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В настоящем электронном сборнике «Европейский и национальный контексты в научных исследованиях. Технология» представлены работы молодых ученых по геодезии и картографии, химической технологии и машиностроению, информационным технологиям, строительству и радиотехнике.

Предназначены для работников образования, науки и производства. Будут полезны студентам, магистрантам и аспирантам университетов.

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In this Electronic collected materials “National and European dimension in research. Technology” works in the fields of geodesy, chemical technology, machine-building, information technologies, civil engineering, and radio-engineering are presented.

It is intended for trainers, researchers and professionals. It can be useful for university graduate and post-graduate students.

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ARCHITECTURE AND CIVIL ENGINEERING

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THE USE OF INTERLAYERS IN COMPOSITE CONCRETE STRUCTURES**ANTON SEMENOV, ELENA KREMNEVA**

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In the article the factors influencing the strength of the contact joint of composite structures are considered. The feasibility of using interlayers based on modified cement systems was noted. Proper joint operation of structures is ensured by the triunity of material, technological and constructive factors.

Ensuring the joint operation of 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 technical re-equipment of buildings and structures. The joint work of the layers of reinforced concrete composite structure is ensured by the adhesion strength, which is carried out on the basis of the unity of materials, technological and design activities.

The Material aspects include the type of binder, the composition of the concrete mixture and the use of various types of modifiers, as well as the use of various impregnations and primers.

The technological aspects are mainly reduced to the formability of the concrete mix, the wetting of the surface of old concrete, surface preparation methods, as well as the measures for the care of concrete.

The constructive aspects are reduced to an increase in the actual area of the contact joint, which can be achieved by the arrangement of holes and grooves, anchor protrusions and snakes, or through the device of different-shaped keys, which is taken into account in the design calculations by entering a coefficient for various types of surfaces, according to [1].

Recently, modified concrete is widely used in new construction, during reconstruction and technical re-equipment, as they allow not only to reduce energy consumption and cement consumption, but also to reduce labour intensity of placing concrete due to partial or complete exclusion of concrete consolidation. This is primarily due to the work in cramped conditions. The use of modifiers allows to increase the quality of concrete works [2].

The use of modifiers in concrete to improve adhesion and increase the strength of the joint of old and new concrete is an established fact that has a sufficiently large and convincing material in the field of research [2-9]. As for the use of interlayers and primers, this issue has not received sufficient coverage. Today, there is a large number of modified additives, and all of them are widely available and contribute to reducing energy and labor costs. For large volumes of work, the use of modifying additives can be very expensive and not expedient, since the cost of modified concrete is higher than that of ordinary concrete. The layers, in turn, are distinguished by the following characteristics: firstly, they create a kind of buffer zone between old and new concrete and can solve the problems of shrinkage reduction, secondly the amount of modifier in the interlayer may be less than in the structure and there is a substantial saving.

It should be noted that in ordinary composite structures there is one contact joint, while in the arrangement of layers it is necessary to ensure the adhesion strength of two contact joints: the first contact joint is between the interlayer and the old concrete, the second one is between the interlayer and the new concrete, figure 1 [3].

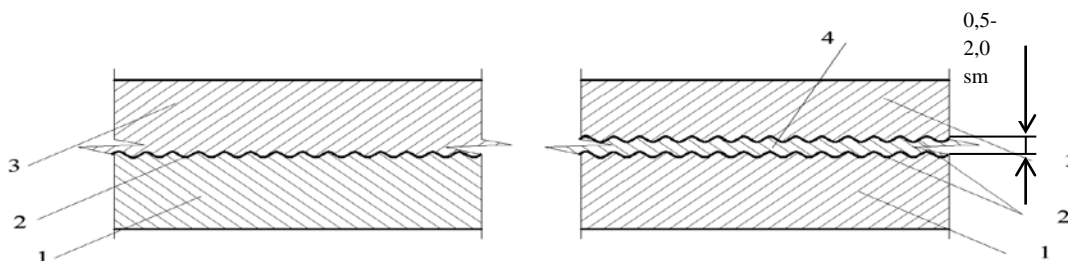


Fig. 1. The presence of one and several contact joints in a design with an interlayer and without it:
1 – old concrete; 2 – contact joint; 3 – grouting concrete; 4 – interlayer

A lot of researches on the contact joints and cohesion of old concrete with new one have been carried out both in the Republic of Belarus and abroad [2–9].

A lot of studies are known with application of cement mortar, cement paste and cement to the surface of old concrete. According to the results of K. Hager and I. Neinning's works [10], the cement powdering over the wetted surface reduced the adhesion strength, while the application of cement mortar sharply increased the adhesion resistance. Based on the results of K. Hager's work, the graph presented in figure 2 is constructed.

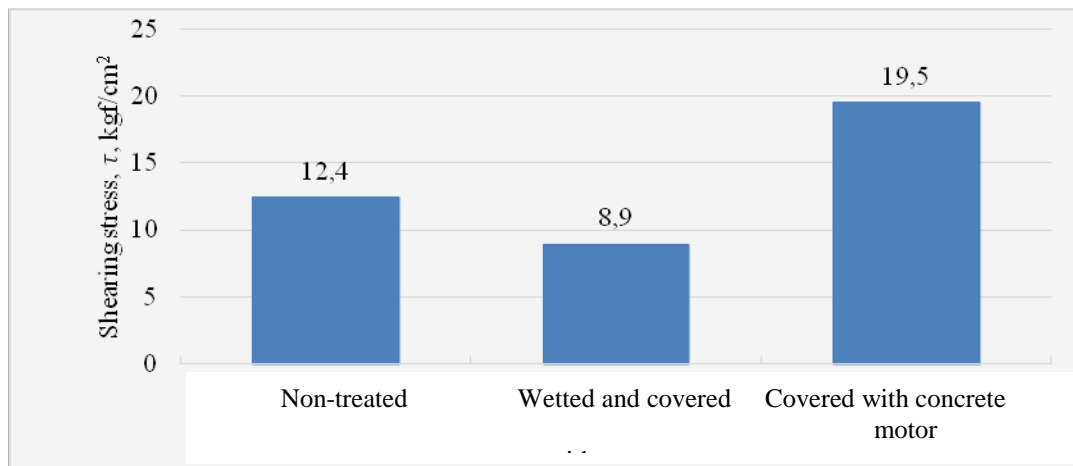


Fig. 2. Change of the shearing stress due to on the type of coupling surface

On the basis of Polotsk State University, a study was conducted to examine the effect of the modifying additive Stakhament 2000M on the layer and its concentration [3]. The change in the strength characteristics of the layer with different concentrations of the super plasticizer is shown in figure 3.

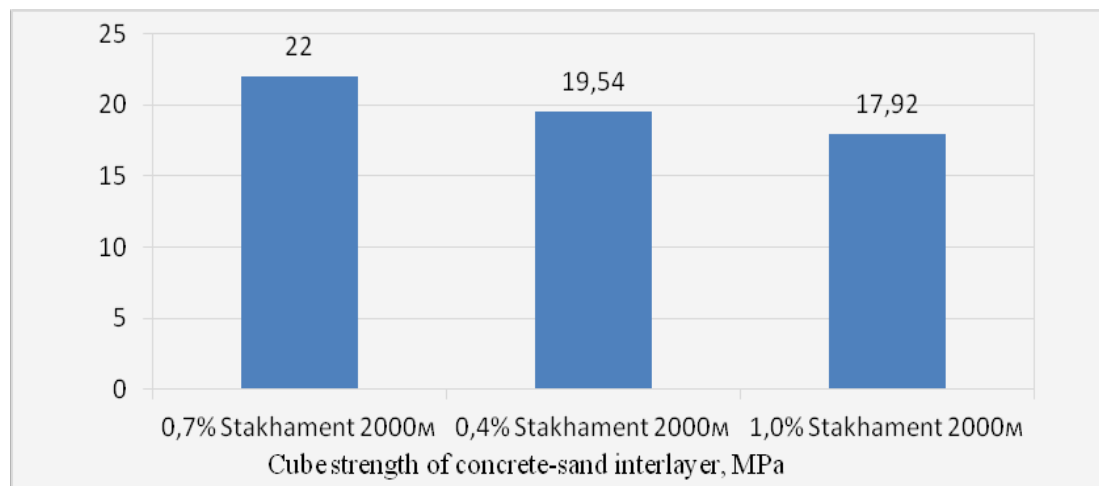


Fig. 3. Changes in the strength characteristics of a cement-sand interlayer, depending on the amount of additive

The influence of different modifier concentrations on the strength of the contact joint is shown in picture 4.

As it can be seen from [3], the use of interlayers based on modified cement systems increases the strength of the contact joint to almost 40%, depending on the concentration of the additive (fig. 4).

Today, Polotsk State University has been conducting the research on the strength of contact joint using the interlayer of the following composition: cement, sand, water, dolomite powder and the additive $Al_2(SO_4)_3$. This composition is selected due to the fact that dolomite powder replaces part of the cement and thereby saves it, and $Al_2(SO_4)_3$ in its turn leads to an increase in the strength of the interlayer.

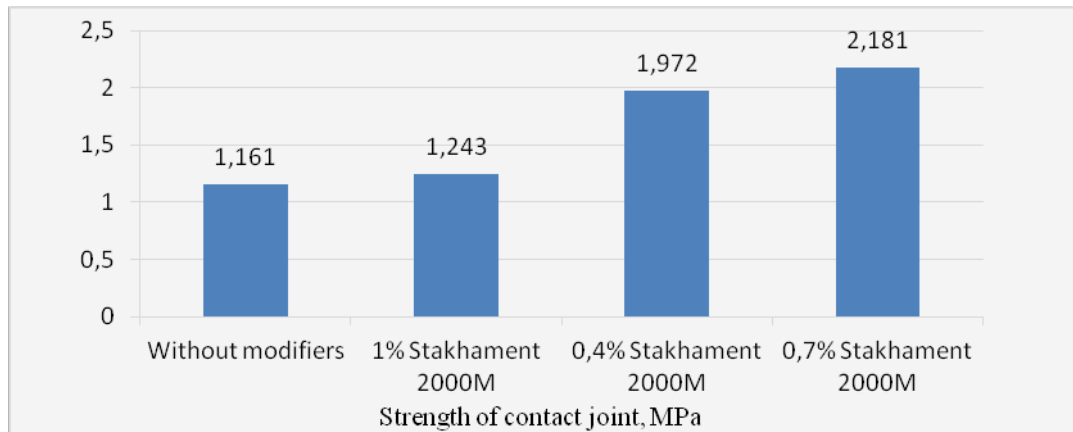


Fig. 4. The effect of the super plasticizer Stakhament 2000M on the strength of the joint

A test rig has been prepared and a test circuit has been selected. The scheme of the composite structure with the interlayer is shown in figure 5.

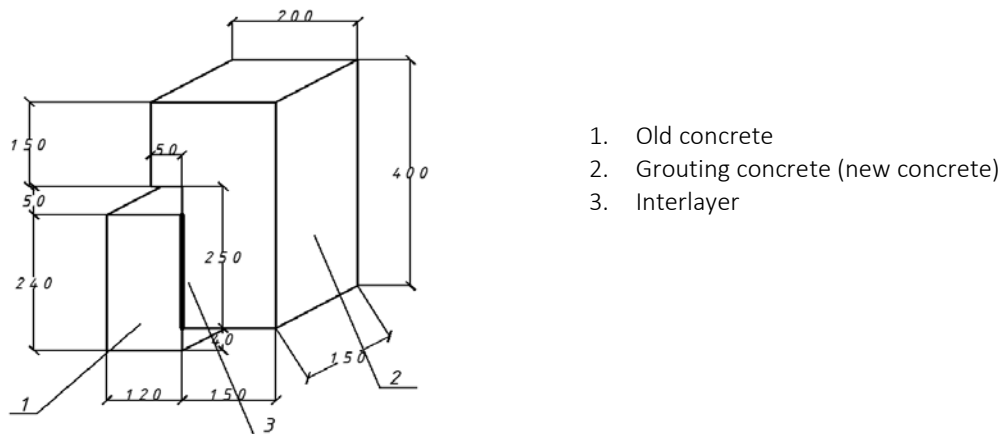


Fig. 5. The scheme of composite structure with interlayer

Based on the above-mentioned material, the following conclusions can be drawn:

- investigation of contact joints in composite structures remains relevant and has not been thoroughly studied;
- strength of the contact joint depends on various factors, the main of which are the conditions of laying new concrete, methods of compaction, maintenance of freshly laid concrete, processing of the interfaced surface of old concrete, the composition of the concrete mixture, etc.;
- the use of interlayers provides an opportunity to save labour and energy resources;
- interlayers have a positive effect on the strength of the contact joint, since shrinkage is reduced;
- it is necessary to develop new compositions of interlayers, using dolomite powder and other components.

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UDC 539.374

MATHEMATICAL MODELLING OF PROCESSES OF COMBINED STRESS
 TAKING INTO ACCOUNT CHANGES OF ELASTIC PROPERTIES AT PLASTIC DEFORMATION

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The change of elastic constants of material owing to elastic plastic deformation is considered in the article. Therefore, the elastic and plastic components of full deformation change and define borders of an elastic kernel. An attempt to determine approaches using changing elasticity modules at mathematical modeling of processes of combined stress is made, expressions of modules of elasticity E are given at a clean bend, G shift – at a cross bend and torsion on condition of transition of material from an elastic state to plastic.

At mathematical modeling of process of combined stress of metal designs and conditions of plasticity the settlement resistance to the bearing ability of $R_d = R_k / \sigma_M$, which is established on the basis of tests of samples at monoaxial loading is manifested in the inequality of a technique of limit states.

However, material in real designs, as a rule, is in a combined stress. In this connection, it is necessary to establish the rule of equivalence of combined stress to monoaxial. As an equivalence criterion, we use the expression of potential energy which accumulates in the material when it is deformed by external influences. The deformation energy we present is the sum of products of volume of A_0 and change of a shape of body A_f in the form.

$$A_i = A_0 + A_f \quad (1)$$

$$A_0 = \frac{1-2\nu}{6E} \cdot (\sigma_x + \sigma_y + \sigma_z)^2, \quad (2)$$

$$A_f = \frac{1+\nu}{3E} \cdot \left[\sigma_x^2 + \sigma_y^2 + \sigma_z^2 - (\sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_z\sigma_x) + 3(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2) \right]. \quad (3)$$

Work at monoaxial tension:

$$A_e = \frac{1+\nu}{3E} \cdot \sigma^2. \quad (4)$$

The ratio of power equivalence of combined stress to monoaxial is:

$$\sigma = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2 - (\sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_z\sigma_x) + 3(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)} \quad (5)$$

Then the generalized coefficient E_{ob} at combined stress will be defined:

$$E_{ob} = \frac{\sigma}{\varepsilon_{ob}} \quad (6)$$

Formulas for definition of E and G on condition of transition of material from an elastic state in plastic are given below:

Central stretching:

$$E = \frac{1}{\varepsilon} \cdot \sum_0^1 \int \frac{\overline{N}_l \cdot N_p}{F} \cdot dS \quad (7)$$

Central compression:

$$E = \frac{\sigma_{cy} \cdot l_o^2}{n^2 \cdot \pi^2 \cdot i^2} = \frac{\sigma_{cy} \cdot \lambda^2}{n^2 \cdot \pi^2}; \lambda \geq 100. \quad (8)$$

$$T = \frac{\sigma_{cy} \cdot \lambda_{pr}^2}{n \cdot \pi^2}; \lambda < 100. \quad (9)$$

where T – the given deformation module; λ_{pr} – the given flexibility.

At a clean bend:

$$E = \frac{1}{\Delta_{ip}} \cdot \sum_0^1 \int \frac{\overline{M}_l \cdot M_p}{I} \cdot dS \quad (10)$$

At shift:

$$G = \frac{1}{\Delta_{ip}} \cdot \sum_0^1 \int \frac{\overline{Q}_l \cdot Q_p}{F} \cdot dS$$

Here:

$$\Delta_{ip} = \frac{1}{\sin y} \cdot \sqrt{\Delta_{1p}^2 - 2\Delta_{1p} \cdot \Delta_{2p} \cdot \cos y + \Delta_{2p}^2} \quad (11)$$

y -corner between movements Δ_{1p} and Δ_{2p}

The change of elastic properties has been noted in a number of experimental works where the decrease of modules of elasticity of E and G in the course of elastic plastic deformation is stated. At the same time, on the way of unloading and the subsequent loading along with elastic and plastic deformations, the hysteresis loop appears. It is necessary to achieve disappearance of a loop by cyclic loading - unloading, and consider deformations registered after that when determining the module of elasticity. According to the offered technique, samples were deformed up to various sizes, at various range and scope of tension. The results of the modules change were almost identical. To determine the influence of size of preliminary plastic deformation plastic deformation 0,014 was reported to a sample. The change of the module G has made at the same time 6,2%. The sample was in addition deformed to 0,0243. Reduction of the module has made another 3,2%, i.e. the general reduction of the module of 9,4%, the obvious correlation between the size of initial deformation and size of change of the module of elasticity is observed. Thus, the decrease in the modules of elasticity depends only on the size of initial plastic deformation.

This conclusion allows us to use the changed elasticity modules at mathematical modeling, obtained experimentally, which allows more accurate consideration of the properties of the material.

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UDC 692

SHIPPING CONTAINER ARCHITECTURE

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The relevance of use of standard shipping containers as housing is considered. Advantages and shortcomings of container construction are analysed. The possibility of realization of a configuration of the building of any complexity from shipping containers is discussed. The features of cutting walls from containers are considered.

Non-conformism is often shown concerning attitudes of people to houses. An architectural variety of houses becomes wider and broader. Some buy for themselves huge houses from concrete or steel and glass with the purpose to emphasize the social status, or choose other, rather extravagant ways. The most unusual and economical of all options is the idea of making a house from shipping containers. Every year more and more people convert containers into houses. For someone the container is just a part of the house, and for someone all the house is to be found in one container [7].

It is difficult to say who was the first to realize the idea of the non-standard house by means of the written-off cargo containers. However the architect and artist from New Jersey Adam Culkin began to actively popularize it. He understood that the world resources of this material for creative work and construction are almost unlimited. Reduction of expenses and the economical relation to the territory also became an advantage of the new approach. Attracting friends and adherents, Adam created own architectural studio Kalkin and Co. The portfolio of the architectural studio contains about ten exclusive container houses and also the quick-house project which provides mass production of combined lodges with a possibility to order them by e-mail. Such designs of fast assembly have won the increasing popularity among people in various corners of the world who care for ecology, saving the means and do not wish to lag behind fashionable architectural trends [1].

However many people are skeptical towards this invention. It is possible to say with confidence that a house built from containers is a full-fledged inhabited private house warmed both from within and outside, with all the necessary engineering networks and communications (heating, water supply, power supply, sewerage, ventilation), with any kinds of finishing indoors and a building facade, with the individual planning custom-made. In the heated house made from containers it is warm and comfortable all the year round. There is no special need to pay more for construction of a cottage. Standard shipping containers are relatively inexpensive. Marine used container size 5898 × 2352 × 2393mm can be bought for 1500 BYR. Marine used container size 12036 × 2350 × 2697mm can be purchased for 2400 BYR. It is very favourable, the container has a ready framework with a draft floor from plywood. Besides, it does not need the powerful base and a binding of the base. Expedient option of the base for a house made from a container is a column base. Concrete support can be superficial, or buried - in the form of usual cylindrical piles or piles with expansion below. The final choice like piles for the house from containers depends on the type of soil and land relief [8].

The main disadvantage of the container house is that in warm weather the house quickly heats up, and at low temperatures containers quickly lose heat. For this purpose first of all it is necessary to provide careful insulation inside or outside and also not to forget about ventilation. To make a shipping container warm the following advice will help [9]:

- Thermal insulation. Proper thermal insulation is the main condition for modular construction in a cold climate. For this purpose it is possible to use polyfoam, mineral wool, special panels and other modern heaters. At insufficient thermal insulation, it is impossible to keep the container house warm irrespective of how much money you spend for heating [9].

- Roof. The loss of heat through the roof is one of the most common cooling factors for a modular home. The best way to prevent this and prepare containers for a cold climate is to carefully insulate the roof. Here, roll or panel heaters, as well as insulating foam can be used [9].

- Window. If it is necessary to build a house from containers in a cold climate, it is very important to correctly calculate the optimal sizes and placement of window openings: windows are one of the main ways of losing heat. Scientists claim that one glass window can lose almost 10 times more heat than the same section of an isolated wall. This does not mean that the windows should be abandoned altogether, but their placement and size should be discussed with the architect [9].

A building from a shipping container can acquire absolutely any shape, thanks to the fact that the containers can be mounted in a variety of ways (fig. 1).



Fig. 1. Variants of container houses

Source: [1–4].

At the expense of the standard sizes and simplicity of design, installation of module containers is carried out in a short time which allows to bring the building into operation quickly. Module containers are placed close to each other, and then the gap between the containers is latched, in the colour of the main covering. Module containers can be located not only separately, but also be united in an integral design in the horizontal and/or vertical directions and consist of one two, three or four containers. It allows to create mobile offices, residential buildings, administrative objects. There is a huge variation of a relative positioning of containers. Some architects even put containers at an angle to the ground. However a simpler and more unusual option of configuration of two containers is their shift from each other.

The container differs from the room in the fact that it is possible to create any configuration from a container, it is possible to cut out from it separate parts and, using wood and glass, create the most unique rooms. It should be taken into account that cutting apertures weakens a container, in the investigation of what all apertures, for the purpose to increase durability, should be strengthened with metal structures. With the purpose to make the building spacious at minimal financial investments, the best option of configuration will be the use of two or more containers for construction with the formation of additional space between them (fig. 2).



Fig. 2. Create additional space between containers

Source: [5, 6].

Based on the information above, we can draw the following conclusions:

- Container construction is a very promising direction in the development of construction in Belarus.
- Container houses can be comfortable and cozy for a person in any climate and at any time of the year.
- Construction of such building requires much less money than building a house of similar size from wood, brick or concrete.
- Containers are perfectly suitable for fast construction.
- Construction of buildings by traditional methods is much more difficult than construction of similar structures from containers.
- Containers can be easily adapted to the required type of planning and take the necessary form due to which fact it is possible to execute practically any architectural concept.
- By means of containers it is possible to create very spacious buildings.

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EFFECTIVE MODIFIERS OF GYPSUM BINDERS SUBSTANCES

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A brief analytical review of the modifiers of gypsum binders is given. It is shown that the modification of gypsum binders enhances the physical and mechanical characteristics: strength, water resistance. It is possible to use as modifiers: sludge of water treatment of Novopolotsk HES, cinder of «Belorusskaya GRES», fiberglass of JSC «Polotsk-Steklovolokno».

One of the main tasks of the construction industry enterprises is the improvement of consumer qualities and functional properties of products: strength, lightness, heat, sound- and water resistance. Today materials and products from gypsum are one of the most popular on the construction market, and the improvement of the properties of these building materials by modifying gypsum binders is an urgent task.

