5-5.0 mm with high boron content. Tubes are manufactured by means of electron-beam or laser welding. Using shelves with packed arrangement pitch pipe allows to place and stored safely in pools a considerable amount of spent nuclear fuel.

#### 3. Create a high-superconducting resonators

Work is underway to create a high-superconducting niobium RF 1.3 GHz cavities by electron-beam welding (Fig. 3, *a*). Microwave resonators from very pure niobium for charged particle accelerators can be made only with the use of electron-beam welding. EBW process ensures the preservation of the original metal high-purity in weld joint, as well as the required geometry of welded joints: full penetration weld with  $e_1$  and  $e_2$  width of not less than 4 mm (Figure 3, *b*).

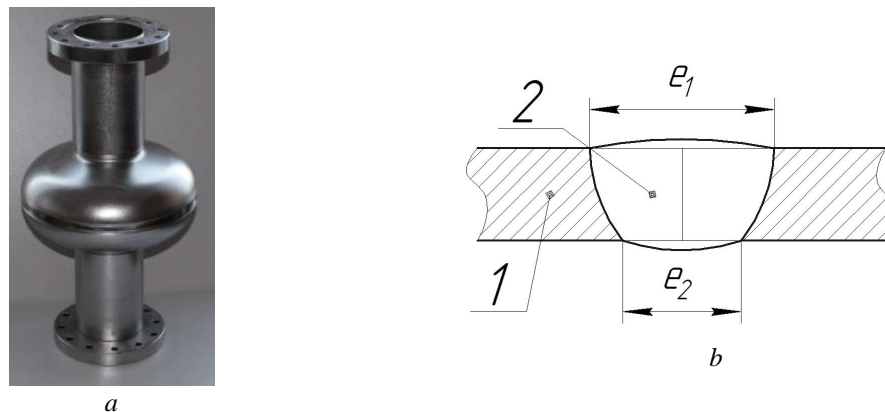


Fig. 3. 1,3 GHz single-cell niobium cavity microwave (*a*) and studied the geometry of the weld (*b*);  
1 – the main metal; 2 – weld joint

Manufacturing technology of microwave resonators are used for most large-scale construction and planned currently charged particle accelerators, including half-cell cavity stamping, welding them together, as well as other design elements. The most responsible step is the welding of the two half-cells at the equator. Upon receiving the welded joints of the microwave resonators high demands are made to the geometry of weld joints and metal chemical purity of the compounds, which shall not be less than the starting niobium. The latter is the key to saving the superconducting properties of niobium high purity is achieved by etching welded edges before welding in the acid mixture, with compliance of purity during storage and transportation of parts before welding.

Obtaining the required geometry of the weld when welding components Nb microwave resonators is not an easy task and requires a detailed study of the relationship between the EBW regime parameters and welds characteristics. However, there are publications showing about obtaining of defects in welding equator half-cells, including the production of cavities in series with exhaust welding conditions [4].

Presented plasma source has characteristics that allow to realize a wide range Electron Beam technology, makes it a quite universal technological equipment.

#### REFERENCES

1. Окс, Е.М. Источники электронов с плазменным катодом: физика, техника, применения / Е.М. Окс – Томск : Изд-во НТЛ, 2005. – 216 с.
2. Источники электронов с плазменным эмиттером / Ю.Е. Крейнделю [и др.] ; под общ. ред. Ю.Е. Крейнделю. – Новосибирск : Наука, 1983. – 120 с.
3. Плазменный эмиттер электронов с сеточной стабилизацией. Ч. I / А.В. Жаринов [и др.] // ЖТФ. – 1986. – Т. 56, Вып. 1. – С. 66 – 70.
4. Разработка и применение источников интенсивных электронных пучков: сб. науч. тр. / науч. ред. Г.А. Месяц. – Новосибирск : Наука, 1976. – 191 с.

UDC 519.2

## INDEPENDENT RE-TESTING AS THE ASYMPTOTIC GAUSSIAN RANDOM PROCESS

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*Independent re-tests are considered as a random process with discrete time. The asymptotic behavior of the process through the method of moments is set and the contribution asymmetries and excesses of arbitrary orders in the deviation of Bernoulli distribution from the asymptotic formula, appearing in the local theorem of Laplace is defined. It is shown that the latter cannot be applied to calculate the number success probabilities which are far from their most probable values.*

The probability  $m$  of progress in  $n$  independent tests is defined by Bernoulli's formula [1]

$$P(n, m) = C_n^m p^m (1-p)^{n-m}, \quad (1)$$

in which  $C_n^m$  - numbers of combinations,  $p$  - probability of success in one experience. For larger  $n$  calculation  $C_n^m$  becomes a problem. In particular MathCAD cannot work with the numbers exceeding  $10^{307}$ . To bypass this difficulty the limiting theorems of Laplace are used which, however, not always provide the required accuracy at all and are not applicable for  $m$  far from the most probable values.

At the same time, if  $n$  grows, Bernoulli's scheme can be considered as a casual process with discrete time. At the same time it is  $m$  convenient to investigate evolution of the distribution law by method of the moments, realized in [2-5] for the description of dynamics of a sorption and diffusion. Thus, it is possible not only to find out a process asymptotic, but also to define the amendments to it caused by asymmetries and excesses of the distribution law. This publication is devoted to the solution of these tasks.

It is known that all information on the distribution law  $m$  contains in the initial moments

$$v_k(n) = \sum_{m=0}^n m^k \cdot P(n, m). \quad (k = 0, 1, \dots) \quad (2)$$

In particular,

$$v_1(n) = np, \quad \sigma(n)^2 = v_2(n) - v_1(n)^2 = np(1-p) \quad (3)$$

- respectively the expectation and dispersion  $m$ .

To define an asymptotic of process it is necessary to investigate asymmetries and excesses  $m$ :

$$A_{2k-1}(n) = \frac{\mu_{2k-1}(n)}{\sigma(n)^{2k-1}}, \quad E_{2k}(n) = \frac{\mu_{2k}(n)}{\sigma(n)^{2k}} - \omega(k), \quad (k = 2, 3, \dots) \quad (4)$$

where

$$\omega(k) = \int_{-\infty}^{\infty} x^{2k} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx = 1 \cdot 3 \cdot \dots \cdot (2k-1), \quad (5)$$

$$\mu_k(n) = \sum_{m=0}^n (m - v_1(n))^k \cdot P(n, m) \quad (6)$$

- central momen. It is convenient to find them by means of characteristic function:

$$\theta(\tau, n) = \sum_{m=0}^n e^{i\tau(m-np)} \cdot P(n, m) = (p e^{i\tau p} + q e^{-i\tau p})^n, \quad (7)$$

$$\mu_k(n) = i^{-k} \theta^{(k)}(0, n), \quad (8)$$

where  $i$  - imaginary unit,  $(k)$  - derivative order on  $\tau$ .

From (4) – (8) follows, that

$$A_{2k-1}(n, p) = \sum_{l=1}^{k-1} \frac{f_{2l-1, 2k-1}(p)}{\sigma(n)^{2l-1}}, \quad E_{2k}(n, p) = \sum_{l=1}^{k-1} \frac{f_{2l, 2k}(p)}{\sigma(n)^{2l}}, \quad (9)$$

where

$$f_{1,3}(p) = 1 - 2p, \quad f_{2,4}(p) = 6p^2 - 6p + 1, \quad f_{1,5}(p) = 10(1 - 2p), \dots \quad (10)$$

- independent from  $n$  decomposition values. It agrees (3), (9) at  $n \rightarrow \infty$  asymmetry and an excess disappear that is characteristic of the asymptotic Gaussian process

$$P(n, m) \xrightarrow{n \rightarrow \infty} P_0(n, m) = \frac{1}{\sqrt{2\pi}\sigma(n)} e^{-\frac{x(n,m)^2}{2}}, \quad x(n, m) = \frac{m - np}{\sigma(n)}. \quad (11)$$

Let's find out a contribution in

$$\Delta(n, m) = P(n, m) - P_0(n, m) \quad (12)$$

asymmetries and excesses of the random orders. Taking into account (9) we will write down

$$\Delta(n, m) = P_0(n, m) \sum_{l=1}^{\infty} \frac{\varphi_l(x(n, m))}{\sigma(n)^l} = \Delta_1(n, m) + \Delta_2(n, m) + \dots, \quad (13)$$

where senior degree of polynomials

$$\varphi_{2l-1}(x) = \sum_{i=0}^l x^{2i+1} C_{2l-1, 2i+1}, \quad \varphi_{2l}(x) = \sum_{i=0}^{l+1} x^{2i} C_{2l, 2i} \quad (l = 1, 2, \dots) \quad (14)$$

is equal to quantity linearly of the independent equations received by means of following from (6), (11) – (13) identities

$$\frac{\mu_k(n)}{\sigma(n)^k} = \sum_{m=0}^n x(n, m)^k \cdot P_0(n, m) \left( 1 + \sum_{l=1}^{\infty} \frac{\varphi_l(x(n, m))}{\sigma(n)^l} \right), \quad (k = 0, 1, \dots) \quad (15)$$

for calculation appearing in (14) coefficients  $C_{l,i}$ . At  $n \rightarrow \infty$  the sum on  $m$  in (15) becomes integral

$$\Delta x(n, m) = x(n, m+1) - x(n, m) = \sigma(n)^{-1} \xrightarrow{n \rightarrow \infty} 0,$$

$$x(n, 0) = -\sqrt{np/q} \xrightarrow{n \rightarrow \infty} -\infty \quad x(n, n) = \sqrt{nq/p} \xrightarrow{n \rightarrow \infty} \infty,$$

therefore

$$\frac{\mu_k(n)}{\sigma(n)^k} \xrightarrow{n \rightarrow \infty} \int_{-\infty}^{\infty} x^k \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \left( 1 + \sum_{l=1}^{\infty} \frac{\varphi_l(x)}{\sigma(n)^l} \right) dx. \quad (16)$$

The equations relatively  $C_{l,i}$  turn out equating in (16) expressions at identical degrees  $\sigma(n)$ . As the integral from an odd function is equal in the symmetric limits to zero, even and odd  $k$  will be considered separately

$$\frac{\mu_{2k+1}(n)}{\sigma(n)^{2k+1}} \xrightarrow{n \rightarrow \infty} \int_{-\infty}^{\infty} x^{2k+1} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \sum_{l=1}^{\infty} \frac{\varphi_{2l-1}(x)}{\sigma(n)^{2l-1}} dx, \quad (17)$$

$$\frac{\mu_{2k}(n)}{\sigma(n)^{2k}} \xrightarrow{n \rightarrow \infty} \int_{-\infty}^{\infty} x^{2k} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \left( 1 + \sum_{l=1}^{\infty} \frac{\varphi_{2l}(x)}{\sigma(n)^{2l}} \right) dx. \quad (18)$$

From (17) taking into account (5), (14) follows

$$\frac{\mu_{2k+1}(n)}{\sigma(n)^{2k+1}} \xrightarrow{n \rightarrow \infty} \sum_{l=1}^{\infty} \frac{1}{\sigma^{2l-1}} \sum_{i=0}^l C_{2l-1, 2i+1} \omega(k+i+1), \quad (19)$$

Then



$$C_{2l-1,2i+1} = \frac{f_{2l-1,2l+1}(p)}{\rho(l)} \cdot \frac{(-1)^{i+l} C_l^i}{\omega(i+1)}, \quad \begin{pmatrix} l = 1, 2, \dots \\ i = 0, 1, \dots, l. \end{pmatrix} \quad (20)$$

where

$$\rho(l) = 2 \cdot 4 \cdot \dots \cdot 2l \quad (21)$$

- works of even numbers,  $C_l^i$  - numbers of combinations.

Let's similarly consider in (16) even  $k$ . From (18) taking into account (5), (14) follows

$$\frac{\mu_{2k}(n)}{\sigma(n)^{2k}} - \omega(k) \xrightarrow{n \rightarrow \infty} \sum_{l=1}^{\infty} \frac{1}{\sigma^{2l}} \sum_{i=0}^{l+1} C_{2l,2i} \omega(k+i). \quad (22)$$

Then for even polynoms

$$C_{2l,2i} = \frac{f_{2l,2(l+1)}(p)}{\rho(l+1)} \cdot \frac{(-1)^{i+l+1} C_{l+1}^i}{\omega(i)}. \quad \begin{pmatrix} l = 1, 2, \dots \\ i = 0, 1, \dots, l+1. \end{pmatrix} \quad (23)$$

Thus, formulas (3), (11) – (14), (20), (21), (23) allow to replace expression, which is hard to calculate at larger  $n$ , for probability of achievements in Bernoulli's scheme. Results of the calculations executed by them in a graphic form are presented in fig. 1. It is visible that even for  $n = 5$  the error of a zero approximation (fig. 1a) almost completely disappears (fig. 1b) at the accounting of asymmetry and an excess of minimum orders ( $P_2(n, m) = P_0(n, m) + \Delta_1(n, m) + \Delta_2(n, m)$  see (12), (13)).

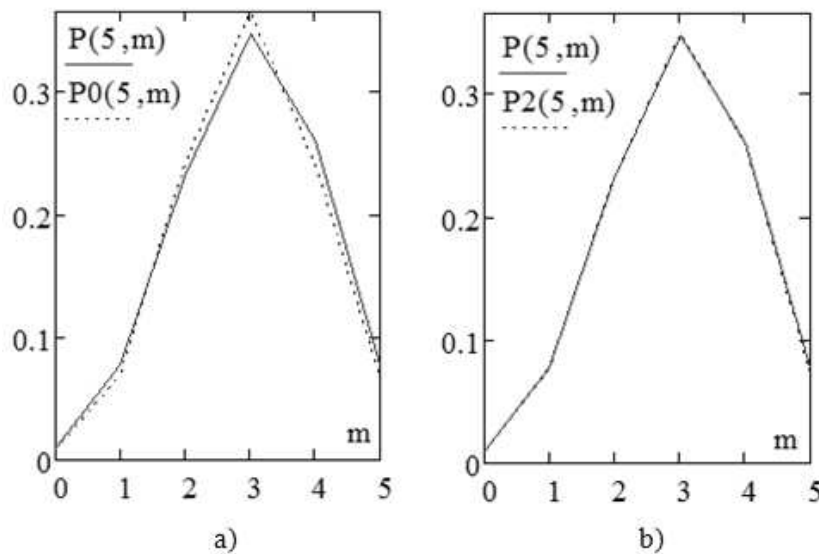


Fig. 1. Influence of asymmetry and excess of minimum orders on probability of  $m$  progress in 5 experiences of Bernoulli's scheme with  $p = 0.6$

According to (13), (14) it is possible to use the local theorem of Laplace (answering to a zero approximation in decomposition (12), (13)), if  $|x(n, m)|^{m+2} = o(\sigma(n)^n)$ . In particular, for  $m$  progress, far from the most probable number,  $|x(n, m)|$  at increase in number of experiences grows in proportion  $\sqrt{n}$  (see (3), (11)) that leads to a divergence of decomposition (13) on the inverse degrees  $\sigma(n)$ . As a result, the relative accuracy of the asymptotic formula (11) appearing in the local theorem of Laplace beyond all bounds increases (fig. 2) and it is impossible to use it that, however, not always makes a reservation [1].

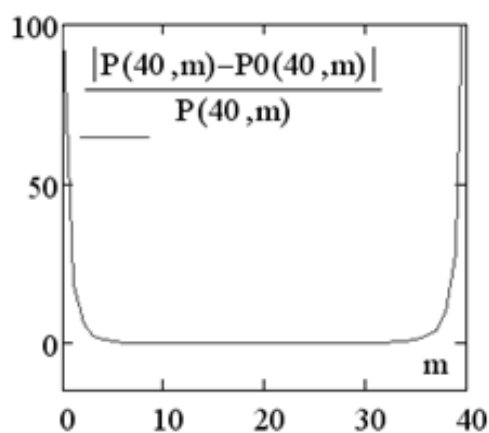


Fig. 2. The relative accuracy of a zero approximation for  $p = 0.6$

Thus, it is offered to consider independent retests as casual process with discrete time established. The asymptotic of process through the method of the moments was established and the contribution of asymmetries and excesses of the random orders to a deviation of distribution of Bernoulli from the asymptotic formula appearing in the local theorem of Laplace was defined. It is shown that the latter cannot be applied for the calculation of the number success probabilities which are far from their most probable values.

#### REFERENCES

1. Гмурман, В.Е. Руководство к решению задач по теории вероятностей и математической статистике / В.Е. Гмурман. – М. : Высш. шк., 1975. –334 с.
2. Теоретико-вероятностный подход к решению уравнения диффузии / С.Г. Ехилевский [и др.] // Вестник Полоцкого государственного университета. Сер. С, Фундаментальные науки. – 2015. – N 4. – С. 94–105.
3. Ехилевский, С.Г. Влияние асимметрии высших порядков на динамику сорбции вредной примеси / С.Г. Ехилевский, О.Н. Мурашкевич // Вестник Полоцкого государственного университета. Серия В, Промышленность. Прикладные науки. – 2014.–№ 3.
4. Ехилевский, С.Г. Теоретико-вероятностный подход к моделированию динамической сорбционной активности / С.Г. Ехилевский, О.В. Голубева, Д.В. Пяткин // Вестник Полоцкого государственного университета. Серия В, Промышленность. Прикладные науки. – 2013. – № 11. – С. 144–151.
5. Ехилевский, С.Г. Метод моментов и динамика сорбционной активности при малых временах / С.Г. Ехилевский, О.В. Голубева, С.А. Ольшаников // Вестник Полоцкого государственного университета. Серия В, Промышленность. Прикладные науки. – 2013. – № 3. – С. 150–156.

UDC 004.9+004.056

**INTEGRATED WINDOWS AUTHENTICATION IN WEB APPLICATIONS****DMITRY SAVCHENKO, OKSANA GOLUBEVA, TATYANA CHERNYAK**  
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*The paper discusses a method of transparent user authentication within a web application running in an internal network organized into a domain by means of Microsoft Active Directory.*

A web application typically needs to function differently for different users and to process specific data for every user. This requires that the web application is aware of which user interacts with it and this knowledge should be confirmed to be correct. This leads to the requirement of a user to authenticate before starting to interact with the application. A typical approach for this is so that at first the user should register in the application, thus, creating personal credentials, such as user name and password, and then as the first step of every interaction session the user is required to prove his or her identity by providing the credentials via a web form. An alternative approach would be to rely on a trusted third party to provide user authentication. This can be achieved by leveraging OAuth 2.0 protocol [1, 2] to obtain access token to the third-party service REST API [3] and then making subsequent API request to obtain some user identifier and in this way authenticate the user. This approach requires the user to be registered and authenticated within the third-party web service.

The two authentication approaches described above are mostly suitable and, thus, widely used by global web applications available worldwide in the internet. However, a lot of web services can be installed on private servers and used in internal networks of some organizations. These can be privately developed applications and/or applications that process business-sensitive information that should not be let outside the internal network. While methods of web form authentication and third-party authentication can still be used by internal web applications, they are typically redundant in such cases. A user has already been authenticated within organization network when logging in to his or her computer (most often Microsoft Active Directory [4] is used to organize network domain) and the best solution is for the internal web application to transparently authenticate such a user without asking him or her for credentials or performing communication with a third party.

The Generic Security Service Application Program Interface (GSS-API) is a security services standard, that defines a generic interface for callers to make requests to underlying security services [5]. The definitive concept of GSS-API usage is the exchange of opaque messages (they are called "tokens") which hide the implementation detail from the higher-level application. The client and server sides of the application are written to convey the tokens given to them by their respective GSS-API implementations. GSS-API tokens can usually travel over an insecure network as the mechanisms provide inherent message security. After the exchange of some number of tokens, the GSS-API implementations at both ends inform their local application that a security context has been established.

The Microsoft Security Support Provider Interface (SSPI) is the well-defined common API for obtaining integrated security services for authentication, message integrity, message privacy, and security quality of service for any distributed application protocol [6]. SSPI partially confirms with GSS-API interface while having some Windows-specific extensions. A single implementation of SSPI is called a security service package. The SSPI allows an application to use any of the available security packages on a system without changing the interface to use security services. Microsoft Windows provides several security packages, NTLM (NT LAN Manager) and more progressive Kerberos are among them. A higher level package Negotiate is also provided: it does not define different security service implementation, but serves as a decorator for NTLM and Kerberos instead. Negotiate package allows communication parties to select between Kerberos and NTLM depending on which of these two is supported by both parties, considering Kerberos as a preferred one.

The Hypertext Transfer Protocol (HTTP) provides a simple and generic challenge-response authentication mechanism which may be used by a server to challenge a client request and by a client to provide authentication information [7]. This mechanism allows various specific implementations that leverage different authentication techniques. Authentication information challenging is done by a server with the *WWW-Authenticate* header and response code 401 (unauthorized). Providing authentication information by a client is achieved with the *Authorization* header.

The GSS-API standard, SSPI interface and its NTLM, Kerberos and Negotiate implementations alongside with HTTP authentication mechanism together provide means for implementing integrated windows authentication for web applications that operate within a Windows network domain. This can be achieved by leveraging HTTP Negotiate Authentication scheme [8]. This scheme defines authentication protocol in terms of GSS-API and can be mapped to the terms of the SSPI Negotiate package implementation. According to this schema, the following protocol of data exchange is used by client and server application. When the server receives a request

for a resource that is access-protected and an acceptable Authorization header has not been sent, the server responds with a 401 (unauthorized) status code and sends a WWW-Authenticate header denoting "Negotiate" as a required authentication schema. No gss-api data is provided in the header of the initial response. Upon receipt of the response containing WWW-Authenticate header, the client is expected to retry the previous request, sending Authorization header along with it. The header should denote "Negotiate" as a used authentication schema along with base64-encoded [9] gss-api data. The gss-api data should contain security context token, obtained from the client system GSS-API implementation (SSPI Negotiate security package). The server then uses its system GSS-API implementation to validate security context token received and, thus, authenticate the user. The server then returns the requested resource with 200 (success) status code; WWW-Authenticate header may be also sent containing server security context token if mutual authentication is required. Depending on GSS-API implementation there may be multiple legs of security token exchange between the client and the server.

The following can be seen as an example of negotiate authentication.