For the preparation of composite gypsum binders, such modifications of gypsum binders as sludge of water treatment of HES, cinder-fly, ceramic dust, brick waste, ground quartz sand, microsilica can be used. The resulting modified binders are characterized by a new level of technological properties compared to the previously known waterproof gypsum binders and have improved operational properties [1].

The performed studies [2] showed that the effective modifier of a gypsum binder is a sludge of water treatment which contains compounds of calcium carbonate. It was shown [3] that modification of the construction gypsum with complex additives based on fine carbonate affects the process of organization of the structure of the material and promotes the formation on the surface of the elements of the crystallization structure of the hardened stone shielding protective films from hardly soluble calcium phosphates. It is noted [3] that the modified building gypsum has increased strength and water resistance, and in the manufacture of products, the consumption of the binder is reduced.

The solution of the problem of increasing the physical and technical properties of gypsum materials and products can be achieved by the creation of crystalline hydrate neoplasms of increased density and strength due to the use of various nanomodifiers. Voitovich E.V [4] it was proposed to use a nanostructured silica component in the composite gypsum binder. As a result, the strength is increased to 40%, the water absorption decreases and the density is slightly increased. Based on this composite binder, which makes it possible to obtain products with improved performance properties, it is proposed to produce pierre-grate plates.

The studies carried out in [5] on determining the effect of ultradispersed additives on the structure and properties of anhydrite compositions showed that with an increase in the content of additives, a monotonous increase in the mechanical characteristics of the composite material occurs. When ultrafine powders are used, the strength of the anhydrite composition increases, the water resistance increases by 20–60%, depending on the type of the ultradisperse additive, the water absorption decreases from 12,7 to 10,4%.

A qualitatively new level of material properties is provided by composite gypsum binders of low water demand (CGB) [6]. CGB is a homogeneous mixture of any gypsum binder with a hydraulic component, previously obtained by joint activation of portland cement, siliceous additive and superplasticizer. This hydraulic component is an organomineralic modifier (OMM) of gypsum binders. OMM includes: a siliceous mineral additive, which can be used as cinder-fly, ceramic dust, waste from the production of bricks and other ceramic products, broken glass, fine quartz sand, microsilica, silica gel, spent silica gel, and the like materials; portland cement of any variety of grades 400–500; lime, dry plasticizing additive (superplasticizers based on naphthalenesulfonic acids or carboxylates, technical lignosulfonates, etc.). It is noted [6] that by varying the composition, components and dispersity, it is possible to obtain OMM intended for the production of composite binders for various application conditions.

To produce gypsum materials and products with improved properties, mineral additives and fillers are widely used. Among them, the use of micro- and nanofibres for reinforcing gypsum stone is of interest, their positive influence on the physical-mechanical as well as the operational properties of the products is noted. It is established [7] that the strength of gypsum material is increased due to the introduction of fibrous materials such as glass fibers, basalt and polymer fibers in combination with various additives into the composition of the raw mixes.

Of practical interest are studies aimed at studying the feasibility of effective use sludge of water treatment of Novopolotsk HES as a modifier of gypsum binder. The chemical composition of the sludge of water treatment is shown in table 1.

Table 1. – Chemical composition of sludge of water treatment of Novopolotsk HES

CaCO ₃	3MgCO·MgOH·2H ₂ O	CaSO ₄ ·2H ₂ O	Fe(OH ₃)	SiO ₂	CaSiO ₃	Organic compounds
62,8 – 68,2%	5,8 – 10,6%	3 – 9,5%	4,1 – 6,7%	0,5 – 4,7%	3,9 – 6,6%	4,9 – 8,9%

The chemical composition shows that the main compound contained in the sludge is calcium carbonate (62,8 – 68,2%). For the experiments, the sludge was dried in a drying cabinet of the brand «SNOL 58/350» for 5 hours to constant weight at a temperature of 110 ° C. The dried sludge, after cooling, was ground in an DIM drum mill and sieved on a MS mechanical sieve. The fraction of the sludge passed through the № 008 sieve was used. The value of the true density of the sludge of water treatment was determined according to GOST 8735 [8] and it was 2170 kg/m³. The bulk density corresponds to STB EN 1097-3 [9] and was 780 kg/m³. The sludge of water treatment was introduced in an amount of 5% of the mass of the binder.

As a modifier, the cinder of «Belorusskaya GRES» as well as 5% of the mass of the binder was also considered. The chemical composition of the cinder is shown in table 2.

Table 2. – Chemical composition of the cinder-slag mixture of the «Belorusskaya GRES» (mass. %)

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	SO ₃	etc.
87,62	4,39	1,08	3,08	0,55	0,61	1,79	0,24	0,19	<0,10	0,07

According to the chemical composition, the ash and slag mixture consists mainly of silicon and aluminum oxides (more than 90%). By modulus of basicity, the cinder-slag mixture refers to the low-calcium mixture, the calcium oxide content is about 3%. The cinder-slag mixture was dried at a temperature of 110 ° C. to constant weight. In the experiments, a fraction passed through a № 008 sieve was used.

As a reinforcement additive, a waste of production of the fiberglass of JSC «Polotsk-Steklovolokno» was used - cutting of alkali-resistant fiberglass SSSH-160 (100) – 1800/1800. The main characteristics of the grid: the size of the cross-section is 20 x 25 mm; nominal weight – 160 g/m².; breaking load – 1800 N; chemical resistance is very high. The content of the reinforcing additive in the composition of the raw mix was 5% of the mass of the gypsum binder.

To conduct experimental studies, gypsum was used for construction of «Taifun Master» № 35 of G-5 III A grade manufactured by LLC «Taifun». Determination of the physico-mechanical characteristics of the modified gypsum binder was carried out on samples of beams by size 40 x 40 x 160 mm. Testing of the samples was carried out 2 hours after molding in accordance with GOST 23789 [10] on a hydraulic press of PGM - 500 MG 4A. The results of the studies are presented in table 3.

Table 3. – Physical and mechanical properties of modified gypsum binder

Composition number	Composition	Density, kg/m ³	Strength, MPa (%)	
			to bend	for compression
1	Control	1765,6	2,9 (100)	5,2 (100)
2	With the addition of sludge	1695,3	3,3 (113,8)	7,7 (148,1)
3	With the addition of fiber	1691,4	4,7 (162,1)	6,4 (123,1)
4	With the addition of cinder	1664,1	3,6 (124,1)	5,2 (100)
5	With the addition of sludge and fiber	1639,3	3,1 (106,9)	5,3 (101,9)
6	With the addition of cinder and fiber	1614,6	3,1 (106,9)	5,9 (113,5)

Analysis of the obtained results allows us to establish that the introduction of a water treatment slurry of 5% leads to an increase in flexural and compressive strength. The flexural strength increased by 13,8% compared to the strength of the control composition, the compressive strength by 48,1%.

Reinforcement of gypsum stone with cuttings of a glass mesh in an amount of 5% of the mass of the binder increases the bending and compression strength by 62,1% and 23,1%, respectively, compared to the control samples.

Analysis of the results of the studies showed that the introduction of ash additive leads to an increase in bending strength by 24,1%, the compressive strength remained at the level of the control sample.

The joint introduction of sludge of water treatment and cutting of the fiberglass (composition 5) in an amount of 5% of the binder weight leads to an increase in bending strength by 6,9% and a compressive strength by 1,9% in comparison with the control composition in the gypsum binder sludge. The strength of the gypsum binder, which contained cinder in its composition as a modifier and was reinforced with cuttings of the fiberglass (composition 6) increased in comparison with the control composition: bending strength by 6,9%, compressive strength by 13,5%.

Thus, the modification of gypsum binders with additives of sludge of water treatment, cinder and reinforcing by cutting of the fiberglass allows to increase the strength parameters and reduce the density of gypsum stone.

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THE CHURCH OF THE RESURRECTION OF CHRIST IN THE CITY OF DZISNA

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This article presents the analysis of the historical, cultural, architectural and planning aspects of the creation and history of one of the most unique architectural monuments of Dzisna town – the Church of the Resurrection of Christ, which is known since the beginning of the XIII century. This is one of the few fully extant monuments of history and culture in the district of Mijory.

Introduction. The settlement has been known since the XI century as the fortress of the Polack principality – Kopec-town (from the word "to dig"). The first written mention of Dzisna dates back to 1461. However, the fortified settlement on the island at the confluence of the two rivers is known from later data – according to the information of Polack "scribe book" for 1563. It says about the existence of the Kopec, that is, the earthen fortification. At the same time, opposite to the fortified island, on the left bank of the Dzisna river there already existed the "village of Dzisna". Thus, the rapid development and strengthening of the city in the XVI century is explained not only by its favorable strategic and topographical position, but also by the "habitation" of this land in the preceding centuries. The full-fledged city of Dzisna appeared in 1569, when the city received its second coat of arms – "Ladou" and the right to self-government (Magdeburg law) from the Grand Duke Sigismund Augustus. Two centuries ago it was the second most populous city in the Polack district. The city was built according to the regular plan of the German architect O. Hodemann (fig.1). The local streets preserved the original layout of the XVI century.

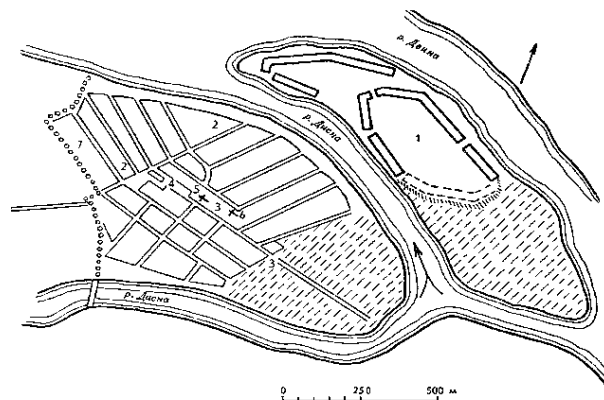


Fig. 1. Dzisna. The plan of the end of the XVI century. (according to O. Hodemann):
 1 – the lock; 2 – Castle Street; 3 – Voskresenskaya street; 4 – market area;
 5 – Resurrection Church (wooden); 6 – the parish church; 7 – city fortifications

The research part. One of the main attractions of Dzisna is the Church of the Resurrection of Christ. The temple is known since the beginning of the XIII century. Since 1633, there was an Orthodox monastery in the building of this church, an Orthodox brotherhood was functioning. In 1810 it was closed. The remainder of it was preserved in the form of the silver cross.

At first the temple was wooden and therefore burned several times during fires. According to the legend, during the last fire in June 1822, the miraculous icon of the Mother of God "Odigitriya" arrived along the river Dzvina. On the 12th of May in 1870 a new stone church was consecrated, it was built with the funds from the treasury and significant donations of the governor-general of the Vilnia province, Mikhail Muravyov. The Church of the Resurrection of Christ was not closed and was active during the following two wars.

During the liberation of Dzisna in 1944, the Church of the Resurrection of Christ was slightly damaged: only the bell tower was partially destroyed. The temple could be restored, but the authorities didn't allow that. The church was turned into a factory warehouse, and then it gradually came to complete desolation: the bell tower was destroyed, the dome needed repairs, the floors in the temple were spoilt, the brickwork was damaged (fig. 2).



Fig. 2. The Church of the Resurrection before restoration

"Hodegetria of Dzisna" was moved to the church in the Orthodox cemetery. The church of post-war at the beginning of the XX century was named after the icon of the Mother of God "Hodegetria" (Fig. 3).



Fig. 3. The temple of the icon of Our Lady "Hodegetria"

The Church suffered several robberies. During the second one, in 1980, among other things, a silver robe was stolen from the miraculous icon. Having stolen many ancient icons and church utensils, thieves could not bear the miraculous icon. "... It was stripped of silver clothes, leaving white wounds on the age-old levkas. It was thrown to the floor. The dusty trail of the sneakers of the modern barbarian tarnished the garments of the Mother of God ... But the image was resurrected and transformed, correcting everything material ... "The artist-restorer, who unselfishly restored it, wrote about this wonderworking shrine. His name was Igor Surmachevsky, a professional Minsk artist, designer and collector, more than twenty years engaged in the restoration of ancient icons (Fig. 4).

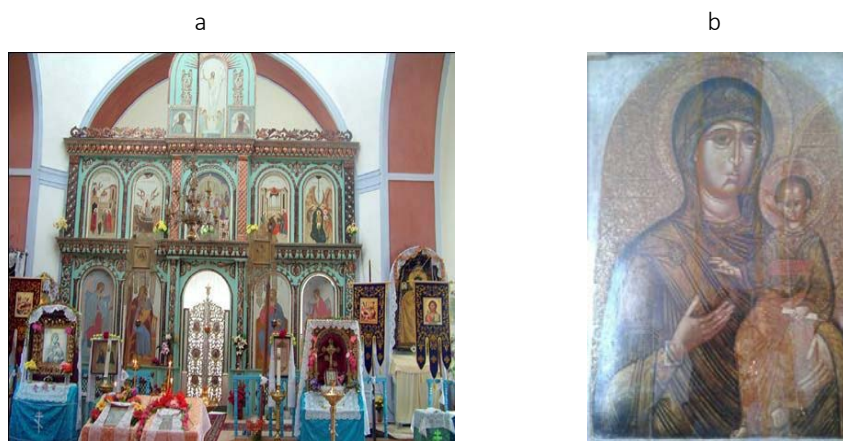


Fig. 4. The Church of the Resurrection of Christ:
a – the iconostasis; b – icon "Hodegetria of Dzisna"

In 1989 the building of the church was returned to believers. In 1991, after the reconstruction, it was consecrated (Fig. 3). The miraculous icon was moved to the temple, and it is still there today.

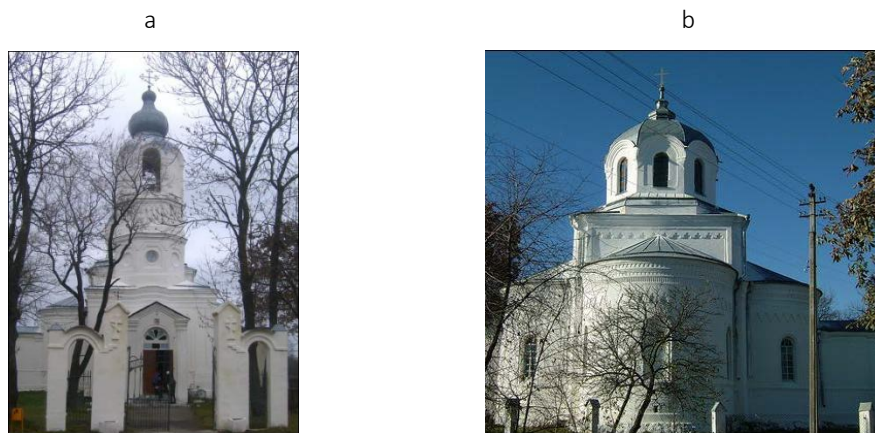


Fig. 4. The Church of the Resurrection after restoration:
a – the main facade; b – side facade

Every year on August 10, during the festival in honor of the icon "Hodigitria", the icon from the Resurrection Church is solemnly carried across the city to the temple in the cemetery, then they have a prayer service and then carry the icon back. Not only local residents take part in the festival, but also pilgrims from different countries come to Dzisna.

Conclusion. The Church of the Resurrection of Christ in Dzisna belongs to the objects of historical and cultural heritage. This church is interesting to everyone, who studies monuments of architecture of the Retrospective-Russian style. In addition, the church is of great importance for Orthodox Christianity as an object of spiritual heritage.

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PECULIARITIES OF SELECTION OF CALCULATED PRIMARY MODELS AT THE NUMERICAL INVESTIGATION OF THE FOUNDATION UPPER STRUCTURE SYSTEM

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The principles of calculating basis and foundation deformations according to the national and European norms are given. According to European norms, the limiting states of USL and SLS are considered. The similarities and differences in the calculation principles of the deformations of the bases and the foundations of shallow deposits according to European and national norms are revealed and generalized. The theoretical bases of each of the considered models are given in the article. To select a model that meets the requirements of calculations accuracy and costs minimization, a comparative analysis of common soil models described in the scientific literature and used in calculations of settlement and dynamic effects of buildings is carried out.

Introduction. Ensuring the reliability of the building structure with the minimum cost of materials is largely determined by the degree of accuracy of the base soil model choice, most plausibly reflecting the deformation properties of specific soil massifs. In the modern construction practice, according to the regulatory documents [1, 2], calculation is carried out for two groups of limiting states (on bearing capacity and deformations). These calculations verify only the limiting states when achieving the structural elements of the structure, the construction as a whole or its base ceases to meet the specified operational requirements [7].

When calculating the structures of the buildings operated in the conditions of an unevenly deformable basis, an important task is to determine the reactive (contact) pressures in the ground. The values of internal forces and the size and strength of the cross-sections of the building's structures directly depend on the nature of the distribution of contact pressures. To determine the contact pressures in the foundation of structures, as a rule, calculation models that schematically describe the natural mechanical properties of the ground environment are used. It is necessary to take into account the properties of the soil bases, which depend not only on the conditions of their natural occurrence, but also on the stress state, enabling the researchers to create a large number of different models of the soil foundation. At present, the use of numerical calculations of the basis-foundation-upper structure system with the use of software-computing complexes such as SCAD Office, Lira, Robot Structural Analysis, Plaxis, Ansys, Abaqus and others is becoming increasingly widespread. In these software complexes, various models of the ground base have been implemented [9].

Analysis of recent achievements and publications. In [3, 4, 8] the specific features of computational basis models and buildings and the methods of evaluating their stiffness characteristics are presented. In addition, the iterative principles of accounting for the joint work of the building and the foundation and ensuring the reliability and durability of buildings as elements of the "foundation-construction" system are shown in these works. The article [9] determines and compares the sediment values of the structure obtained from the results of the application of the normative technique of SP 22.13330.2011 with precipitation obtained from the results of application of various soil models implemented in the SCAD Office and Plaxis 3D software complexes. In [6], a technique is proposed and an algorithm for solving the problem to determine the probability of exceeding the boundary deformations of the "building-foundation" system is developed. In the book [5] various kinds of finite elements of basis modeling and examples of the basis numerical modeling by the finite element method are offered.

Allocation of the previously unresolved parts of the common problem. Despite the increased interest of well-known scientists in the selected problems, the choice of the base soil model, most plausibly reflecting the deformation properties of specific soil massifs, does not lose relevance. These issues remain undisclosed in full, which requires their further development.

Objective. To identify the features of the application of various soil models for the further numerical study of the "basis - foundation - upper structure" system.

Main part. The bases, foundations and upper structures work together and should be designed as one single whole. To design such a system, one should evaluate the features of the entire system operation and each of its component parts separately.

The most common in the design practice of joint methods of designing bases, foundations and supra-fundamental structures, i.e. system basis - foundation – upper structure, have two groups:

1. Comprehensive joint calculation of the above-ground structure, foundation and soil basis.

2. Use of the data of the foundation permissible movements, corrective coefficients and recommendations that take into account the rigidity of the structure in the design of bases and foundations.

The first group of methods considers the construction, foundation and basis as an indivisible, jointly deformed whole. At the same time, various calculation schemes or calculated idealizations of upper structures, foundations and bases are used.

The calculation of the system is as follows. First, the frame on non-deformable supports is considered. From the forces acting on the structure and the effects, the reactions of the supports are determined, according to which, in compliance with the calculated formulas, the dimensions of the foundations are assigned and the corresponding displacements of the bases are calculated. Then the frame on elastically compliant bonds is calculated, and the values of the base displacements are determined, which is compared to the deformations of the basis under the same loads. In the design process, the dimensions of the foundation structure and the rigidity of the ties can be corrected. As a result, when designing by successive calculations, it is necessary to achieve the state when the deformations of the base and the displacement of the foundation are close to each other.

The second group of methods combines techniques for assessing the joint work of the basis and the upper structure, in which the rigidity of the upper structures is accounted for approximately by correcting coefficients and classifications of rigidity structures. Such methods are developed in the norms for designing the foundations of buildings and structures [1, 2] and are most often used in practice because of their simplicity. In fact, these methods use the principle of estimating the limiting states of structures by generalized deformation criteria, which are established either experimentally on the basis of statistical processing of the results of the field observations of the buildings and structures settlement, or on the basis of a preliminary calculation of the structure for the displacement of the supports. For example, to assess the strength of structures in a frame building, it is sufficient to calculate the difference in its foundations settlement and compare it with the permissible value recommended by the standards or a standard design.

To assess the stress-strain state of the base, it is necessary to have a model of soil that will allow us to predict mathematically the behavior of the soil mass in case of various types of loads. The essential complexity of the foundation construction problems is that they, as a rule, are not one-dimensional, i.e. the ground base is in a complex stressed state.

Different models of soil base can be divided into the following groups:

- models based on Winkler's hypothesis of direct proportionality between pressure and draft;
- models that treat the soil as a homogeneous, elastic solid;
- combined models and models of an intermediate character between the Winkler hypothesis and the hypothesis of an elastic half-space.

In models based on the Winkler hypothesis, they are based on direct proportionality between the pressure on the elementary area and its vertical displacement. This dependence was proposed by Winkler in 1867. On its basis in the 80s of the 19 century, Zimmerman proposed the method of the bed coefficient to calculate the railway track, which became the prototype of all the subsequent models of this group. In the model proposed by Pasternak P.L., the mechanical properties of the soil base are described by two bed coefficients. The first coefficient C_1 characterizes the resistance of the base to compression and is measured in kN / m^3 ; the second coefficient C_2 – characterizes the resistance of the base to the shear and is measured in kN / m . The resistance to shear is due to the presence of cohesion and internal friction between the soil particles. The foundation settlement is counteracted by the reactive pressure P distributed around the sole and the stresses distributed along the outline of the sole, which are associated with vertical displacements through the coefficient C_2 .

In models that regard the soil as a homogeneous elastic solid body, in accordance with the solutions of the theory of elasticity, it is necessary to consider three problems: spatial, plane and axisymmetric. For tape foundations, the solutions of a planar and spatial problem are used.

In the spatial problem, the ground base is regarded as linearly deformed half-space bounded from above by a horizontal plane. In the plane problem, the ground base is considered as a linearly deformable half-plane. The base in the form of a half-plane can be conditionally separated from the half-space by two parallel vertical planes.

Klepikov S.N. [10] proposed a model for the variable stiffness coefficient, which is defined as the ratio of the mean design pressure $P(x)$ at the point x of the foundation to the sediment of the base $S(x)$ at this point. The sedimentation of the base $S(x)$ is determined by conventional methods (the method of layerwise summation, the method of a linearly deformed layer). The distribution of the normal pressures along the depth at any point x within the basis of the basement is determined using the method of corner points. It is assumed that only elastic deformations of the soil have distributive properties, and plastic deformations do not possess this proper-

ty. In this connection, the total settlement of the basis $S(x)$ is divided into elastic $S_e(x)$ and plastic $S_p(x)$, determined by the method of layerwise summation using respectively the residual (plastic) strains modulus E_{pl} and the elastic strain modulus E_{el} . These modules are determined by the results of field tests of the soil with dies or laboratory compression tests taking into account loading and unloading trajectories. Taking into consideration the described features, the stiffness coefficient is obtained not only by the physical properties of the soil, but also by the variable, that reflects the deformability of the basis only under a concrete foundation or its section. However, in real conditions, the arrays are composed of separate, essentially different soil layers whose thicknesses are not the same on the building spot. Some of the structures have different depths, and the strength and deformability of the soils and structural elements differ by several orders of magnitude.

Thus, the use of the theoretical apparatus of classical theories to solve practical problems of geotechnics is impossible in many situations. For such cases, it is necessary to use numerical methods and the most common finite element method (FEM) in the calculation practice in particular.

Conclusions:

1. With all the advantages of modern elastic-plastic models, they do not adequately describe the regularities of soil behavior when they are compacted with different schemes and loading rates. The technique for determining their parameters for specific soil variants remains difficult for engineering practice.

2. It is also necessary to take into account the fact that when determining the stresses in a soil mass with the use of the theory of elasticity, assumptions are made that regard the soil as a linearly deformable isotropic body experiencing a one-time loading. When the same structure interacts with the unevenly deformed basis, the soil mass works under conditions of complex loading, in which both the separation of the foundation from the basis and the development of plastic deformations are possible. Therefore, in order to solve contact problems under conditions of uneven deformations of the base, it is necessary to perform calculations by the method of successive loading with iterative refinement of the rigidity of the basis at each load level, for example, in the calculation systems SCAD Office and Plaxis 3D.

3. On the basis of the already existing ground base models, the ground base model of the particular ground conditions in Vitebsk region of the Republic of Belarus will be elaborated, which will later be applied for the joint calculation of the "basis-foundation-upper structure" system.

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UDC 504.06

**THE AIR HEATER OF THE HOUSEHOLD GAS COOKER
FOR HEAT AND AIR SUPPLYING OF KITCHENS
IN THE RESIDENTIAL BUILDINGS WITH RAISED HEAT-SHIELDING
AND GERMETICAL EXTERNAL PROTECTIONS**

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The article deals with the creation of a heat exchanger that allows more efficient use of the energy from gas combustion for heating and supplying fresh outdoor air to ventilated kitchens to ensure optimum technological gas combustion and controlled air exchange in terms of microclimate comfort with the possibility of their installation in the operated buildings without significant capital costs.

Introduction. The imperfection of technology for the use of fuel and energy resources in the urban development sector and in the municipal and domestic sector of the economy, consuming more than a third of all solid, liquid and gaseous fuels and electricity, is burdensome for the entire national economic complex of the Republic of Belarus, which imports most of it, energy intensity of the gross national product and significantly reduces the competitiveness of the products. In this regard, further improvement of the engineering systems of heat and gas supply and air supply of buildings with external fences of increased thermal protection and tightness, directed to energy and resource saving in comfortable living conditions, is one of the most important directions of the state programs of scientific research of the Republic of Belarus.

The thermal ventilation of gasified kitchens is designed to create an air-exchange process inside residential buildings with the function of heating the fresh air. The device is intended for the heat-air supply of kitchens in residential and civil buildings with external fences of increased tightness.

Body. The gas cooker [1] with the tubular heat exchanger built in the design of a wall which application is possible only in a new building is known. Besides such design of the heat exchanger under the scheme «a pipe in a pipe» has not developed enough surface of heat exchange and consequently has low efficiency of the use of warmth of leaving top internal gases for heating supply external ventilating air not exceeding $\eta = 27\%$.

The improvement problem is to create such a heat exchanger that would allow using warmth from burning gas for heating and giving fresh external air in the ventilated premises of kitchens with more efficiency for maintaining optimum technological burning of gas and normalised air exchange parameters of microclimate comfort. It is also important to consider the installation of the heat exchanger in buildings without considerable capital expenses.

The air heater of a gas cooker is executed as a separate device of a compact design with the height not exceeding the height from the floor to the ceiling of a kitchen premise, depth $in = 0,1$ m, and width to equal width of a gas cooker, i.e. $and = 0,5 \div 0,6$ m.

Air heater of a gas cooker allows using the warmth from burning gas not only for cooking, but also for providing fresh external air oxygen at its self-adjustable supply in necessary quantity, proportional to the amount of burnt gas used with its simultaneous heating for the account of the secondary power resources containing in the deleted products of burning gas.

Wide application of the proposed gas cooker heater in town planning will allow to lower power consumption for heating buildings. As according to the scheme applied all around CIS countries, using a gas cooker or a gas water heater in a gasified building stipulates opening window leaves with air supply. It is indispensable for the maintenance of gas burning technology and the assimilation of the combustion products to the regulated values of maximum-permissible concentration (maximum concentration limit) with their subsequent removal through the exhaust channels of ventilating systems.

Such technology of ventilation of the installed gas buildings leads to overcooling of these buildings in a cold season and to unjustly overestimated consumption of thermal energy spent on heating the premises and heating the external cold air that permeates through window leaves and reduces comfortable microclimate parameters complying with sanitary-and-hygienic requirements.

In fig. 1 is the longitudinal section of a gas cooker air heater, in fig. 2 – type on B-B, in fig. 3 – type on A-A.

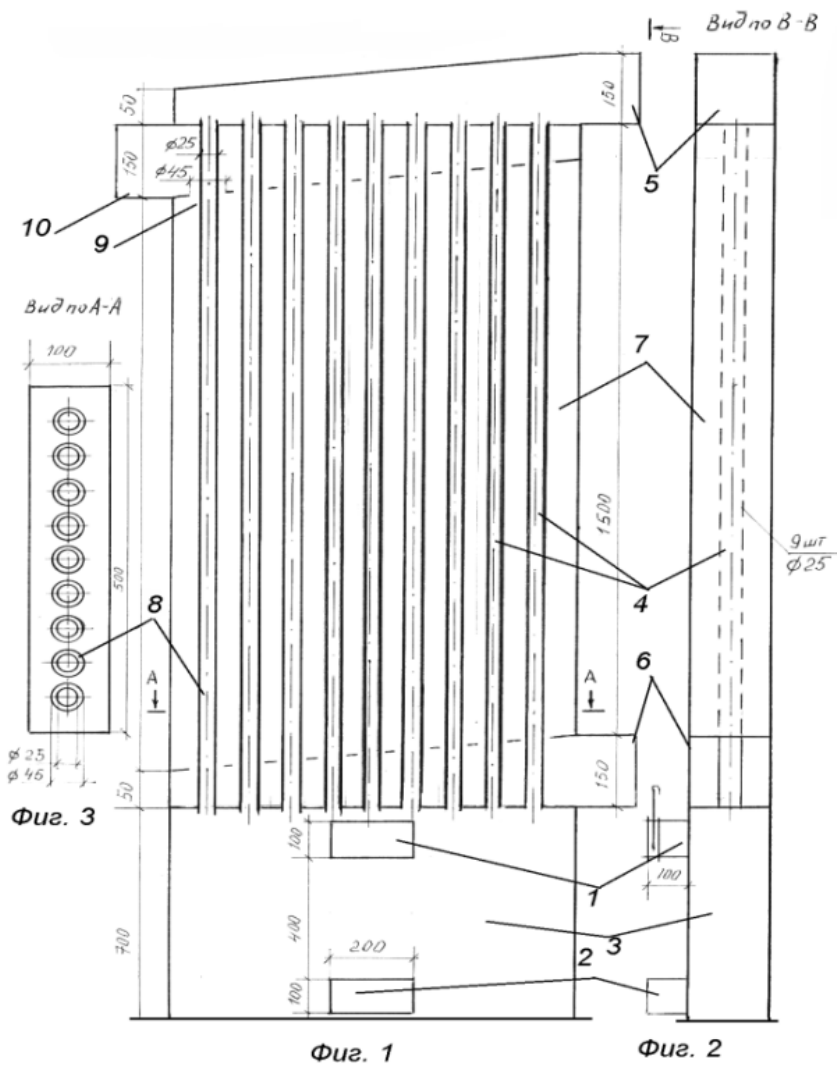


Fig. 1. A heat exchanger of a gas cooker

The air heater of a gas cooker represents a heat exchanger implemented in the form of a parallelepiped with overall dimensions of width, depth and height 0,5 x 0,1 x 2,5 m, set into vertical position between the gas cooker and the wall surface. The device consists of the inlet branch pipe for the gas combustion products top 1 and bottom 2, the reception chamber 3, heat-exchange tubes 4, the chamber for the cooled heating heat-carrier with a target branch pipe 5, a branch pipe 6 for the external cold air input, the intertube chamber 7 with bottom 8 and the top 9 apertures for admission and release of heated up air and a branch pipe 10 for the output of fresh external warmed-up air into the premise.

The air heater of a gas cooker works in the following way:

At burning of gas tap the combustion products from the cooker make through the top 1 and the bottom 2 entrance branch pipes of the air heater of a gas cooker. The mix of gas-burning products and exhaust air with the temperature of about $t = 120 \div 350 \text{ } ^\circ\text{C}$ arrives at the reception chamber 3, from where in regular intervals it is distributed to the tubes 4 and under the influence of exhaust ventilation rises upwards, exchanging warmth with washing their external surface outside air. The air is supplied in regular intervals through the branch pipe 6 and bottom ring apertures 8 into the intertube chamber 7, from where through the top ring apertures 9 and the branch pipe 10 it gets to the top zone of the ventilated premise of the kitchen.

Thanks to the advanced design of the heat exchangers with actively developed heat-exchange surface the heat removal reaches values of $\eta = 62 \div 78 \%$ depending on the burnt gas discharge rate and the heat-exchange mode.

More detailed theoretical propositions are presented in [2].

Executed heat engineering and aerodynamic calculations have allowed defining the optimum constructive sizes of the air heater of a household gas cooker, which are represented in fig. 1-3.

Conclusion:

1. Theoretical bases of calculation of the recuperative heat exchanger of a gas cooker on the basic criterial dependences of the physical processes similarity theory of heat exchange have been developed at heating of ventilating external air by leaving the warmth of gas burning products at variable temperature and aerodynamic modes.

2. The technique of experimental research has been developed. It is aimed at specifying the laws of the change of the heat effect intensity of the direct-flow heat exchanger working under the scheme «pipe in pipe» by using the calculation method on dimensionless complexes for defining the final temperatures of heat exchange environments on two experimentally certain temperature values of heated up and heating heat-carriers.

3. The results of the complex theoretical and experimental research analysis have been taken as the principle of the design procedure and the further perfection of the designs of recuperative heat exchangers with the peak efficiency of using the warmth of top internal gases.

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**PRECONDITIONS OF COMPUTATIONAL MODEL OF THE BENDING STRENGTH
OF REINFORCED CONCRETE STATICALLY INDETERMINATE BEAMS WITH HYBRID REINFORCEMENT**

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In this article, the variant of application of composite reinforcement together with metal (hybrid reinforcement) in bent statically indeterminate reinforced concrete elements is considered. The advantages and prospects of application of this type of reinforcement are shown. The possibility of using a block model for calculating the strength of elements with hybrid reinforcement is considered. The assumed assumptions for the calculation model are determined and the calculation algorithm is presented.

At present, nonmetallic composite reinforcement is finding increasing use in construction, which in international practice is customary for designating FRP – *fiber reinforced polymer composite* [1–3]. In particular, such reinforcement is widely used in the erection of concrete objects, exploited in aggressive environments, special purpose structures. However, it is worth paying attention to the fact that certain difficulties are hindering the wide introduction of this type of reinforcement. Among them, one can note the absence of unified requirements of state or international standards for the mechanical properties of composite rods and methods for calculating structural elements reinforced with composite reinforcement, unified requirements for quality control methods and rules for rod acceptance. In addition, a number of negative properties of the composite play a significant role in the use of composite fittings (glass, basaltic and aramid fibers): low fire resistance, low modulus of elasticity, and low alkali resistance, on which the durability of the designed structure will depend.

Recently, more attention has been paid to the problem of developing effective solutions for the application of composite rods in bent reinforced concrete elements, which do not require additional costs for eliminating the main disadvantages of the composite. To date, even high tensile strength (more than 1000 MPa) does not allow solving the main problem of using composite reinforcement as working (with a complete replacement of steel) in reinforced concrete constructions, namely the low value of the modulus of elasticity (about 50 GPa). Investigations in this field [4–6] have shown that when a reinforced concrete bending element is reinforced solely with composite reinforcement, after the formation of normal cracks, there is practically no plastic deformation zone and, consequently, the destruction of this type of elements is fragile. Thus, the use of composite reinforcements in bent elements without prior strain is impractical today. It is worth paying attention to the fact that the prestress of nonmetallic reinforcement causes great technological difficulties: from the method of tension to the development of reliable anchors.

The situation can be greatly improved by using a composite and metal reinforcement in the stretched zone of the reinforced concrete element (the so-called hybrid or combined reinforcement). Experimental studies [7] of statically determinate beams with combined reinforcement made it possible to obtain the plastic form of the destruction of the element. In addition, the authors noted that the plastic deformation of the structure, even with a minimal introduction of composite rods, proved to be substantially longer than for the elements reinforced solely by metal reinforcement. The analysis of the test results [7] suggests that even a small amount of composite reinforcement, which will work in the elastic stage, can have a positive effect in the operation of statically indeterminate bins. This effect can be achieved in terms of more rational redistribution of effort. The expected favorable result from the use of hybrid reinforcement will allow expanding the field of application of composite reinforcements without preliminary tension.

The issue of calculating reinforced concrete elements with composite reinforcement does not lose relevance. In international practice, thanks to extensive experimental and theoretical research conducted in recent years, the basic principles and recommendations for calculating and designing structures with composite fittings have been developed [1–3]. However, in work [8] the authors note that the use of composite reinforcement in a structural element in conjunction with steel requires a significant adjustment of the design models. The most promising and possible solution to such problems is the so-called block calculation model. In general, for statically indeterminate reinforced concrete beams with metal reinforcement, this model [9] considers a block element separated by two adjacent cracks. The solution to the problem in the general case is reduced to the solution of the system of equations based on the positions of the modified deformation model, which includes the equations of the equilibrium of longitudinal forces, moments and the equilibrium equation for an individual rod, the slip equations. In addition, the deformation diagrams of the materials used and the diagrams linking the values

of tangential stresses and the values of slippage (mutual displacement) supplement the system of equations. A detailed algorithm for calculating static-indeterminate beams with metal reinforcement is presented in [9].

It should be noted that the key role in the design model is given to the "tangential stresses-slippage" diagram, which is essentially the law of the coupling of the reinforcing bar and concrete. For steel reinforcement, the parametric points of this diagram are taken according to the instructions of ModelCode 2010. The diagram of the adhesion law for composite reinforcement is also specified in MC 2010, but the values of the parametric points must be obtained experimentally for a specific type of reinforcement. One of the solutions to this problem can be considered the results of extensive studies under the leadership of Gaitano Manfredi [9–13], in which the averaged values of the parameters of points on the diagram "tangential stresses – slippage" for GRP rods were obtained.

Thus, to solve the problem of developing a computational model of bent elements with hybrid reinforcement, all the necessary initial data are available. However, to implement the calculation, it is necessary to determine the total averaged parameter, which in the end will be the criterion for the termination of the iterative calculation process [14]. After the successful realization of this, the distribution of the relative deformations of the stretched concrete and reinforcement will be obtained for the entire element, which in the future will allow us to calculate the value of the curvature distribution in all necessary cross sections along the length of the block. If we consider an example with metal or fiberglass reinforcement, the criterion for the termination of the iterative process is the attainment of the relative deformations of the stretched-zone concrete in the cross-section of the bent element of the limiting values. This indicates the formation of a new crack or relative deformations of the stretched concrete of the relative deformations values of the stretched armatures, which indicates the beginning of the joint deformation zone of the reinforcement and the concrete. Thus, in case of termination of the iterative process at each of its steps, we obtain the slip values of the reinforcing bar relative to the concrete, and subsequently the resulting displacement is the basis for calculating the strength of the entire element. Nevertheless, there are a number of certain difficulties: if we look at the diagram of the adhesion law for metal and fiberglass reinforcement in numerical terms, it is obvious that the materials are displaced in concrete in completely different ways (Fig. 1).

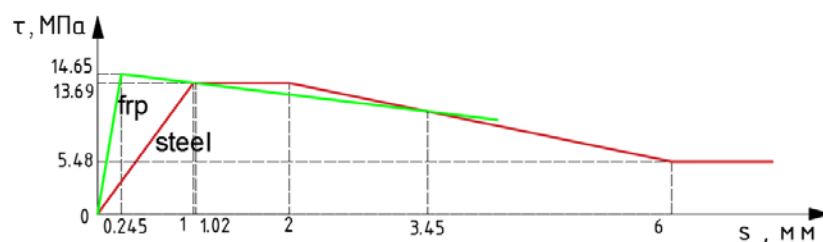


Fig. 1. Laws of adhesion of fiberglass and metal reinforcement with concrete

The situation is similar to the diagram of deformation of these materials (Fig. 2).

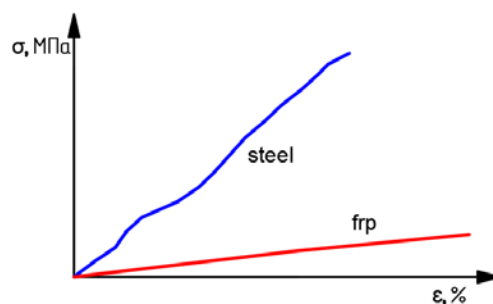


Fig. 2. Material deformation diagram

One possible solution to the presented problem can be obtained by equating effective zones of stretched concrete between metal and composite bars. Thus, when implementing the iterative process, the following assumption should be adopted: the concrete of the stretched zone of the bent element is deformed equally throughout the area.

When implementing the iterative calculation process, one-time deformation of metal and composite rods will be considered according to the algorithm for calculating the block fracture model. Having adopted the above

assumption, in the first step of the iterative process, the tensile stresses in the concrete, which in turn depend on the tensile forces and the stresses in the reinforcing bars corresponding to them, will be equated and their average value determined. Based on the obtained average value of the stress, the relative deformations of the concrete will be the same for sections with metal and composite rods. The value of the relative deformations of concrete will allow us to determine the values of tangential stresses in reinforcing bars and the displacement of concrete rods in concrete.

In the second and the subsequent stages of the iterative calculation procedure, the following algorithm will be repeated: the stresses in concrete for the sections with metal and composite reinforcement are determined, their mean value is derived, and the relative deformations in the stretched concrete are determined. Further, on these values all the necessary parameters of the considered site are calculated. The criteria for the termination of the iterative process will be similar to the standard calculation criteria for a block fracture model of the bent elements with metal or composite reinforcement.

The proposed computational model of bent statically indeterminate reinforced concrete elements with hybrid reinforcement will allow expanding the application area of composite reinforcement without prestressing.

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UDC 697.922

THE USE OF SOLAR ENERGY FOR VENTILATION SYSTEM OF CULT BUILDINGS

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Ventilation system, heating system, air heating, solar energy, energy efficiency, reduced heat loss, religious buildings, Chapel, flat solar collector, solar air heating, ecohouse, energy-efficient House, Trombe wall, Edward Morse, Felix Trombus, tilt attractive solar panel passive heating system, the building's façade, the building walls, ventilation of the cult buildings with shutters-grille, air duct.

In the last fifteen years, the construction of energy efficient and environmentally friendly houses has actively begun its development [1, 3]. The progress in the design of heating and building ventilation systems by using alternative energy sources is associated primarily with the deterioration of the ecological situation on the Earth, the increasing cost of energy, the shortage of primary energy and the development of energy efficiency policy in the world and the Republic of Belarus [2, 3].

The use of solar energy for heating civil, agricultural and residential buildings has long been known. The first mention in the world of the solar energy used in the house construction for heating the exterior walls of the building dates back to 1800. It was when Edward Morse described the heating effect of a brick exterior wall in the sun and its long cooling behind the glass partition at night. Later in 1960, this property of stone and brick walls heated up in the sun during the day and keeping (accumulating) the heat at night was used in the design projects of a French designer and architect Felix Trombe. His design proposal to place the outer wall of the building behind a glass frame in 1960 was called «Trombe wall». This method of heat storage of solar energy is used in the construction of houses, conservatories and greenhouses, but it was given a new name – passive solar air heating system of a house.

The scheme of a passive solar heating system of a residential building Fig. 1 is proposed in [4] Chapter 16, paragraph 16.1. Such schemes of air heating of residential areas are pictured on page 113 Fig. 5.6 [5].

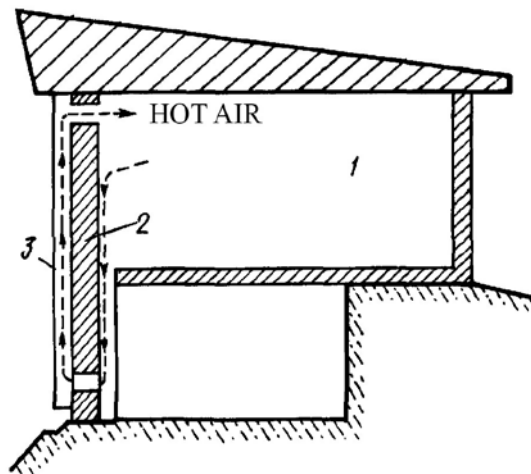


Fig. 1. Passive solar heating system of a building with natural convection in the space between the glazing of the southern façade and a storage wall:
1 – building; 2 – thermal storage wall; 3 – cladding glass

It is important to place "layers" in the flat collector of solar energy (CSE) and consider their number. The scheme of CSE designs is not known fig. 2 [4, Fig. 16.10.].

One of the ways to use solar energy is an energy-efficient building "ECOHOUSE SOLAR-5" fig. 3 [6] containing walls, solid and vented, roof gabled window openings, solar collectors and solar water heating photovoltaic panels mounted on the roof of the building. The roof pitch facing the south is made double-part, where its lower level is fixed at an angle from 30° to the horizon up to the magnitude, which is calculated by the formula $90-f^\circ$ where f is the latitude of the building area.