The client requests an access-protected resource from the server via HTTP GET method request:

*Client: GET example/path/document.html*

Since no Authorization header is sent by the client, the server should respond with the request for authentication:

*Server: HTTP/1.1 401 Unauthorized*

*Server: WWW-Authenticate: Negotiate*

The client then is required to obtain user credentials using *GSS\_Init\_sec\_context* call. In terms of SSPI the client should first call *AcquireCredentialsHandle* function to obtain Negotiate security package credentials handle (*client credentials handle*), and then call *InitializeSecurityContext* passing client credentials handle as an argument and receiving first part of the security context data. This context is then base64-encoded and sent to the server:

*Client: GET example/path/document.html*

*Client: Authorization: Negotiate Y2xpZW50LW5lZ290aWF0==*

Upon receiving the request, the server should validate the client security context data using *GSS\_Accept\_sec\_context* call. In terms of SSPI it should as well first obtain Negotiate security package credentials handle (*server credentials handle*) by calling *AcquireCredentialsHandle* and then call *AcceptSecurityContext* passing server credentials handle and the client security context data as arguments. The *AcceptSecurityContext* function returns the status (whether the passed client security context is valid, invalid or not complete) and the server security context data that should be passed to the client in WWW-Authenticate header. If the client security context is incomplete, the server should return 401 (unauthorized) header along with base64-encoded server security context:

*Server: HTTP/1.1 401 Unauthorized*

*Server: WWW-Authenticate: Negotiate c2VydmVyLWVbnRleHQ=*

The client should decode received server security context data and pass it to *GSS\_Init\_sec\_context* call. In terms of SSPI the data along with previously acquired client credentials handle is passed to *InitializeSecurityContext* call. The second part of client security context received from the function call is then base64-encoded and sent to the server:

*Client: GET example/path/document.html*

*Client: Authorization: Negotiate c2Vjb25kLWVudC1jb250ZXh0*

This cycle continues until the security context is complete. When the return value from the *GSS\_accept\_sec\_context* function (*AcceptSecurityContext* in terms of SSPI) on the server indicates that the security context is complete, it may supply final authentication data to be returned to the client. If the server has more gss-api data to send to the client to complete the context, it is to be carried in a WWW-Authenticate header with the final response containing the HTTP body. So finally, the server returns 200 (success) status code along with the final part of the gss-api data and the requested document body:

*Server: HTTP/1.1 200 Success*

*Server: WWW-Authenticate: Negotiate ZmluYWw2c2VydmVyLWVbnRleHQ=*

*Server:*

*Server: <!DOCTYPE html>*

*Server: <html>*

*Server: <head>*

*Server: ...*

Since Negotiate Authentication Scheme is supported by all major web browsers, described technique allows to perform fully transparent user authentication. The user neither needs to register within the web application, nor is required to supply his or her credentials before being able to use the application. The user simply navigates to the required URI via a web browser, authentication is then performed automatically in a secure manner, and the user gets recognized by the application and is able to interact with it.

## REFERENCES

1. RFC 6749 — The OAuth 2.0 Authorization Framework [Electronic Resource] / Dick Hardt. – Mode of access: <https://tools.ietf.org/pdf/rfc6749.pdf>. – Date of access: 20.01.2017.
2. RFC 6750 — The OAuth 2.0 Authorization Framework: Bearer Token Usage [Electronic Resource] / Michael B. Jones, Dick Hardt. – Mode of access: <https://tools.ietf.org/pdf/rfc6750.pdf>. – Date of access: 20.01.2017.
3. Fielding, Roy. Architectural Styles and the Design of Network-based Software Architectures / Roy Thomas Fielding; University of California. — Irvine, 2000. — 162 p.
4. Active Directory [Electronic Resource] / Microsoft Corporation. – Mode of access: <https://msdn.microsoft.com/en-us/library/bb742424.aspx>. – Date of access: 20.01.2017.
5. RFC 2743 — Generic Security Service Application Program Interface Version 2, Update 1 [Electronic Resource] / John Linn. – Mode of access: <https://tools.ietf.org/pdf/rfc2743.pdf>. – Date of access: 20.01.2017.
6. The Security Support Provider Interface [Electronic Resource] / Microsoft Corporation. – Mode of access: <https://msdn.microsoft.com/en-us/library/bb742535.aspx>. – Date of access: 20.01.2017.
7. RFC 1945 — Hypertext Transfer Protocol — HTTP/1.0 [Electronic Resource] / Tim Berners-Lee, Roy T. Fielding, Henrik Frystyk Nielsen. – Mode of access: <https://tools.ietf.org/pdf/rfc1945.pdf>. – Date of access: 20.01.2017.
8. RFC 4559 — SPNEGO-based Kerberos and NTLM HTTP Authentication in Microsoft Windows [Electronic Resource] / Karthik Jaganathan, Larry Zhu, John Brezak. – Mode of access: <https://tools.ietf.org/pdf/rfc4559.pdf>. – Date of access: 20.01.2017.
9. RFC 4648 — The Base16, Base32, and Base64 Data Encodings [Electronic Resource] / Simon Josefsson. – Mode of access: <https://tools.ietf.org/pdf/rfc4648.pdf>. – Date of access: 20.01.2017.

**JAVA AGENT DEVELOPMENT FRAMEWORK**

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*JADE is a Java framework that allows implementation of agent applications in compliance with the FIPA specifications for interoperable intelligent multi-agent systems. It represents an agent middleware providing an Agent Platform and framework that simplifies development. This article presents the JADE software describing its intended uses and internal architecture. The main architectural issues and design decisions are discussed.*

**Introduction.** The growth in networked information resources requires information systems that can be distributed on a network and interoperate with other systems. Such systems cannot be easily realized with traditional software technologies because of the limits of these technologies in coping with distribution and interoperability. The agent-based technology seems to be a promising answer to facilitate the realization of such systems because they were invented to cope with distribution and interoperability [5].

Agent-based technologies are still in their initial stages and only few truly agent-based systems have been realized. Agent-based technologies cannot realize their full potential, and will not become global, until standards to support agent interoperability are available and used by agent developers and environments for the development of agent systems are available.

Several researchers are working towards the standardization of agent technologies (for example OMG [7] and FIPA [6]) and in the realization of development environments to build agent systems. Such development environments provide some predefined agent models and tools to make easy the development process. Moreover, some of them try to allow interoperability with other agent systems through the use of a well-known agent communication language. However, the use of a common communication language is not enough to easily support interoperability between different agent systems. The standardization work of FIPA is in the direction to allow an easy interoperability between agent systems, because FIPA, beyond the agent communication language, specifies also the key agents necessary for the management of an agent system, the ontology necessary for the interaction between systems, and it defines also the transport level of the protocols.

In this article, JADE (Java Agent Development Framework) is presented as a software framework to develop agent applications in compliance with the FIPA specifications for interoperable intelligent multi-agent systems. The goal is to describe JADE main features and, in particular, the architecture of the agent platform.

**FIPA specification.** The Foundation for Intelligent Physical Agents (FIPA) [6] is an international non-profit association of companies and organizations sharing the effort to produce specifications of generic agent technologies. FIPA is planned not just as a technology for one application but as generic technologies for different application areas, and not just as independent technologies but as a set of basic technologies that can be integrated by developers to make complex systems with a high degree of interoperability.

FIPA is based on two main assumptions. The first is that the time to reach consensus and to complete the standard should not be long, and, mainly, it should not act as a brake on progress rather than an enabler, before industries make commitments. The second is that only the external behavior of system components should be specified, leaving implementation details and internal architectures to agent developers. In fact, the internal architecture of JADE is proprietary even if it complies with the interfaces specified by FIPA.

The first output documents of FIPA, called FIPA97 specifications, specify the normative rules that allow a society of agents to inter-operate, that is effectively exist, operate and be managed. First of all they describe the reference model of an agent platform, as shown in Figure 1. Basically, it identifies the roles of some key agents necessary for the management of the platform, and specifies the agent management content language and ontology. Three key mandatory roles were identified into an agent platform. The Agent Management System (AMS) is the agent that exerts supervisory control over access to and use of the platform; it is responsible for authentication of resident agents and control of registrations. The Agent Communication Channel (ACC) is the agent that provides the path for basic contact between agents inside and outside the platform; it is the default communication method which offers a reliable, orderly and accurate message routine service; it must also support IIOP for interoperability between different agent platforms. The Directory Facilitator (DF) is the agent that provides a yellow page service to the agent platform. Notice that no restriction is given to the actual technology used for the platform implementation: e-mail based platform, CORBA based, Java multi-thread applications and other could all be FIPA compliant implementations.

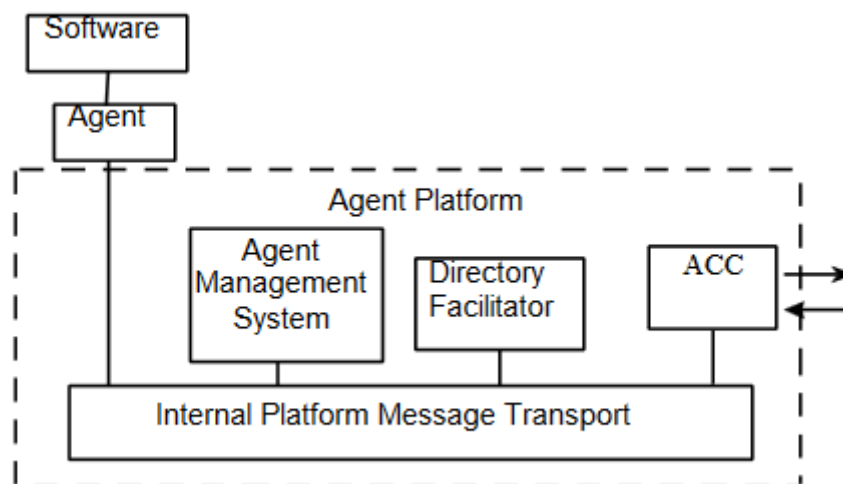


Fig. 1. FIPA reference model of an Agent Platform

### JADE

JADE (Java Agent Development Framework) is a software framework to make easier the development of agent applications in compliance with the FIPA specifications for interoperable intelligent multi-agent systems. The goal of JADE is to simplify development while ensuring standard compliance through a comprehensive set of system services and agents. To achieve such a goal, JADE offers the following list of features to the agent programmer:

- FIPA-compliant Agent Platform, which includes the AMS (Agent Management System), the DF (Directory Facilitator), and the ACC (Agent Communication Channel). All these three agents are automatically activated at the agent platform start-up;
- distributed agent platform. The agent platform can be split on several hosts (provided that there is no firewall between them). Only one Java application, and therefore only one Java Virtual Machine, is executed on each host. Agents are implemented as one Java thread and Java events are used for effective and light-weight communication between agents on the same host. Parallel tasks can be still executed by one agent, and JADE schedules these tasks in a more efficient (and even simpler for the skilled programmer) way than the Java Virtual Machine does for threads;
- a number of FIPA-compliant DFs (Directory Facilitator) can be started at run time in order to implement multi-domain applications, where the notion of domain is a logical one as described in FIPA97;
- programming interface to simplify registration of agent services with one, or more, domains (i.e. DF);
- transport mechanism and interface to send/receive messages to/from other agents;
- FIPA97-compliant IOP protocol to connect different agent platforms;
- light-weight transport of ACL messages inside the same agent platform, as messages are transferred encoded as Java objects, rather than strings, in order to avoid marshalling and unmarshalling procedures. When sender or receiver do not belong to the same platform, the message is automatically converted to/from the FIPA compliant string format. In this way, this conversion is hidden to the agent implementers that only need to deal with the same class of Java object;
- library of FIPA interaction protocols ready to be used;
- automatic registration of agents with the AMS;
- FIPA-compliant naming service: at start-up agents obtain their GUID (Globally Unique Identifier) from the platform;
- graphical user interface to manage several agents and agent platforms from the same agent. The activity of each platform can be monitored and logged.

### Architecture of the Agent Platform

The JADE Agent Platform complies with FIPA97 specifications and includes all those mandatory agents that manage the platform that is the ACC, the AMS, and the DF. All agent communication is performed through message passing, where FIPA ACL is the language to represent messages.

The software architecture is based on the coexistence of several Java Virtual Machines (VM) and communication relies on Java RMI (Remote Method Invocation) between different VMs and event signaling within a single VM. Each VM is a basic container of agents that provides a complete run time environment for agent execution and allows several agents to concurrently execute on the same host. In principle, the architecture allows

also several VMs to be executed on the same host; however, this is discouraged because of the increase in overhead and the lack of whatever benefit.

Each agent container is a multithreaded execution environment composed of one thread for every agent plus system threads spawned by RMI runtime system for message dispatching. A special container plays the front-end role, running management agents and representing the whole platform to the outside world. A complete Agent Platform (AP) is then composed of several agent containers. Distribution of containers across a computer network is allowed, provided that RMI communication between their hosts is preserved. A special light-weight container is being implemented for the execution of agents within a Web browser.

There are different packages present in JADE for example

- jade.core.event: implements the distributed event notification service;
- jade.core.management: implements the distributed agent life-cycle management service;
- jade.core.messaging: implements the message distribution service;
- jade.core.mobility : implements the mobility and cloning service;
- jade.content and its sub-packages contain the collection of classes that support creating and manipulating expressions according to a given content and ontology;
- jade.domain contains the implementation of the AMS and DF agents.

**Conclusions.** JADE is written and represented in Javalanguage and is made by various Javapackages, giving application programmers both ready-made pieces of functionality and abstract interfaces for custom, application dependent tasks. Java was the programming language of preference because of its many attractive features, particularly geared towards object-oriented programming in distributed heterogeneous environments; some of these features are Object Serialization, Reflection API and Remote Method Invocation (RMI).

JADE provides its users with standard agent technologies while keeping runtime overheads low. The development of JADE is still continuing and further improvements and implementations have already been planned, included support for agent mobility as specified by FIPA98.

#### REFERENCES

1. Создание распределенных информационно-управляющих систем на базе агентно-ориентированного подхода [Электронный ресурс] // ст. XII Всерос. совещание по проблемам управления, Москва, ИПУ РАН, 16-19 июня 2014 г. – Режим доступа: <http://vspu2014.ipu.ru/proceedings/prcdngs/8984.pdf>. – Дата доступа: 02.11.2014.
2. Об одном универсальном методе построения моделей для сложных много-агентных систем [Электронный ресурс] / Компьютерные исследования моделирование. – Режим доступа: [http://crm.ics.org.ru/uploads/crmissues/crm\\_2013\\_4/13401.pdf](http://crm.ics.org.ru/uploads/crmissues/crm_2013_4/13401.pdf). – Дата доступа: 02.11.2014.
3. Особенности разработки мульти-агентных систем на JADE Semantic Agent Framework [Электронный ресурс]. – Режим доступа: [http://www.ssc.smr.ru/media/ipuss\\_conf/15/6\\_04.pdf](http://www.ssc.smr.ru/media/ipuss_conf/15/6_04.pdf). – Дата доступа: 02.11.2014.
4. Леонтьев, А.А. Эволюция информационных технологий [Электронный ресурс] / А.А. Леонтьев // Интернет и библиотека: триумф Интернета или несбывшиеся надежды. – Режим доступа: [http://fulltext.pl.spb.ru/unor/metod/NTB\\_2012\\_10\\_35.pdf](http://fulltext.pl.spb.ru/unor/metod/NTB_2012_10_35.pdf). – Дата доступа: 02.11.2014.
5. Genesereth, M.R. Software Agents / M.R. Genesereth and S.P. Ketchpel // Comm. of ACM, 37(7):48-53.1994.
6. Foundation for Intelligent Physical Agents. Specifications. 1997. – Mode of access: <http://www.fipa.org>.
7. Object Management Group. 95-11-03: Common Facilities RFP3 Final Draft. 1995. – Mode of access: <http://www.omg.org/docs/1995/95-11-03.ps>.
8. Agent-based control framework in JADE. – Mode of access: [http://www.scs-europe.net/dlib/2014/ecms14papers/abs\\_ECMS2014\\_0132.pdf](http://www.scs-europe.net/dlib/2014/ecms14papers/abs_ECMS2014_0132.pdf). – Date of access: 02.11.2014.
9. Analysis of RDBMS and semantic WEB search in university system (International Journal of Engineering Sciences & Emerging Technologies, Oct.2014.). – Mode of access: <http://www.ijeset.com/media/0003/8N18-IJES0702913-v7-is2-604-621.pdf>– Date of access: 02.11.2014.
10. Mining in ontology with Multi Agent system in semantic web (The International Journal of Multimedia & Its Applications (IJMA) Vol.6, No.5, October 2014) – Mode of access: <http://airccse.org/journal/jma/6514ijma04.pdf>. – Date of access: 02.11.2014.



UDC 621.371:550.837.6

## COMPARATIVE EVALUATION OF METHODS OF ELECTRICAL PROSPECTING OF HYDROCARBON DEPOSITS

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*The analysis of geological exploration methods for hydrocarbon deposits are given. The different modes of interaction of electromagnetic waves with hydrocarbons are mentioned. The evaluation of the accuracy of determining the boundaries of oil and gas fields, set the level of identification of hydrocarbons are made. The analysis of electromagnetic methods of searching a wide frequency range are mentioned. The characteristic of the most prospectively hydrocarbon detection methods is shown. Recommendations for the integrated use of electromagnetic methods of searching are suggested. The research results can be used to develop electromagnetic hydrocarbon search techniques, proximal and distal radar systems.*

**Introduction.** Modern electromagnetics requires reliable, high-precision, environmental and electromagnetic methods of production (EMM) search, identification and delineation of hydrocarbon deposits (HS) [1 – 6]. Methods of electrical search of oil and gas are based on the differentiating of earth's surface for electromagnetic properties. Characteristics of EMW are determined by geoelectric structure of the investigated terrain profile. Electrical problems may be solved with the help of both artificial and natural sources of radiation EMW. Highlight of the desired object is carried out by electromagnetic anomalies identified in the territory [7 - 13]. The aim of this work is to study the EMM and the devices to improve the reliability of intelligence, research and delineation of oil and gas.

**Analysis of electrical methods.** We analyze the electrical methods in order to optimize the frequency, polarization, amplitude, modulation, and other parameters of the probing signals. Applying them in practice is possible, taking into account the specific characteristics of HS, allowing collectively improve the accuracy of determining the boundaries and identification of hydrocarbons. Table 1 presents data on the frequency range and features of 12 methods.

Table 1 – Comparison of electrical methods

№ п/п	Methods	Frequency. MHz.	Accuracy borders, m	Level identification, %	Opportunity of use transport facilities
1	2	3	4	5	6
1	The registration of natural radiation HS	8500	30 – 50	90	+
2	The registration of borders HS on the abnormal field changes at two frequencies	F1 = 1 – 10; F2 = 10 – 100;	10 – 30	95	+
3	The use of acoustic signal	0,0001; 50	50 – 80	85	–
4	The use of modulated signals	F1 = 1 – 10; F2 = 10 – 100;	30 – 50	90	+
5	The use of measuring antenna impedance.1	F1 = 10000; F2 = 34000;	40 – 60	85	+
6	The measurements of antenna patterns	0,001 – 0,003; 1 – 150	60 – 80	80	–
7	The measurement of phase characteristics in the amplitude of the signal modulation mode	F1 = 1000 – 5000; F2 = 10 – 100;	35 – 55	85	+
8	The measurements of the phase characteristics of the surface impedance in the amplitude modulation mode, the frequency of the signal	F1 = 100– 2000; F2 = 10 – 100;	30 – 50	90	+
9	The studies of reflection characteristics	F1 = 1 – 10; F2 = 10 – 100;	30 – 50	90	+

Table 1 Conclusion

1	2	3	4	5	6
10	The research of reflective characteristics in the mode of powerful low-frequency signal	F1 = 1 – 10; F2 = 10 – 300;	20 – 40	90	–
11	The research of reflective characteristics in the mode of a powerful high-frequency signal	F1 = 1 – 10; F2 = 10 – 300;	20 – 40	90	–
12	The use radio pulse signal	20 – 35	5 – 20	95	+

## REFERENCES

1. Электроразведка. Справочник геофизика : в 2 кн. / под ред. В.К. Хмелевского и В.М. Бондаренко. – 2-е изд. – М. : Недра, 1989. – Кн. 1. – 437 с. ;
2. Электроразведка. Справочник геофизика : в 2 кн. / под ред. В.К. Хмелевского и В.М. Бондаренко. – 2-е изд. – М. : Недра, 1989. – Кн. 2. – 378с.
3. Гололобов, Д.В. Радиотехнические системы поиска и идентификации углеводородных залежей в режиме двухчастотного взаимодействия / Д.В. Гололобов, В.Ф. Янушкевич // Весці НАН Беларусі. Сер. Фіз. тэхн. – 2002. – № 1 – С. 49 – 54.
4. Moskvichew, V.N. Interaction of electromagnetic waves (EMW) with anisotropic inclusion in communication line / V.N. Moskvichew // 9-th Microw. Conf. NICON – 91, Rydzyna, May 20-22, 1991. – Vol. 1. – P. 240–244.
5. Гололобов, Д.В. Поверхностный импеданс среды над углеводородными залежами в режиме частотно-модулированных сигналов / Д.В. Гололобов, С.В. Калинин, В.Ф. Янушкевич // Весці НАН Беларусі. Сер. Фіз. тэхн. 2010. – № 4. – С. 98–101.
6. Москвичев, В.Н. Исследование взаимодействий электромагнитных волн с углеводородной залежью / В.Н. Москвичев // Радиотехника и электроника. – 1988. – Вып. 18. – С. 91–96.
7. Финкельштейн, М.И. Применение радиолокационного подповерхностного зондирования в инженерной геологии / М.И.Финкельштейн, В.А. Кутев, В.П. Золоторев.– М. : Недра, 1986. – 182 с.
8. Гололобов, Д.В. Радиолокационный портрет углеводородной залежи / Д.В. Гололобов // Электромагнитные исследования с контролируемыми источниками : тез. докл. Междунар. геодез. конф. Санкт-Петербург, 27 – 31 мая 1996 г. / ВИГР – Рудгеофизика ; редкол.: А.А. Петров [и др.]. – СПб., 1996. – С. 42–43.
9. Гололобов, Д.В. Влияние параметров амплитудно-модулированного воздействия на фазовые составляющие поверхностного импеданса анизотропной среды плазмоподобного типа / Д.В. Гололобов, О.В. Орлова, В.Ф. Янушкевич // Вестник Полоцкого государственного университета. Сер. С, Фундаментальные науки. Физика. – 2010. – № 9. – С. 98–101.
10. Степуленок, С.В. Взаимодействие амплитудно-частотно-моделированных сигналов со средой над углеводородными залежами / С.В. Степуленок, В.Ф. Янушкевич // Вестник Полоцкого государственного университета. Сер. С, Фундаментальные науки. Физика. – 2009. – № 9. – С. 103–108.
11. Гололобов, Д.В. Фазовые методы идентификации углеводородных залежей / Д.В. Гололобов, В.Ф. Янушкевич, А.О. Рак // Инженерный вестник. – 2005. – № 1(20). – С. 16–18.
12. Янушкевич, В.Ф. Зондирование анизотропных сред двухчастотными и модулированными сигналами / В.Ф. Янушкевич // Полоцкого государственного университета. – Минск. – 8 с. – Деп. в БелИСА 12.06.97 г. – № Д 199713 / Рефер.сб. непубликуемых работ. – 1997. – Вып. 5. – С. 11.
13. Электродинамические параметры подводных источников в поле поверхностной электромагнитной волны / Д.В. Гололобов [и др.] // тез. докл. 35 Всероссийской межвузовской НТК. – Владивосток, 1992. – Т. 1, ч.1. – С. 59.