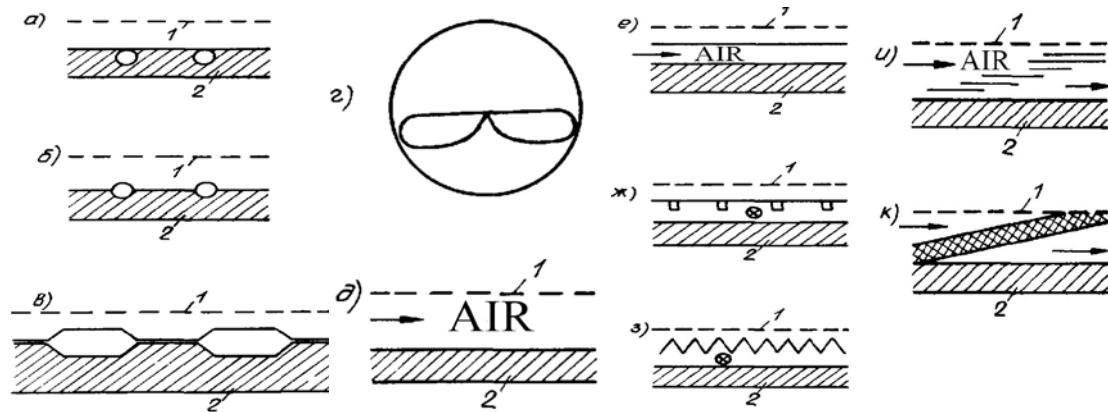


Fig. 2. Schematic designs of liquid (a-g) and air (d-k) solar collectors
 1 – glass; 2 – adsorber (beam-absorbing panel)

In addition, the northern roof pitch is made double-part, where its lower level is fixed at an angle of 12 to 26.5° to the horizon and bulges out beyond the plane surface of the outer walls in form of a visor at no more than a quarter of their height.

This model of energy efficient buildings provides energy savings by the creation of a comfortable thermal mode due to the additional heat supply directly from solar heating and reduced heat losses in winter, wind effects and natural aeration and shading of residential premises in summer.

Described are domestic and foreign models of energy efficient buildings, accomplished for the temperate climatic zone of the Northern hemisphere [7, 8].

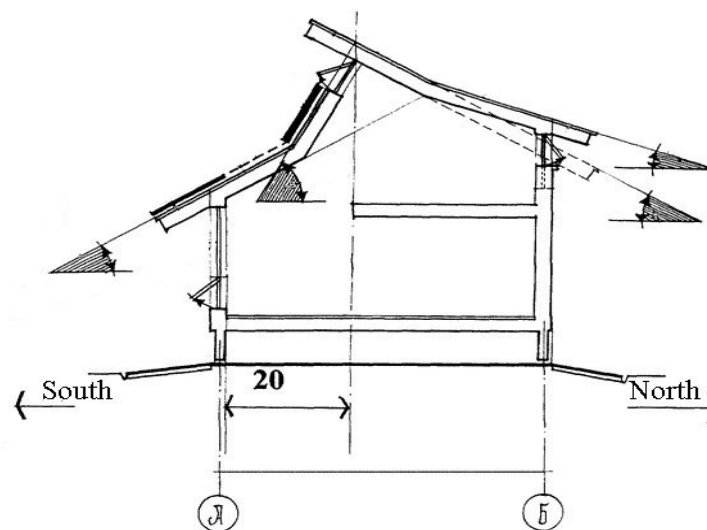


Fig. 3. Ecohouse solar-5

We calculated the sizes of the solar collector and the gap width for the passing of air. It makes 50 mm. The adopted design features of the collector of solar energy (CSE) for ventilation system of Russian Orthodox Church cult buildings are shown (fig. 4). CSE similar systems can be used for other civic buildings. To adopt the air velocity in the CSE 4 m/h is very important. The ventilation rate in the building of the church is not less than 30 m³/h and contains the outside air for 1 man [9]. 50 people can be simultaneously present in the square prayer hall of the church building.

The air intake will take place on the eastern side of the building through the exterior air intake grilles, which are installed on the duct fixed on the outer wall of the building at the height of not less than 2000 mm [11].

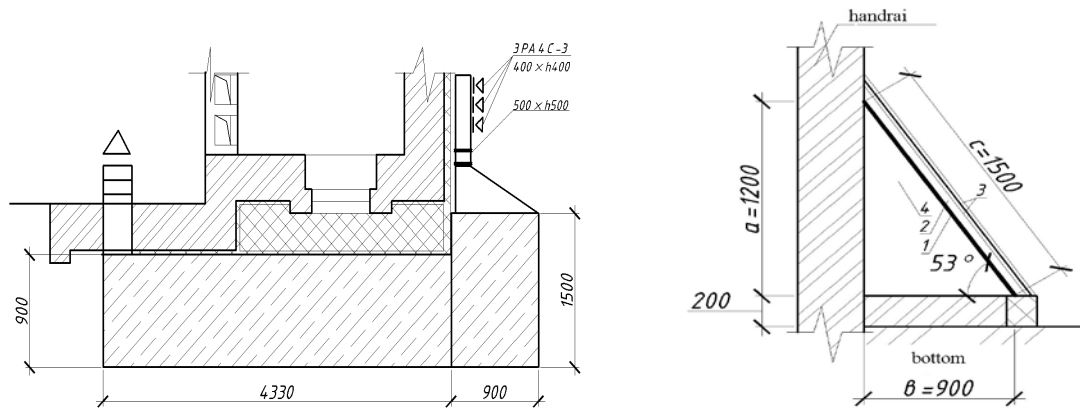


Fig. 4. Sectional view of a solar collector (CSE) the southern and eastern side of a church wall:
 1 – copper plate, 2 – space for air, 3 – CSE, 4 – vacuum

Calculated dimensions design of air flat CSE and its placement fig. 5–6, which is a flat panel are located at an angle β with eastern and southern façade of the church. Angle β is equal to the latitude of area [4, paragraph 16.3]. The absorber is made of the plates of good conductive metal (copper). Non-selective glass that does not transmit light waves as well as heat and radiation is used. In contrast, there are no flat solar collector tubes, the air is heated directly in contact with the plate absorber. To increase the heat transfer the absorber has a ribbed form or perforation. The collector should be well isolated from the walls of the buildings to reduce the heat loss. Air circulation in such systems can be both natural and forced using fans and silencers. We propose to install a valve with an axial fan and a silencer on the inner side of the building after CSE.

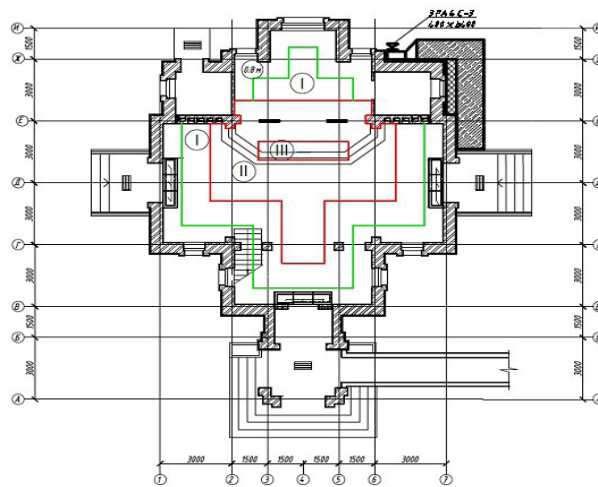


Fig. 5. Plan of the church and the placement of the flat solar collector (CSE) on the eastern and southern facades

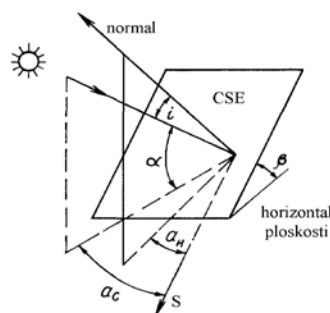


Fig. 6. The flat layout of the CSE

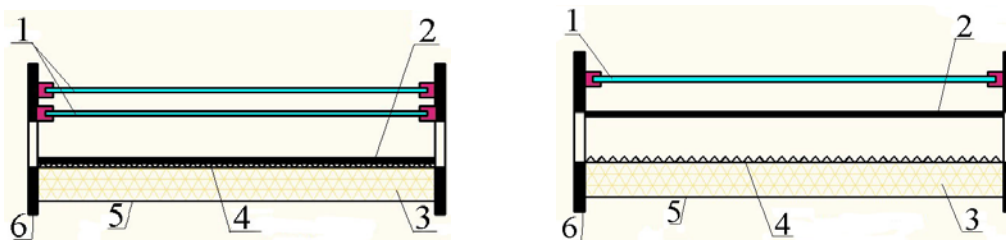


Fig. 7. The proposed design of the flat CSE:

1 – glass, 2 – solar panel, 3 – heat-insulation, 4 – heat-reflecting foil surface, 5 – bottom, 6 – flange

Both designs of the collectors are fairly simple from a technical standpoint (design, installation), as well as conveniently mounted from the available material fig. 7. The diameter of the duct and ventilation design of the transition is calculated [11]. The design standards for houses of worship in the Russian Federation differ from those adopted in the Republic of Belarus [10, 12].

The results of the work are as follows:

1. The application of CSE for hot air heating systems and ventilation systems in the houses of worship (fig. 4, 5, 8.)
2. The use of the flat solar energy collector to heat incoming air is an alternative way to support the work of the general ventilation aimed at dissipating dangerous substances emitting from people, burning candles and lamps in the cult church building accommodating 50 people.
3. For civil buildings, at the period of negative temperatures the hot air heating systems of the outside air is required in addition to CSE.
4. The flat CSE may be considered as an alternative to liquid heat solar components. However, the disadvantage will be the difficulty of implementing water heating and its connection to the traditional water heating systems because it is more convenient for air heating systems.

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ON TAKING ACCOUNT OF THE HETEROMODULARITY OF THE MATERIAL
 WHEN MAKING CALCULATIONS OF TRUSSES WITH RIGID JOINTS

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This article deals with the influence of the heteromodularity of the material on the parameters of the ten- sity and deformity state (TDS) of truss constructions with a rigid connection of the rods in the joints with a nodal scheme of loading. For the heteromodularity of the material to be taking into account one should use a bilinear diagram of the dependence between tensions and deformations of the material in truss rods. The calculation of trusses is carried out with the help of the force method. The determination of the coefficients and free terms of canonical equations is fulfilled according to Maxwell-More's generalized formula, which takes into account the heteromodularity of the material. The influence of the heteromodularity of the construction material on the pa- rameters of the TDS of a truss is illustrated with a representative example.

In the linear theory of calculating pivoted constructions, the construction material is, as a rule, considered a homogeneous isotropic elastic body the behavior of which is described with the modulus of elasticity E which is the same in case of tensility and pressure. However, as the experimental investigations [1, 2] show, the moduli of elasticity at tension E^+ and pressure E^- are different for a number of modern construction materials. They differ essentially.

More than that, the phenomenon of heteromodularity, to this or that extent, is inherent practically in all traditional construction materials. Thus, according to [3], heteromodularity is established for numerous steels and alloys. The coefficient of heteromodularity (μ) for them is less than 1 and varies from 0.75 to 0.97.

An essentially heteromodular material is concrete [4]. Thus, the coefficient of the heteromodularity of different types of heavy concrete is more than 1 and varies from 1.07 to 1.82. At the same time, the coefficient of heteromodularity of light concrete can be either more or less than 1.

Based on the experimental data obtained $f E^+ / E^-$ or various materials which differently resist tension and pressure, a phenomenological theory [5] was built. It describes the behaviour of a heteromodular material and proposes general methods of solving problems of the theory of elasticity in case of such a material. Accord- ing to this theory, the diagram of tension-deformation for the materials with different moduli of elasticity, in case of tension and pressure, is represented in the form of a bilinear diagram with a gap in the value of the incli- nation angle of the tangent in point 0 (Fig. 1).

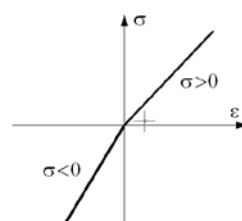


Fig. 1. The diagram of tension-deformation

The heteromodularity of construction material in this case is characterized by the moduli of elasticity ratio

$$\mu = \frac{E^-}{E^+} .$$

This article deals with the influence of the heteromodularity of material on the parameters of the TDS of a truss with a rigid connection of the rods in joints with a nodal scheme of loading. For the parameters to be determined one should apply a force method and use, as a basic system, a hinge and rod system obtained when notionally replacing rigid joints with hinges. The basic unknown quantities in this case are nodal moments.

The coefficients and free terms forming part of the canonical equations of the force method are calculated according to Maxwell-More's formula which for a heteromodular material, in case of taking into account the flexural and longitudinal deformation, looks like [6]

$$\Delta_i = \sum_k \int \frac{m_i M_p}{D} ds + \sum_m \int \frac{n_i N_p}{E^- A} ds + \sum_j \int \frac{n_i N_p}{E^+ A} ds, \quad (1)$$

where D is the flexural rigidity of the cross-section for a heteromodular material or the reduced flexural rigidity.

For the symmetrical cross-section of arbitrary form, the reduced flexural rigidity is determined by the formula

$$D = E^- I^- + E^+ I^+, \quad (2)$$

where the quantities I^- and I^+ characterize respectively the moments of inertia in the compressed and stretched parts of the cross-section regarding the neutral axis.

The position of the neutral axis is determined with the help of the equation

$$E^- S^- = E^+ S^+, \quad (3)$$

where S^- is the static moment of the compressed part of the cross-section; S^+ is the static moment of the stretched part of the cross-section.

Using the obtained formulas (2), (3), it is possible to determine the position of the neutral line and the reduced flexural rigidity for any of the cross-sections found when making calculations of pivoted constructions. Thus, for example, the position of the neutral line for the rectangular cross-section is described with the correlations

$$h^-(\mu) = \frac{1}{1 + \sqrt{\mu}} h; \quad h^+(\mu) = \frac{\sqrt{\mu}}{1 + \sqrt{\mu}} h,$$

where h^- , h^+ are, the height of the compressed and stretched part of the cross-section respectively. Then the reduced rigidity of the rectangular cross-section is described with the a formula of the following kind

$$D = \frac{b}{3} \left(E^- (h^-)^3 + E^+ (h^+)^3 \right).$$

Thus, when making calculations of trusses with the force method, considering the heteromodularity of a material, the formula for calculating the coefficients of canonic equations according to (1) will look like

$$\delta_{ij} = \sum_k \int \frac{m_i m_j}{D} ds + \sum_m \int \frac{n_i n_j}{E^- A} ds + \sum_j \int \frac{n_i n_j}{E^+ A} ds, \quad (4)$$

and for calculating the free terms of the equation according to (1), considering the used variant of the basic system of the force method, the formula will look like

$$\Delta_{iP} = \sum_m \int \frac{n_i N_p}{E^- A} ds + \sum_j \int \frac{n_i N_p}{E^+ A} ds. \quad (5)$$

For the numerical evaluation of the influence of the material heteromodularity on the values of the parts of the coefficients of the canonical equations which take into account the influence of the flexural deformations, it is possible to introduce the coefficient of the influence of the material modularity

$$\zeta = \frac{D}{EI_z}. \quad (6)$$

In the case of the rectangular cross-section, this coefficient looks like

$$\zeta = \frac{1}{4} \frac{(1 + \sqrt{\mu})^2}{\mu}$$

In Fig. 2 the graph shows the dependence of this coefficient on the quantity μ

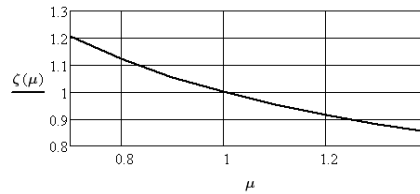


Fig. 2. The dependence of the influence coefficient on μ

Let's give the numerical evaluation of the influence of heteromodularity on the parameters of the TDS of a truss with rigid joints, using a particular example. Let's consider a two-pivoted truss with rigid connection in the joint under the influence of arbitrary nodal loading. (Fig. 3)

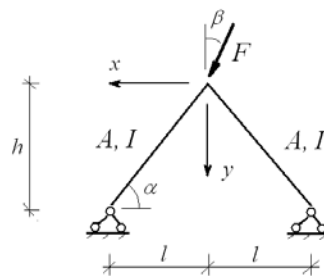


Fig. 3. Two-pivoted truss

The calculation of the truss is carried out with the force method. In the capacity of a basic system one should take a truss with a hinged connection of the rods in the joint (Fig. 4)

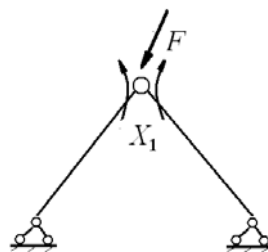


Fig. 4. Basic system of the force method

The canonical equation of the force method looks like

$$\delta_{11} X_1 + \Delta_{1p} = 0$$

The unknown quantity in the equation (1) is the nodal bending moment.

The inner efforts of the solitary state, which are connected with the calculation of the coefficient and free term of the equation, in the dimensionless form, look like this:

- the bending moments

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

– the longitudinal forces

$$n'_1(\alpha) = \cos \alpha; \quad n'_2(\alpha) = \cos \alpha$$

The longitudinal forces of the loading state, which are connected with the calculation of the free term, in the dimensionless form, look like this

$$N'_1(\alpha, \beta) = -0.5 \frac{\cos \beta}{\sin \alpha} \left(1 + \frac{tg \beta}{tg \alpha}\right); \quad N'_2(\alpha, \beta) = 0.5 \frac{\cos \beta}{\sin \alpha} \left(\frac{tg \beta}{tg \alpha} - 1\right),$$

and the bending moments in the loading state, don't appear.

If we take into account the calculation of the coefficient by the formula (4) and the free term by the formula (5) the nodal bending moment looks like:

- in case $\beta \leq \alpha$

$$X'_{1\mu}(\alpha, \beta, \lambda, \mu) = 1.5 \frac{\zeta \cos \beta}{\cos^2 \alpha (3\zeta + \lambda^2 \mu tg^2 \alpha)}$$

- in case $\beta \geq \alpha$

$$X'_{1\mu}(\alpha, \beta, \lambda, \mu) = 0.75 \left[(1+\mu) + (1-\mu) \frac{tg \beta}{tg \alpha} \right] \frac{\zeta \cos \beta}{\cos^2 \alpha (3\zeta + \lambda^2 \mu tg^2 \alpha)}$$

The dependence of the quantity of the obtained nodal bending moment on the parameters of the truss α , β , λ , μ is represented in the graphs in Fig. 5

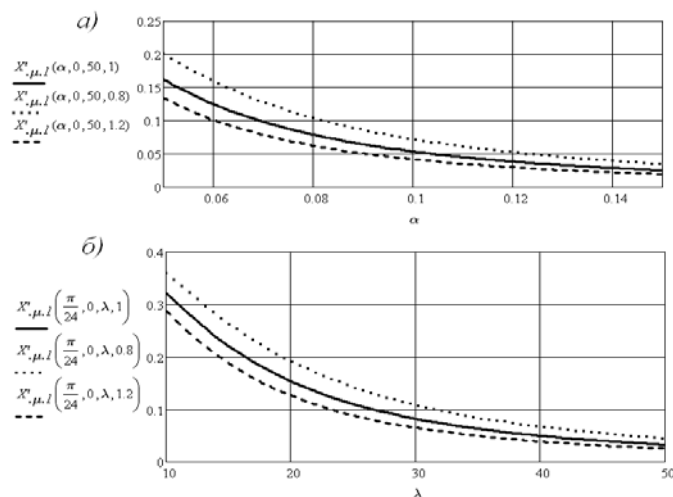


Fig. 5. The graphs showing the dependence of the quantity of the nodal bending moment on the parameters of the truss

It follows from the graphs in Fig. 5.a that the quantity of the nodal bending moment increases with the decrease of angle α and decreases with the increase of angle β that is with the appearance of the horizontal component of the nodal loading in the joint. From the graphs in Fig. 5.b it follows that the quantity of the nodal bending moment increases with the decrease of the flexibility in the truss rods. Besides, the quantity of the nodal bending moment in the truss essentially depends on the coefficient of the heteromodularity of the material μ . At values $\mu < 1$ the nodal moment increases, and at values $\mu > 1$ it decreases in comparison with the quantity of this moment disregarding the heteromodularity of the material.

The dimensionless increases in the longitudinal forces in the truss rods, which appear as a result of the nodal bending moment, for a heteromodular material described with the formulas

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

$$\Delta N_{2\mu}(\alpha, \beta, \lambda, \mu) = 1 - k_{2\mu}(\alpha, \beta, \lambda, \mu),$$

where

$$k_{1\mu}(\alpha, \beta, \lambda, \mu) = 1 + \frac{n_1' X_{1\mu}'(\alpha, \beta, \lambda, \mu)}{N_{1p}'};$$

$$k_{2\mu}(\alpha, \beta, \lambda, \mu) = 1 + \frac{n_2' X_{2\mu}'(\alpha, \beta, \lambda, \mu)}{N_{2p}'}$$

are the coefficients of the influence of the rigidity of the joint on longitudinal forces in the truss rods, the heteromodularity of the material taken into account.

The dependence of the increases of the longitudinal forces on the parameters of the truss $\alpha, \beta, \lambda, \mu$ is presented in the graphs in Fig. 6

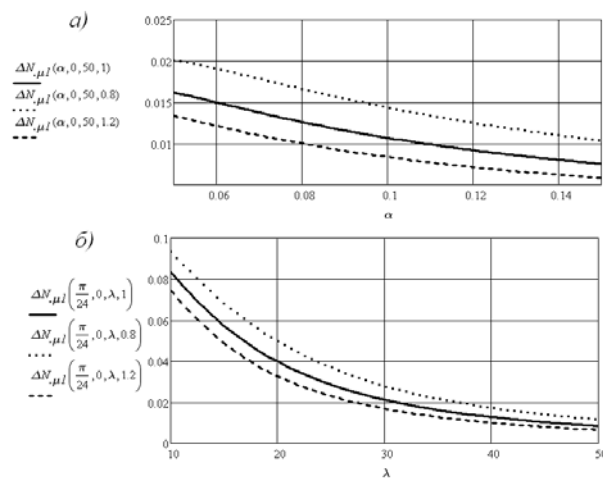


Fig. 6. The graphs showing the dependence of the quantity of the longitudinal forces increase on the parameters of the truss.

From the above graphs it follows that in case of the most unfavourable combination of the parameters of the truss, the quantity of the increase of the longitudinal forces doesn't exceed 10% of the values of the longitudinal forces according to the hinged scheme of the truss. However, at the values $\mu < 1$ this increase grows and at the values $\mu > 1$ it falls in comparison with the quantity of the increase of the longitudinal forces disregarding the heteromodularity of the material.

The dimensionless increases of the normal tensions in the truss rods which appear as a result of the nodal bending moment, for the heteromodular material are described with the formulas

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

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

where

$$k_{1\sigma\mu}(\alpha, \beta, \lambda, \mu) = k_{1\mu}(\alpha, \beta, \lambda, \mu) + \lambda \cos \alpha \frac{X_{1\mu}'(\alpha, \beta, \lambda, \mu)}{N_{1p}'(\alpha, \beta)};$$

$$k_{2\sigma\mu}(\alpha, \beta, \lambda, \mu) = k_{2\mu}(\alpha, \beta, \lambda, \mu) + \lambda \cos \alpha \frac{X_{2\mu}'(\alpha, \beta, \lambda, \mu)}{N_{2p}'(\alpha, \beta)}$$

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are the coefficient of the influence of the rigidity of the joint on the normal tensions in the truss rods. The dependence of the increases of the normal tensions on the parameters of the truss α , β , λ , μ is presented in the graphs in Fig. 7

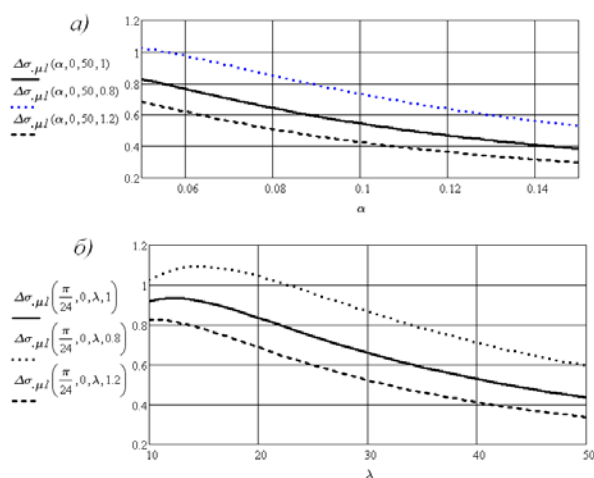


Fig. 7. The graphs showing the dependence of the increase of the normal tensions on the parameters of the truss

From the presented graphs it is possible to draw the following conclusions. Firstly, when taken into account the heteromodularity of the construction material of the truss rods may have a noticeable influence on the growth of the increases of the normal tensions as a result of the appearance of the nodal bending moment. Secondly, a significant influence on the manifestation of the heteromodularity effect is caused by the parameters of the calculation scheme of the truss.

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PHYSICAL-MECHANICAL AND STRUCTURE-FORMING PARAMETERS OF CONCRETE

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This article describes a three-factor experiment, inscribing three different additives improving the characteristics of concrete and reinforced concrete. The experiments explain the physical and mechanical properties of concrete, the mechanism of action of chemical admixtures resisting the corrosive influence on structures, the kinetics of corrosion, and the structure-forming parameters when using each of the additives. The experiments also show the performance of the admixtures on the mobility and workability of the concrete mixture. Conclusions are drawn, that each of the three additives acts differently on the structural formation of concrete.

Introduction. The task of the construction industry is to maximize the economy of material assets and technological energy consumption in the production of constructional works, with ensuring the maintenance and performance characteristics of structures. One of the most important ways to improve productivity in construction, aside to using modern equipment, is the addition of chemical admixtures for various purposes

Task formulation. The study of various chemical admixtures and their effect on concrete.

Briefly, chemical admixtures are those ingredients in concrete other than hydraulic cement, supplementary cementitious materials (SCMs), water, aggregates, and fiber reinforcement that are added to the mixture immediately before or during mixing. The development of ideas concerning the mechanism of additives, is inextricably linked with the progress in the theory of hydration and hardening of mineral binders. Also, studies related to the rational economy of heat treatment of reinforced concrete structures are very relevant, but they require an optimal class of the additive with its optimization with a mineral binder. The effectiveness of an admixture depends upon factors such as its composition, addition rate, time of addition; type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportions; mixing time; slump; and temperature of the concrete.

By aggressive environments, we take into consideration those environments in which corrosion of constructional materials occur. According to its aggregate state, aggressive media can be gaseous, liquid or solid, and in many cases multiphasic. On the basis of modern representation of the physical-chemical phenomena and surface contact interactions theory, we can change, in the desired direction, the properties of cement paste, concrete mix and the concrete itself by introducing specific additives (modifiers) into the cement systems.

The superplasticizer S-NPI, hydrophobizer GJK-10, and carboxymethylcellulose CMC were used as the main additives improving the corrosion resistance, as well as strength and mobility.

Studies were carried out on fine-grained concrete of composition 1:3. As well as, portland cement M:300 and sand $M_s - 2,1$. The testing of the beams $40 \times 40 \times 160$ cm, was carried out according to the GOST-310.4-8 for determining the bending strength, they were studied on the MII-100 installation, on the hydraulic press PSY-125 for determining the compressive strength, and also for the corrosion resistance according to the methods approved by NIIB, based on the exploitation conditions of the studied structures. In quantitative terms, the admixtures from the weight of the cement in (%) were:

- 1) S-NPI: 0.3-1.0%;
- 2) CMC: 0.5-1.0 %;
- 3) GJK-10: 0.2%.

All additives were introduced with the medium dissolved after preparation of dry cement-sand mixtures. The sample where put in a normally humid medium.

The tests computing the increase of strength, were characterized by the two additives S-NPI and CMC. The results showed that S-NPI increased the strength:

- Compression: 1.7 times;
- Bending: 1.4 times;

and that CMC also increased the strength:

- Compression: 1.1 times;
- Bending: 0.8 times.

In the case of achieving the maximum mobility, the ultimate strength is maintained when using S-NPI by 60%, and by 40% when using CMC, from the initial state of the concrete beam.

When determining the corrosion resistance, the samples were placed in a CaCl_2 solution (calcium chloride), of concentration 30 grams of salt per 100 ml of water at a temperature of 50°C. Intermediate tests of the samples were carried out after 7 days.

The results of the weight loss of all samples did not exceed 3%, the loss of strength when using CMC was 5%, and with the admixture S-NPI was 2%.

Table 1. – Strength measurement at different times in different mediums

№	Code	S-NPI	GKJ-10	CMC	Measurement	28 days		3 months in water		2 months in salt		2 months in water		5 months		4 months in salt		4 months in water	
						X ₁	X ₂	X ₃	\bar{Y}_1^1	C	B	C	B	C	B	C	B	C	B
1	a	1	0	0	2.2	460	54.6	384	57.2	421	114	409	66.5	326	73	364	77.5	400	44.8
2	b	0	0.02	0	2.2	324	44.7	292	37	297	72.6	323	39.9	258	32.9	200	62.7	302	44.6
3	c	0	0	1	3	248	33.4	169	30.9	192	40	221	41.6	156	41	155	43.1	138	38.6
4	abc	1	0.02	1	3	192	30.2	166	34.3	138	21	163	28.1	168	28.2	136	36.3	105	24.3
5	ac	1	0	1	2.8	162	25.5	116	23.9	80	22.85	93	14.6	104	12.8	73	30.7	71	21.3
6	bc	0	0.02	1	2.9	228	32.6	226	35.2	188	51.9	187	31.9	190	39.9	143	48.4	105	27.8
7	ab	1	0.02	0	2	456	48.1	377	44.4	370	51.9	308	49.4	306	37.9	203	57.7	358	46.9
8	-1	0	0	0	2.3	340	41.1	139	44.4	325	75.9	300	49.6	302	35.6	273	61.8	354	48.2
9	2a	1	0.01	0.5	2.9	200	26.8	152	29.4	186	50.6	163	32.4	169	29.6	91	31.6	153	25.8
10	(-2a)	0	0.01	0.5	2.8	224	31.3	209	35.7	117	53.4	178	30.1	184	33.4	137	39.6	151	34.5
11	2b	0.5	0.02	0.5	2.6	168	23.7	199	31.1	107	19.7	164	38.2	120	25.9	95	31	135	34.8
12	(-2b)	0.5	0	0.5	2.8	288	33.4	236	40	235	38.7	213	40.1	184	34.9	132	42.4	156	39.6
13	2c	0.5	0.01	1	3	218	37.5	208	35.7	163	30.7	203	35.5	136	28.5	108	34.1	193	36.2
14	(-2c)	0.5	0.01	0	2.3	314	34.2	332	46.4	385	81.3	296	45.5	242	41.5	161	71.4	260	53.2
15	0	0.5	0.01	0.5	3	212	20	184	30.6	195	33.7	150	35.2	213	37.2	101	35.1	140	36.5

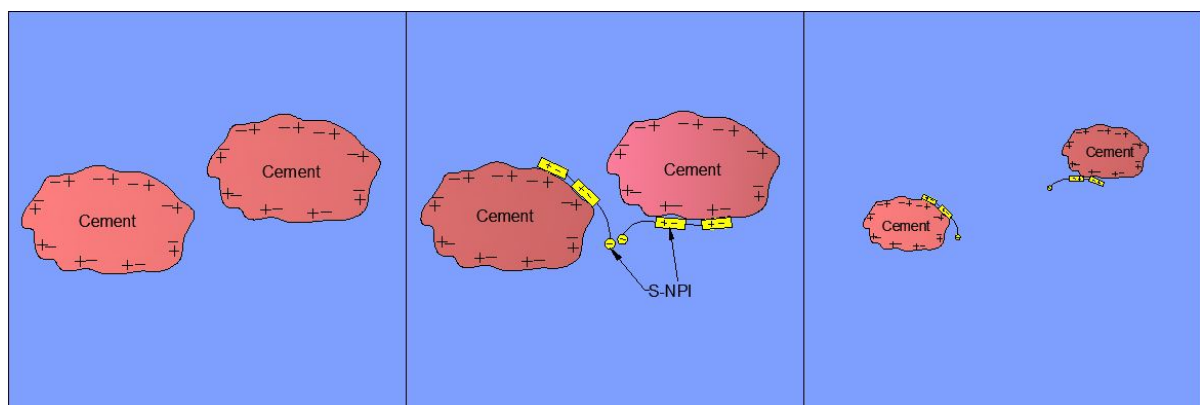


Fig.1. Mechanism of dispersive action of water-reducing admixtures

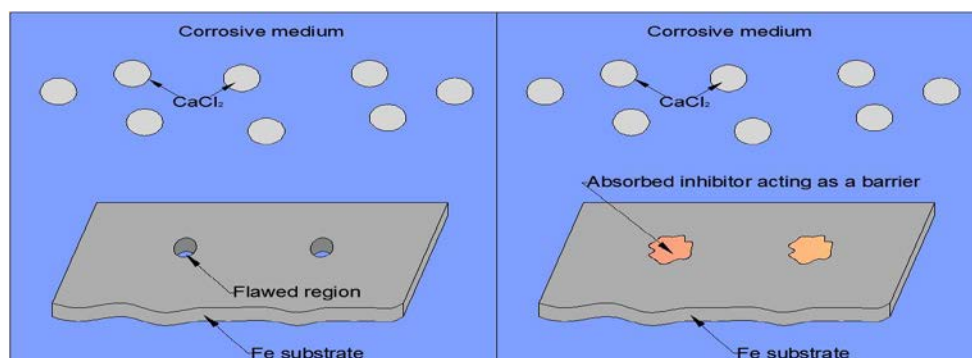


Fig.2. Mechanism of corrosive inhibitors

One of the most effective ways to increase the durability of concrete and reinforced concrete structures to the impact of the environment, is to control the structure of concrete during the period of its formation, which is achieved by adding surfactants, in particular organ-silicon compounds of various types to the concrete mixture. Silicone compounds, used as additives to concrete, release some amount of gas (hydrogen) into the concrete mixture upon their contact with an alkaline medium or to have an air-entraining effect. Air-entrainment dramatically improves the durability of concrete exposed to cycles of freezing and thawing and deicer chemicals. In addition, the additives hydrophobize the walls of pores and capillaries, which leads to a decrease in the adhesion of ice and salt crystals to them in the case of simultaneous action of salt solutions and freezing. At the same time, the capillary suction of liquid into concrete is also excluded or significantly reduced.

We make observations and fix the change in the mixture, with respect to the change in the composition and amount of the admixture. Based on the technical requirements, such a solution did not present an opportunity to put into the pipe, since it was dry. Therefore, in order to have a comfortable application, we applied the S-NPI additive, which improves the state of the cement-sand mortar.

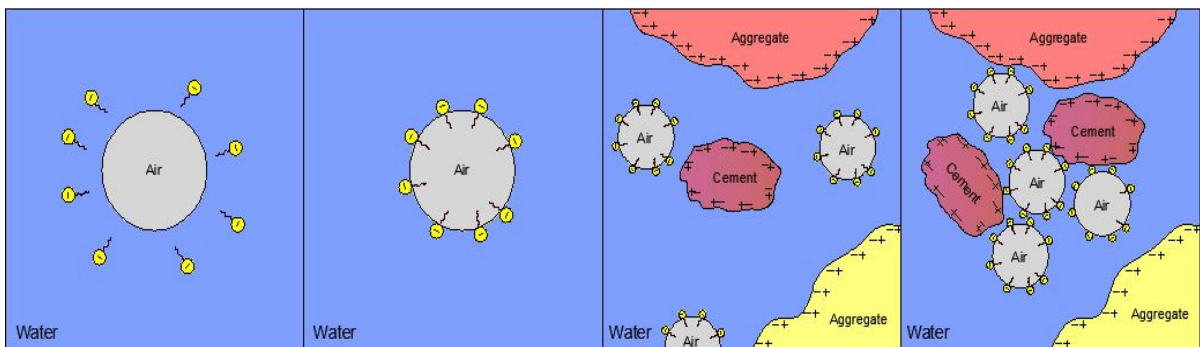


Fig. 3. Mechanism of air-entrainment

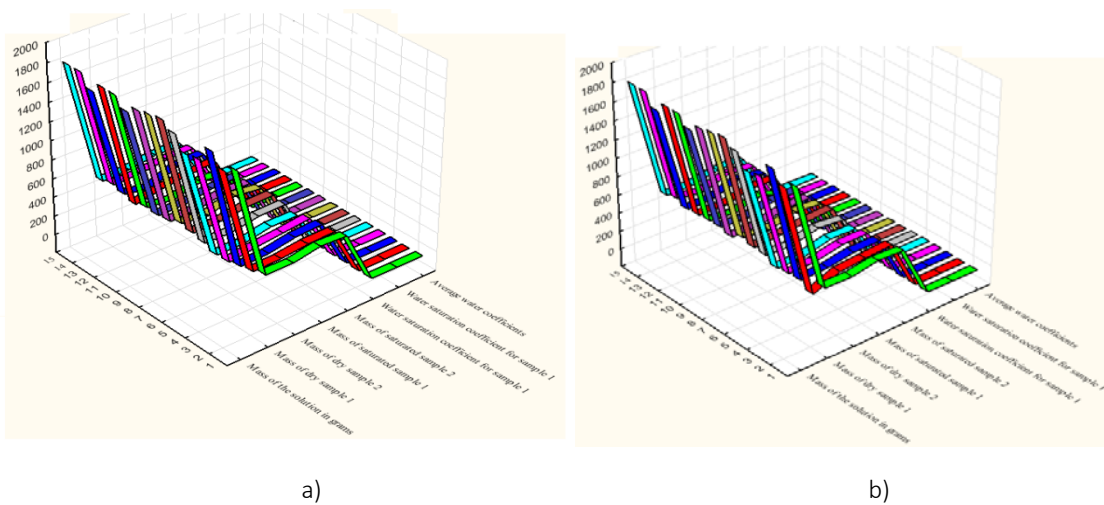


Fig. 4. Variation of water saturation based on the medium: a) water; b) salty medium

Table 2. – The variation in water saturation based on the medium

Mass of the solution in grams	1750	1680	1700	1600	1600	1675	1750	1700	1650	1750	1625	1750	1750
	Average mass	1660	1580	1800	1590	1590	1750	1800	1750	1650	1750	1675	1800
Mass of dry saturated samples	1705	1630	1750	1595	1595	1712.5	1775	1750	1650	1750	1650	1775	1775
	1	545	500	440	435	480	515	533	480	470	465	500	465
Mass of saturated samples	2	545	510	480	435	480	512	500	485	475	425	505	470
	1	600	545	535	500	530	555	595	540	520	540	540	515
Water saturation coefficients	2	580	550	550	495	530	560	555	530	550	555	550	520
	1	10.09	9	12.63	13.63	13.79	10.41	11.63	12.5	10.63	11.82	14.8	10.75
Water saturation average	2	6.42	7.84	12.24	11.45	13.79	9.38	11	10.3	11.1	12.24	8.91	10.64
	average	8.225	8.42	12.44	12.54	13.79	8.58	11.32	11.4	10.87	13.52	8.46	10.7
Salty medium	1	555	505	475	445	505	510	540	475	505	480	520	485
	2	550	525	490	445	495	530	510	480	490	485	485	485
Mass of saturated samples	1	595	540	530	515	565	560	590	540	555	575	570	540
	2	580	565	540	515	540	580	565	550	545	535	540	550
Water saturation coefficients	1	7.2	6.93	11.57	13.9	11.88	9.8	9.25	13.68	9.9	13.54	9.61	11.34
	2	5.45	7.62	10.2	12.5	9.09	9.43	10.78	14.58	13.26	10.3	11.34	13.4
average	6.31	7.28	10.89	13.2	15.7	10.49	9.62	10.02	14.13	11.58	11.92	10.48	12.37
The required amount of media shutter for slumping the cone by 107 mm	18 kgs. of the mixtures												
	2200 ml	2200 ml	3000 ml	2800 ml	2900 ml	2000 ml	2300 ml	2900 ml	2800 ml	2600 ml	2800 ml	2300 ml	3000 ml

Based on observations, we deduced several results:

- The first composition was the control mixture. We took 500g of sand of brand 1500g for the fraction, and according to the spread of the cone ($105 < 107 < 110$), the required amount of water (275 g) was determined. After mixing, the solution was placed in a mold and vibrated.

- The second composition – is the composition in which we applied the admixture CMC – 0.5-1% mass of the cement. The CMC was dissolved in water so that the resulting emulsion did not exceed 275 g. Emulsion – adhesive liquid. After mixing, the solution turned out to be dry. On the shaking pad, the cone slumped by 101mm, and the upper part of the cone collapsed.

The solution was placed in a mold and vibrated on a vibrating pad (T.V. = 3.45 min) until the appearance of cement milk.

At 1% the cone remained unchanged 100mm, and all of it almost collapsed after 30 impacts on the shaking pad. The solution was placed in a mold and was vibrated for 3 minutes on the shaking table until the appearance of the cement milk.

- The third composition is the composition which was supplemented with GKJ-10 - 2.5ml of GKJ-10 dissolved in water. With the introduction of the admixture into the water, no visual changes occurred except for a change in the color, under the color of the admixture (light brown). After mixing, the solution was placed on a shaking pad. The solution increased its mobility, which is evident from the slumping of the cone by 107mm. The solution was then placed in a mold and was vibrated for 2.5 minutes.

- In the fourth composition, we decided to combine CMC and GKJ-10 leaving $W/C = \text{constant}$ and $W = 275\text{mm}$. After mixing, the solution was placed on the shaking pad. After 30 impacts, the cone slumped by 105mm, which is 2mm less than the third composition. The appearance of cement milk happened after 2.15 minutes.

After those studies, we can make several conclusions:

1. The usage of S-NPI decreases the water-cement ratio, has a great effect in increasing the mobility of the concrete mixture, and vastly increases the strength of concrete for compression, as well as for bending.

2. The usage of CMC helps in obtaining a better concrete in case of mobility, with the preservation of the concrete strength. Also the usage of CMC increases the corrosion inhibition of the concrete mixture.

3. The usage of GKJ-10 helps preserve the durability of concrete by a large factor.

4. The usage of complex mixture, in our case CMC and GKJ-10, helps maintain the durability of concrete with the preservation of corrosion inhibiting.

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**USE OF MODIFIED CEMENT-SAND INTERLAYER IN COMPOSITE CONCRETE
AND FERROCONCRETE CONSTRUCTIONS**

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The joint work of layers of reinforced concrete composite structure is provided by the strength of adhesion, which is carried out on the basis of the unity of materials, technological and design activities. In this article, the influence of modified concrete on the strength of joints of composite structures is shown. The purpose of this study is to provide the optimum strength of the adhesion of concretes of a composite concrete and reinforced concrete structures using interlayers modified with the Stahement 2000M.

In view of the widespread use of modified concrete both in monolithic and prefabricated constructions and also in reconstruction, the effect of modifiers on the strength of the contact seam is very important. Investigations of the durable connection of new and old concrete, prefabricated and monolithic, have become widespread both in Belarus and abroad, in the works of scientists in research, design and training institutes [1-9]. On the basis of Polotsk State University for more than 10 years, a number of studies concerning the effect of modifiers on the strength of the contact seam have been carried out. These studies have been carried out using concrete with modified additives ATP, Superplast RT, Stahement F, Stahement 2000M [1, 2, 5]. At this stage, studies are carried out with the HA polymerizer Stahement 2010. The analysis of these works confirms the fact that the introduction of modifiers into the concrete mixture favorably affects the strength of the contact seam compared to the concrete without any additives, and the concentration of the modifier affects the strength of the contact seam. However, for large volumes of work, the use of modifying additives can be very expensive and unpractical, because the cost of modifiers is quite high. A rational solution to this problem may be in the usage of interlayers based on cement systems, including modified interlayers.

The contact seam generally is a combination of at least two elements, for example, the connection of building-in concrete with old concrete during reconstruction, prefabricated elements with monolithic concrete in prefabricated-monolithic construction, joining sections of monolithic concrete with newly laid in case of monolithic construction, joints in prefabricated buildings. In general, all the works devoted to this topic, consider the presence of only one contact seam. However, with the use of adhesives, impregnations, primers and interlayers, the structure is a system consisting of three layers, with two seams, which solve two main problems: 1) the strength of adhesion of old concrete with interlayer and 2) the strength of adhesion of interlayer with building-in concrete.

In the course of work, on the basis of the Polotsk State University, the influence of the contact surface type on the adhesion strength and the effect of the concrete design class on the strength of the contact seam was studied and analysed. Also some experimental studies concerning the influence of interlayers on the basis of cement systems, including those modified by the hyperplasticizer Stahement 2000M, on the strength of the contact seam of a composite concrete and reinforced concrete structure have been carried out.

Surfaces after treatment were classified in accordance with GOST 13015.0-83 [10], with the assignment of a surface category A5. The average depth of roughness of the surface of the samples was determined in the range from 0.24 to 0.33 mm, using the "sand spot" method. However, due to visual assessment, you can see the difference in the amount of protruding on the surface of the aggregate. It was suggested that the amount of aggregate at the interface would have a different effect on the resistance of the contact seam. Therefore, the sample surfaces were conditionally divided into three categories, depending on the amount of protruding aggregate (Figure 1).

The first group included samples which surfaces did not show the particles of a large aggregate, the second group included samples of a large amount of aggregate on the surface (5-10%), the third group - more than 15%. To reduce the influence of this factor on the test results, we used samples of all three categories in each test series.

The highest values of the strength of the contact seam were observed on samples which adhesion surface was conditionally assigned to group 3 within the category of surface A5, i.e. with the largest amount of filler protruding on the surface.