UDC 004.93

## OBJECT LOCALIZATION AND CLASSIFICATION BASED ON CONVOLUTIONAL NEURAL NETWORKS

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*The paper deals with the basic structural elements of the convolution neural network as well as methods for describing and tested methods of localization of objects in the neural network. Effective approaches are proposed for the construction of algorithm of objects localization. The results of the implementation of the algorithm are presented.*

Neural networks are used to solve complex problems that require analytical calculations similar to those that the human brain does [1]. The structure of the neural network in the world of programming came straight from biology. With this structure, the machine acquires the ability to analyze and even memorize a variety of information. The most common applications of neural networks are:

- classification - distribution of the parameters of data. For example, the input contains a set of people and you need to decide who of them you will grant a credit to. This work can be performed by a neural network by analyzing information such as age, solvency, credit history and so on;
- prediction - ability to predict the next step. For example, the rise or fall of shares, based on the situation on the stock market;
- recognition - currently the widest application of neural networks. It is used by Google, when you are looking for photos, or in phone cameras when it determines the position of your face and makes it stand out and many more.

Simple localization and classification tasks can be solved quite well with small size datasets. But objects in realistic settings exhibit considerable variability, so to learn to recognize them it is necessary to use much larger training sets. Convolutional neural networks (CNNs) constitute class of models, for which capacity can be controlled by varying their depth and breadth, and they also make strong and mostly correct assumptions about the nature of images [2].

A convolutional neural network consists of alternating convolution layers, pooling, local response normalization (LRN). A convolution neurons layer uses the same weights. Neurons using the same weights are combined into the card features (feature maps), and maps each neuron characteristics associated with a part of the previous layer of neurons. In the calculation of the network it turns out that each neuron performs convolution (conversion of determining the degree of similarity) of a region of the previous layer (defined by the set of neurons associated with the neuron). Each neuron of  $m$  layer is associated with only a part of neurons of a led layer ( $m-1$ ). Each neuron layer  $m$  has one and the same weight. Pooling is a layer spatial association or sub-sampling layer (performing the functions of reduction of the dimension of feature maps space) from several neighboring neurons of a feature map a maximum one is chosen, i.e. from multiple input signals the highest goes to the neuron output. LRN is a normalization of the contrast layer which does not have adaptive link weights. The same operation is applied to each connection which produces data scaling, increases too small numbers and decreases too big ones.

Each convolution layer has only the width, height and depth Fig.3. In a separate layer of neurons all neurons have the same weight, and each neuron is a convolution filter. A convolution layer allows determining the coordinates of the point and structures that are responsive to this network, while a fully connected layer allows you to define specific structure belonging to this class. To keep track of these data a convolution layer is built in the network. The layer is called class activation mapping (CAM) which is followed by a Global average pooling layer (the layer of a conventional Inner product) [3].

CAM layer will look deep 1024, and with the core 3:

```
layer {
  name: "CAM_conv"
  type: "Convolution"
  bottom: "output"
  convolution_param {
    num_output: 1024          #layer depth
    pad: 1
    kernel_size: 3           #convolution kernel size
    group: 2
  }
}
```

```

}
}

```

This is followed by normalization of the contrast layer.

```

layer {
name: "CAM_relu"
type: "ReLU"
bottom: "CAM_conv"
}

```

Pooling layer with kernel 14 and step 14, the nucleus size depends on the number of neurons convolution layer, in this layer the size of the convolution happened 196x196x1024:

```

layer {
name: "CAM_pool"
type: "Pooling"
bottom: "CAM_conv"
pooling_param {
pool: AVE
kernel_size: 14          # core
stride: 14              # step
}
}

```

Inner Product used for classification network, in this case 1000 classes:

```

layer {
name: "CAM_fc"
type: "InnerProduct"
bottom: "CAM_pool"
inner_product_param {
num_output: 1000        #1000 classes
}
}

```

From an inner product layer coming after CAM we take neuron links weights with the highest value, the number of such neurons will be determined by the number of classes found in the image. If one class is found than one neuron is used, if two classes are found than two neurons are used and so on, i.e., the number of neurons is determined by the number of classes found.

Each output value of a convolution layer is multiplied by the weight value of the link with a neuron of the next layer, and then summed over the depth. As a result we get a 2-D matrix of a value where the probability of finding an object of this class according to these coordinates will be equal, the coordinates of the object will be equal to the coordinates in the resulting matrix:

$$M_c(x, y) = \sum_k w_k^c f_k(x, y), \quad (1)$$

where  $w_k^c$  – is the weight of a convolution neuron layer link to neuron 'k' of a complete coherent layer, belonging to class 'c';

$f_k(x, y)$  – is output value of the convolution neuron layer.

Further, for the resulting matrix the average value is selected and the maximum is divided and then we obtain the threshold values which keep out noise. Formula 2 is used for the construction of object contour:

$$Conmap = \frac{\max(M_c(x, y))}{\sum M_c(x, y)}. \quad (2)$$

The result is a contour of an object. Fig. 1 shows an example for contours of objects detection.

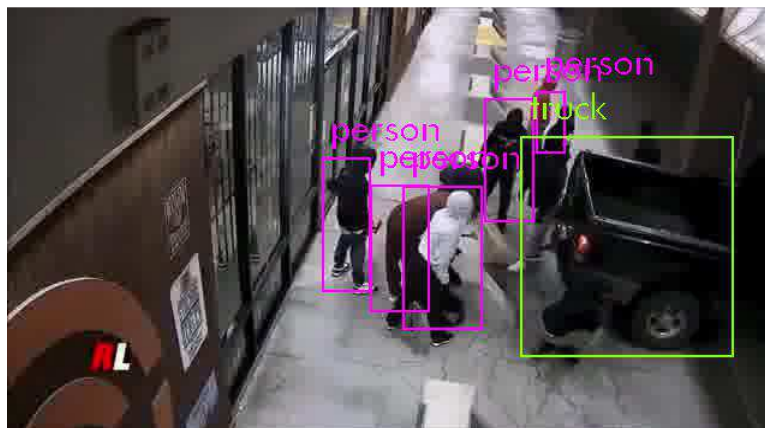


Fig. 1. Example for contours of objects detection

During the experiments, it was found a number of shortcomings of the algorithm such as low accuracy of determining the coordinates of objects in the images that have a large number of objects of the same class. This neural network is characterized by a high working speed. To increase the accuracy of the search the detection of existing facilities was made and for further experiments Faster RCNN was used.

Faster RCNN generates hypotheses about finding the object in the feature space maps conv5 (top convolution) [4]. To do this, run fully convolution 3x3 layer that generates a hypothesis called RPN, moreover, several for different aspect ratios and scale. RPN generates hypotheses and scales them using ROI pooling, and transmits them to a completely coherent layer, perceptron. This layer is trained on the basis of hypotheses to find the coordinates of the object. ROI Poling is identical to Max Pooling except that for ROI Poling the size of the input data is not set in advance it divides the input into the hypothesis of equal size squares, and selects one maximum value.

At the output of the network we get hypotheses and probabilities, which assess the presence of an object. The results are presented in Fig. 2. As you can see the algorithm copes with the task, and has a high accuracy in the images with a lot of objects of the same class.

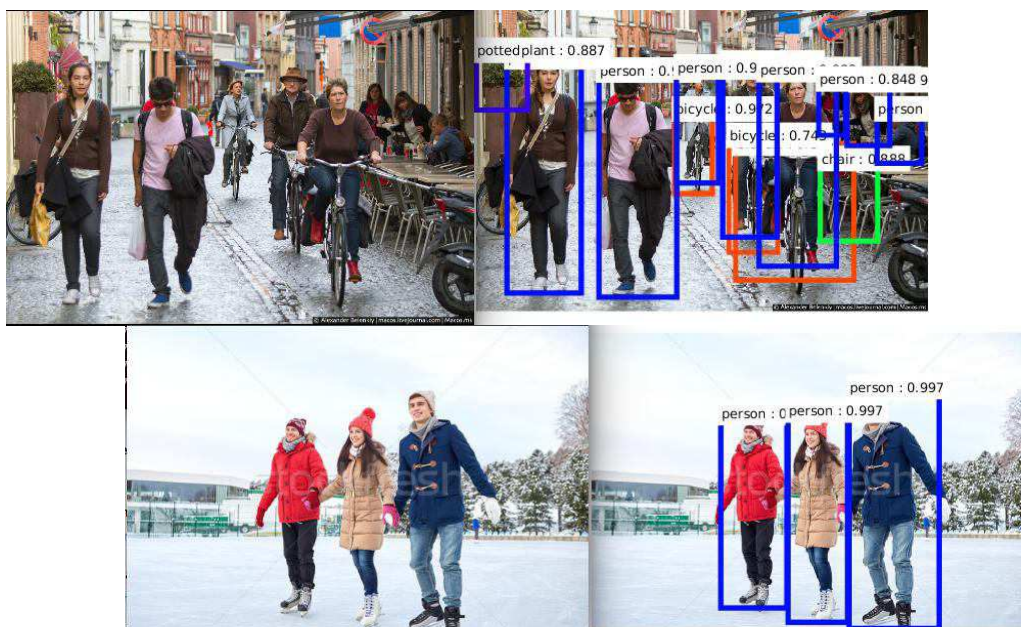


Fig. 2. Example of localization of many objects of the same class using Faster RCNN

Next, we plan to combine two neural networks Faster RCNN and CAM into a single network. CAM network will be used to focus on the most significant elements of the image. Next, to the found image elements hypotheses about the position of objects found on sites will be generated for a subsequent processing by Faster

RCNN method. This approach will significantly increase the speed of Faster RCNN while maintaining the accuracy of the classification.

## REFERENCES

1. Neural network & its applications [Electronic resource]/ – Mode of access: [http://www.slideshare.net/Ahmed\\_hashmi/neural-network-its-applications](http://www.slideshare.net/Ahmed_hashmi/neural-network-its-applications). – Date of access: 10.09.2016.
2. Krizhevsky, A. Image Net Classification with Deep Convolutional Neural Networks [Electronic resource] / A. Krizhevsky, I. Sutskever, G. Hinton // University of Toronto. – 2012. – Mode of access: <https://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf>. – Date of access: 14.11.2016.
3. Learning Deep Features for Discriminative Localization [Electronic resource] / B. Zhou [et al.]. – Mode of access: <https://arxiv.org/pdf/1512.04150v1.pdf>. – Date of access: 12.09.2016.
4. Rich feature hierarchies for accurate object detection and semantic segmentation [Electronic resource] / R. Girshick [et al.]. – Mode of access: <https://arxiv.org/pdf/1311.2524v5.pdf>. – Date of access: 12.09.2016.

UDC 004

## METHODS AND MEASURES SIMILARITIES ALGORITHM FOR FINDING A COMPLEX ARRAY

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*This work describes the basic methods and algorithms for determining the measure of similarity. We identified two promising methods for determining the similarity measure of polynomials, namely the function of the correlation coefficient and functions based on the Hausdorff metric. The analysis of the main measure distances (metrics) is represented.*

Cluster analysis is the common name of the computational procedures set used in the creation of the classification. As a result of the procedures the group which is very "similar" objects or "clusters" has been formed. More specifically, the cluster method is a multivariate statistical procedure, which collects data containing information on a sample of objects, and then arranges the objects in a relatively homogeneous group [1].

Examples of the cluster analysis use of are: informatics - simplifying information, data visualization, image segmentation, intelligent search. Economy is the analysis of markets and financial flows, elimination of laws on the stock exchanges. Marketing is market segmentation, analysis of consumer behavior, positioning products. Astronomy is the selection of stars and galaxies groups, the automatic processing of satellite images. Security systems are the recognition of biometric data. Applied Image Processing System is the machine vision system for technological processes, systems for diagnostics and condition monitoring objects, search and recognition of objects for processing medical images.

For the data cluster analysis similarity measure is used. There are four types of the subsections similarity: the correlation coefficients; distance measures; associative factors and probability coefficients of similarity. Although all similarity types of were used at one time, only the correlation coefficients and the distances are widely used [2].

1. The correlation coefficient is a measure of the mutual influence nature that indicates changes between two random variables. Defined by the expression (1):

$$r_{jk} = \frac{\sum_{i=1}^n (x_{ij} - \bar{x}_i)(x_{ik} - \bar{x}_k)}{\sqrt{\sum_{i=1}^n (x_{ij} - \bar{x}_i)^2 \sum_{i=1}^n (x_{ik} - \bar{x}_k)^2}}, \quad (1)$$

where  $x_{ij}$  – the value of  $i$  for the  $j$  variable object;  $\bar{x}_j$  – the average of all values of the variables  $j$  object;  $n$  – number of variables.

Correlation coefficient ranges from  $-1$  to  $+1$ , where zero indicates that there is no communication between objects.

The main drawback of the correlation coefficient as the similarity measure is that it is sensitive to the form by reducing the sensitivity to the magnitude of the differences between the variables. Furthermore, the correlation calculated in this manner has no statistical sense [3].

Despite these shortcomings, the coefficient is widely used in the cluster analysis applications. Hammer and Cunningham have shown that with proper use of cluster correlation coefficient method is superior to other similarity factors as to reduce the number of incorrect classifications.

2. Mery distance (metric) is widely popular. Two objects are identical when describing their variables take the same value. In this case, the distance between them is zero. Distance measures dependent on the choice of scale measurements and usually not bounded above [4]. One of the most famous distance is the Euclidean distance, defined as (2):

$$d_{ij} = \sqrt{\sum_{k=1}^p (x_{ik} - x_{jk})^2} \quad (2)$$

where  $d_{ij}$  – the distance between objects  $i$  and  $j$ ;  $x_{ik}$  – the value of the variable  $k$  for the object  $i$ ,

$$d_{ij} = \sum |x_{ik} - x_{jk}|.$$

To give higher weights more distant from one another objects using squared Euclidean distance.

A well-known measure is also Manhattan distance or "taxicab geometry" (city-block) (3).

$$d_{ij} = \left( \sum_{k=1}^p |x_{ik} - x_{jk}| \right)^\gamma \quad (3)$$

You can define other metrics, but most of them are private forms except from a special class of metric distance functions, known as Minkowski metric.

There distances are not the Minkowski metric, and the most important of them - Mahalanobis distance  $D^2$ . The expression of the metric (4):

$$d_{ij} = (x_i - x_j)^T S^{-1} (X_i - X_j) \quad (4)$$

where  $S$  – totalintra - variance - covariance matrix,  $x_i$  and  $x_j$  – vectors variables for objects  $I$  and  $j$ .

In contrast to the Minkowski metric and Euclidean, this metric is related to the correlations of the variables with the help of the covariance matrix of dispersions.

Function based on the Hausdorff metric.(5)

$$R^H = 1 - \frac{1}{l} \max_{ij} |o_{ij} - b_{ij}^*| \quad (5)$$

where  $i \in 0 \dots N - 1, j \in 0 \dots N - 1$

Lack of distance measures is that the similarity score is strongly dependent on differences in the data shifts. Moreover, the metric distances vary under the influence of variables measuring scale transformations.

3. The coefficients of associativity apply when it is necessary to establish the similarity between objects described by binary variables, where 1 indicates the presence of a variable, and 0 – in its absence. There are three measures that are commonly used: simple coefficient, Jaccard coefficient and the Gower coefficient.

4. Probabilistic similarity coefficients. The great difference of this type described above lies in the fact that, the similarity between two objects is not calculated. The formation of clusters is computed information gain from the merger of two objects, and those associations that give a minimum prize shall be treated as a single object. Probability measures are only suitable for binary data and are attached directly to the source data prior to processing. What are some things discover each other similarity or difference, is a very important moment for the classification process.

#### Similarities

The problem is not a simple recognition of similar or dissimilar things, and in what place they occupy in the concept of scientific research. Today, cluster analysis is one of the most efficient large amounts of data processing tools and is used all over the place, which applies computer technology [5].

Algorithms squared error

The task of clustering can be regarded as the construction of the optimal partition of objects into groups. This optimality can be defined as a requirement to minimize the mean square error of the partition (6):

$$e^2(X, L) = \sum_{j=1}^K \sum_{i=1}^{n_j} \|x_i^{(j)} - c_j\|^2 \quad (6)$$

where  $c_j$ -"center of mass" of the cluster  $j$  (point with the average values for the characteristics of the cluster).

Algorithms square error related to the type of flat algorithms. The most common search algorithm is k-means. This algorithm builds a predetermined number of clusters located as far as possible from each other. The algorithm is divided into several stages:

1. Randomly select  $k$  points, which are the initial "centers of mass of" clusters.
2. Classify each object to the cluster with the closest "center of mass".
3. Calculate the "centers of mass" of clusters according to their current structure.
4. If the stopping criterion of the algorithm is not satisfied, return to the n. 2.

As a stopping criterion of the algorithm is typically selected minimum change in the mean square error. It is also possible to stop the algorithm if step 2 was not the objects move from cluster to cluster. The disadvantages of this algorithm include the need to specify the number of clusters to split. [3]

The most promising method for finding similarity measures polynomials are a function of the correlation coefficient and the function based on the Hausdorff metric.

1. Finding a similarity measure by the correlation coefficient. Formula features presented in the article number 1.



Its popularity is method to two factors: the correlation coefficients are relatively easy to count, their use requires no special mathematical training. In combination with the ease of interpretation, the ease of use factor has led to its widespread use in the analysis of statistical data.

Coefficient is shown in figure 1.

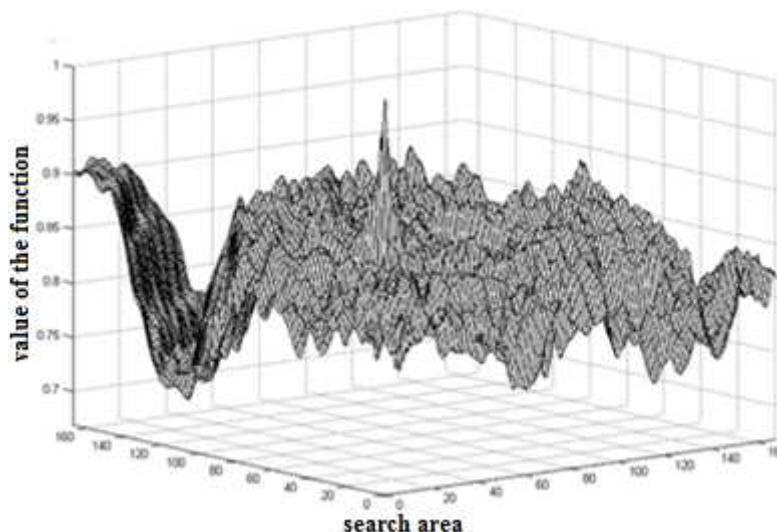


Fig. 1. The graph of the correlation function

2. Finding a similarity measure by a function based on the Hausdorff metric. The function presented in the article number 6.

Hausdorff metric used as a measure of similarity, are very sensitive to noise. Therefore, in itself does not guarantee symmetric rigor of the evaluation itself similarities, but at the same time measure satisfying combination of other assets, but not a metric, can in most cases give a better estimate of the similarities than the other measure, which is a metric [6].

Hausdorff metric is shown in Figure 2.

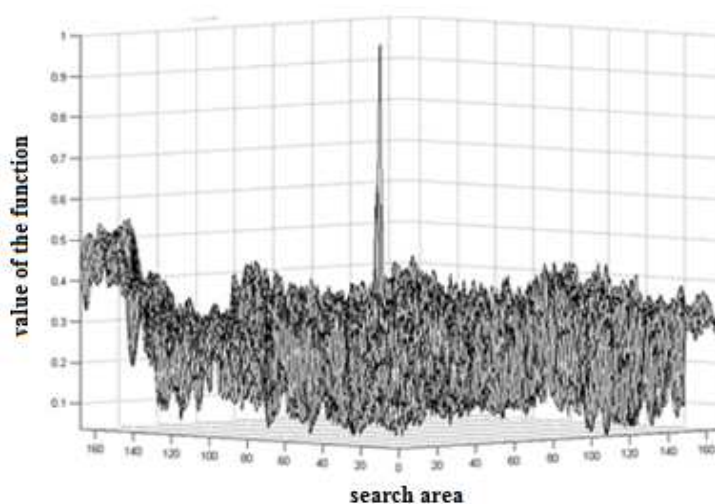


Fig. 2. Schedule Hausdorff metric function

**Conclusion.** In this scientific article we discussed the main methods for determining similarity measures, and identified two promising method for determining the similarity measure on the basis of two polynomials function of the correlation coefficient and the Hausdorff metric. The selection of these methods was due to the implementation of the criteria to measures computes the similarity: symmetric, be normalized values average rating, resistance to noise, the monotony, the speed calculation of similarity measures.

## REFERENCES

1. Воронцов, К.В. Алгоритмы кластеризации и многомерного шкалирования. Курс лекций / К.В. Воронцов. – М. : МГУ, 2007. – 170 с.
2. Котов, А. Кластеризация данных / А. Котов, Н. Красильников. – 2006. – 213 с.
3. Чубукова, И.А. Курс лекций «DataMining» / И.А. Чубукова // Интернет-университет информационных технологий – Режим доступа: [www.intuit.ru/department/database/datamining](http://www.intuit.ru/department/database/datamining). – Дата доступа: 20.01.2017г.
4. Васильев, Н. Метрические пространства / Н. Васильев. – Квант, 1990. – 326 с.
5. Харин, Ю.С. Теория вероятностей, математическая и прикладная статистика: учебник / Ю.С. Харин, Н.М. Зуев, Е.Е. Жук. – Минск : БГУ, 2011. – 464 с.
6. Метрические пространства. – Режим доступа: <http://dfgm.math.msu.su/files/ivanov-tuzhilin/2014-2015/METRGEOM2014-1.pdf>. – Дата доступа: 20.01.2017.

UDC 004.054

**INTEGRATION OF MODERN IT-TECHNOLOGIES  
FOR EFFECTIVE ORGANIZATION MANAGEMENT**

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*The article considers the problem of creating reliable, modern, adaptive, flexible and functional IT-technologies for organization management. The IT strategy that defines a set of priority initiatives in the field of information technology is illustrated. The article presents a strategy for a coherent and coordinated development of the information and technical complex in an organization, involving all departments, on the basis of common requirements.*

For the last five years the development of information technology has entailed changes in organizations. New techniques and technologies are being applied not only to automate data collection and processing, but also to implement various ideas and ways of obtaining competitive advantage. IT-technology has become an indispensable tool for reaching local, tactical, strategic goals and for sustainable organization development. An information system capable of providing timely, necessary, accurate and balanced information for distributing in the main areas of financial-economic and production activities of the company is suitable for comprehensive analysis and is sufficient for a decision.