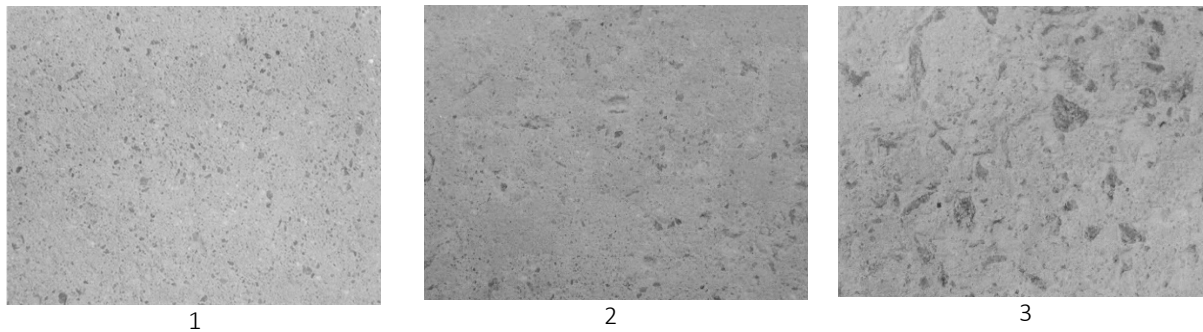


Fig. 1. The mating surface, depending on the amount of protruding coarse aggregate:
 1 – 0-5% of the area of the investigated surface; 2 – 5-10% of the area of the investigated surface;
 3 – more than 15% of the area of the investigated surface

The main objective of this study is to study the effects of the presence of a modifying additive in the interlayer and its concentration. To solve this problem, 3 series of G-1-0, G-1-0.4 and G-1-0.7 samples were created. The presence of the hyperplasticizer Stahement 2000M allows to achieve the necessary plasticity of the mixture with the use of less water, thereby increasing the strength characteristics of the elements, and reducing the shrinkage of hardening concrete. Based on the results of the experimental shear resistance, it was concluded that the use of interlayers based on modified cement systems increases the strength of the contact seam by about 40%, depending on the concentration of the additive. The most reliable joint work of composite concrete elements is provided by using a cement-sand interlayer with an additive concentration of 0.7% of the cement mass. The strength of the contact seam of samples with the optimum concentration increased by 1.87 times, i.e. by 46.5% in comparison to samples without an interlayer. From the above reasoning, it can be concluded that the use of a cement-sand interlayer with the use of modifying additives can significantly improve the cohesion of concrete elements.

For a more vivid evaluation of the surface of the adhesion of the samples after destruction, we decided to determine the coefficient of adhering particles of the old concrete on the surface of concrete (k). The coefficient was derived as the ratio of the area of adhering particles to the total area of the bonding surface. The averaged values for the groups of samples are shown in figure 2.

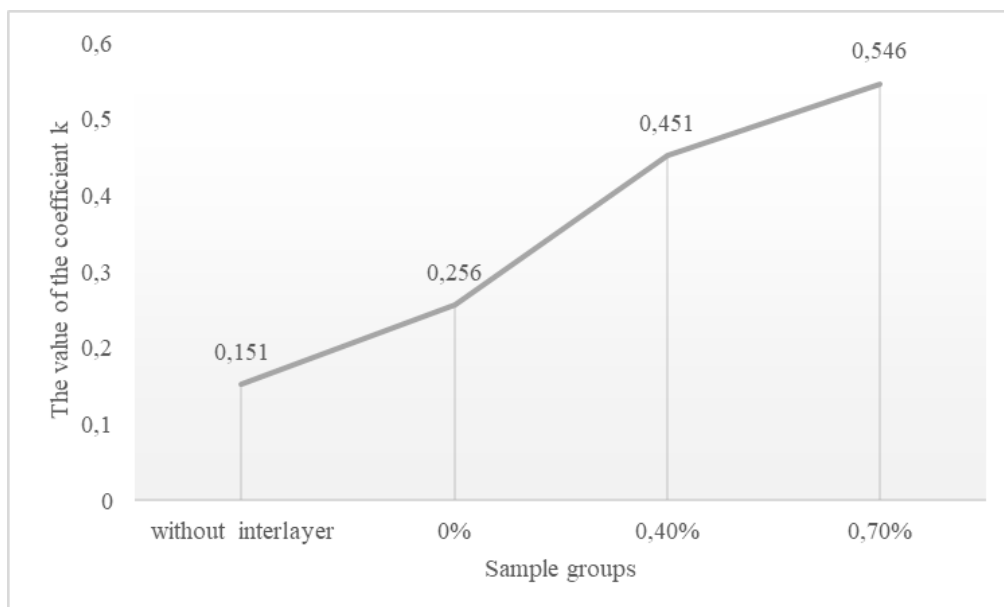


Fig. 2. Change in the amount of adhering particles of old concrete, depending on the group of samples analyzed

This work was carried out with the aim to obtain qualitative indicators in the study of interlayers based on modified cement systems. However, even at this stage of research, it can be concluded that the use of interlay-

ers based on modified cement systems, in particular the Stachemant 2000M hyperplasticizer has positive influence on the composite reinforced concrete structures.

Based on the results of the research, the following conclusions can be drawn:

- the presence of a cement-sand interlayer in the bonding zone of the samples increases the strength of the contact seam by an average of 6% as compared to samples without an interlayer;
- Stachemant 2000M in the interlayer increases the strength of the contact seam by about 40%, depending on the dosage;
- the addition of an additive of 0.7% of the weight of the cement increases the strength of the contact seam by an average of 46.5% compared to samples without an interlayer and by 43% compared to samples with unmodified interlayer;
- the strength of the contact seam can vary within up to 50% for different roughness of the interface surface, within the limits of one surface category (in particular, A5), and therefore in the normative documentation it is necessary to introduce additional gradations of surfaces.

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INFLUENCE OF ROMAN ARCHITECTURE ON ARCHITECTURE OF BELARUS OF X – XIII CENTURIES

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The learning of the history of Belarus in the period from X to XII century shows, that on the territory of our land the rich and rather original culture was formed. However, historians differently assess the ethnic character of this culture. Some of them consider it as a part of the culture of the ancient Russian, while others consider it to be Belarusian culture. There are various concepts: "culture of the western land of Russia", "Belarusian culture", "Old Belorussian culture". [1] Nevertheless, the high organization of the society, the formation of statehood, the formation of new feudal relations, the favorable trade position, extensive political ties - all these points contributed to the cultural progress on the lands of Belarus. The vast development of cities which were centers of feudal principalities, as well as trade and craft centers and the adoption of Christianity, were the reason for the formation of new trends in monumental architecture in the period under consideration. [2] The determining factor in the cult construction was the influence of the Byzantine Empire, as Kievan Rus adopted the Christianity of the Eastern rite from the Church of Constantinople.

The penetration of Roman architecture into the architecture of the Belarusian land can be reduced to two main directions: penetration through Byzantine architecture and through direct contacts of cities with Europe. In the XI-XII cent. castles, towers, monastery churches, churches, city houses were built on the territory of Belarus to the Romanesque pattern. Buildings were noted for their monumentality, solidity of designs, and severity: they were decorated with abstract geometric patterns and sculptures. Unfortunately, nowadays there are very few monuments of Romanesque style preserved. All of them were later destroyed or ruined because of frequent wars, many of them were rebuilt, supplemented, reconstructed and did not save their original form. [3]

Sacred architecture. One of the first temples, built on the territory of the Belarusian lands, where you can see the influence of the Romans, was the St. Sophia Cathedral in Polotsk. It was built between 1044-1066. It was conceived as a "short version" of Sophia of Kiev and Sofia of Novgorod, where such temples had been already built, and should symbolize political equality with Kiev and Novgorod. The cathedral was rebuilt many times and did not save its original form, that's why there are some difficulties in the study of the original form. Some sources say that it was the cathedral with seven domes, others say that it was the cathedral with five domes. It was rebuilt 6 times, so the original architecture of the cathedral has now completely changed. According to a plan, the original form of the cathedral was a quadrangle with 5 naves and 3 apses and was of the type - basilica. From north to south, the length of Polotsk Sophia is 26.2 m. From the west to the east - 25.5 m. The walls of the temple were laid out of stone according to the technique of Byzantine masonry "with hidden rows". The foundation was the alternation of rows of stone (plinth) - one coincided with the plane of the wall, the other was heated to a shallow depth comparatively to the upper and lower stone. The niche, which was formed, was filled with a solution of sticky crumbs. This method of laying made the cathedral very picturesque. In some places, the system masonry "with hidden rows" alternated with inserts with work stones, which indicated the formation of the principles of the local architectural school. The decor of the interior was enhanced by multiple murals. [4] The introduction of faceted apses, as typical of wooden churches, is one of the features of the Polotsk Sophia Cathedral, neither in Kiev, nor in Novgorod, are such apses not found. A distinctive feature of the cathedral is the absence of external bypass galleries and towers. Due to this, the outer volume of the temple was more compact and dynamic.

The breadth of the range, the richness of types and the variety of building methods make up the distinctive features of architecture created on Belarusian land at that time. The most striking and characteristic examples of architecture of the 12th c. are the Cathedral of the Savior-Euphrosyne Monastery in Polotsk, the Church of the Annunciation in Vitebsk and Borisoglebskaya, or Kolozhskaya in Grodno.

The Cathedral of the Savior-Euphrosyne Monastery, built between 1128 and 1156 by architect John, is a six-columned one-domed building. It reflected the characteristics of the general direction of ancient Russian architecture of the 12th century. They are - small dimensions, simplicity of the plan, monumentality of appearance; as the combination of some basilica with an average square, inherent in the Romance style.

Vitebsk Annunciation Church of the XII century adjoins the Polotsk group of churches. Its elongated plan, dismembered by six pillars on the 3rd nave, looks like the plan of the Savior-Ephrensinsky Cathedral. Here, also, the middle nave is significantly larger than the lateral ones, in the western part of the temple there are

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choirs with a staircase in the thickness of the wall. In the Annunciation Church, as in no other buildings of this period, basilicas were determined.

Grodno school of architecture manifestation of the Romanesque style in the first place was the use of polished stone for decoration of facades and voice, which in form were closer to European analogues. The example of it is the Borisoglebskaya (Kolozhskaya) church. The building belongs to the six-pillar, three-apsed temples. Its walls are relatively thin, supporting pillars have a circular cross-section. The masonry of the walls of the church is made of thin brick-slab brick. For architectural details a different shaped brick is used. In the altar part under a thick layer of plaster the fresco paintings of the XII century were discovered in 1870 during the repair works. The most interesting points are the facades of the church: they are dismembered by vertical drafts-blades of a step profile. The surface of the walls is decorated with insets of rough polished multi-colored boulders and majolica plates different colors. Majolica and stones – certain symmetry, but not strict, that's why the facades have become even more picturesque: they are as if inlaid with precious stones. [5]

However, the Minsk Castle Church has the greatest interest in studying the influence of the Romanesque tradition on the temple architecture of Belarus, the elements of which were revealed during the excavations of 1949 in the territory of the detinets. According to the scientists' assumptions, this temple was erected by Polish masters in place of a wooden church, burnt in 1067 and had characteristic features of the Romanesque style. Unfortunately, its construction for unexplained reasons was never completed (the walls were erected to a height of just above 1 m), but the surviving fragments indicate the originality of the Castle Church construction. It was a small, three-apsed three-aisled temple with dimensions of 12/16 m with four pillars, on which the dome should rest. The main apse of the temple supported the perimeter of the walls by more than 4 m, which was typical of Byzantine churches. But the fact that this ledge in the wall was flattened by the protruding lateral apses was quite an original solution. Unusual for domestic architecture was the foundation of the church, which included wooden elements.

Such a deviation from Byzantine traditions can only be explained by the fact that during the construction of the church Minsk was independent of Polotsk and claimed to create an independent principality. But in 1084 Minsk was again destroyed by the troops of Vladimir Monomakh. And Polotsk restored his power here. Probably, for these reasons the construction of the church in Minsk was stopped, the stone remained were used to strengthen the outer wall, and the unfinished church turned into a city necropolis where archaeologists found 21 burial places. In the middle of the XIII century the fragments of the Castle Church were completely covered with earth, which saved them from further destruction. In 1993, in honor of the temple on the bank of the river Svisloch a small memorial was created - a contour of the church was laid out from the tiles and a commemorative sign dedicated to the 200th anniversary of the Minsk diocese was installed.

Besides Minsk, Romanesque temples were apparently erected in other cities of Belarus. Due to the Ipatiev Chronicle it is known that "Volynian towers" in Brest and Kamenets stone temples were built simultaneously. Unfortunately, the Kamenetskaya Annunciation Church was destroyed in the Middle Ages, and fragments of the Church of St. Petra in Brest were destroyed in the XIX century during the construction of the fortress. These temples were erected according to the technique of the Baltic masonry of large bricks. Most likely, they were cross-dome with three apses.

Defensive structures. The defensive structures of the ancient cities of Belarus included a moat and a shaft with wooden walls that surrounded the Detinets, the roundabout city and some of the villages. The complication of the system of fortifications was first carried out through erection at the corners of the fortress and at the entrance of multi-tiered wooden towers. However, in the XII - XIII centuries, on internecine feuds, the external threat from the side of the crusaders and the Mongol-Tatars increased. This required the strengthening of traditional defensive structures, which were no longer able to guarantee security. Grodno and Polotsk were able to replace the wooden walls of the detinets with stone ones, but the lack of a large amount of natural material made this way difficult and expensive.

In medieval Europe, the solution was found in the creation of the city or fortress of a separate well-fortified object. In France, these were the so-called "dungeons", which were a complex of stone structures with a large tower-dominant, adapted to the habitation of the feudal lord. In Germany, "burgfried", where the population sought shelter during the breakthrough of the enemy through the outer belt of fortifications.

On the Belarusian land, such defensive fortifications were spread from Western Ukraine, and therefore were known under the name of "Volyn Tower". Romanesque style was manifested:

Firstly, in the use of natural stones and large brick blocks.

Secondly, in the Vendian or Baltic masonry system, when two longitudinally placed bricks alternated with one transverse

Thirdly, in a certain design of joints and semicircular completions of window openings and flat niches. In contrast to Western Europe, these buildings in Belarus had a simplified composition (separate towers or towers defending the entrance to the fortress), and could also be built from wood. The last, of which disappeared only in the XVI-XVII centuries due to changes in the fortification and the transformation of castles into chic palaces.

The only "Volyn Tower" in Belarus preserved almost unchanged is the Kamenets or Belaya Vezha, located 40 km north of Brest. This stone 5-tier round in terms of construction (height about 30 m, wall thickness 2.5 m, outdoor diameter 13.6 m). The tower is built on a powerful stone foundation with a height of about 2.3 m, 16 m in diameter. It is made of bricks of dark red and yellowish color with characteristic oblong grooves in the lower part. [6] It should be noted that along with the Romance influence, the Kamenetz Vetz also absorbed the Gothic features.

Romance style in temple painting and sculpture. The most ancient frescoes in Belarus are the murals of St. Sophia Cathedral in Polotsk, murals of the Transfiguration Cathedral of the Euphrasinsky Monastery. They were made in 40-50 years of the XII century. This is the only monument that came to us in the original version. The system of murals of the Savior-Transfiguration Cathedral is similar to the Byzantine-Kiev cathedral. In the dome there is the image of the Savior, on the stained-glass windows - images of the Evangelists. At the end of the apse there is the image of the Mother of God. The paintings were made with an orientation to the Byzantine scheme. In addition to the monumental paintings in Polotsk, the outstanding achievements of painting of the XII century are frescos in the Dobroveschenskaya church in Vitebsk, Borisoglebsk church in Novogrudok, painting of the Lower Church (the first half of the 12th century) in Grodno. Monumental painting of the ancient Belarusian lands possessed a high level of development. Distinguished by some details, it indicates a unified nature of technical techniques, a single system of accommodation of artistic images in the interior, of orientation to Byzantine traditions [3].

The influence of Roman culture spread to sculptural monuments of the centuries. They are divided into two groups: cult and secular. They were small in size figures (sizes from 4 to 6 cm). A high artistic example is the image with the image of Constantine and Helena (middle of XII century), Found in Polotsk. The rectangle of the plate is completely filled with 2 figures. The work is characterized by conditionality and massiveness of forms

The article examined the influence of Romanesque architecture on the Belarusian land in the X-XII centuries. The main directions of the penetration of Romanics into the Belarusian culture are shown. The characteristic of the Roman architecture element in such areas as: temple architecture, defensive structures, monumental painting and sculpture is analyzed and identified.

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**THE INTEGRATED BINDER WITH THE USE OF ASH OF THE BELARUSIAN STATE DISTRICT POWER STATION
OF THE URBAN VILLAGE OREKHOVSK**

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The article considers the effectiveness of the application of ash from the Belorussian state district power station of the urban village Orekhovsk in the integrated binder based on Portland cement. The results of the determination of the activity of the integrated binder according to the procedure of EN 450-1 are given. The dosage of ash in an amount of 10–20% of the mass of the binder is established, which increases the activity of the integrated binder.

Plans for the development of energy are associated with the increase by 2020 of the share of own energy resources (including: peat, firewood, biomass) in the balance of boiler-furnace fuel to 32 ... 34% [1]. Without the use of modern processing technologies, the increase in ash-waste streams will lead to an increase in the areas of slag-hills, which will cause irreparable damage to the environment.

The Belorussian state district power station of the urban village Orekhovsk in the Vitebsk region works on local fuels. This station is equipped with a boiler plant, which operates on milling peat and wood chips. In the furnaces the fuel is burned in a fluidized bed of quartz sand. The average burning temperature does not exceed 800°C.

Chemical composition of the ash and slag mixture is formed (mass %) according to Interstate Standard 10538-87 "Solid fuel. Methods for determining the chemical composition of ash" [2] is presented in Table 1.

Table 1. – Chemical composition of the ash and slag mixture of the Belorussian state district power station (mass %)

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	SO ₃	loi
87.62	4.39	1.08	3.08	0.55	0.61	1.79	0.24	0.19	<0.10	0.07

According to the chemical composition, the ash and slag mixture consists mainly of silicon and aluminum oxides (92%). According to the modulus of basicity ($M_o < 1$), the ash and slag mixture is acidic [3], the content of calcium oxide and magnesium oxide is 3.63%.

The use of ash-and-slag wastes of dry sampling in the production of building materials is one of the most promising areas of utilization.

In the article [4] rational areas of application of low-calcium ash-and-slag wastes of TPP are generalized. The effectiveness of application of autoclaved hardening in the production of binders, as a hydraulic additive to cements, as well as aggregate in heavy and cellular concrete were noted.

Acid ash has pozzolanic activity, that is, the ability to bind at normal temperatures calcium hydroxide, forming insoluble compounds. In the technology of autoclaved cellular concrete, acid ash interacts with CaO of lime, forming mainly calcium hydrosilicates. This allows to achieve better physical and mechanical characteristics of ash cellular concrete in comparison with sand cellular concrete, in particular, reduction in density and higher strength and frost resistance.

The research carried out by E.A. Stroitelova [5], have confirmed the high efficiency of the use of acid fly ash to replace part of the fine aggregate in fine-grained concrete in order to increase strength parameters. A decrease in the capillary porosity of cement stone due to improved particle size distribution and pore colmation with additional calcium hydrosilicates formed during the interaction of fly ash with Portland cement hydration products is established.

In the work of A.V. Ukhanov [6] it is shown that the dump ash-slag mixture can be used as a mineral additive for the production of concretes, mortars and dry construction mixtures. It is shown that fly ash can both reduce and increase the water demand, the viscosity and plasticity of concrete mixes, can lead to an increase in the strength of concrete, and also can cause significant linear expansion of the cement stone when it is hydrated. In this case, the chemical composition of the ash plays a decisive role.

To determine the possibility of effective use of the ash and slag mixture of the Belorussian state district power station in concrete mixtures and concretes, a set of studies is planned. The first step was to determine the activity of the integrated binder, in which a fraction of the ash-slag mixture passed through a No. 008 sieve

was used as a mineral additive, i.e. fly ash (further ash) with the following characteristics: bulk density 960 kg/m³; the true density is 2100 kg/m³.

The determination of the activity of integrated binder was carried out according to the procedure EN 450-1 "Volatile fly ash for concrete. Part 1. Definition, requirements and criteria of conformity" [7]. The essence of the technique is to compare the compressive strength and flexural strength of mortars at the age of 3, 7 and 28 days, made of Portland cement of the hardness class 42.5 (control composition) with the compressive strength and flexural strength of mortars made from Portland cement in an amount of 90%, 80% and 70% and ash in the amount of 10%, 20% and 30% of the binder by weight. For testing, samples were made with 4x4x16 cm bricks that were hardened in normal-humid conditions for 1 day, then placed in a container with water, the temperature of which was 20°C, and stored there until the desired age. The ultimate strength of the bending samples was determined on a MII-100 machine, and then each of the halves obtained was tested for compression using two metal plates, the area of which was 25 cm². The results of determining the activity of complex binder are presented in Table 2.

Table 2. – The activity of the integrated binder

Composition number	Mixture composition				Strength at the age of 3 days, %		Strength at the age of 3 days, %		Strength at the age of 3 days, %		
	No	Binder, mass %	W/C	W/B	Water	flexural strength	compr. strength	flexural strength	compr. strength	flexural strength	compr. strength
1	Control composition Cement 42.5 - 100%	0,5	0,5	225	100	100	100	100	100	100	100
2	Cement - 90% by mass + ash and slag mixture 10%	0,56	0,5	225	87	94	96	106	108	114	
3	Cement - 80% by mass + ash and slag mixture 20%	0,625	0,5	225	66	82	74	99	84	108	
4	Cement - 70% by mass + ash and slag mixture 30%	0,714	0,5	225	54	56	60	69	77	81	

The activity of the integrated binder in the early periods of hardening (at the age of 3 and 7 days) decreases. Compression strength at the age of 3 days decreased by 6%, 18%, 44% with the amount of ash in the integrated binder, respectively 10%, 20%, 30%. The compressive strength at the age of 7 days for composition No. 2 exceeds the strength of the control sample by 6%. At an ash content of 20%, 30%, the activity of the integrated binder at the age of 7 days is below the control value. At the age of 28 days, the compressive strength exceeds the strength of the control sample by 14% and 8%, respectively, with an ash content of 10% and 20% in the integrated binder composition. At an ash content of 30%, the binder's activity is significantly reduced and at the age of 28 days it is 80% of the strength of the control sample.

The tests showed that the addition of ash in the composite cement based on Portland cement leads to a decrease in activity at the age of up to 7 days. In the subsequent periods of hardening, there is an intensive set of strength of the samples and by 28 days the strength exceeds the control values. At an ash content of 30%, a significant decrease in the activity of the integrated binder is observed. This dosage of ash is not recommended. Thus, an effective composition of the integrated binder is a composition with the replacement of Portland cement with ash in an amount of 10-20%.

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**NORMATIVE SUPPORT OF DEVELOPMENT OF TECHNOLOGICAL CHARTS
FOR CONCRETING OF MASSIVE CONSTRUCTIONS****NATALIA SHPILEVSKAYA, KHRYSYTSINA PALETAI, ALEXANDER SHVEDAU****Polotsk State University, Belarus**

When concreting large-sized overall constructions there is not always the possibility of uninterrupted laying of the concrete mix. In the production of concrete work, breaks in concreting are caused both by technological and organizational factors. But in the organizational and technological documentation there are no specific parameters and technologies for the device of cold joint. Also there are no normative documents concerning the design of the work for the construction of these joints.