Effective development of IT-technologies to address key challenges in the organization requires:

1. formation of the IT- organization's strategy;
2. analysis and evaluation of the current state of IT-security;
3. formation of IT concept;
4. an approach to the implementation of IT development concept;
5. work on IT development concept implementation;
6. feasible study of an individual organization information projects on the basis of allocation efficiency

factors.

IT-strategy is a programme of information systems development in accordance with the strategy of an organization, current and future market needs. Basic parameters for creating information base are laid in IT-strategy development and should meet the following requirements:

1. Scalability – the system must take into account the growing needs of an organization;
2. Flexibility – the system should be easily adjustable by changing internal processes and external environment;
3. Standardization – various components of the system must be compatible and coordinated with the information security requirements;
4. Cost-effectiveness – the use of a decision should be economically justified;
5. Independence – the customer does not have to depend on providers' solutions, although it is not necessary to keep a staff of programmers.

The relationship of strategic goals and objectives of an organization and information strategies can be expressed as follows:

- business strategy determines the direction of an organization's main sphere of activity and the reasons for this direction;
- IT-strategy identifies information required to maintain and optimize a business strategy and shows how these techniques and systems may be implemented in an organization [1].

Analysis of information systems in the organization is carried out in order to determine their compliance with the functional business tasks at different levels of management, user environment, the structure of information flows, the organization of data storage and access. The purpose of this diagnosis is to determine the current state of IT-security for its further development in accordance with the strategy developed by IT.

For information diagnosis, the following steps should be followed:

- IT-diagnostics ensure the basic functional processes and management tools;
- analysis of IT-infrastructure;
- characteristics of information security;
- description of organizational maintenance of IT;
- typology and characterization of IT-software costs.

Basic principles IT-technologies concept formation:

- IT development should be in line with the strategic development of the organization;

## ITC, Electronics, Programming

- consolidation in the architecture of organization's IT-structure and content of business key processes;
- coordination with business priorities;
- protection of IT investments;
- a comprehensive solution;
- balance between the current and long-term objectives.

The main output from automation can be achieved through management processes optimization, operational processes and management of financial funds in an organization. Hence the development of a modern IT-technology should proceed in four main areas:

1. Consistent automation of operational processes, providing cost reduction and improvement in key performance indicators of business units of the organization;
2. Development of a corporate information system based on integrated solutions and efficient procedures for collection, processing and presenting information;
3. Creation of an IT-infrastructure, to satisfy modern requirements for the level of reliability and safety;
4. Increase in user productivity and unit personnel of IT [2].

The development system project for creating an integrated information system involves the integration of existing and emerging components. It is a fundamental approach to the implementation of the development of IT-technologies concept. The amount and timing of individual projects are determined by evaluation of IT-software company current state. A detailed analysis of the results determines the direction of IT-technologies company development. A project implementation programme begins with preparation for the implementation, and detailed work planning of individual tasks automate business functions within the framework of the development strategy of IT- technologies [3].

The organization working on the concept implementation is related to the definition of the roles and functions of IT-security departments. The organizational structure of the IT-department allocates units responsible for the development of IT-project management IT-department. The activities of this unit are based on a project [4]. Head of the unit generates the required number of project teams, where employees collect the corresponding specialization. At the same time project teams may be formed of professionals who are subordinated to other heads of departments, depending on the specifics of each project implementation of process management IT-strategy and progress control. Results of each project are based on the following principles:

1. In IT service there must be a group of quality experts-auditors;
2. The quality of each project has to be controlled;
3. The organization should be clearly defined and project risks should approved of;
4. Common indicators for monitoring the designing process should be set;
5. The project participants' motivation should be linked to project results;
6. A mandatory control procedure should be carried out on the project completion;
7. Single control processes must be set.

As a result of the latest IT-technology organization will receive a reliable, flexible and scalable IT-technology that enables a qualitatively new level of organizing processes such as project management, management operations, management risks, sales, finance and other business processes. IT-technologies increase the efficiency of information exchange between the departments of the organization, increasing the speed of decision-making and tasks units implementation, which is one of the most important factors of success of the organization - its profitability and competitiveness.

## REFERENCES

1. Gurkov, I. B. Strategy and corporate structure / I. B. Gurkov. – M. : Case, 2008. – 288 p.
2. Mikhailov, A. Strategic planning of information management system / A. Mikhailov. – M. : Higher School of International Business Academy of National Economy, 2001. – 134 p.
3. The ability to use the information system in educational institutions / E.E. Mayorov [et al.] // The role of intellectual capital in the economic, social and legal culture of the XXI century: a collection of scientific works of the participants of the International scientific-practical conference. – SPb. : Publishing house SPbUME, 2015. – 554 p.
4. The development of modern IT-technologies to address key challenges in the organization / E.E. Mayorov [et al.] // The role of intellectual capital in the economic, social and legal culture of the XXI century: a collection of scientific works of the participants of the International scientific-practical conference. – SPb. : Publishing house SPbUME, 2015. – 554 p.

UDC 621.371: 550.837.6

## ANALYSIS METHODS OF TREATMENT INCOHERENT RADAR IMAGES IN REMOTE SENSING SYSTEM BASED ON FILTER SPECKLE – NOISE

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*The analysis of non-coherent processing of radar imaging methods. Availability speckle - noise leads to deterioration decryption radar image (RI), radiometric resolution and accuracy of the measurement object components radar portrait, as well as increased requirements for the data channel and means for displaying information. The main method of reducing speckle - noise is filtering (linear, adaptive and combined methods) generated as a result of the synthesis of the amplitude or luminance RI. Home treatment of such filtering - incoherent accumulation.*

**Introduction.** Radar systems of space-based earth surveillance are an effective means of obtaining the operational and long-term information about the state and dynamics of objects and regions of the globe in global and regional scale, regardless of weather conditions and time of day.

The scientific and engineering basis for the implementation of such systems was laid in the middle of the last century. They were prepared by advancements in aircraft instrumentation, including the development of the Research Institute – 17 panoramic radar "Cobalt" for on-board equipment of the complex impact "Rubidium" Tu – 4 (1949). With this apparatus the problem of navigation and aiming was solved for large area objects in the absence of optical visibility [1–5].

Improving equipment (introduction of frequency tuning, color display, automatic detection of objects on the Earth's surface, and others.), and most important, the transition from the panoramic radar for radar side-looking (DBR) with improved angular resolution in azimuth (up to 9 ... 15 arc. min), contributed to the development of a new use of radar – earth surveillance.

Intensive research on improving radar earth surveillance led to the creation of fundamentally new means of radar – coherent radar antenna synthetic aperture (SAR), can solve the problem of radio-wave with a spatial resolution in the unit and of a meter [6 – 10].

**Main part.** Historically, the first generation of cosmic X-ray diffraction was permitted on the horizontal distance coarser than the resolution limit. Optical signal was used for the synthesis of RI `processing device selection synthetic aperture so as to have the same resolution in both coordinates. Available stocks signal duration was used for non-coherent accumulation.

The method in which a single element resolution synthetic diagram directivity antenna (DNA) averaged radar images obtained at different Doppler frequencies (within element incoherent accumulation), called «Multi-look» in foreign literature. Figure 1 is a block diagram within Element incoherent accumulation. With digital synthesis RI implementation within Element savings achieved by separation into sub-aperture signal, coherent processing (partial synthesis complex radar images (CRI) obtained at different Doppler frequencies with different local azimuth angle), and the subsequent detection of the partial summation of radar images. Instead of a time signal separation can be applied separation azimuth spectrum of Doppler frequencies subspectre followed by their synthesis, detection and partial summation of radar images. The same incoherent accumulation operation can be performed in range. In principle, the number of cases does not have to be an integer, for example, optical or accumulation of overlapping sub-aperture (subspectre).

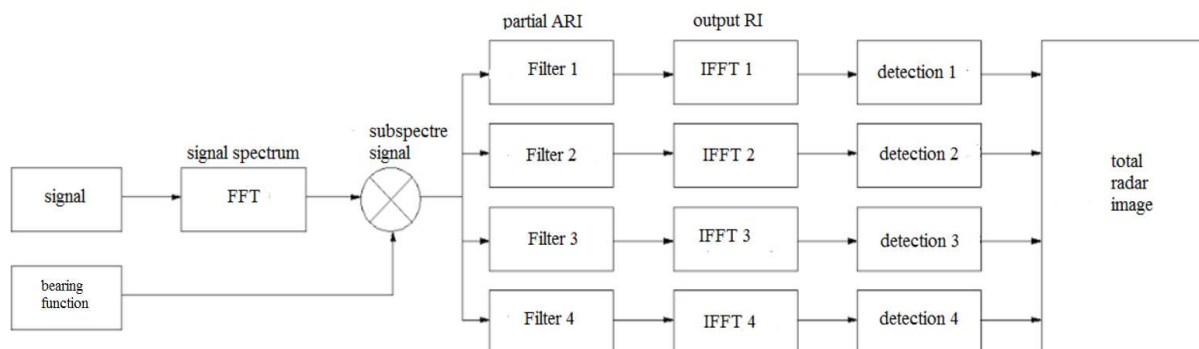


Fig. 1. Block diagram within Element incoherent accumulation

One of the most effective and widely used in the synthesis of RI autofocus algorithms is phase - gradient algorithm phase-gradient algorithm (PGA) autofocus based on the extraction of uncompensated phase error directly from the bright point targets. The theoretical justification of the algorithm synthesis came from radar images using compression Azimuth method of harmonic analysis. The input process for PGA algorithm in this case is pre-compressed in range radio- hologram, which compensated for the law chirp with residual disabilities that require removal. The resulting range in each channel complex SAR images is a range Radioholograms. By applying Inverse Fast Fourier Transform (IFFT) operation can reverse transition from CRI Radioholograms to partially compensate for deviation.

There are many embodiments of PGA algorithm. Its upgraded version is used as the input process part focused CRI compensation phase error is performed in the spectrum CRI azimuth, which is consistent with the original idea of the method in connection with the equivalence of Fast Fourier Transform (FFT) and IFFT procedures.

In addition to considering options within element incoherent accumulation is possible, and in some cases more promising option intercell incoherent accumulation, in which first obtained KRI with high resolution in both coordinates, and then after the detection is carried out by averaging the required number of observations. though this option requires more CPU performance synthesizing radar images, but for high-resolution X-ray diffraction it has a number of advantages:

1) the possibility of adaptive selection of the size and configuration of the averaging window for the use of modern automatic segmentation algorithms for radar data, wavelet - filtration, neural processing, the fractal analysis.

2) the possibility of radar pictures of small objects for recognition and classification after finding them on the smoothed image.

3) archiving and detailed radar images KRLI for later use, including interferometric processing of images taken at different times.

Block diagram intercell incoherent accumulation is shown in Figure 2. The input information is the luminosity RI or complex, after which detection is performed (square). Filtration speckle - noise may include linear operations, and not linear (logarithm, estimation of local parameters, etc.).

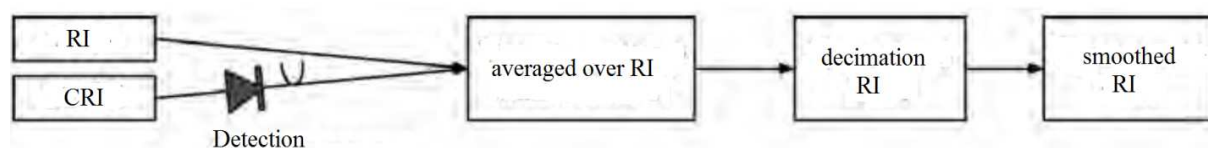


Fig. 2. Block diagram intercell incoherent accumulation

Tasks suppress speckle - noise can be divided into:

1) global, providing exposure to all the main radar image or a portion thereof. These include algorithms summation of independent radar data with constant parameters within the frame;

2) Local, based on local statistical evaluation. These include methods of improving deshifirruemost and visual properties of the radar image, but does not retain the measuring properties of radar images;

3) Non-local filtering methods wherein the first step of the processing performed in the local small block detection statistics are analyzed and determining the nature of the anomaly.

**Conclusion.** Methods of radar systems of space-based earth surveillance require an integrated approach for operational and long-term information about the state and dynamics of objects and regions of the globe in global and regional scale, regardless of weather conditions and time of day. Performance Optimization of probing signals and search RTS will contribute to the successful solution of a space-based applications. Application within Element incoherent accumulation gives the gain in improved radiometric resolution.

## REFERENCES

1. Radar systems of space-based earth surveillance / ed. VS Verba. – M. : Radio Engineering, 2010. – 680 p. : silt.
2. Armand, N.A. Modern satellite SAR system for Earth remote sensing: Achievements and Prospects / N.A. Armand, A.I. Zakharov // Works on ERS conference. Moore. 2003.
3. Belorukov A.A. Methods of smoothing speckle – noise in radar images of the Earth's surface // International electronics. – 1990. – № 6. – S. 26–35.
4. Radar stations with digital synthetic aperture antenna / V.N. Antipov ; ed. V.T. Goryainov. – M. : Radio and communication, 1988. – 304 p.

5. Neronsky, L.B. Prospects for improvement of space vehicles radar earth observation // High Tech. Number 200. 8–9. – S. 66– 87.
6. Bogomolov, A.F. "Venus - 15", "Venus - 16": synthetic aperture radar in orbit WIS / A.F. Bogomolov, N.V. Zherikhin, G.A. Sokolov // Math. Universities. Ser. "Radiophysics". – 1985. – Vol. XXVIII, N 3. – P. 259–274.
7. Burenin NI radar with synthesized antenna. – M. : Sov. Radio, 1972. – 160 p.
8. Garbuk, SV, VE Gershenson Space remote sensing system. – M. : Skanex, 1997. – 296 p.
9. Elizavetin, I.V. Assessment of incoherent accumulation in processing data from the spacecraft // Study of Earth from space. – 1993. – №1. – P. 32–35.
10. Elizavetin, I.V. Comparative evaluation of filtering of radar images using wavelet - transformations / I.V. Elizavetin, D.S. Goodilin, O.I. Semenov // Aerospace technology : Proceedings of the All-Russian Scientific - Technical Conference, May 22, 2002, Reutov FSUE "NPO Machine Building" / Ed. R.P. Simon-yantsa. – M. : Publishing House of the MSTU. Bauman, 2003. – P. 233–243.

**APPROACHES TO THE DEVELOPMENT OF MOBILE APP FOR THE ANDROID  
OPERATION SYSTEM AND INTERACTION WITH RESTFUL API AS AN EXAMPLE  
OF OFFICIAL AGGREGATE ERIP “EXPRESS PAYMENT” OF THE “TRIINKOM” COMPANY**

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*The article considers the approach to the development of a mobile app the Android operation system and interaction with RESTful API as an example of official aggregate ERIP “Express Payment” of the “Triinkom” company under the HTTPS protocol. There are also descriptions of important points of designing the app architecture.*

**Introduction.** We live in a world of modern technologies, where every day we can see the forward movement, discovery of new and improvement of already existing technologies. One of the events, which have changed human life, was finding a global network the Internet. Nowadays, it is hard to imagine our world without the Internet. With the help of it, people can find different kinds of information, communicate, shop, entertain themselves, study and work. Development of the Internet technologies makes people’s life easier. Most people of the society have either personal computers or laptops, and also different kinds of smartphones and tablets. The question that appears is how it can be easily to implement any kind of interaction between different devices in any place and time. If to extract all the opportunities from all mobile devices, then you can include more users, increase the sales and service monetization.

Therefore, we have to think of the universal analogue, which can face any challenge without an additional equipment in any place and time.

**Ways for solving problems.** Wide spreading of such apps as browsers, lets us talk about web-apps as a cross-platform. For example, we can use this method in order to create an interface between computer and mobile phone. However due to the fact, that it is important to save the traffic on the mobile phone, fast loading with a bad connection or working of an app in offline mode with differed delivery of information, then browsing of web-site on the web-browser doesn’t quite fit other major web-services. The use of mobile apps also will remove the loading from the server, as pictures and other information won’t be loaded.

It was decided to use an interaction with RESTful API for saving traffic and to simplify sharing messages with a server.

RESTful API – is an architectural style of interaction components of a distributed app in the network. REST represents itself as an agreeable set of restrictions, taken into account when designed by a distributed hypermedia-system. In special cases(online stores, searching systems, other systems based on data) it increases productivity and simplifies an architecture. In a broad sense, all components with REST interact similar to interactions of clients and servers on the World Wide Web.REST are an alternative to RPC. On the Internet, a call for remote procedure represents a simple HTTP request (usually “Get” or “Post”; this kind of request is called “REST request”), and the important data can be transmitted as a query option.

It was decided to use a library from Googlecompany, which is called the “Google Cloud Messaging” in order to receive PUSH-notification from the server. It is easy to connect it by using the automatic system of the Gradle assembly and by adding it to the configuration file `compile 'com.google.android.gms:play-services-gcm:9.6.1'`, `apply plugin: 'com.google.gms.google-services'` and `classpath 'com.google.gms:google-services:3.0.0'` and to generate this configuration file in the JSON format on the official Google site.

Gradle – is an autobuildsystem, which is built upon Apache Ant and Apache Maven principles, but represents DSL in a Groovy language instead of the traditional XML-shape presentation of the configuration project.

It was decided to use the HTTPS protocol and the library for encryption from the Apache company in order to protect information of an app and messages. To connect it you can use the Gradle by adding to configuration file the line `compile 'commons-codec:commons-codec:1.10'`.

HTTS (HyperText Transfer Protocol Secure) – is an expansion of the HTTPprotocol, which supports encryption. The data transferred via HTTPS protocol are “packaged” in a cryptographic protocol SSL and TLS. Unlike HTTP, the TCP-port 443 is used for HTTPS by default.

It was decided to use the data exchange in the JSON format, since through its conciseness comparing with XML, the JSON format will be more suitable for serialization of complex structures. When we talk about web-apps, in this manner it’s suitable in the tasks of data exchanges both between browser and server (AJAX), and



between servers themselves (software HTTP-interface). It was decided to use the standard programming language package JAVA "org.json.JSONObject" in order to transfer the JSON into the object and back.

JSON (JavaScript Object Notation) – is a text format of the data exchange based on JavaScript. As many other text formats, JSON is easy to read. The JSON format was designed by Douglas Crockford.

It was decided to use the Material Design pattern in order to develop the user-friendly and attractive interface. For its use you can add the following lines to the configuration file Gradle: *compile 'com.android.support:design:24.2.1', compile 'com.android.support:appcompat-v7:24.2.1', compile 'com.github.rey5137:material:1.2.2'.*

The Material Design – is a design of software and apps that belongs to the Android operating system from Google. First presented at the Google I/O conference on 25 June 2014. The idea of design lies in apps, which open and fold like cards by using shadow effects. The ideas of Google designers, that apps should not have rough edges and cards should switch among themselves smoothly and almost invisible.

It was decided to use embedded Android operation system database SQLite for saving big data and small configuration data by using Android Shared Preferences.

SQLite – is an embedded cross-platform relational database, that supports a complete set of SQL and available in the source code. In 2005 the project was rewarded for Google-O'Reilly Open Source Awards.commands.

Android Shared Preferences – is an interface, which allows you manually to seek and manipulate data app settings with the help of method call get SharedPreferences from your Activity.

**Methods for solving problems.** Obviously, while implementing an app it is important to create some architecture. The model MVC will be very suitable. It consists of 3 elements: model, submission and controller.

The model is certain data, that describe subject area and some operation can be implemented over them. The user also can be provided with the information on a graphical interface.

The submission is thus that graphical interface.

The controller implements some algorithms for receiving data submission, processing and sending them back.

The Layout is used in the XML mark-up language for the submissions development in Android app. To create it you can type it manually or use embedded tools in IDE.

Working with sending and processing data was convenient to create separate classes, which were done while developing mobile apps. Sending data occurs using Apache library through the HTTPS protocol. Tables were created in relational database for saving data from server. Token that was received while authorizing is convenient to keep in Shared Preferences for its loading at the next application launch. The structure of primary and foreign relation keys in the database are presented in table 1.

Table 1 – Primary and foreign relation keys

№ p.n.	Table name	Primary key	Foreignkeys	Description
1	Invoices	PK invoice_no	FK currency, FK service_no	The table contains headers invoices
2	Invoice_details	PK invoice_no	FK _invoice	The table contains details invoices
3	Payments	PK payment_no	FK currency, FK service_no	The table contains headers payments
4	Payment_details	PK payment_no	FK_payment_no	The table contains details payments
5	Directory_currencies	PK currency		The tablecontainscurrencies
6	Directory_services	PK service_no		The tablecontainsservices

The verification of connection with the Internet was implemented at every request to API.

To receive PUSH-notifications the GCM Receiver is registered at startup as a separate server, but during the closing, apps are being destroyed.

There were used following methods with RESTful API for action distinction with resources at the HTTP-methods level:

1. GET — generation of the resource.
2. POST —creation of the resource.
3. PUT — updating of the resource.
4. DELETE — removing of the resource.

## ITC, Electronics, Programming

Nowadays there are many different mobile devices with different screen resolution and hardware. There is no opportunity to test this app on all these devices. That's why it was decided to use the server Firebase Cloud Messaging from Google company for bug tracking system of an app and for keeping statistics on the used machines and Android versions.

Each activity has its controllers, models, adapters and submissions. The app is optimized for different screen resolutions and Android operation system versions starting from 4.0.

Example of JSON response obtaining of new accounts:

```
{
  "Items": [
    {
      "InvoiceNo": 7841,
      "AccountNo": "Test238",
      "Status": 1,
      "Created": "20160905173134",
      "Expiration": "20160905",
      "Amount": "102,00",
      "Currency": 933,
      "ServiceNo": 3050
    },
    {
      "InvoiceNo": 7840,
      "AccountNo": "Test237",
      "Status": 1,
      "Created": "20160905173134",
      "Expiration": "20160905",
      "Amount": "102,00",
      "Currency": 933,
      "ServiceNo": 3050
    }
  ]
}
```

Screen shapes of mobile app are presented in figure 1 and 2:

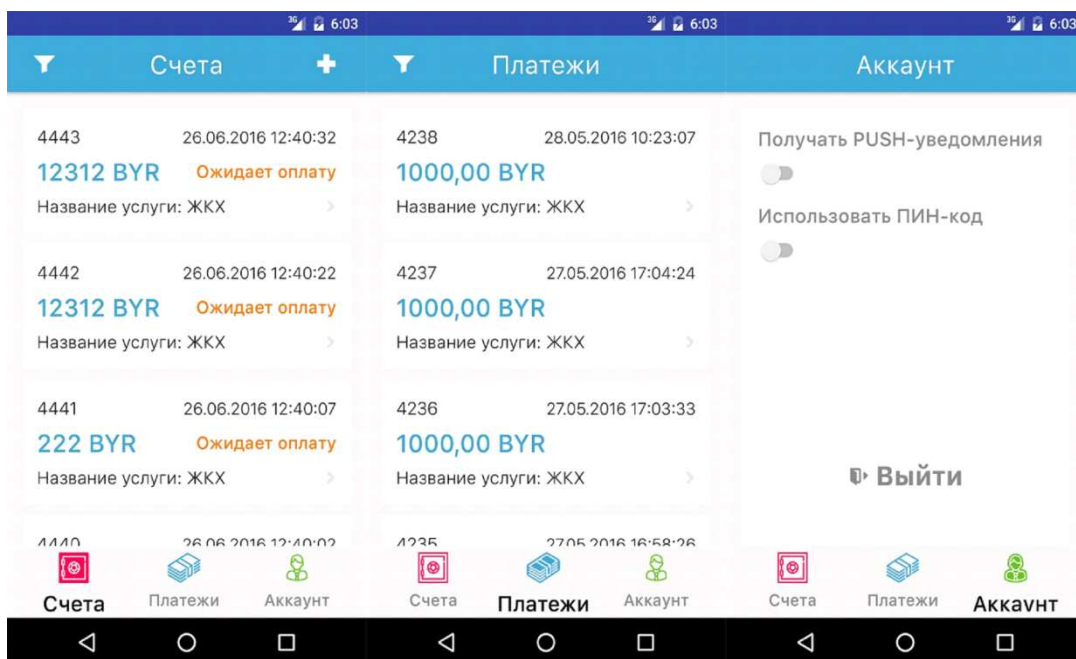


Fig. 1. Screen shapes of mobile app.

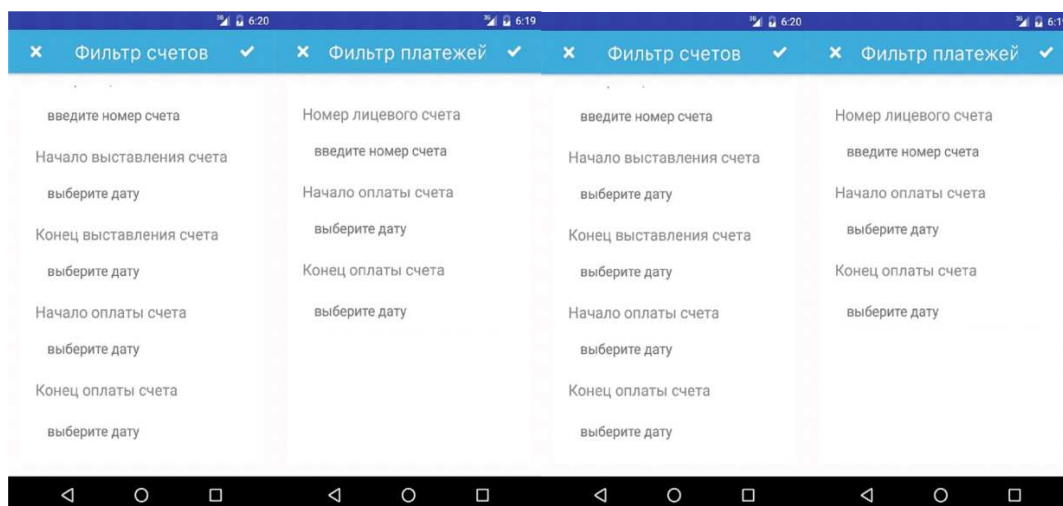


Fig. 2. Screen shapes of mobile app.

**Conclusion.** In conclusion, we should emphasize, that the correct approach while developing a mobile app is the use of modern libraries, that allow us to carry out its tasks. We must stick to recommendations from Google company, which has developed and still developing Android operation system and to use the design of the Material Design pattern for creating user-friendly and attractive interface.

The article considers popular and necessary libraries and describes the opportunities of their implementation in application developing. It also describes the safe way of data exchange between application and server.

The use of the MVC pattern and object-oriented approach to programming also can ease the process of development quiet well. In particular, it allows to avoid repetitions in code.

#### REFERENCES

1. RESTful API [Electronic resource]. – 2016. – Mode of access: <https://en.wikipedia.org/wiki/REST>. – Date of access: 22.12.2016.
2. Gradle [Electronic resource]. – 2016. – Mode of access: <https://en.wikipedia.org/wiki/Gradle>. – Date of access: 20.12.2016.
3. HTTPS [Electronic resource]. – 2016. – Mode of access: <https://en.wikipedia.org/wiki/HTTPS>. – Date of access: 24.12.2016.
4. JSON [Electronic resource]. – 2016. – Mode of access: <https://en.wikipedia.org/wiki/JSON>. – Date of access: 20.12.2016.
5. Material Design [Electronic resource]. – 2016. – Mode of access: [https://en.wikipedia.org/wiki/Material\\_Design](https://en.wikipedia.org/wiki/Material_Design). – Date of access: 26.12.2016.
6. SQLite [Электронный ресурс]. – 2012. – Режим доступа: <https://habrahabr.ru/post/149356>. – Дата доступа: 23.12.2016.
7. AndroidSharedPreferences [Электронный ресурс]. – 2012. – Режим доступа: <https://habrahabr.ru/post/139330>. – Дата доступа: 27.12.2016.

## MODERN PROBLEMS OF DEPLOYMENT AND MAINTENANCE OF HIGH-LOADED APPLICATIONS

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*This article is about recent problems of deployment and managing high-loaded systems and applications and their solutions.*

**Introduction.** Iterative method has become the most popular and the most efficient method of application development, it means that deployment stage has become a significant part of a life cycle for most applications. Of course, this stage should be automated as much as possible, because it takes a lot of time to write your code, deploy it, configure environment and launch your application.

Continuous integration and continuous delivery have become almost the requirement for developing high-quality applications. Modern market offers a list of products for realization of these concepts, and it's important to choose better solution.

Generally, development process consists of three parts: development, testing and deployment. In case of high-loaded systems deployment can be the most important stage, because applications under load may cause various problems and it's very important to setup environment in the right way.

Amazon Web Services provides a huge amount of tools for automating deployments and releases, for testing your applications and systems; it makes the development process faster and easier. AWS CodePipeline offers a smart automated solution for an application build, test, and release process, allowing fast and reliable application updates.

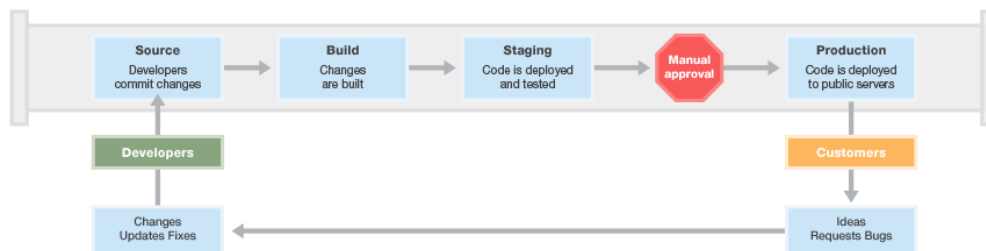


Fig. 1. AWS CodePipeline release process

Using AWS CodePipeline, developers can define a full release process for building code, deploying to pre-production environments, testing the application, and releasing to production – all from one platform. It allows performing live load tests of any size. AWS CodePipeline offers advanced scripting capabilities, a flexible SaaS platform for easy test executions, scheduling, automation and results analysis, GUI-supported scripting with no programming required, full API, and integration with APM tools including AppDynamics and New Relic [1].

Another problem of deployment is how to setup your environment. It can be achieved in different ways, but the smartest and most flexible solution is "Infrastructure as Code". Infrastructure as Code is the process of managing and provisioning computing infrastructure (processes, services databases, virtual servers, etc.) and their configuration through machine-processable definition files, rather than physical hardware configuration or the use of interactive configuration tools [2].

AWS CloudFormation enables you to create and provision AWS infrastructure deployments predictably and repeatedly. It helps you leverage AWS products such as Amazon EC2, Amazon Elastic Block Store, Amazon SNS, Elastic Load Balancing, and Auto Scaling to build highly reliable, highly scalable, cost-effective applications in the cloud without worrying about creating and configuring the underlying AWS infrastructure [3]. AWS CloudFormation enables you to use a template file to create and delete a collection of resources together as a single unit. Also AWS CloudFormation has built-in tools for monitoring your environments. It allows using various metrics to check your instances, like CPU utilization, memory utilization, application load, incoming and outgoing requests, disk utilization and other.

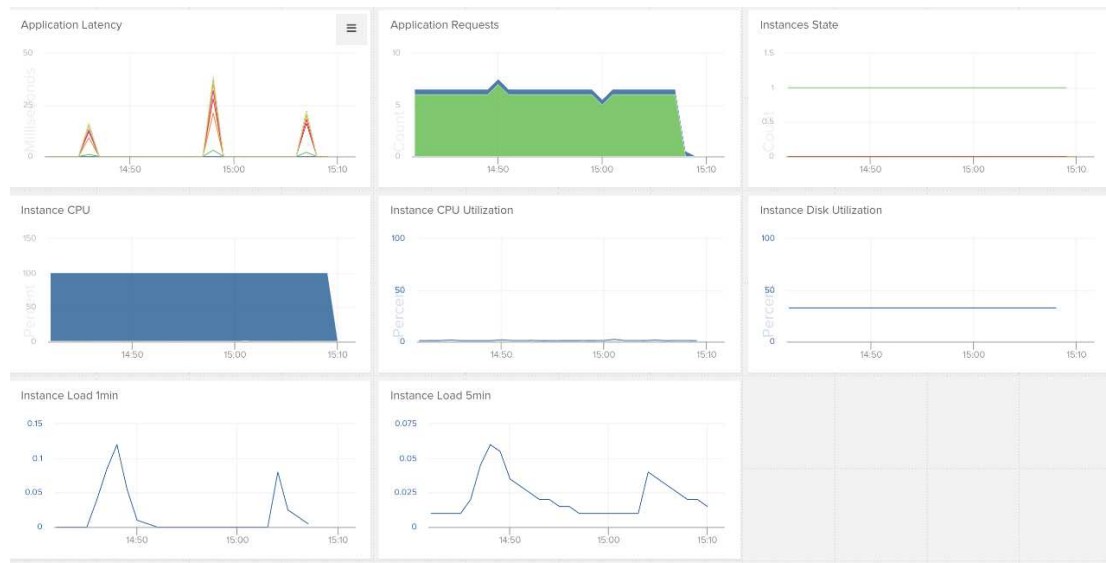


Fig. 2. AWS Cloudformation metrics

Cloudformation works great with microservice architecture, because in case of adding a new microservice all you should do is to define a new container in a template for your service rather than changing the whole structure of your environment.

When an application is run, it's important to know about any abnormal effects in your environment. For example, if your environment has a high CPU utilization or too many requests are sent to your server, you should be notified to be able to prevent any problems as soon as possible. Amazon CloudWatch provides a reliable, scalable, and flexible monitoring solution that you can start using within minutes. You no longer need to set up, manage, and scale your own monitoring systems and infrastructure. You can define your custom alarm, set an alarm rule and get a notification when something happens. Besides, AWS CloudWatch allows storing logs from Amazon EC2 instances, load balancers, or other sources.

The configuration of the environment for high-loaded applications is different from other applications. Of course, each application has its own requirements for building environment, but there are some general principles:

1. Automated backups.

If an application stores any important data in databases, all data should be backed up to be able to restore it.

2. Load balancing.

Load balancing improves the distribution of workloads across multiple computing resources. It helps to minimize response time, optimize your instance and avoid overload of any single resource. With the load balancer you have just one public DNS and many instances.

3. Auto scaling.

Auto Scaling is a web service designed to launch or terminate Amazon EC2 instances automatically based on user-defined policies, schedules, and health checks. Auto scaling works perfectly with the load balancing and alarms. For example, when CPU utilization increases greatly, a new instance will be added to a load balancer, and when there is no load on the server, the instance will be terminated.

4. Using private virtual network for environments.

A system or an application can be encapsulated with the help of a private virtual network. All resources can be placed into this network, and only needed port will be exposed. It's a good solution for improving application security.

5. Using proxies and multiple instances in different regions.

Sometimes requests have long response time because of a long distance between a client and a server. The solution is to place environments in different regions.

**Conclusion.** Amazon Web Services is the best solution for deploying and managing a large high-loaded system as it has all tools for deploying, managing and monitoring your environment, testing, building and releasing your application. With the help of AWS all general principles of deployment of heavy loaded systems can be easily achieved. AWS allows developers to create reusable solutions for different projects. AWS SDK provides a rich API for deploying instances, managing environments, testing applications, building snapshots using various

programming languages such as Java, .NET, Javascript, PHP and others. All resources are created in a cloud, so you have to pay only for what you need.

#### REFERENCES

1. AWSCodePipeline – AWS Documentation [Электронныйресурс] / AWSCodePipeline. – Режим доступа: <https://aws.amazon.com/documentation/codepipeline/>. – Дата доступа: 20.01.2017.
2. Wikipedia [Электронныйресурс] / Infrastructure as Code. – Режим доступа: [http://en.wikipedia.org/wiki/Infrastructure\\_as\\_Code/](http://en.wikipedia.org/wiki/Infrastructure_as_Code/). – Дата доступа: 20.01.2017.
3. AWSCloudformation–AWSDocumentation [Электронныйресурс] / AWS Cloudformation. – Режим доступа: <http://aws.amazon.com/documentation/cloudformation/http://habrahabr.ru/company/redmadrobot/blog/252773/>. – Дата доступа: 20.01.2017.

UDC 621.371: 550.837.6

## SIMULATION ALGORITHM OF RADIO HOLOGRAMS FORMATION IN A REMOTE EARTH SENSING SYSTEM

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*The article considers radio holograms formation in a remote earth sensing system. The linear-frequency-modulated signal is selected as the probe signal. Calculations of the basic signals parameters to form radio holograms are made. Construction of radio holograms is produced by multiplying the maximum and minimum aperture values of the reflected signal at the array of data.*

**Introduction.** Relevance considered in this article is concerned with challenges in improving algorithms of radio holograms forming in a remote earth sensing system.

Radar systems of space-based land review are an effective means of obtaining operational and long-term information about the state and dynamics of objects and regions scale, regardless of weather conditions and time of the day.

Satellite radiolocation is by far one of the major and most dynamically developing directions of remote sensing today.

The basis of satellite radiolocation is made by development of methods and equipment to ensure the formation of radar images of the Earth surface with high spatial resolution which serves as information support for a wide range of scientific, economic and defensive tasks.

The purpose of this operation consists in development of an image generation algorithm in digital radars with the synthesized aperture (RSA) by creating radio holograms in the environment of Matlab.

**Main part.** Let us consider the use of the algorithm based on the formation of radio hologram pulse radar method with respect to the X-band frequencies of the carrier wave 9.5-9.8 GHz. A transmitting device generates radar pulses with the same repetitive pauses as received by radio receiver at the station. Measuring range to the object is based on determining the time interval between the sending and receiving signals. For high resolution we need to generate short pulses of no more than 0.1 microseconds. However, such pulses have a low energy level. A transmitting device provides a short range of such pulses. To increase the range of pulses they should be transmitted in tens of microseconds in length. Sufficient resolution is provided by pulse duration at the receiver due to internal modulation.

The most widely used form of probing cosmic signals in digital imaging radar is packs linearly frequency-modulated pulses, which have a number of advantages as compared to PSK signals.

Probe signal is determined by the formula:

$$U_t(t) = \sum_{k=0}^{N-1} A(t - kT_p) \exp\{j2\pi f_0(t - kT_p) + j\Phi_k\}, \quad (1)$$

where  $A(t)$  – pulse envelope;

$\Phi_k$  – phase of the transmitted pulse

$N$  – number of the transmitted pulses

$$U_r(m, n) = U_{max} \text{rect}\left(\frac{m - m_T - \frac{N_t}{2}}{N_t}\right) \cdot \exp\left[j\pi \Delta F \tau \left(\frac{m - m_T - \frac{N_t}{2}}{N_t}\right)^2 - j2\pi \cdot \frac{2R_T(n)}{\lambda}\right] \quad (2)$$

$m_T$  range reference number for the leading edge of the goal aperted by the recoil momentum

$N_t$  – number of samples in the duration of the probe pulse

$R_{min}$  – range of the first reference in the gate receiving radio hologram

Receiving radio hologram multiplication occurs at the maximum and minimum values of the reflected signal data of the aperture array.

Array data synthetic aperture

$$u = du^*(-m/2:m/2-1), \quad (3)$$

$du$  – upper half of the frequency of the wavelength;

$m$  – number of samples in azimuth.

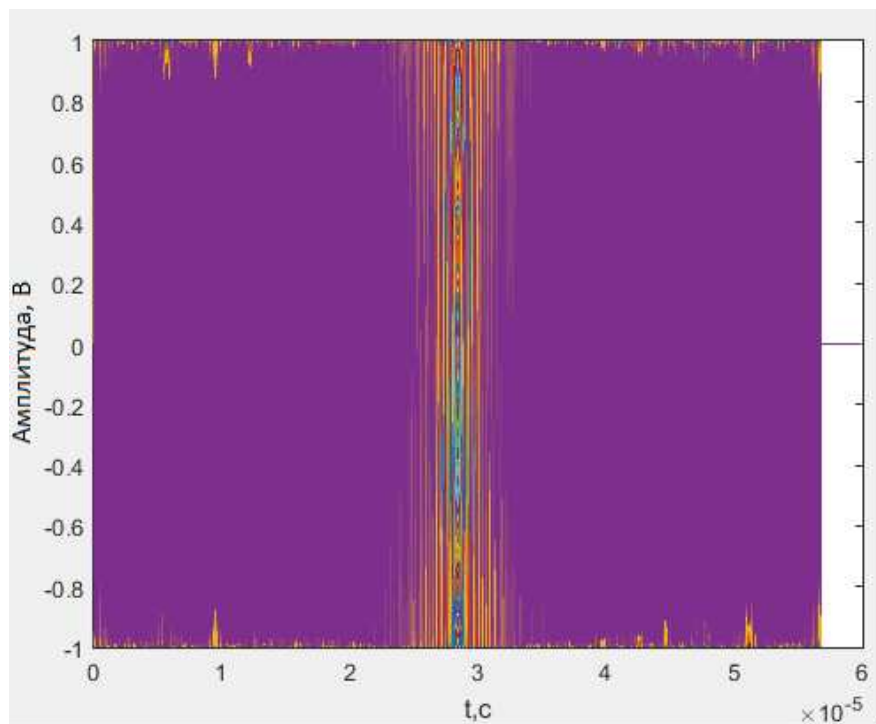


Fig. 1. Target complex video signal received from a single point at the output of the phase detector in the receiver for receiving the sensing gate will look as follows:

Radio holograms are graphical representation of the digitized analog input signal which reflect and carry information about aperture change, time and number of samples for further processing and the construction of the radar picture.

Bystry time is characterized by temporal counting on ranges, slow time temporal counting on an azimuth. Using other approach, it is possible to define slow time as time of movement of the radar, and bystry – as the propagation time of a signal on range coordinate i.e. bearing information on the researched Earth's surface.

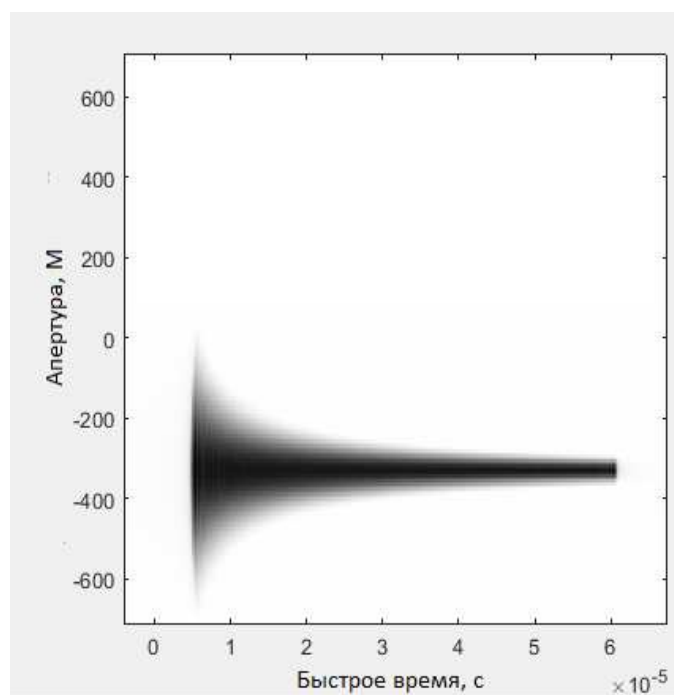


Fig. 2. Radio hollogram routing mode



**Conclusion.** Thus, carried out analysis has shown that application of different operation modes will allow to carry out surface shooting of sections of the Earth surface with high resolution, determined by requirements to the sizes, definition of delimitation of objects, necessary structure and quality of an observed surface, assignment of the obtained information. The formation algorithm of radio holograms is considered on the basis of the impulse method of radiolocation in relation to  $X$  – the range with frequencies of bearing oscillations of 9, 5 - 9,8 GHz. The research results can be applied in remote Earth sensing systems.

## REFERENCES

1. Радиолокационные системы землеобзора / В.С. Верба [и др.] ; под ред. В.В. Шахгильдяна. – М. : Радио и связь, 2000. – 656 с.
2. Устройства генерирования и формирования радиосигналов / Л.А. Белов [и др.] ; под ред. Г.М. Уткина, В.Н. Кулешова, М.В. Благовещенского. – М. : Радио и связь, 1994. – 416 с.
3. Неронский, Л.Б. Радиолокаторы с синтезированной апертурой антенны / Л.Б. Неронский, В.Ф. Михайлов. – М. : Радио и связь, 1987. – 320 с.
4. Electronic resources. – Режим доступа: <https://innoter.com/satellites/931>. – Дата доступа: 22.10.2016.
5. Режимы работы спутников [Электронный ресурс]. – Режим доступа: <http://www.dni.ru/tech/2013/11/11/263752.html>. – Дата доступа: 20.06.2016.
6. Радиоголографические измерения [Электронный ресурс]. – Режим доступа: <http://www.dissercat.com/content/radiogolograficheskaya-izmeritel'naya-sistema-dlya-yustirovki-radioteleskopov-seti-kvazar>. – Дата доступа: 20.06.2016.
7. Панченко, Б.А. Микрорешетчатые антенны : справ. пособие / Б.А. Панченко, Е.И. Нефедов. – М. : Радио и связь, 1986. – 144 с.
8. Educational and methodological materials. – Stephen, J. Chapman MATLAB Programming for Engineers /Stephen J. Chapman, 2009. –345с.
9. Educational and methodological materials. – William, J. Palm III Introduction to MATLAB for Engineers / William J. Palm III . 2013. –424с.
10. Educational and methodological materials. – Edward B. Magrab An Engineers Guide to MATLAB: With Applications from Mechanical, Aerospace, Electrical, Civil, and Biological Systems Engineering / Edward B. Magrab 2007. – 648 с.