Construction of massive concrete and reinforced concrete designs, such as base plates, fortification and engineering constructions (causeway, air-raid shelters, dams, etc.), as a rule, is made by separate sections.

When the structures are divided into sections (charts) of concreting, joints are formed, which if possible should be arranged at the same time performing several functions at once. The construction of work joints is caused by the inevitable pause of concreting due to all sorts of organizational (the end of the work shift, the breakdown of equipment, the lack of materials, etc.) and technological reasons (the need for mounting overlying reinforcement, repositioning of scaffolding and formwork, limiting loads on support structures, etc.).

Recommendations on the size of the allowed interval of overlapping concrete layers before the formation of the working joints are very vague and contradictory. According to various sources [1, 2] this interval should not exceed the time of "beginning of setting of cement", "beginning of setting of concrete", "beginning of setting cement in concrete", just "setting time of concrete", etc. But none of these terms isn't standard, and this makes it difficult to analyze their validity. In some sources [3] the recommended approximate values of allowable intervals are in the range of 2 - 4.5 hours. Almost in all standards [4–6], the choice of the allowable interval is assigned to the construction laboratory, and there is no methodology and criteria for its determination. The break in concreting affects the strength of the joining of the concrete layers.

For example, in the article [7] it is noted that during breaks in concreting the quality of the top (contact) concrete layer worsens because of water separation process. It takes place most intensively during the first 1-1.5 hours. The author explains the reduction in the strength of the joint with the age of "old" concrete in the first hours after its packing by the reduction in cohesion. However, according to [1-3], the strength of the butt joint, even with a break in concreting of 5 hours or more, is significantly higher than the strength of the joint with fully cured concrete, even with careful preparation of its surface. These results obtained in the laboratory do not take into account at the same time the most important production factor - the possibility of damaging the emerging crystallization structure of "old" concrete when it transfers loads to it from the unloaded material, the movement of workers and machinery.

In practice the critical duration of a break in mix laying corresponding to the beginning of formation of crystallization structure is defined by the ability of "old" concrete to be diluted at vibration. When at immersion of the vibrator in it not swimming away cracks are formed, it is necessary to arrange a working joint. At breaks more than the determined time further laying of mix can be spent only after set by earlier poured concrete of durability not less than 1,5 MPa. Otherwise its structure can be broken.

When laying a concrete mixture in massive thickly-reinforced plates of a large area (foundation plates, bottoms of tanks and sedimentation tanks, etc.) according to standard technological chart, [8-10], the main technological requirement is the continuous laying on the entire height of the slabs. Existing methods [11] determining the timing of setting cement systems have drawbacks, they do not uniquely define the term beginning and end of setting.

Let's consider some typical technological charts for concreting slab foundations. In 7351 TC "Technological chart for the construction of a monolithic reinforced concrete foundation plate" is a schedule of work on the installation of foundation slabs using a concrete pump [8]. The technological chart is designed for concreting a base plate with a size of 44m x 20m x 1m, $V_b = 880 \text{ m}^3$. The labor costs of workers will amount to 193,6 people-hours. According to the schedule of work, the duration of laying the concrete mix is 6,5 days, when working in 1 shift. Hence, a working joints arrangement is required.

Table 1. – Schedule of work on the foundation of the slab using an concrete pump /8/

Point No	Name of technological processes	Measuring unit	Scope	Labor costs		Membership	Process time, days	Working days														
				of workers, man-h.	of machine operator man-hours(duty of machine, mach.-h.)			1	2	3	4	5	6	7	8	9	10	11	12	13		
1	2	3	4	5	6	7	8	9														
1.	Fitting and steel lashing	t	55	230,89		Steelfixers: 3grade-3 man 2 grade-1 man	7,0	[Gantt chart: bars from day 1 to 7]														
2.	Welding of node point of reinforcement joints	t	16,94	108		Ark welder 3grade-1 man Steelfixer 2grade-1 man	6,6	[Gantt chart: bars from day 1 to 6]														
3.	Fittings by truck crane	t	55	7,15	3,52 (3,52)	Crane operator 5grade-1 man Scaffolders: 2grade-2 man	0,4	[Gantt chart: bars from day 1 to 4]														
4.	Setting forms	m ²	128	57,6		Building joiners: 4grade-1 man 2grade-1 man	3,5	[Gantt chart: bars from day 4 to 7]														
5.	Feeding of concrete mix by concrete pump	m ²	880	158,4	53,68 (53,68)	Crane operator 4grade-1 man Metal worker 4grade-1 man Concretor 2grade-1 man	6,5	[Gantt chart: bars from day 4 to 10]														
6.	Concrete placement	m ²	880	193,6		Concreters 4grade-2 man 2grade-2 man	6,1	[Gantt chart: bars from day 4 to 10]														
7.	Servicing of concrete surface	m ²	880	5,46		Concretor 2grade-1 man	0,67	[Gantt chart: bars from day 4 to 5]														
8.	Formwork disassembling	m ²	128	33,28		Building joiners: 4grade-1 man 2grade-1 man	2,0	[Gantt chart: bars from day 11 to 13]														
				794,38	57,20 (57,20)																	

In TC 6306031077/31077 /9 / "Arrangement of flat monolithic reinforced concrete foundation slabs in civil buildings" the schedule of works on the foundation of the slab with a concrete pump is presented.

Table 2. – Schedule of work on the foundation of the slab using an concrete pump /9/

Name of processes	Measuring unit	Scope	Labor costs		Adopted membership	Process time, relays	Working relays							
			of workers, man-h.	of machine operator man-hours (mach.-h.)			1	2	3	4	5	6	7	8
Feeding and installation of reinforcement, including mounting clamps, fixing corners	t	0,86	43,44	0,40 (0,40)	Crane operator 5gr.-1 Steelfixers: 4gr. - 1 3gr. - 1 Ark welder 3gr. - 1	1,77	[Gantt chart: bars from relay 1 to 1.77]							
Feeding and installation of formwork boards, including dobors;	t	2,99	18,52	8,75 (8,75)	Crane operator 5gr.-1 Metal workers: 4gr. - 1, 3gr. - 1	1,13	[Gantt chart: bars from relay 2 to 3.13]							
Reception, feeding and laying of concrete mix	m ³	143	45,36	9,15 (9,15)	Operator by concrete pump 4 gr. - 1 Concreters: 4gr. -1, 2gr. - 1	1,38	[Gantt chart: bars from relay 3 to 4.38]							
Dismantling of formwork panels	m ²	44,19	8,84	2,65 (2,65)	Crane operator 5gr.-1 Metal workers: 4gr. - 1, 3gr. - 1	0,54	[Gantt chart: bars from relay 5 to 5.54]							

The technological chart is designed for concreting a foundation slab under a building in the form of a monolithic reinforced concrete slab of a 20-storey building. The technological chart provides the installation of a monolithic reinforced concrete slab 1 m high, in the section between the axes 1-2 and the rows of GE in a height of 0,7 m from concrete M200 with the use of large-panel formwork, $V_b = 143 \text{ m}^3$. The duration of receiving, feeding and laying of the concrete mix is 1,38 shifts according to the schedule of works. Therefore, a work joints arrangement is required.

In TC 4.01.01.63 [10] "The technological chart for the construction of flat monolithic reinforced concrete foundation slabs in general purpose buildings and structures with a slab thickness of up to 1200 mm" presents the schedule of works for the foundation plate using a concrete pump.

Table 3. – Schedule of work on the foundation of the slab using an concrete pump /10 /

Name of processes	Measuring unit	Scope	Labor costs		Adopted membership	Process time, relays	Working relays															
			of workers, man-h.	of machine operator man-hours (mach.-h.)			2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32
Unloading, sorting of materials and mechanized shuttering works (items 1,2,4 by calculation)	100m ³ by slab	19,8	322,6	151,98	Team №1 Ironworkers: 4 gr. - 1 3 gr. - 1 2 gr. - 1 Crane operator 5gr. - 1	161,98	[Gantt bar from relay 2 to 18]															
Manual shuttering work (items 3,5 by calculation)	"	19,8	59,76		Team №2 Metal workers: 4 gr. - 1 3 gr. - 1	59,76	[Gantt bar from relay 2 to 8]															
Reinforcement work and installation of grids for BH1 (items 6,7,8,10 for calculation)	"	19,8	716,2	176,62	Team №3 Steelfixers: 4 gr. - 1 2 gr. - 3 Ark welder 5 gr. - 1 Crane operator 5gr. - 1	179,04	[Gantt bar from relay 2 to 24]															
Welding (item 9)	"	19,8	28,29		Team №4 Concreters: 3 gr. - 1 2 gr. - 2 Operator 5gr. - 1 Crane worker 5gr. - 1	118,8	[Gantt bars: 2-4, 6-8, 10-12, 14-16, 18-20, 22-24, 26-28, 30-32]															
Concrete work (items 11, 12, 13 by calculation)	"	19,8	356,4	247,5	Team №1 Ironworkers: 4 gr. - 1 3 gr. - 1 2 gr. - 1 Crane operator 5gr. - 1	7,01	[Gantt bar from relay 32 to 32]															
Servicing of concrete (item 14)	"	19,8	31,0	6,82			[Gantt bar from relay 2 to 2]															
Demolition of formwork and loading of materials (paragraphs 15,16,17 by calculation)	"	19,8	21,02	6,82			[Gantt bar from relay 32 to 32]															
Total:			1536	582,92																		

The technological chart is designed for concreting a foundation slab measuring 37,2 m x 44,35 mx 1,2 m, $V_b = 1980 \text{ m}^3$. Here the duration of concrete works is 118,8 hours, 7 days according to the schedule of works. There are breaks in the concreting - a device of working joints is required.

Analysis of organizational and technological documentation (technological charts) for concreting large-sized overall structures allows us to conclude that they are missing, and the issue of working joints has not been resolved. In the graphical part, the working joint looks like a dashed line with the "working joints of concreting" callout. But the technological charts do not take into account the main factor - the time for the construction of working joints.

The norms do not provide specific guidance and recommendations for this work. The composition of works for laying a concrete mixture in a construction, according to NZT, Sat.4 [12] includes: 1. Reception of a concrete mixture. 2. Laying the concrete mixture directly into place. 3. Leveling of concrete mix with partial over-turning. 4. Vibrating with vibrators. 5. Smoothing of the exposed surface of concrete. 6. Rearrange the vibrators. That is, the issue of working seams remains unresolved.

The issue of working joints remains undeveloped. The working seam in the drawings is shown in the following way: the usual dashed line with the "working joints of concreting" callout. There are no specific instructions on its design. Consequently, it remains unclear how to practically organize the work on concreting the structures on the construction site in the presence of working joints.

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CASTLE IN DISNA

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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 – castle in Disna. This is one of the few fully extant monuments of history and culture in the Miory district.

Introduction. Disna is a town in Miory district of Vitebsk region of Belarus. Located on the Disna river at the point where it flows into the river Zapadnaya Dvina.

The settlement has been known since the XI century as a fortress of the Polotsk principality Kopets-town. We know about the fortified settlement of Disna in the Polotsk province on the island at the confluence of two rivers according to the information of Polotsk's "scribe book" (1563). It says about the existence of the Kopets, that is, the earthen fortification (from the word "dig"). At the same time, opposite the fortified island, on the left bank of the Disna River there already existed the "village of Disna". Thus, the rapid development and strengthening of the town in the XVI century is explained not only by the favorable strategic and topographical position, but also by the "obzhitost" of this land in the preceding centuries.

The research part. In the XIV century the castle served as an outpost on the outskirts of Polotsk, controlled all traffic on the river. However, at that time the town did not exist here. Most likely, Kopets-town represented the usual earthworks with insignificant use of wooden structures. And after the victory over the Crusaders in the Battle of Grunwald (1410), even these minor structures were abandoned by the army because of the lack of threat in this direction.

However, everything changed after 100 years. During the Livonian War, the Grand Duke of Lithuania and the Polish king Zhigimont August ordered to construct fortifications on the island and to establish a town near the castle. All residents of the town were given various tax benefits for 8 years. It is noteworthy that the king gave the order for the foundation of Disna in 1566, and in 1567 he gave the coat of arms (three stone towers) to the town. And after 2 years (in 1569) – Magdeburg law and a new coat of arms (a boat on a blue field) (Fig. 1).



a



b

Fig. 1. the portrait of Zhigimont August (a) and the coat of arms of Disna (b)

The location of the island was really successful – at the confluence of the Disna and the Western Dvina rivers. Surrounded from all sides by a water barrier, it was reliably protected from enemy forces.

The new castle, built on the site of the old fortifications in 1563, was built by the Italian architect S. Geng. All military-fortification works were led by B. Korsak and pan R. Khodkevich. Henceforth Kopets began to be

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called the Old Castle. In essence, it was a single military fortress, well known in the wars of the XVI-XVIII centuries (Fig. 2).

The castle occupied an area of 5 hectares. The height of earthen shafts reached 5 meters. First they had a wooden palisade, which was later replaced by more modern walls. The water barrier should also be noted. At that time, the width of the Western Dvina River reached 100 meters, and the Dysna - 90 meters.

According to the inventory of 1654, the castle had 9 towers, 3 of which were gates – 2 Dvina (located on the side of the Western Dvina) and 1 Disna (from the side of the Disna River). By this time the castle shafts which were permanently fortified reached a height of 10 meters, and their width at the base was 19 meters.

The towers were rectangular, measuring 8.5 by 8.5 meters. They had 2 tiers, and their height reached 9 meters. They were covered with wooden shingles. The armament of the castle consisted of more than 40 guns.

There is a legend that earlier Disna castle was not an island but a common ledge at the confluence of the Disna and Western Dvina rivers. But Stefan Batory, wanting to strengthen the castle's defense, ordered to dig a ditch to connect the riverbeds. So the castle became an island. And this passage between the island and the land is still called by local residents "Batoryev Perekop".

In 1654, because of the war with the Russian kingdom, the inhabitants of the captured town also migrate to the island, where wooden fortifications were built next to the castle. Those fortifications were called the Lower Disna Castle. While the castle itself was called the Upper Disna Castle. But for the sake of justice, we note that this is not entirely true. The wooden fortifications built by the townspeople were the so-called "podzamok". And both buildings were a single defensive structure. Together, the two buildings had already 14 towers.

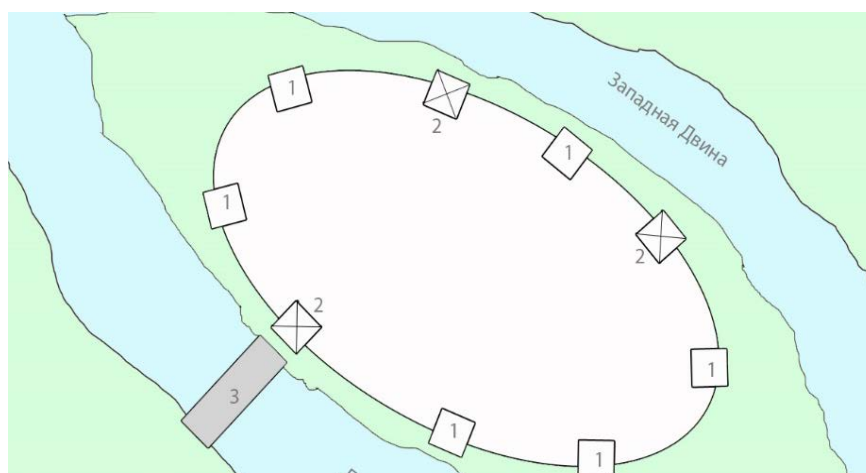


Fig. 2. Castle in Disna: 1 – castle towers; 2 – tower towers; 3 – the bridge

Disna Castle has repeatedly served as a meeting place for statesmen of different countries, as well as a place for gathering militia for hikes. More than once the kings of the Polish-Lithuanian Commonwealth stayed here.

During the Livonian War in 1579 the Disna Castle became the site of the troops for the liberation campaign of Stephen Batory on Polotsk.

During the "bloody flood" in 1654 the castellan of Disna surrendered the city without a fight to the Moscow army led by V. Sheremetov and S. Streshnev. However, the castle which was an independent structure, did not surrender to the enemy. Part of the townspeople also crossed to the island by boats, not wishing to obey the Russian army. And after 7 years, in 1661, the garrison of the castle secretly crossed to the shore and captured all the enemy troops. And the burmist, who handed over the town, was hanged on a castle gate.

The castle was destroyed during the Northern War. During these years, it was twice attacked by the enemy and experienced two violent fires – in the 1700s and 1720s. The destruction was so strong that the authorities decided not to restore the fortifications.

After the Northern War, only the castle shafts remained on the island, which eventually, under the influence of the river current, floods, rains and snows collapsed into the river. Although earlier the island was the highest place in Disna.

Until now, only the castle shafts have been partially preserved (Fig. 3). From time to time, archaeological excavations are carried out on the island.



Fig. 3. The island, where the Disna Castle was located

Conclusion. Disna is the smallest town in Belarus. And even in spite of the fact that there is an ancient center of the Belarusian land near – Polotsk, it is hardly worthwhile to restore the ancient castle. It is possible that someday a memorial sign will appear on the island, in honor of the building, which once protected the northern borders.

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FOAM CONCRETE AND LIGHT STEEL THIN-WALL CONSTRUCTIONS IN BUILDINGS AND STRUCTURES

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Prefabricated frame and frameless technologies for the construction of buildings and structures are considered. The structures of roof and floor slabs made of foam concrete and light steel thin-walled structures are shown. The issue of the possibility of taking into account the joint work of light steel structures and foam concrete is considered.

Innovative technologies can significantly simplify any processes. The construction industry is no exception. Today it is possible to build constructions and houses much faster, easier and cheaper due to quickly erectable structures. Such structures are built within a short period of time with minimal labor costs [1,2]. At the same time, technological progress in various types of structures leads to a decrease in their weight and cost of manufacturing or installation, while maintaining the same load-bearing capacity and performance. [3]

Among the construction technologies used for the construction of prefabricated houses, it is possible to distinguish frame and frameless ones (Fig.1). Further, to frame technologies we can refer:

- construction of light steel thin-walled structures (LSTWS). With the use of lightweight galvanized profile sheet [4];
- construction of light metal structures (LMS);
- technologies with the use of SIN beams, bisteel beams, post tensioned beams, beams with an orthotropic deck;
- tent constructions, etc.

The frameless technologies are:

- Arch technology;
- Construction of 3D printed houses [5], etc.

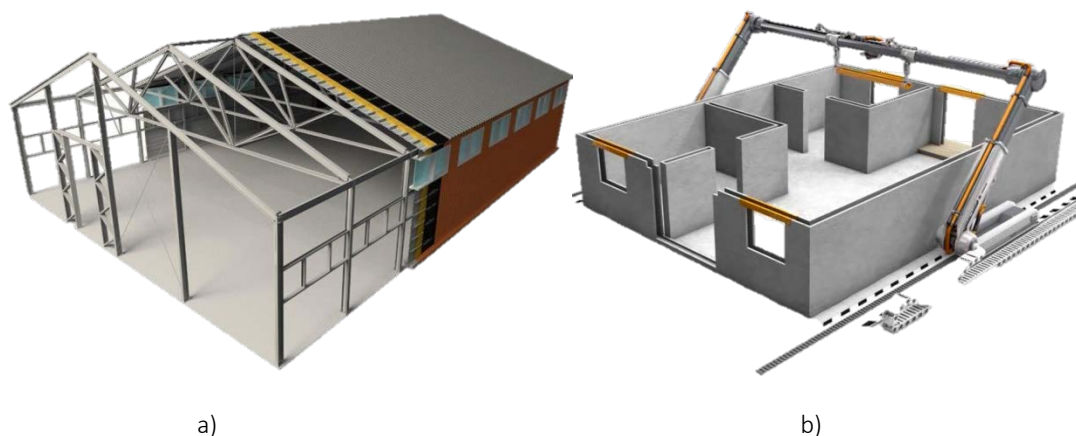


Fig. 1 Technologies of prefabricated buildings and structures: a) frame [4]; b) frameless [5]

Table 1 provides a comparison of selected technologies in the construction of buildings of metal structures, bricks, monolithic concrete and panels [2].

It can be seen from the table that the best result for the ratio of indicators is typical for metal frame buildings and structures. One of the types of metal frames is LSTWS, which are becoming increasingly popular [2, 6–8]. The main advantage of LSTWS framing is its industriality. Building frames are delivered to the construction site in the form of ready-to-mount sets of marked parts, equipped with erection drawings and instructions. Structures of thin-walled frames are light-weight, which allows using shallow foundations. It should also be noted that the house, built of LSTWS, has virtually no construction waste. The construction uses hypoallergic materials that are safe for human health and the environment [2, 7, 8].

Table 1. – Comparison of certain types of erection technologies

Characteristics	Metal frame construction	Brick construction	Cast-in-situ concrete	Panel construction
Average construction period of a 6-storey building	4–6 months	10–12 months	8–10 months	6–8 months
Average ratio of construction cost	1	2	1,5	1,2
Average ratio of the cost of finishing works	1	1,5	1,5	1,5
Average ratio of reduced labor costs	1	2	1,5	1,2
Average ratio of energy consumption for heating	1	1,5	1,5	1,3
Possibility of light foundation	there is	no	no	no

As insulation for LSTWS systems, basalt mineral wool mats and plates, fiberglass wool, green fiber or other fibrous insulating materials are used. [8] Erecting LSTWS, foam concrete which is a light porous faux stone material on a cement binder, has become widespread too.

Cast-in-situ foam concrete is absolutely nonflammable and is applied in fireproof designs, creates monolithic layer of thermal insulation and can be filled practically into any mould. It is also extremely durable and cost-effective [9]. The possibility of obtaining foam concrete under any weather conditions is important too.

With the joint use of LSTWS and foam concrete the best types of corrosion protection of steel is galvanizing as it provides mechanical protection against oxidants, high adhesion to foam concrete, cathodic protection of iron due to excessive zinc electrons [2].

The combination of light steel thin-walled structures and cast-in-situ foam concrete allows such quality of construction that rare domestic or foreign technology can offer. Durable and reliable structures are ideal for both private residence and commercial use [10].

The most common structures in buildings and structures are flexible members such as beams, roof and floor slabs. Designs of roof and floor slabs of lightweight foam concrete are very diverse. They are a combination of foam concrete with a corrugated sheet used as a leave-in-place form; with a corrugated sheet throughout concrete with flexible C section interior supports; and as floor slabs of C sections or C section trusses filled with foam concrete (Fig.2).