**NEW PARADIGM OF PROCESSING OF COMMAND LINE ARGUMENTS**

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*The article describes the author's method of command line arguments processing. The main features of the method, in contrast to the existing analogues, is the versatility, natively-friendly interface that allows quick start at first use and does not require deep study of documentation.*

Programming technologies are not static; both, the programming paradigm itself that defines not only a set of ideas and concepts, and the style of writing computer programs [1]. Going to a higher level of abstractions, the code, according to the author, is becoming more intuitive, readable. The development of computer technology expands the style of software writing from the code "how it will be convenient for the compiler, processor" up to the code "how it will be convenient to a person". If one considers the development of the libraries used in the creation of software – firstly, the development is not only based on the maximum speed of its methods' work, and secondly, with the creation of maximum comfort, quick start of their usage, even to the detriment of the first one.

Functions of the «getopt ()» and the «getopt\_long ()», being today the de facto standard tool for processing of command line arguments in the UNIX / Linux environment, were developed in 1980s [2, p. 43]. Originally, the functions were created for the «C» language, but almost for any language today there are special libraries that implement their functioning or work on their base. For example, the "Argp" created for the line of the "C" languages [3], "the getopts" for "the bash" [4], the "optparse" for the "Python" [5] and others.

Functions of the «getopt ()» and the «getopt\_long ()», as well as their derivatives, seem the author archaic today, even "greeting from the 80's." For such a trivial, far from being the main, but extremely important task, as processing of command line arguments [6], it is needed, perhaps, more than one man-hour to figure out how to use them properly. At the same time, through the author's personal experience, if you fill the «Argp» structures once, and understand how to do it, you will not have to deal with it again, using it for the second time.

The problem described, forms a clear goal: in the development of a new method of command line arguments processing, the priority is - to provide maximum comfort, natively-friendly interface, quick start at first use which does not require deep study of documentation.

Not only to the author of the article the interface of the methods described seems too complicated, outdated, or having insufficient functioning. There were written numerous articles on this topic, have been repeatedly taken and are still taken successful attempts to create a simpler interface, while extending the functioning of existing methods. A good example would be the library «shflags», which uses the same function of the «getopt ()», but in addition to parsing of options, it can also check their values and even independently calls the variables for options according to their long name [7]. Similar successful analogues of standard functions can be found in almost any language, for example, a more advanced library «argparse» for the «Python» [8], replacing an «optparse» library [5], which has already become, in some cases, standard.

Behind the apparent way out, lies the problem, not obvious at first glance. Functions of the «getopt ()» and the «getopt\_long ()» were universal, as they were the only ones, and therefore one did not have to delve into the nuances and differences of numerous methods. Now it turns out that in every programming language, one way or another, eliminating the drawbacks of the original functions, there is its own implementation of the command line arguments processing, with its library and a set of methods that with each successive version is increasingly removed from the original functions of 1980s.

The author, positioning himself as a system programmer-administrator, often needs to write small support programs, at the same time quickly switching from one language to another. These can be all sorts of scripts written in a script language, as well as programs written with the line of "C" languages. Processing of the command line, considering all the possible «POSIX» agreements, may not be a trivial task [6], which, in its turn, affects complexity of the application, known to the author processing methods. Often, according to the author's experience, the code of command line processing may be longer and even more complicated than the code of the main program, for example, of a short script. At the same time constant switching between the methods of options processing, different programming languages, only aggravates the situation additionally taking away time and efforts.

It is therefore necessary to develop not only simple, but also definitely a universal method of command line arguments processing, which does not require switching between languages.

One of the easiest ways to create a universal method is if a separate application is responsible for the processing of options (see Fig. 1). In this case, the "program" transmits to the "handler", in the form of a configu-

ration file or line, the structure of options used, as well as a command line that requires processing. The "handler" parses the command line according to the transmitted structure of options, stores the received data to a temporary file and completes its work. As needed the "program" sends requests to the "handler" – the "handler" compares them with the file and sends an appropriate response to the "program".

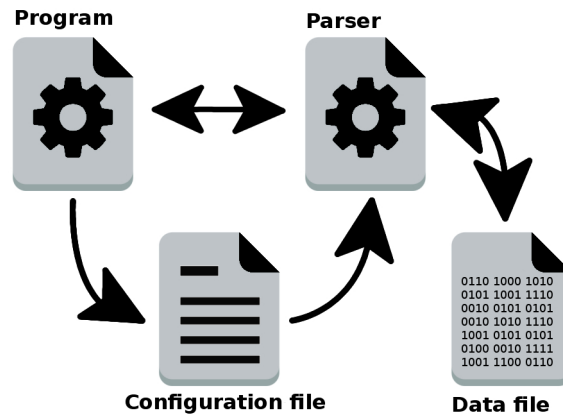


Fig. 1. General processing circuit

The circuit with the handler, in the form of a separate program, is the price that one needs to pay for versatility. Such a method cannot be called rapid, but the command line arguments processing is a procedure which usually does not require quick computations. The number of requests can be reduced to the minimum, up to the receipt of all "formalized" data in response to the transference of the command line. If the speed of information exchange between the "program" and the "handler" is important, then, the following example of the database, instead of single calls, to open session is enough, at which the "handler" will be finishing his work not after working off another request, but after a certain interval of time. Sleep interval is prolonged while the expectation of a new request. Under such a scheme of work, the "handler" does not require, at every request, to read or reset the data to a temporary file, he will do it only after a sleep interval. The data file is removed by the "handler", on request, at the end of the program life cycle.

If the scheme with the handler, in the form of a separate program, is responsible for versatility of the method, therefore the comfort and natively-friendly interface will be responsible for the structure of the configuration file. As the configuration file, one can choose any format, from «YAML» [9], «XML» [10], and «JSON» [11] in respect of their own developments. According to the author, the best solution for the formation of the configuration file, will be the use of «JavaScript» language [12].

Although the format of the "YAML" configuration file, for example, may be called "user-friendly", however, it cannot be called standard. Separation of syntactic elements is produced by a sequence of dash signs ending with a special symbol [9]. This may be unaccustomed for people not familiar with the format, which means that it can bring additional inconvenience in their work. The format «XML» has a redundant marking, behind which, eventually, the basic data are lost [10]. «JSON», unlike «XML», has a minimalistic marking that is actually unostentatious [11]. Moreover, the extended format – «JSON5», supports comments, has a simpler format allowing the existence of minor errors (for example, it is allowed to have a comma after the last element in an object or list), etc. [13].

The "JSON" is based on the «JavaScript» [11] and its extended format, in principle, is already ideally suitable for the use in the "program-handler" scheme. However, using, instead of the format «JSON5», the programming language in which the «JavaScript» was based [12], we do not limit ourselves to the format, but obtain all the available functions of the programming language, which opens up new opportunities. The "handler", in this case, will act in the role of interpreter, producing line analysis, handling and program execution, described in the configuration file.

Using the scenario programming languages in the configuration files is not a new method, but proved perfectly. A good example would be the configuration file of the domain «XEN», that is, in fact, the script in the language of «Python». This means that in the configuration file can be used any structure of this language, making it flexible and efficient. For example, you can combine configuration files of several machines into one, and to run any of them using this file with a parameter, indicating the domain with the help of which a machine should start and so on [14]. At the standard use, for example, initialization of variables, programming languages, the method of application is not different from the method used in simple configuration files, for example, in the «INI» file, distributed in «MS Windows» [15], and therefore does not complicate the code.

## REFERENCES

1. The Great Encyclopedia of Oil and Gas [Bolshaya EHnciklopediya Nefti I Gaza] // Development – programming [Razvitie – programmirovaniye]: site, 2016. – Mode of access: <http://www.ngpedia.ru/id360477p1.html>.
2. Robbins, A. (2005), Linux: programming in examples: Trans. from Eng. [Linux: programmirovaniye v primerah], KUDIC-OBRAZ, Moscow, 656 c.
3. GNU Operating System // Parsing Program Options with Argp: site, 2015. – Mode of access: [http://www.gnu.org/software/libc/manual/html\\_node/Argp.html#Argp](http://www.gnu.org/software/libc/manual/html_node/Argp.html#Argp).
4. CIT Forum // getopts - parse of command options [getopts - razbor opcij komandy]: site, 2016. – Mode of access: [http://citforum.ru/operating\\_systems/manpages/GETOPTS.1.shtml](http://citforum.ru/operating_systems/manpages/GETOPTS.1.shtml).
5. Python // optparse — Parser for command line options: site, 2016. – Mode of access: <https://docs.python.org/dev/library/optparse.html>.
6. GNU Operating System // GNU Coding Standards: site, 2015. – Mode of access: <http://www.gnu.org/prep/standards>.
7. Habrahabr // Administering → bash script with support for long (gnu-style) options [Administrirovanie → bash skript s podderzhkoj dlennyh (gnu-style) opcij]: site, 2016. – Mode of access: <https://habrahabr.ru/post/133860>.
8. Python // Argparse Tutorial: site, 2016. – Mode of access: <https://docs.python.org/3/howto/argparse.html>.
9. The Official YAML Web Site // YAML 1.2: site, 2016. – Mode of access: <http://yaml.org/>.
10. XML.com // XML: site, 2014. – Mode of access: <http://www.xml.com/>.
11. JSON // Introducing JSON: site, 2016. – Mode of access: <http://www.json.org/>.
12. JavaScript // JavaScript: site, 2016. – Mode of access: <http://www.javascript.com/>.
13. JSON5 // JSON5: site, 2016. – Mode of access: <http://www.json5.org/>.
14. XGU // Configuration file XEN [Konfiguracionnyj fajl XEN]: : site, 2009. – Mode of access: [http://xgu.ru/wiki/Конфигурационный\\_файл\\_Xen](http://xgu.ru/wiki/Конфигурационный_файл_Xen).
15. non GNU // INI formats: : site, 2016. – Mode of access: <http://www.nongnu.org/chmspec/latest/INI.html>.

UDC 004.42

**WEB PORTAL OF AMATEUR HANDBALL IN THE REPUBLIC OF BELARUS**

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*The article presents an analysis of the technologies that are used in the implementation of server-side Web applications. ADO.NET Entity Framework and CodeFirst approach are considered.*

The subject of the project is creating a web application containing information on amateur handball in Belarus, realized on the .net Framework platform.

Web applications or sometimes also web systems are different software products, access to which is provided via web interface. A web application is a client-server application in which the client is a browser, and the server is a Web server. The logic of a web application is distributed between the server and the client, data storage is carried out, preferentially, on the server, information exchange happens on a network. One of advantages of such approach is the fact that clients don't depend on a specific operating system of the user therefore web applications are cross-platform services.

Essential advantage of creating web applications to support fixed functions of a browser is that functions are performed irrespective of the client's operating system. Instead of writing different versions for Microsoft Windows, Mac OS X, GNU/Linux and other operating systems, the application is created once for randomly selected platform.

A web application consists of client and server parts, thereby realizing client-server technology. A client part realizes the user interface, creates server requests and processes responses from it. A server part receives a request from the client, executes computation, after that creates the web page and sends it to the client on a network with the use of HTTP protocol.

Relevance of creating a web application is justified also by the fact that with development of portable computers and mobile devices, the client part of a web application can be used not only on desktop computers and laptops, but also on the mentioned mobile devices. It leads to the fact that the circle of people who will be able to use the developed product is much wider than if the web application was implemented only as a Desktop application.

The main objective of implementing a web application is to give the chance to users to be aware of all amateur competitions which are taking place in our country and also to view information on amateur commands and players.

Developed software should have the following functionality:

- 1 registered users can register sporting events;
- 2 all users can view news;
- 3 all users can view information on commands;
- 4 all users can view information on players;
- 5 all users can view information on actions;
- 6 registered users can change personal data in a private office;
- 7 registration of users with different roles;
- 8 search in a basis of actions;
- 9 editing all data domain by the user administrator;
- 10 authorized users can leave comments to results of actions;
- 11 all users can view photo and video reports;
- 12 the registered users can recover the password by means of email, in case of old password loss.

**Means for solving the problem.** Consider the basic tools and technologies of server-side Web applications, "the Republic of Belarus Web portal amateur handball."

The paper deals with ASP.NET MVC Framework - a framework for building web applications that implement the Model-view-controller pattern. This framework is added to Microsoft's ASP.NET. ASP.NET MVC platform is based on the interaction of three components: controllers, models and views. The controller receives the request, processes the user input, interacts with the model and the view, and returns the user to the result of the query.

The model layer describes the logic of data organization in the application. Submission receives data from the controller and generates UI elements for displaying information. When processing requests, ASP.NET MVC framework is based on the routing system that maps all incoming requests to specific routes in the system that indicates which controller and method should handle the request. A built default route involves a three-tier structure: a controller / action / parameter [1, 2].

In Ninject the IoC-container will be used. Actually IoC (Inversion of Control (Inversion of Control)) is an abstract concept, a set of guidelines for writing a weakly bound code, the essence of which is that each component of the system should be as isolated from others, instead of relying in their work on the details of specific implementation of other components. Dependency Injection (dependency injection) is one of the realizations of this principle and IoC-container is a framework that will allow you to simplify and automate the coding with the use of this approach as much as possible [1, 2].

When implementing the application architecture, "onion" architecture will be used. Onion-architecture is the separation of applications to the levels. And there is one independent layer that is in the center of the architecture. This level depends on the second level, the second level - on the third one, and so on. Thus, it turns out that the second (dependent) level is superimposed around the first (independent) level. Around the second level the third one accumulates, which may also depend on the first level. Figuratively, it can be expressed in the form of a bow, which also has a core around which all other layers are laminated up to the hull.

The number of levels may vary, but the center is always the domain model (Domain Model), that is, those classes of models that are used in the application objects stored in the database. The first level around the domain model forms interfaces that control the operation of the domain model. Usually they are repository interfaces through which we interact with the database.

The outer layer represents such components which are often changed. Typically, the outer layer forms user interface tests, some helper classes application infrastructure. This level also includes concrete implementations of interfaces, announced at lower levels. For example, the implementation of the repository interface, which is declared on the level Domain Services. In general, all the internal levels which can be combined in Application Core define only interfaces and the concrete realization of these interfaces are located on the outer level.

It is also worth noting that all the external storage, such as databases, files, external Web services, from which we can obtain data - all of which are external to the architecture, [1, 2].

ADO.NET Entity Framework and CodeFirst approach will be used for working with the database framework. ADO.NET Entity Framework (EF), an object-oriented data access technology, is object-relational mapping (ORM) solution for .NET Framework from Microsoft. It provides the ability to interact with objects, both through a LINQ LINQ to Entities, and using Entity SQL. To facilitate the construction of web-solutions, ADO.NET Data Services (Astoria) and a bunch of Windows Communication Foundation and Windows Presentation Foundation are used, which allows to build a multi-tier applications by implementing one of the MVC design patterns, MVP or MVVM [1,2].

When designing applications with CodeFirst approach, you first create the data model classes not paying any attention to the Entity Framework. Next, you needed to work with the database, you use a variety of tools, which project out of the database structure to create a class model. Then you can return to this model in the code, for example, to change it. These changes can then be reflected in the database with the help of the same tools.

**Conclusion.** The use of MVC model has allowed a clear distinction between the functional server side without mixing its components resulting in easy understanding and the following code change.

ADO.NET Entity Framework makes it possible to create a database containing all the information and functionality needed for web-based applications without understanding the subtleties of SQL comfortable work. With CodeFirst approach it is possible to create a database from scratch only on the basis of written class models.

Using an IoC container Ninject made web application flexible to changes. We just need to implement the interface fit our way to the top layer of the application without going to the lower layers.

#### REFERENCES

- 1 Википедия – свободная энциклопедия [Электронный ресурс]. – Режим доступа: <https://ru.wikipedia.org/wiki/>. – Дата доступа: 29.01.2017.
- 2 Metanit – сайт о программировании [Электронный ресурс]. – Режим доступа: <http://metanit.com>. – Дата доступа: 29.01.2017.
- 3 Habrahabr – многофункциональный сайт. [Электронный ресурс]. – Режим доступа: <https://habrahabr.ru>. – Дата доступа: 29.01.2017.
- 4 Сандерсон С., Фримен А. ASP.NET MVC3 Framework с примерами на С# для профессионалов (3-е изд., 2012) – 662 с.
- 5 Стиллмен Э., Грин Дж. Изучаем С#. – 3-е изд. – СПб. : Питер, 2014. – 816 с.: ил. – (Серия «HeadFirstO'Reilly»).
- 6 Троелсен Э. Язык программирования С# 5.0 и платформа .NET 4.5. – 6-е изд. : пер. с англ. – М. : ООО «И.Д. Вильямс», 2013. – 1312 с. : ил. – парал. тит. англ.

UDC 004.428.4

## REVIEW OF SPRING CLOUD CONFIG

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*This article focuses on Spring Cloud Config, which is a library of Spring Framework. A short overview of functionality and capabilities of this library is presented.*

**Introduction.** Spring Cloud Config provides server and client-side support for externalized configuration in a distributed system. With the ConfigServer you have a central place to manage external properties for applications across all environments. The concepts on both client and server map are identical to Spring Environment and PropertySource abstractions, so they fit Spring applications very well, but can be used with any application running in any language. As an application moves through the deployment pipeline from dev to test and into production you can manage the configuration between those environments and be certain that applications have everything they need to run when they migrate. The default implementation of the server storage backend uses git so it easily supports labeled versions of configuration environments, as well as being accessible to a wide range of tooling for managing the content. It is easy to add alternative implementations and plug them in with Spring configuration.

Changing configurations on running services can be cumbersome, especially if the application does not have a way to be configured remotely. Spring Cloud Config provides a way to make this easier by introducing a Config Server from which clients fetch their configuration. The figure below illustrates how Spring Cloud Config works.

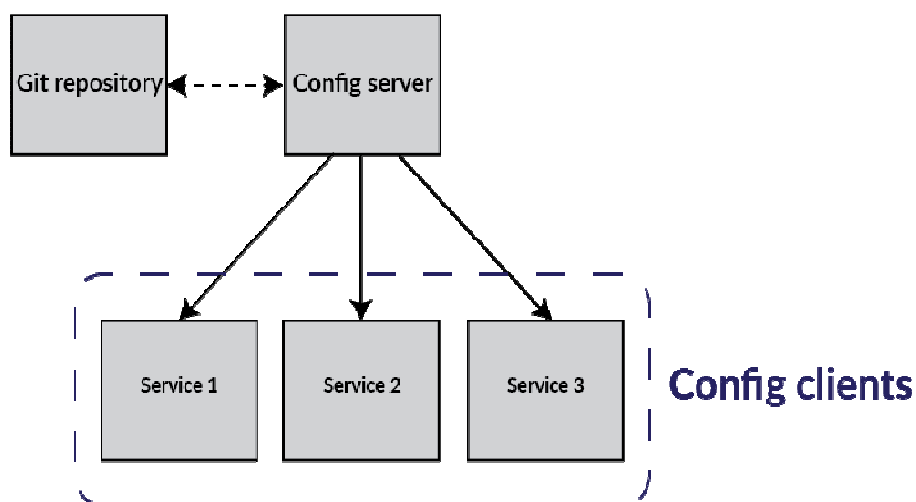


Fig. 1 – Common architecture diagram of how Spring cloud config works

Spring Cloud Config Server provides the following features:

1. HTTP, resource-based API for external configuration (name-value pairs, or equivalent YAML content)
2. Encrypt and decrypt property values (symmetric or asymmetric)
3. Embeddable easily in a Spring Boot application using @EnableConfigServer.

Config Client provides the following features (for Spring applications):

1. Bind to the Config Server and initialize Spring Environment with remote property sources
2. Encrypt and decrypt property values (symmetric or asymmetric)
3. Fail fast and retry

The server is a Spring Boot application so it is very easy to create stand-alone, production-grade Spring based applications that can be "just run".

The default strategy for locating property sources is to clone a git repository (at `spring.cloud.config.server.git.uri`) and use it to initialize a mini SpringApplication. The Spring boot applications environment is used to enumerate property sources and publish them via a JSON endpoint.

## ITC, Electronics, Programming

The HTTP service has the following resources forms:

1. `/{application}/{profile}[/{label}]`
2. `/{application}-{profile}.yml`
3. `/{label}/{application}-{profile}.yml`
4. `/{application}-{profile}.properties`
5. `/{label}/{application}-{profile}.properties`

"Application" is injected as the `spring.config.name` in the `SpringApplication` (i.e. what is normally "application" in a regular Spring Boot app), "profile" is an active profile (or comma-separated list of properties), and "label" is an optional git label (defaults to "master".)

Also you should create `bootstrap.properties` file and add it to classpath of your spring boot application. Then you just need to add one property to this file: `spring.cloud.config.server.git.uri: {pathToGitRepository}`.

That is all, server side of Spring Cloud Config is ready to be used.

Now let's look at client side of Spring Cloud Config. To use Spring Cloud Config features in an application, just build it as a Spring Boot application that depends on `spring-cloud-config-client` (e.g. see the test cases for the `config-client`, or the sample app). The most convenient way to add the dependency is via a Spring Boot starter `org.springframework.cloud:spring-cloud-starter-config`. Then you just need to add one property to your client of Spring Cloud Config: `spring.cloud.config.uri: http://myconfigserver.com`.

That is all. When Cloud Config client will start it automatically and fetch properties from Cloud Config server, all other work for injecting properties to your beans Spring does by itself.

You are free to secure your Config Server in any way that makes sense to you (from physical network security to OAuth2 bearer tokens), and Spring Security and Spring Boot make it easy to do a lot of things.

If the remote property sources contain encrypted content, (values starting with `{cipher}`) they will be decrypted before sending to clients over HTTP. The main advantage of this set up is that the property values do not have to be in plain text when they are "at rest" (e.g. in a git repository). If a value cannot be decrypted, it is removed from the property source and an additional property is added with the same key, but prefixed with "invalid." and a value that means "not applicable" (usually "`<n/a>`"). This is largely to prevent cipher text being used as a password and leaking accidentally.

To use the default Spring Boot configured HTTP Basic security, just include Spring Security on the classpath (e.g. through `spring-boot-starter-security`). The default is a username of "user" and a randomly generated password, which isn't very useful in practice, so we recommend you configure the password (via `security.user.password`) and encrypt it (see below for instructions on how to do that).

In some cases, it may be desirable to fail startup of a service if it cannot connect to the Config Server. If this is the desired behaviour, set the bootstrap configuration property `spring.cloud.config.failFast=true` and the client will halt with an Exception.

If you expect that the Config server may occasionally be unavailable when your app starts, you can ask it to keep trying after a failure. First, you need to set `spring.cloud.config.failFast=true`, and then you need to add `spring-retry` and `spring-boot-starter-aop` to your classpath. The default behaviour is to retry 6 times with an initial backoff interval of 1000ms and an exponential multiplier of 1.1 for subsequent backoffs. You can configure these properties (and others) using `spring.cloud.config.retry.*` configuration properties.

**Conclusion.** Spring Cloud Config allows managing external properties for applications across all environments. Now we are able to create a configuration server to provide a set of configuration files from a Git repository to client applications. As you can see, spring cloud is a very easy and friendly library to use.

## REFERENCES

1. Repository of spring cloud config – Github [Electronic resource] / Github Inc., 2017. – Mode of access: <https://github.com/spring-cloud/spring-cloud-config>. – Date of access: 28.01.2017.
2. Spring framework – Wikipedia [Electronic resource] / Wikimedia Foundation., 2017. – Mode of access: [https://en.wikipedia.org/wiki/Spring\\_Framework](https://en.wikipedia.org/wiki/Spring_Framework). – Date of access: 28.01.2017.
3. Microservice architecture with Spring cloud config – Habrahabr [Electronic resource]. – Mode of access: <https://habrahabr.ru/post/280786/>. – Date of access: 28.01.2017.



UDC 621.391.64

### ANALYSIS OF ACOUSTIC-OPTIC-FIBRE CHANNEL LEAKAGE IN FIBRE-OPTIC COMMUNICATION LINES

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*The paper considers the model of fibre-optic communication lines. The experiment has shown the greatest influence of acoustic signal on the optical signal in the optical fibre passes. Physical principles of formation of leakage channels in fibre cable are described. Modulation types peculiar to the optical signal under the influence of an external acoustic source are listed.*

**Introduction.** Currently, the protection of speech information during the confidential negotiations is an urgent problem. Fibre-optic lines are widely used in information communication systems, as they have a number of advantages over cable lines: data transmission speed, anti-leakage electromagnetic field, etc. Thus, the fibre-optic cable laid in the room can be subjected to acoustic impact, which leads to information leakage channels. The principle of functioning of a leakage channel is described by L.Glushchenko [1], which explains that the light beam is modulated by the fibre under the action of bending vibrations generated by an external acoustic field, i.e., voice information carrier.

If a fibre-optic cable can create a channel of information leakage, then analyzing its characteristics can help to choose ways to protect the link from the removal of confidential information. And determining which of the optical signal transmission parameters are the most informative, you can find the right kind of fibre protection.

**Description of experimental models.** It is known that fibre-optic communication line is a type of communication in which information is transmitted through the optical fibre. The optical fibre is a thin glass strand (about 125 mm diameter) made of quartz. Therefore, to construct a working model of fibre-optic communication lines, you need an optical fibre, the receiver and the transmitter radiation, and an acoustic system. Figure 1 shows a model of fibre optic data transmission.

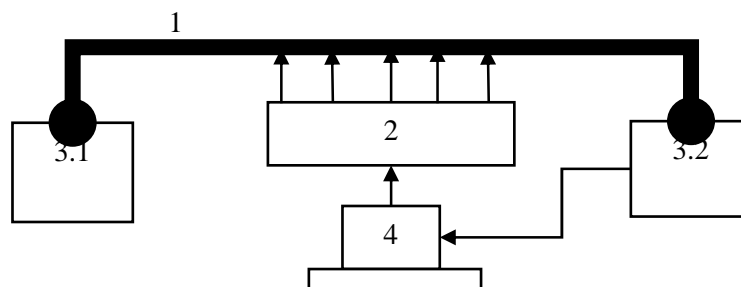


Fig. 1. Model of fibre optic data transmission:  
1 - optical fiber; 2 - speaker system; 3.1 - multi tester optical emitter;  
3.2 - multi tester optical receiver; 4 - PC.

The experiment was carried out with the help of G652 single-mode model of fibre optic data transmission, two optical multi testers capable of changing the luminous flux of the radiation wavelength and frequency modulation. Also, for the simulation of the acoustic signal as the source of confidential information, the computer has a sound generator that plays a constant level of the acoustic signal through the speaker system. Sound generator can adjust the frequency and type of signal as well as audio output. Since selecting an external signal and its influence analysis were not the goal of the experiment, the acoustic signal frequency and power were constant:  $f_{SS} = 1072$  Hz,  $P_{SS} = 1$  W.

We used two types of external influence: sinusoidal and noise acoustic signal, so it was monitored whether the output signal depends on the type of bearing information, and whether it can be overlapped by the noise component. All output data are recorded on the computer via the USB-connection and a special application connected to multi tester.

**Results.** The basic physical principles of leakage channels formation can be divided into the following types [2]:

1. Violation of the total internal reflection;
2. Registration of the scattered radiation at the wavelengths of the main flow of information, and the combination frequencies;

### 3. Parametric methods for recording the transmitted radiation.

Analysis of fibre-optic communication cable flexing showed similarity with the characteristics of the window glass under the influence of micro vibrations. The article [3] shows that the glass is exposed to three types of modulation (amplitude, frequency and phase), so an optical signal flowing in the fibre is subjected to the same modulation. However, there are a pulse modulation and polarization characteristic of fibre under certain physical principles, such as photo elasticity, acoustic-optical, magneto-optical, electro-optical, piezoelectric effects, and the modulation of absorption [4].

Since it is recommended to use wavelength equal to 1550 nm in single-mode fibre, this kind of fibre was used in the experiment. The results, shown in the graph (Fig. 2), were obtained when checking some well-known physical principles affecting acoustic-fibre channel leakage.

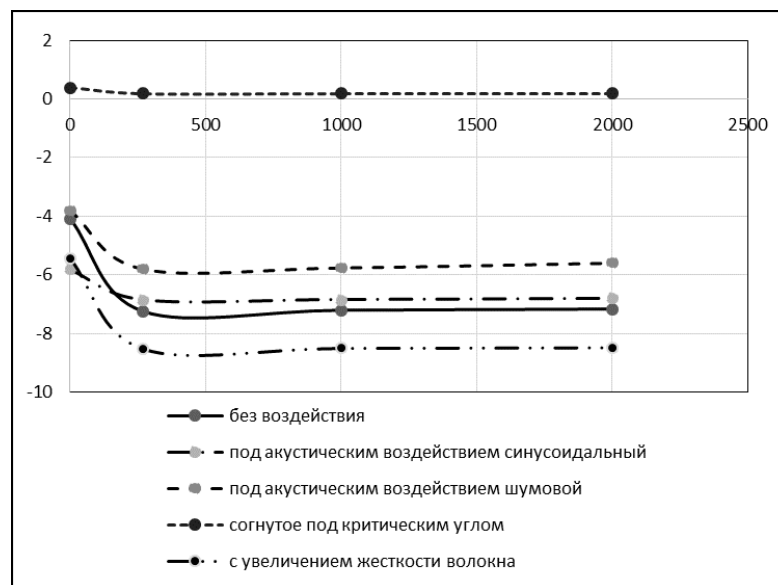


Fig.2. Graph of ratio of output power from the modulated frequency

The graph shows that the fibre is sensitive to an external acoustic field, especially in the state of the transmission line folded to a critical angle. Increasing the stiffness curve is more similar to the original, but the deformation bend is greater, so confidential information leakage is possible from a fiber optic cable stretched in the room. Types of acoustic signal show clearly that the noise acoustic signal is stronger than sinusoidal signal. This suggests that it is possible to conceal confidential negotiations acoustic noise near the laid fibre, but this option is not very convenient to use, therefore, it is necessary to protect it from optical fiber bending vibrations, rather than the acoustic source.

**Conclusion.** Having analysed the acoustic-optical fibre channel of information leakage it can be stated that fibre defence is a difficult task, since it is exposed to different types of acoustic signals and receives all micro fluctuations, however, not all equipment can catch them. Total internal reflection at the bend of the fibre influences confidential information leakage sufficiently. Thus, the analysis showed that the main purpose is to protect the fibre with increased rigidity because it carries the most informative signal by an external acoustic field.

## REFERENCES

1. Глушенко, Л.А. Методический подход к оценке защищенности акустической речевой информации от утечки по акусто-оптоволоконному каналу / Л.А.Глушенко // ОАО НИИ ОЭП, Сосновый бор
2. Гришачев, В.В. Анализ каналов утечки информации в волоконно-оптических линиях связи: нарушение полного внутреннего отражения / В.В. Гришачев, В.Н. Кабашкин, А.Д. Фролов // Информационное противодействие угрозам терроризма. – 2005. – №4. – С. 195–204.
3. Железняк, В.К. Оценка модели оптико-электронного канала утечки речевой информации / В.К. Железняк, И.С. Чернова. – Вестник Полоцкого государственного университета. Серия С, Фундаментальные науки. – 2015. – № 12. – С. 33–39.
4. Моргунов, К.К. Математическая модель оценки защищенности информации в лазерных линиях связи / К.К. Моргунов, Л.А. Глушенко // Журн. ун-та водных коммуникаций. – 2012. – № 1. – С. 103–108.

UDC 004.738.5.056(07)

**DARKNET – ONE OF THE SIDES OF THE INTERNET****YULIYA SHVETS, ELENA SETKO****Yanka Kypala State University of Grodno, Belarus**

*This article is about resources, which can open access to illegal systems of the World Internet space and information protection methods which provide anonymity of the systems work.*

The Internet is a global network, which can give us access to all digital resources. We use it with different aims every day. Every user can get any information, if he knows where he should search for it. On the one hand, implementation of IT-technologies in different areas made person's life more comfortable, but on the other hand, due to this process, a number of crimes have been increased in this area.

As a result, teaching of informatics or modern computer technologies, it is necessary to form culture and skills of correct activity in networks and cloud spaces, using internet resources and network services in the process of education and further professional activity, also experience of making own content on the base of different services.

The aim of the article is the necessity to inform people, which study work on the Internet, about existence of "Depth Internet" and principles of its functioning, effective and legal work on the Internet.

Darknet is a small part of Deep Web [1], which means a diversified content, which is unavailable for most part of search engines. All resources are hidden from accessible search systems in Darknet. Information is defended with special computer software, which provides encryption and anonymity of users.

Anonymous network, where there are own laws and regulations. Place, where you can buy and find everything, regardless of some moral standards. It is a network with a huge choice of related sites. You can find any information. But due to absolute freedom and lack of laws, illegal business is very developed.

Well, "Darknet" is a number of private networks, which use only trusted connection (full anonymity). No one can track a man in this networks and due to this illegal business has become widespread. None of search engines or web browsers gives you access to these resources, none except Tor [2]. Tor or The Onion Router is a free software for enabling anonymous communication. Tor was made in a secret lab of the naval forces of the United States, this system was a secret project, but later the source code was opened.

Tor aims to conceal its users' identities and their online activity from surveillance and traffic analysis by separating identification and routing. It is an implementation of onion routing, which encrypts and then randomly bounces communications through a network of relays run by volunteers around the globe. These onion routers employ encryption in a multi-layered manner (hence the onion metaphor) to ensure perfect forward secrecy between relays, thereby providing users with anonymity in network location. That anonymity extends to the hosting of censorship-resistant content by Tor's anonymous hidden service feature. Furthermore, by keeping some of the entry relays (bridge relays) secret, users can evade the Internet censorship that relies upon blocking public Tor relays.

Because the IP address of the sender and the recipient are not both in clear text at any hop along the way, anyone eavesdropping at any point along the communication channel cannot directly identify both ends. Furthermore, to the recipient it appears that the last Tor node (called the exit node), rather than the sender, is the originator of their communication.

A Tor user's SOCKS-aware applications can be configured to direct their network traffic through a Tor instance's SOCKS interface. Tor periodically creates virtual circuits through the Tor network, through which it can multiplex and onion-route that traffic to its destination. Once inside a Tor network, the traffic is sent from router to router along the circuit, ultimately reaching an exit node at which point the clear text packet is available and is forwarded on to its original destination. Viewed from the destination, the traffic appears to originate at the Tor exit node.

Tor's application independence sets it apart from most other anonymity networks: it works at the Transmission Control Protocol (TCP) stream level. Applications whose traffic is commonly anonymized using Tor include Internet Relay Chat (IRC), instant messaging, and World Wide Web browsing.

Tor can also provide anonymity to websites and other servers. Servers configured to receive inbound connections only through Tor are called hidden services. Rather than revealing a server's IP address (and thus its network location), a hidden service is accessed through its onion address, usually via the Tor Browser. The Tor network understands these addresses by looking up their corresponding public keys and introduction points from a distributed hash table within the network. It can route data to and from hidden services, even those hosted behind firewalls or network address translators (NAT), while preserving the anonymity of both parties. Tor is necessary to access hidden services.

Other than the database that stores the hidden-service descriptors, Tor is decentralized by design; there is no direct readable list of all hidden services, although a number of hidden services catalog publicly known onion addresses.

Because hidden services do not use exit nodes, connection to a hidden service is encrypted end-to-end and not subject to eavesdropping. There are, however, security issues involving Tor hidden services. For example, services that are reachable through Tor hidden services and the public Internet are susceptible to correlation attacks and thus not perfectly hidden. Other pitfalls include misconfigured services (e.g. identifying information included by default in web server error responses), uptime and downtime statistics, intersection attacks, and user error. Hidden services could be also accessed from a standard web browser without client-side connection to the Tor network, using services like Tor2web.

Ensuring the anonymity of users an illegal business has been widely adopted. It is possible to find everything in Darknet: from hard drugs and weapon to the materials of pornographic content involving minors. However it also contains a great number of libraries full of rare literature that is not available in the public domain, it allows to exchange information between witnesses of various incidents, informants, intelligence agents (for safety) and many other things[3]. Various special services use these resources.

Buyers and sellers carry out all money transactions through the use of cryptocurrency bitcoin, which in combination with Tor can ensure anonymity of the parties to the transaction and the inability to lock payment. Bitcoin is a cryptocurrency and a payment system, invented by an unidentified programmer, or group of programmers, under the name of Satoshi Nakamoto. The system is peer-to-peer and transactions take place between users directly, without an intermediary. These transactions are verified by network nodes and recorded in a public distributed ledger called the blockchain, which uses bitcoin as its unit of account (The blockchain is a public ledger that records bitcoin transactions.). Bitcoin is a decentralized virtual currency[4].

Bitcoin is pseudonymous, meaning that funds are not tied to real-world entities but rather bitcoin addresses. Owners of bitcoin addresses are not explicitly identified, but all transactions on the blockchain are public. In addition, transactions can be linked to individuals and companies through "idioms of use" (e.g., transactions that spend coins from multiple inputs indicate that the inputs may have a common owner) and corroborating public transaction data with known information on owners of certain addresses. Additionally, bitcoin exchanges, where bitcoins are traded for traditional currencies, may be required by law to collect personal information.

To heighten financial privacy, a new bitcoin address can be generated for each transaction. For example, hierarchical deterministic wallets generate pseudorandom "rolling addresses" for every transaction from a single seed, while only requiring a single passphrase to be remembered to recover all corresponding private keys. The legal status of bitcoin varies substantially from country to country and is still undefined or changing in many of them. While some countries have explicitly allowed its use and trade, others have banned or restricted it. Likewise, various government agencies, departments, and courts have classified bitcoins differently. Regulations and bans that apply to bitcoin probably extend to similar cryptocurrency systems.

Bitcoin is not recognized as official currency (mostly it is used for buying illegal things).

Despite the fact that Tor has a high level of protection there are quite a lot of security problems that enable to trace a user and transmitted data. Tor is aimed at hiding the link between a client and a server. However it cannot essentially provide transmitted data to be fully hidden as enciphering in this case is only a means of achieving anonymity on the Internet. Therefore additional protection of communication is necessary for maintaining a higher level of confidentiality. Enciphering of the files transferred through Tor by means of their packing in cryptographic containers and the methods of a steganography is also important. The modern student of IT specialties studying a course on information security has to know all this.

## REFERENCES

1. Darknet [Electronic resource]. – Mode of access: <https://ru.wikinews.org/wiki/Darknet>. – Date of access: 28.01.2017.
2. The system of proxy servers [Electronic resource]. – Mode of access: <https://ru.wikinews.org/wiki/Tor>. – Date of access: 28.01.2017.
3. What are bought in Darknet. – Mode of access: <http://www.zdnet.com/article/seven-things-you-did-not-know-about-the-deep-web>. – Date of access: 28.01.2017.
4. Bitcoin [Electronic resource]. – Mode of access: <https://en.wikipedia.org/wiki/Bitcoin>. – Date of access: 28.01.2017.

UDC 004.514

**CLOUD APPLICATION ARCHITECTURES: CLOUD SERVICE MODELS**

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**Introduction.** Cloud computing has recently emerged as one of the buzzwords in the ICT industry. Numerous IT vendors are promising to offer computation, storage, and application hosting services and to provide coverage in several continents, offering service-level agreements (SLA)-backed performance and uptime promises for their services. While these “clouds” are the natural evolution of traditional data centers, they are distinguished by exposing resources (computation, data/storage, and applications) as standards-based Web services and following a “utility” pricing model where customers are charged based on their utilization of computational resources, storage, and transfer of data. They offer subscription-based access to infrastructure, platforms, and applications that are popularly referred to as IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software as a Service). While these emerging services have increased interoperability and usability and reduced the cost of computation, application hosting, and content storage and delivery by several orders of magnitude, there is significant complexity involved in ensuring that applications and services can scale as needed to achieve consistent and reliable operation under peak loads.

Currently, expert developers are required to implement cloud services. Cloud vendors, researchers, and practitioners alike are working to ensure that potential users are educated about the benefits of cloud computing and the best way to harness the full potential of the cloud. However, being a new and popular paradigm, the very definition of cloud computing depends on which computing expert is asked. So, while the realization of true utility computing appears closer than ever, its acceptance is currently restricted to cloud experts due to the perceived complexities of interacting with cloud computing providers.

**The Cloud.** The cloud is not simply the latest fashionable term for the Internet. Though the Internet is a necessary foundation for the cloud, the cloud is something more than the Internet. The cloud is where you go to use technology when you need it, for as long as you need it, and not a minute more. You do not install anything on your desktop, and you do not pay for the technology when you are not using it. The cloud can be both software and infrastructure. It can be an application you access through the Web or a server that you provision exactly when you need it. Whether a service is software or hardware, the following is a simple test to determine whether that service is a cloud service:

If you can walk into any library or Internet cafe and sit down at any computer without preference for operating system or browser and access a service, that service is cloud-based. I have defined three criteria I use in discussions on whether a particular service is a cloud service:

- The service is accessible via a web browser (nonproprietary) or web services API.
- Zero capital expenditure is necessary to get started.
- You pay only for what you use as you use it.

We should take a moment to understand a variety of cloud infrastructure models. It would be easy to contrast these services if there were fine dividing lines among them, but instead, they represent a continuum from managed services through something people call Infrastructure as a Service (IaaS) to Platform as a Service (PaaS) and Software as a Service (SaaS).

**Cloud service models.** Choosing the right service model is a critical success factor for delivering cloud-based solutions. In order to choose the right service model or combination of service models, one must fully understand what each service model is and what responsibilities the cloud service providers assume versus the responsibilities the cloud service consumer assumes.

There are three cloud service models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Each cloud service model provides a level of abstraction that reduces the efforts required by the service consumer to build and deploy systems. In a traditional on-premises data center, the IT team has to build and manage everything. Whether the team is building proprietary solutions from scratch or purchasing commercial software products, they have to install and manage one-to-many servers, develop and install the software, ensure that the proper levels of security are applied, apply patches routinely (operating system, firmware, application, database, and so on), and much more. Each cloud service model provides levels of abstraction and automation for these tasks, thus providing more agility to the cloud service consumers so they can focus more time on their business problems and less time on managing infrastructure.

Figure 1 displays what is called the cloud stack. At the bottom is the traditional data center, which may have some virtualization in place but does not have any of the characteristics of cloud computing. The five characteristics of cloud computing are network access, elasticity, resource pooling, measured service, and on-demand self-service.

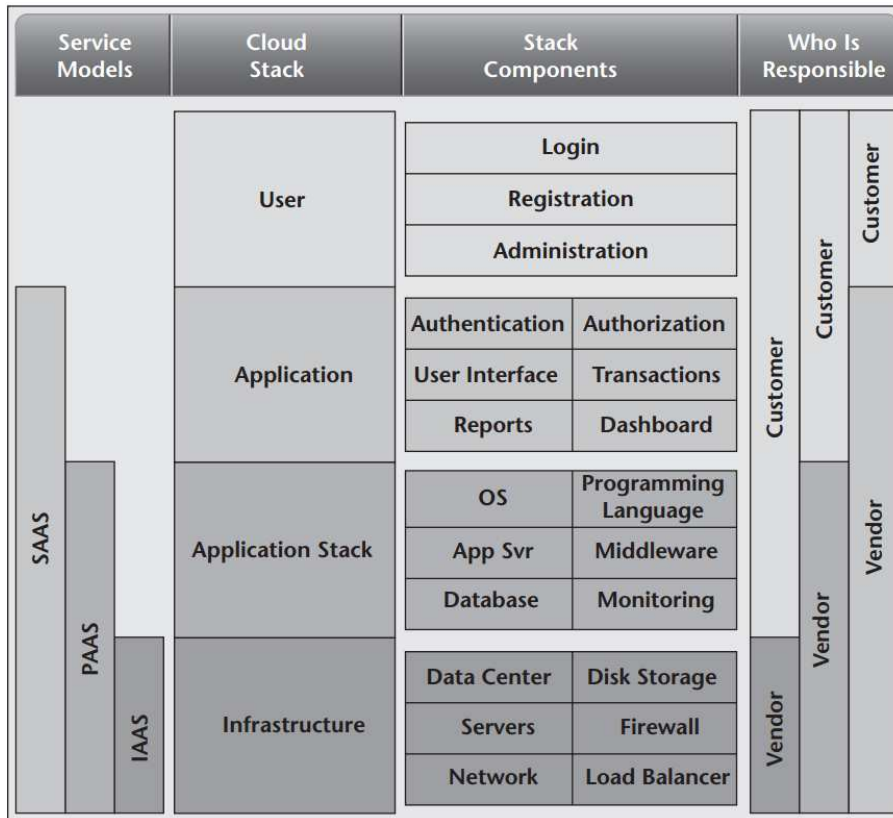


Fig 1. Cloud service models

IaaS

The National Institute of Standards and Technology (NIST) defines IaaS as: “The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications and possibly limited control of select networking components (e.g., host firewalls).”

The Cloud Security Alliance (CSA), a standards organization for cloud security, states that IaaS: “Delivers computer infrastructure (typically a platform virtualization environment) as a service, along with raw storage and networking. Rather than purchasing servers, software, data center space, or network equipment, clients instead buy those resources as a fully outsourced service.”

With IaaS, many of the tasks related to managing and maintaining a physical data center and physical infrastructure (servers, disk storage, networking, and so forth) are abstracted and available as a collection of services that can be accessed and automated from code- and/or web-based management consoles. Developers still have to design and code entire applications and administrators still need to install, manage, and patch third-party solutions, but there is no physical infrastructure to manage anymore. Gone are the long procurement cycles where people would order physical hardware from vendors that would ship the hardware to the buyer who then had to unpackage, assemble, and install the hardware, which consumed space within a data center. With IaaS, the virtual infrastructure is available on demand and can be up and running in minutes by calling an application programming interface (API) or launching from a web-based management console. Like utilities such as electricity or water, virtual infrastructure is a metered service that costs money when it is powered on and in use, but stops accumulating costs when it is turned off. In summary, IaaS provides virtual data center capabilities so service consumers can focus more on building and managing applications and less on managing data centers and infrastructure. There are several IaaS vendors in the marketplace and too many to name in this book. The most mature and widely used IaaS cloud service provider is Amazon Web Services (AWS). Rackspace and GoGrid are also early pioneers in this space. OpenStack is an open source project that provides IaaS capabilities for those consumers who want to avoid vendor lock-in and want the control to build their own IaaS capabilities in-house, which is referred to as a private cloud. There are a number of companies that are building IaaS solutions on top of OpenStack similar to how there are many different distributions of Linux.

### PaaS

The next level up on the stack is PaaS. What IaaS is to infrastructure, PaaS is to the applications. PaaS sits on top of IaaS and abstracts much of the standard application stack-level functions and provides those functions as a service. For example, developers designing high-scaling systems often have to write a large amount of code to handle caching, asynchronous messaging, database scaling, and much more. Many PaaS solutions provide those capabilities as a service so the developers can focus on business logic and not reinvent the wheel by coding for underlying IT “plumbing.”

NIST defines PaaS as: “The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure, including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.”

The CSA describes PaaS as: “The delivery of a computing platform and solution stack as a service. PaaS offerings facilitate deployment of applications without the cost and complexity of buying and managing the underlying hardware and software and provisioning hosting capabilities.”

The CSA also mentions that PaaS services are available entirely from the Internet. PaaS vendors manage the application platform and provide the developers with a suite of tools to expedite the development process. Developers give up a degree of flexibility with PaaS because they are constrained by the tools and the software stacks that the PaaS vendor offers. The developers also have little-to-no control over lower-level software controls like memory allocation and stack configurations (examples: number of threads, amount of cache, patch levels, etc.). The PaaS vendors control all of that and may even throttle how much compute power a service consumer can use so that the vendor can ensure the platform scales equally for everyone. Chapter 5 (“Choosing the Right Cloud Service Model”) explores these service model characteristics in great detail. Early PaaS pioneers like Force.com, Google Apps Engine, and Microsoft Azure dictated both the platform stack and the underlying infrastructure to developers. Force.com dictates that developers write in Apex code and the underlying infrastructure must be on Force.com’s data center. Google Apps Engine originally required that developers code in Python and on the Google data center while Azure originally required .NET technologies on Microsoft data centers. A new breed of PaaS vendors have emerged and have created an open PaaS environment where consumers can implement the PaaS platform on the infrastructure of their choice and with many options for the development stack, including PHP, Ruby, Python, Node.js, and others. This approach is critical for widespread adoption by enterprises since many enterprises require or prefer to keep some or all of the application on-premises in a private cloud. Often, large enterprises leverage hybrid clouds by keeping their data in a private cloud and moving non-mission-critical components into the public cloud. Both Google and Microsoft now support multiple development languages, whereas in the past they only supported one. Heroku and Engine Yard are examples of mature public PaaS solutions that provide multiple stacks for developers, although at the time of the writing of this book they can be deployed only on AWS. Another huge advantage of PaaS is that these platforms integrate with numerous third-party software solutions, which are often referred to as plugins, add-ons, or extensions.

By leveraging APIs to access numerous third-party solutions, developers can provide fail over, high service level agreements (SLAs), and achieve huge gains in speed to market and cost efficiency since they don’t have to manage and maintain the technology behind the APIs. This is the power of PaaS, where developers can quickly assemble a collection of mature and proven third-party solutions simply by calling APIs and not having to go through a procurement process followed by an implementation process for each third-party tool. PaaS allows companies to focus on their core competencies and integrate with the best-of-breed tools in the marketplace. PaaS is the least mature of the three cloud service models but analysts predict a huge boom in the PaaS marketplace in the next several years.

### SaaS

At the top of the stack is SaaS. SaaS is a complete application delivered as a service to the service consumer. The service consumer has only to configure some application-specific parameters and manage users. The service provider handles all of the infrastructure, all of the application logic, all deployments, and everything pertaining to the delivery of the product or service. Some very common SaaS applications are customer relationship management (CRM), enterprise resource planning (ERP), payroll, accounting, and other common business software. SaaS solutions are extremely common for non-core-competency functionality. Companies choose to rely on SaaS solutions for non-core functions so they do not have to support the application infrastructure, provide maintenance, and hire staff to manage it all. Instead they pay a subscription fee and simply use the service over the Internet as a browser-based service. NIST defines SaaS as:

The capability provided to the consumer is to use the provider’s applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the

underlying cloud infrastructure, including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

#### REFERENCES

1. Buyya, R. Cloud Computing: Principles and Paradigms / R. Buyya, J. Broberg, A. M. Goscinski. – Hoboken : Wiley, 2011. – 664 p.
2. Reese, G. Cloud Application Architectures: Building Applications and Infrastructure in the Cloud / G. Reese. – Sebastopol : O'Reilly Media, 2009. – 208 p.
3. Kavis, M.J. Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS) / M.J. Kavis. – Hoboken : Wiley, 2014. – 224 p.



UDC681.586.773:624.072.233.5

**COMPREHENSIVE ANALYSIS OF SIGNALS IN THE PROCESS  
OF ULTRASONIC FLAW DETECTION****ALIAKSEI SHLIAKHTSIONAK, DMITRIY DOVGYALO**  
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*This article describes the main stages of the complex analysis of the signals received by the ultrasonic flaw detector in the monitoring process. In practice the flaw of the head of the rail was detected and the defectogram of the defective section was analyzed.*

The introduction of the state of the art equipment, designed for a non-destructive control of rails, and the complex analysis of signals, formed by sensors included in a scanning pattern require timely and advanced training of the personnel involved in control. Correct and qualitative interpretation of the information received from the rail and processed by an electronic flaw detector unit increases monitoring efficiency and allows determining the parameters and the position of the flaw with respect to the cross-section of the rail with a high degree of accuracy.

To date, non-destructive inspection system is a multi-stage structure, the main feature of which is a variety of measuring devices, instruments and apparatus used according to the control objectives. The list of non-destructive testing methods used is quite wide. These include:

- electrical;
- magnetic;
- acoustic;
- visual;
- thermal;
- etc.

One of the most difficult for automatization, but effective methods is an echo-method of ultrasonic flaw detection. Great difficulty in the automatization process for this method is the need for incorporation of a number of factors (the cutoff of false actuations, the selection of a useful signal on their background; inability to accurately determine the cause of various emergency situations that arise during the process of ultrasonic testing, etc.), that can not only complicate the receiving signals from an object under control, but also significantly distort the results of the control, which in its turn can lead to the skipping of dangerous flaws. Thus, the question of further improving of already used control methods, implemented on the basis of portable flaw detectors, study of features of signals recording and methods of their comparison for presenting the overall state of section defectiveness as well as upgrading the skills of the staff carrying out control come to the fore.

The analysis of suspect cross sections is impossible without the knowledge of the monitoring circuit of the device. In general, a group of piezoelectric transducers (PET), implemented on the basis of a specific device (flaw detector), that provide the most efficient detection of flaws in accordance with the goals and objectives can be referred to as a monitoring circuit (sonic test).

Today, there is a wide variety of circuits used to control the rail head. Each of them has its advantages and disadvantages. Circuits, that use more than one method, demonstrate the highest efficiency (for example, a circuit named "ROMB" which realizes both EHO- and mirror- methods, each of which is active at specific time points so that they don't work simultaneously). These circuits allow detecting flaws with different types of reflective surface along with the detection of differently directed flaws.

In flaw detection devices (RDM-22) used in the experiment for the control of the whole railhead there are the following PETs:

Channel #1 – the channel is realized by using pitch-and-catch PET with the acceptance angle of an ultrasonic wave in the controlled object of 0°. In practice, the channel shows high efficiency in detecting various types of horizontal bundles and cracks. The inspection area depending on a rail type is between 0 and 190 mm.

Channel #2 – PET with the acceptance angle of 70° along the longitudinal rail axis in the direction of ultrasonic flaw detector movement (channel 7 - in the opposite direction). The practical utility of this channel is in its ability to detect cracks developing under the extended horizontal bundles which are impossible to detect by PET with other acceptance angles due to the peculiarities of the reflection of ultrasonic waves from different types of reflective surfaces. It surely detects cracks developing at an angle of 18-20° from the normal. The inspection area depending on the type of a rail is between 3 and 45 mm.

The main drawback of this transducer is the greatest dependence of the size, measured from the defective cross-section, on the temperature among all transducers used in RDM-22. So, in the range of temperatures from

minus 40°C to plus 50°C a nominal acceptance angle of this transducer changes from 60° to 74°. Changing the acceptance angle to 74° leads to the formation of a surface wave which is sensitive to the smallest surface flaws.

Channel # 3;6;8 – PETs with the acceptance angle of 55°, unfolded at 34° relative to the longitudinal rail axis and directed to the working face of the rail against the direction of the ultrasonic flow detector, to the non-working face of the rail against the direction of the ultrasonic flow detector, to the working face of the rail in the direction of the movement of the ultrasonic flow detector respectively. The turn of inserts by 34° allows controlling the whole volume of the rail head. The only drawback of those PETs is high sensitivity to surface flaws. In some cases, even with small and shallow bundles, due to multiple reflections of ultrasonic waves (RAS) between the bundle and the surface, the operator may give a false conclusion about a flaw in the rail. The inspection area of this channel is 144 mm.

PETs with the acceptance angle of 55°, unfolded at 34° relative to longitudinal rail axis, represent the circuit named “SNAKE”. This circuit is the most complex one in terms of both the process of reflection of ultrasound beams from different faces of the rail head and understanding of the principle of signals display on B-scan. This is due to the fact that for the detection of flaws in the head of the rail one-, two- and three-fold reflected from its edges beams are mainly used.

Figure 1 illustrates the path of the ultrasonic beam propagation in the rail head using the circuit "snake" and a fragment of the defectogram where there are signals of a standard reflector (for example, the end of the rail).

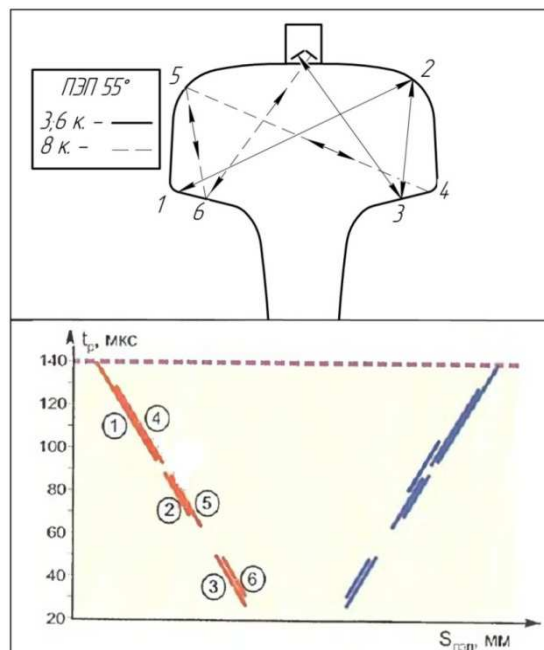


Fig. 1. The path of ultrasonic beam propagation using “SNAKE” circuit and fragment of defectogram with a standard reflector

When using such a circuit, the whole inspection area can be divided into: near (3; 6), medium (2; 5) and far (1; 4) areas. Due to this, by analyzing the signals received by the sensors, the location of the flaw with respect to the cross-section of the rail can be highly likely defined. Thus, if the signals are identified in the near and middle areas of channels 3 and 6 we can talk about the flaw located in the gauge corner. If these channels recorded signals in the far area then it is a flaw located in the non-working face of the rail. These statements are valid for channel 8 adjusted to its turn with respect to the longitudinal axis of the rail.

In order to improve non-destructive control methods used in the railroad industry, and to develop skills of complex signal analysis of operators involved in its implementation, selective inspection of defective sections was carried out. Control break was carried out to confirm the presence of the rail head flaw.

The inspection of the rail specimen with the size of 110 mm (the minimum length of a specimen for destructive tests) was carried out by an ultrasonic flaw detector UDS2-RDM-22 with manual PETs with acceptance angles of 0°, 55° and 70° realized on a compatible circuit. The inclusion of transducers based on a compatible circuit using echo method is aimed at the detection of flaws with a diffuse surface, i.e. those flaws, the average grain size of which is comparable or larger than the wavelength. It should be noted that in practice such flaws are expanding flaws, whose planes, in the process of the growth of a flaw, has not acquired a mirror-like surface. If

the surface is mirror-like, the use of echo method is impractical as an ultrasonic wave is totally reflected from a flaw encountering on its way. In this case it is expedient to use a mirror method, for example K-method.

Figure 2 illustrates the fragment of defectogram of the specimen.

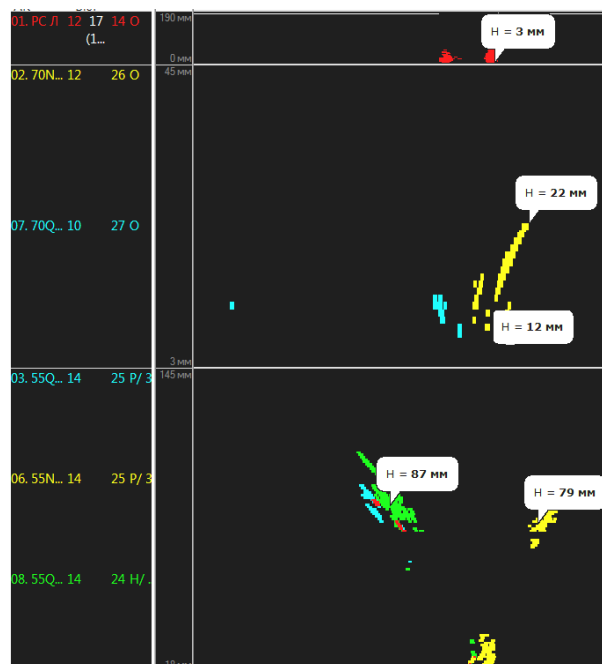


Fig. 2. The fragment of the defectogram of a specimen

The first priority during defectograms analysis is to identify valid signals against noisy ones. The implementation of this stage of the analysis requires the following:

- The mapping of defectograms of previous runs of ultrasonic flaw detectors with registrars with defectograms of the final run. The purpose of this phase is to identify individual signals within the section of interest (defective), which are present in all defectograms.

- By using the function of multithreshold registration and displaying signals on a defectogram, in the case of large amounts of these signals it is necessary to cut off noise and interference. The main feature of noises is that they represent a random process, and often of the same level. So, the threshold shift of a display allows you to get rid of noise and leave only useful signals on the flaw detector display.

As a result of this phase we identified the main signals which position is shown in Figure 2.

The second stage of the complex analysis is to determine the parameters of the recorded signals. So, from the fragment of the defectogram (Figure 2) it follows that:

- there is a damage 65 mm long on the tread surface;
- the damage on the tread surface is 2 to 3 mm deep, which is registered by channel #1 (the angle of entering of ultrasonic vibrations into the rail is 0°);
- channels # 3,6 and 8 (55°) has recorded signals in the depth range of 80 to 90 mm;
- the signal, recorded in the near zone of channel #6 can't be regarded as a clear signal from the flaw, as its presence may be due to the presence of surface damage;
- channel #2 (70°) registered a signal with length from 12 to 22 mm;
- the signal in channel #7 (70°) is a stray and it has been expelled from the signals requiring analysis at the first stage.

The third stage of the complex analysis is to assess the defective section and to make a complete picture of its defectiveness on the basis of the obtained data.

Based on the functionality of the 2nd and 7th channels of ultrasonic flaw detector RDM-22 (70° channels designed to monitor the central part of a railhead), we can conclude that there is a reflector in the central part of a railhead. The signal recorded by channel #2 at a depth of 78 mm indicates the presence of a flaw in the central part of the rail head. Signals located in the 3rd and 6th channels at a depth of 85 mm indicate a flaw, dislocated in the gauge corner.

Having analyzed the defective section, it was concluded that the flaw is located in the central part of the rail head with the development in the gauge corner.

As shown in Figure 3, as a result of the destructive test the complex analysis data have been confirmed.



Fig. 3. Result of the destructive test

So, we can safely say that as a result of complex analysis data confirmed by the destructive test the flaw of the rail head was identified and is described as accurately as possible.

#### REFERENCES

1. Шляхтёнок, А.В. Особенности и принципы выявления дефектов головки железнодорожного рельса / А.В. Шляхтёнок, Д.А. Довгяло // Труды молодых специалистов Полоцкого Государственного Университета, 2016.
2. Марков, А.А. Дефектоскопия рельсов. Формирование и анализ сигналов / А.А. Марков, Е.А. Кузнецова. – СПб.: Ультрапринт, 2014. – 332 с.
3. Александрова, С.Б. Ультразвуковая дефектоскопия : учеб.-метод. комплекс / С.Б. Александрова. – Барановичи : ДЦППК-2, 2008. – 205 с.

UDC 004.418

## REVIEW OF GOOGLE CLASSROOM API AS A WAY TO DEVELOP APPLICATIONS FOR IMPROVING LEARNING PROCESS

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*This article will focus on Google Classroom as a way to organize and simplify the learning process. Particularly here issues related to the API will be discussed, which allows you to expand Google Classroom possibilities to obtain a missing functionality.*

Education plays a very important role in today's world. And it should be noted that information technologies can help to increase its quality. Services such as Google Classroom can contribute to it.

Simplification is due to the fact that it is possible to have an access to it both from the educational institution and at home. And both teachers and students can have an access. At the same time everyone can have feedback. Also, in Google Classroom it is possible to provide materials and give assignments. At the same time the deadlines is set for their implementation. In addition, in Google Classroom it is possible to access data via Google Drive.

But often services perform not all functions that are required. In this case, the development of the required module and integration of it into the service using the provided API developers helps. Google provides such an opportunity. Google Classroom API includes the following parts:

- manage courses and aliases;
- manage teachers and students;
- manage coursework and submissions;
- manage course invitations;
- manage guardians [1].

Google Classroom API was made like RESTful service with OAuth authorization.

REST or RESTful Web services are one way of providing interoperability between computer systems on the Internet. REST-compliant Web services allow to request systems to access and manipulate textual representations of Web resources using a uniform and predefined set of stateless operations [3].

OAuth is an open standard for authorization, commonly used as a way for Internet users to authorize websites or applications to access their information on other websites but without giving them the passwords [2].

Courses in Google Classroom are lessons on a certain subject during a certain period of time. The course can be identified either by using a unique id, or by assigning an alias.

For courses you can invoke such methods as "create", "delete", "get", "patch" and "update". For aliases you can run "create", "delete" and "list". Description of these methods for the courses is presented in Table 1.

Table 1 – Methods for working with courses

Method name	Possible error codes	Method description
create	PERMISSION_DENIED NOT_FOUND FAILED_PRECONDITION ALREADY_EXISTS	Creates a course
delete	PERMISSION_DENIED NOT_FOUND	Removes information about course
get	PERMISSION_DENIED NOT_FOUND	Gets information about course
list	PERMISSION_DENIED INVALID_ARGUMENT NOT_FOUND	Gets information about course that permitted to current user

Table 1 Continued

Method name	Possible error codes	Method description
patch	PERMISSION_DENIED NOT_FOUND INVALID_ARGUMENT FAILED_PRECONDITION	Updates some fields in information about course
update	PERMISSION_DENIED NOT_FOUND FAILED_PRECONDITION	Updates information about course

Methods for aliases are similar to the methods for the courses.

As you can see, when methods invoke, errors can occur. Error codes descriptions presented in Table 2.

Table 2 – Possible error description

Error name	Error description
PERMISSION_DENIED	Error occurs when operation is not permitted to current user
NOT_FOUND	Occurs if object does not exist
FAILED_PRECONDITION	Error occurs when owner's account is disabled or reached limit of course members.
ALREADY_EXISTS	Attempt to create object that already exists(course of alias)
INVALID_ARGUMENT	Error occurs when field or some fields filled incorrect

Google Classroom also includes work with students and with teachers. Teachers can create courses, and students should study them. Both groups can be identified by their e-mail and working with them a special API - Google Admin API is used.

To create a student or a teacher the method "create" can be used, to remove - the method "delete". If the student should be added on behalf of the teacher, you should use the method "invitations.create ()".

For invitation such methods as "accept", "create", "delete", "get", "list" can be used. Their functions correspond to the same methods of the courses, and the accept method is to add a student to a teacher's course. When they are performed they can cause errors, such as "PERMISSION\_DENIED", "FAILED\_RECOGNITION", "NOT\_FOUND".

Also API includes possibility of work with course works. They are given to students at a particular time. To work with tasks such methods as "create", "get" and "list" can be used.

Materials can be attached to tasks and you can invoke methods such as "get", "list", "modifyAttachments", "patch", "reclaim", "return", "turnIn" over them. Methods that haven't been described previously are presented in Table 3.

Table 3 – Methods for working with submissions

Method name	Possible error codes	Method description
modifyAttachments	PERMISSION_DENIED INVALID_ARGUMENT NOT_FOUND	Modifies attachments to the submission
Method name	Possible error codes	Method description
reclaim	PERMISSION_DENIED FAILED_PRECONDITION INVALID_ARGUMENT NOT_FOUND	Reclaims submission that owns to student

Table 3 (continued)

return	PERMISSION_DENIED INVALID_ARGUMENT NOT_FOUND	Returns student submission
turnIn	PERMISSION_DENIED INVALID_ARGUMENT NOT_FOUND	Turns in student submission to teacher

Guardians are the profiles that can get information about students, their courses and coursework, but they are not students. For guardians you can invoke such methods as “delete”, “get” and “list”.

In conclusion, it should be noted that the service Google Classroom is a very user friendly application that helps in the organization of educational process. Its great advantage is that its API is open and if you need to create a new module, you can do it yourself.

The article describes key elements of API. As you can see, its possibility to improve the learning process is quite great.

#### REFERENCES

1. Classroom API | Google Developers [Electronic resource] / Google Inc., 2016. – Mode of access: <https://developers.google.com/classroom>. – Date of access: 17.12.2016.
2. OAuth – Wikipedia [Electronic resource] / Wikimedia Foundation., 2016. – Mode of access: <https://en.wikipedia.org/wiki/OAuth>. – Date of access: 17.12.2016.
3. Representational State Transfer – Wikipedia [Electronic resource] / Wikimedia Foundation Inc., 2016. – Mode of access: [https://en.wikipedia.org/wiki/Representational\\_state\\_transfer](https://en.wikipedia.org/wiki/Representational_state_transfer). – Date of access: 17.12.2016.

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