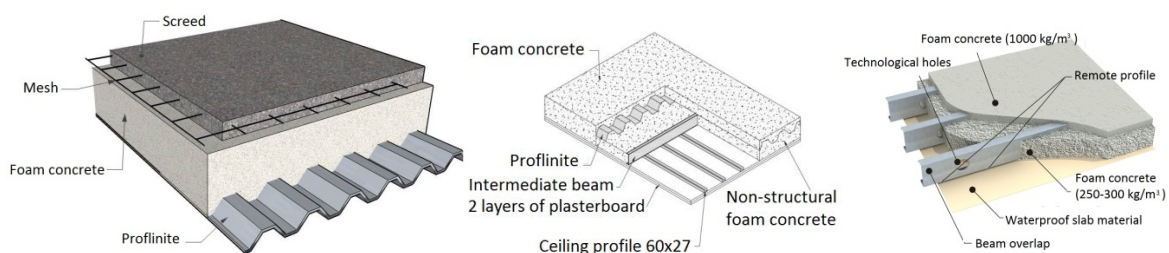


Fig. 2. Options for slab designs with joint use of LSTWS and foam concrete [3, 4]

Despite the widespread nature of such structures currently there are certain ambiguities in standard technical documents for the calculation of the design of roof and floor slabs of foam concrete and light sections, it is not clear how to account for joint work of LSTWS and foam concrete. This aspect needs further study [11]. It can be assumed that accounting for joint work of LSTWS and foam concrete in calculations will cut corners on materials of steel structures choosing light sections [10].

This kind of research is conducted in Russia, Belarus, Ukraine, Poland etc. [2,7,8]. Polotsk State University conducts research on the joint work of foam concrete and light steel thin-walled structures using flexible members as an example, namely, roof slabs.

The analysis of the studied material allows us to draw the following conclusions:

1) Buildings made of metal frame are very popular and profitable compared to brick, panel and monolithic ones.

2) Buildings and structures of LSTWS have little construction waste, safe for human health and the environment.

3) Heat-storing properties of the walls of LSTWS and foam concrete buildings are higher in comparison with wood and brick ones.

3) The combination of LSTWS and lightweight concrete allows us to increase the speed of construction, as well as significantly reduce the load on the foundation.

4) The standard technical basis for the calculation of structures of foam concrete and LSTWS needs to be supplemented in terms of accounting for the joint work of foam concrete and LSTWS.

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UDC 621.91.02

3D MODELING OF BLOCK-MODULE FACE-MILLING CUTTER CONSTRUCTIONS

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The article introduces the results of constructing of block-module face-milling cutters based on 3D modeling application.

Efficient operation of the cutting equipment is impossible without establishing a perfect tool inventory providing greater reliability and economical and labour-saving use of expensive breakthrough machinery which in its turn results in the growing role of the mentioned equipment.

Computer development allows for a wide application of specially developed computer-aided design and computer-aided manufacturing systems (CAD/CAM) in creating cutting tools.

Developing CAD/CAM systems in the field of metal cutting equipment requires a high degree of mathematical formalization of design styles and maximum unification in solving particular projection problems [1].

Implementation of CAD systems results in:

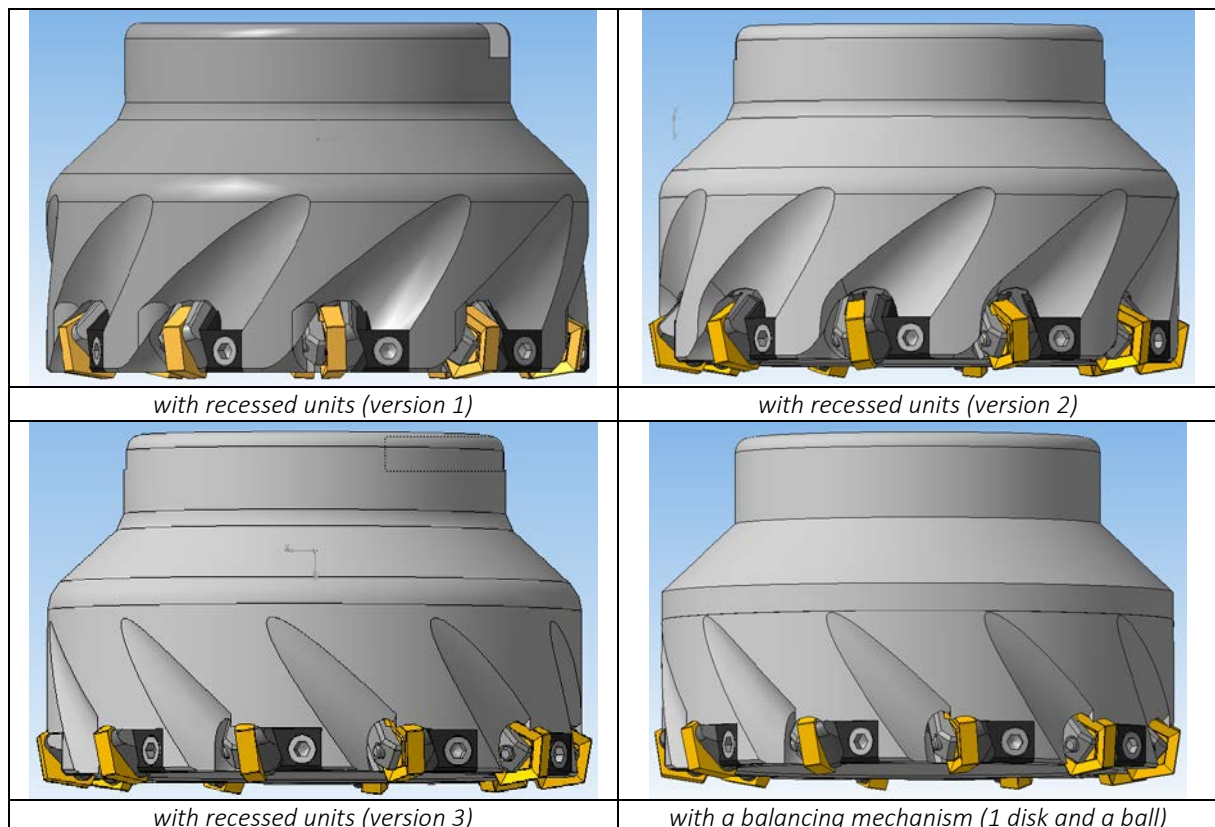
- time-saving design and manufacturing;
- higher quality and standard;
- reduction of material consumption;
- optimization of the constructs at the development stage.

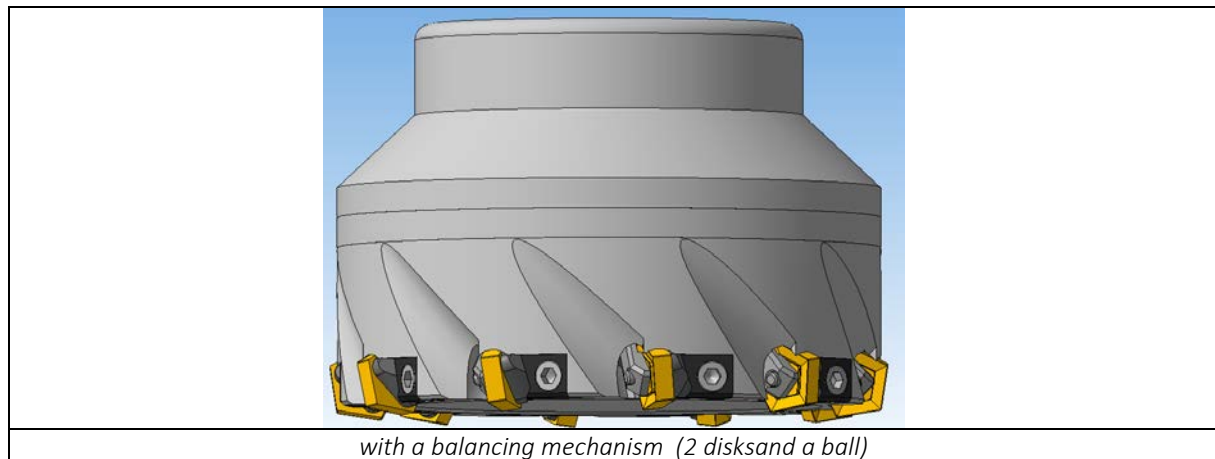
In this connection 3D modeling of general purpose cutting equipment has gained steady ground, being applied in various machining conditions.

The multipurpose block-module face-milling cutter constructions introduced are composed of about 80 % common parts [2, 3].

Model constructions of block-module face-milling cutters of arational shape are given in table 1.

Table 1. – Model constructions of block-module face-milling cutters of a rational shape





The manufacture of block-module tool constructions such as complex workpieces in mechanical engineering is based on the development of an adequate 3D-model of a tool (workpiece). It is creating 3D models identical to those designed in block-module cutting tool constructions that enables better quality and time-saving production (complex and science-intensive output). Being a reliable, flexible and easy to use process 3D modeling has become an essential means to make the process of unified tools projection more efficient and finally to integrate CAD/CAM problems into a single system environment [4].

A considerable benefit in the increase of labour productivity is derived from the possibility of prompt problem solutions of the modeling process with return information flows (reverse engineering), when a set of parameter-oriented models actualize the closest approximation to an optimal variant.

Consistency of the results obtained is determined by an extensive normative framework used during the process of parameter-oriented models design.

Modern graphics packages provide capabilities of three-dimensional representation of complex technical processes, open up a totally new approach to electronic records: visual information is more easily perceived by the users than traditional textual manuals, it does not require translation into other languages and using optimized 3D-data allows the user to receive instructions over the Internet, view them on different computing machines, convert them into G-codes for further machining under numerical program control.

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UDK 620.169.2

**THE USE OF NON-DESTRUCTIVE METHODS OF CONTROL IN THE EXAMINATION
OF EXISTING FERRO-CONCRETE BUILDINGS AND FACILITIES****TAISIA KAZYANINA, ALEXANDER KOLTUNOV****Polotsk State University, Belarus**

Currently thanks to the reconstruction it is possible to modernize most of the technically and morally obsolete buildings. However, it is worth noting that in the reconstruction of existing buildings and structures, an important stage is the determination of the parameters of the reinforcement and concrete (the thickness of the protective layer, the location of the reinforcement, the diameter, etc.). In order to perform verification calculations and subsequently determine where and how to strengthen it is necessary to conduct whether they are needed. This is especially important, as in the reconstruction of buildings and structures (associated with the construction of new floors), and when the object is replaced by a functional purpose.

The most important task in surveying structures is to determine the urgent class of reinforcement and, consequently, its strength parameters. To date, there are many different methods and approaches.

In most of the normative and technical documents for the inspection of buildings and structures, recommendations for determining the parameters of the reinforcement are provided. However, not all of the methods make it possible to determine the required parameters reliably and accurately. Some of the methods are obsolete, some are not practical because of the difficulties accompanying their use. A promising non-destructive method is considered, which makes it possible to determine the class of reinforcement by measuring the hardness of steel. Studies of the relationship between the strength and hardness of steels to date, many works have been devoted. The fundamental dependence for steels is reflected in GOST 2276-77 "Metals and alloys. Method for measuring Brinell hardness by portable hardness testers of static action" [1, 2].

The most common methods for determining concrete strength in structures are non-destructive testing methods. Among them, the most common methods nowadays are the methods of the third group: the ultrasonic method in accordance with GOST 17624-2012 [3], the methods of shock pulse and elastic rebound in accordance with GOST 22690-88 [4]. It should be noted that ultrasonic devices can be used not only to control the strength of concrete, but also for flaw detection, quality control of concreting, determining the depth of cracks, etc. It should also be noted that the strength of concrete is not the only factor affecting the durability and strength of the entire structure as a whole. Concrete should be considered as a material with fluctuating characteristics by a random principle. To achieve the same class of concrete, many different variations in the composition of the concrete mix can be used. Thus, structures having the same class of concrete can differ in their structure. This is due to the use of various technological and material science approaches. The main factors influencing the structure of concrete stone include the use of different grades of cement, different content of mineral additives in cement, variations in concrete mixes according to workability, water-cement ratio, the changes of which are associated with the use of cement of various activities, as well as with the use of various modifying additives. Thus, within the same strength, mixtures with different structures can be obtained, increasing the water-cement ratio leads to an increase in porosity, and hence permeability. While the use of modifying additives makes it possible to obtain concrete mixtures of a given ductility with a reduction in the amount of water used, which leads to a denser structure of concrete stone. With regard to the technological aspect, an important role is played by the methods of compacting the concrete mixture and the conditions of hardening.

The purpose of the study of this article is to analyze the correct use in practice of the method of checking the strength of reinforcement by the results of hardness measurements. Determination of the dependence of the transition from hardness to the class of reinforcing steel used in prestressed structures, and also the determination of the influence of errors in the methods of nondestructive testing of the strength of reinforcement and concrete on the determination of the load-carrying capacity of bent structures.

The strength of concrete was determined using the methods of nondestructive testing (the method of plastic deformations - using the Kashkarov hammer). The location and diameter of the reinforcement in the reinforced concrete structures were determined by the electromagnetic method using the IZS-10H instrument in accordance with GOST 22904-93 [5].

The diameter of the reinforcement was refined by mechanically opening the protective layer of the reinforcement. At the same time, the condition of the reinforcement was determined, the nature and degree of its corrosion, which was estimated by the depth and area of damage. The mechanical characteristics of the rein-

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forcement were determined by the type of profile established at the dissection, and also by means of the portable hardness tester Constant K5U, on previously prepared surfaces, followed by the derivation of the "strength-hardness".

To determine the effect of errors in instruments used in the testing of reinforced concrete structures by the methods of nondestructive testing the worst bending moment in the calculation was taken from the values obtained having the greatest deviation from the mean value. The obtained bending moments were compared with the theoretical value of the bending moment adopted for the test series of plates.

The calculation of the bending moments was carried out in the program complex Beta 4.2.

The analysis of the obtained results showed that the strength properties of the reinforcement exert a significant influence on the load-carrying capacity of the structure, while the parameters of the concrete do not give significant changes. Thus, when using non-destructive testing methods, taking into account instrument errors, it is possible to determine the load-bearing capacity of the structure. However, deviations from the reference values range from 4.1% to 27.7%, depending on the instruments used. It should be taken into account that in the calculation the maximum and minimum values obtained on the instruments were taken, in practice, while performing tests by methods of nondestructive testing, a series of tests should be carried out with subsequent averaging of the results, which minimizes the effect of the drop-out values and more accurately determines the parameter.

Tests to determine the hardness of reinforcing steel samples were carried out using a portable hardness tester Constant K5U. All the tests with the static hardness tester were carried out using the same method which implies:

1. Determination of the position of reinforcing bars.
2. Opening the protective layer of concrete and determining the parameters of reinforcement by indirect characteristics in places where the reinforcing bar does not reach the maximum bending moments and the anchorage is not broken (at a distance $\frac{1}{4}$ of the span length).
3. Cleaning of the surface of the reinforcing bar with a cutting device of the required depth of 100 mm on each reinforcing bar.
4. The surface of the samples at the test site is processed to the required roughness by an angle grinder (USM) using a small grain size nozzle. The roughness parameter should be no more than $Ra = 0.32$ mkm [6].
5. Running 15 tests for each reinforcing bar.
6. Derivation of the mean and determination of the temporary resistance of the reinforcing bar according to the deduced "hardness-strength".

On each rod was carried out for 15 tests. To determine the dependence of hardness on the cut value on samples of class S800, thin sections of various depths. The thickness of the cut layer was assigned – 1 mm, 2 mm, 3 mm, 4 mm. To determine the optimum depth of cut, during the work, additional studies were conducted on reinforcing bars of class S540 and S600.

Since during the testing of the reinforcing bar in the body of the reinforced concrete structure and clamped in the vice, the fixation conditions can affect the results of the measurements, then comparative tests were carried out on the rods extracted from the existing structure and located in its body. In both cases, the readings of the hardness meter did not differ significantly. Thus, it can be concluded that the tests carried out.

Since the distribution of the results can be considered normal, therefore, one can deduce the relationship between the hardness indices and the temporary resistance of the materials of the tested samples. Using the ratio of the values of the temporary resistance of the samples and their hardness values in the Excel program, a linear dependence:

$$\sigma_B = (15HR + 570) \mp 5, \text{ at } p = 0.7973$$

Taking into account the variability of the time resistance for the studied classes, it is possible to identify the zones of identification of the class of reinforcement. For comparison, we give a visual reflection of the zoning of reinforcement classes on the boundary values of the time resistance and hardness of steel for samples with a diameter of 12 mm, classes S540 and S800 at a cut of 1, 2, 3 mm (Figure 1).

From the graphs, it can be concluded that the optimal depth of cut for determining the time resistance is a 2 mm thin section. Since Figure 1 (3) shows that only at the 2 mm cutoff, the values of the time resistance for classes S540, S600 and S800 are not superimposed on each other. However, an additional study is needed for reinforcing bars of large diameters, since with larger diameters the required depth of cut may be greater, depending on the method of manufacturing the reinforcement.

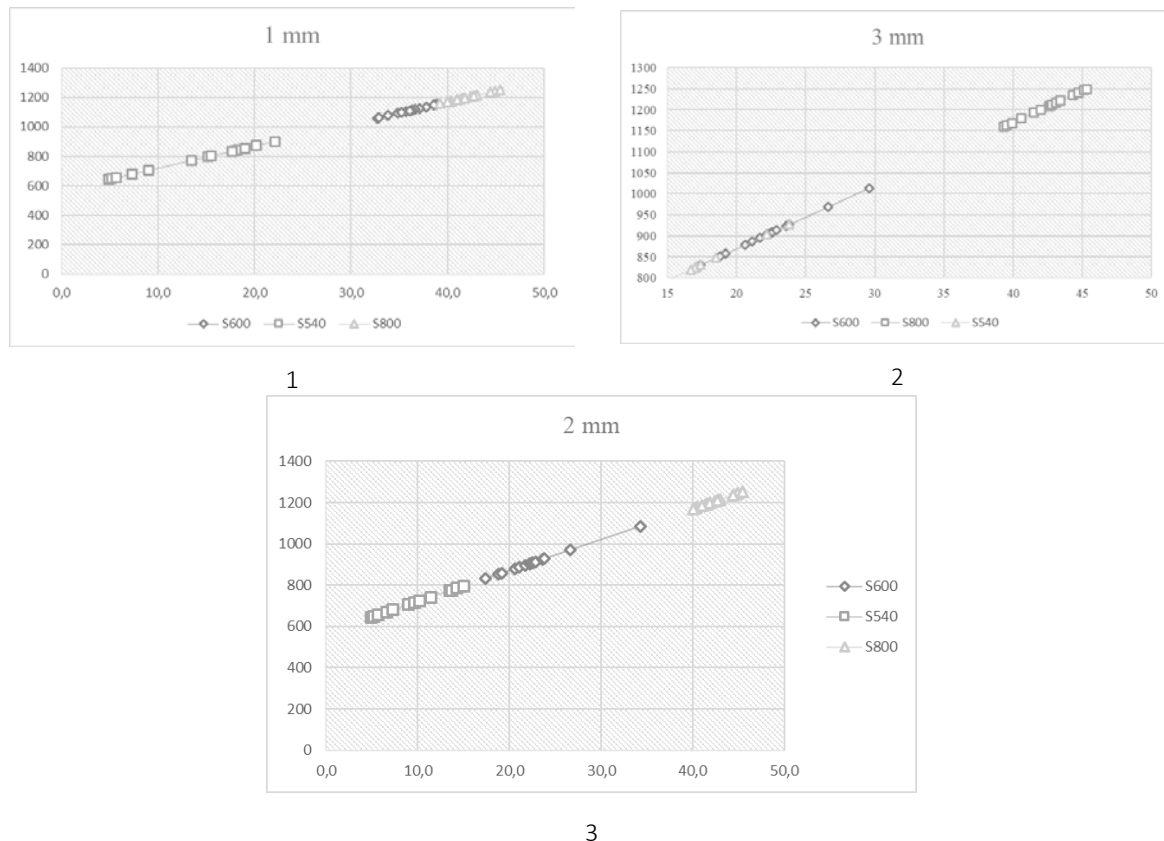


Fig. 1. Zoning classes of reinforcement by the boundary values of the temporary resistance and hardness of steel

Based on the foregoing, it is possible to draw the conclusions indicated below:

- The "strength-hardness" dependence was deduced on samples of class S800, which, when tested on samples of classes S540 and S600, showed sufficient convergence. The result of the measurement, taking into account the expanded uncertainty, can be represented in the form:

$$\sigma_B = (15HR + 570) \mp 5, \text{ at } p = 0.7973$$

- the optimum depth of cut for determining the time resistance for diameters of 10, 12, 14 mm is a 2 mm section. However, an additional study is needed for reinforcing bars of large diameters;

- when inspecting bent elements, special attention should be given to the strength characteristics of the reinforcement, since they have the most significant effect on the bearing capacity. The permissible load on a structure obtained using non-destructive testing devices gives comparable results when compared with those recommended in the series.

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UDC 624.012.3.

USE OF MODIFIED CONCRETE, LAYERS, PRIMERS
IN COMPOSITE CONCRETE CONSTRUCTIONS

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The issue of contact joints in composite reinforced concrete structures is considered. It is shown that there are many factors affecting the shear resistance of the contact joint. It is noted that the use of modified concrete, layers and primers increases resistance to shear of the contact joint.

Currently, the combined use of materials with different properties is a very relevant and promising aspect in construction, as it makes it possible to connect several elements with different characteristics in one design. At the same time, the positive properties of each material are used separately, reliable operation of the entire structure and its combined work is ensured.

Combined work of composite concrete and reinforced concrete structures and their reliable operation is impossible without ensuring the strength of the contact joint. A contact joint in general is a connection of at least two elements: the combination of new concrete (joint grouting) with the old (precast) concrete, during reconstruction; precast elements with monolithic concrete, in industrialized construction; connection of sections of monolithic with newly laid or after a technological break, in monolithic construction; as well as for embedment and joints, for prefabricated construction.

Basically, in most of the works available on this subject, only one contact joint is considered, however, it should be noted that when using primers and layers the structure is a system consisting of three layers with two joints (Fig. 1) [1].

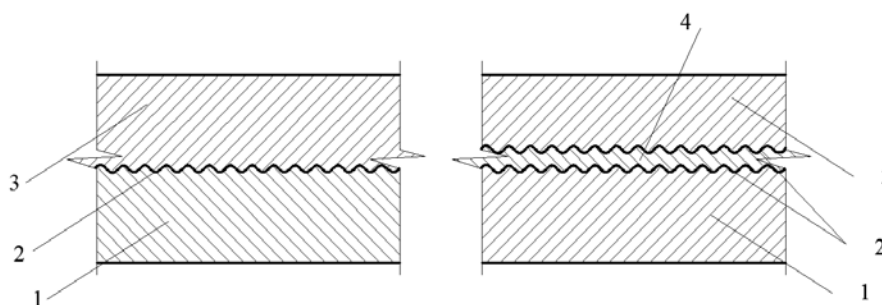


Fig. 1. Presence of concrete joint in the structure
1 – old concrete; 2 – contact joint; 3 – joint grouting; 4 – layers and primers

Resistance to shear of the contact joint depends on the surface preparation of the old (precast) concrete, and on the methods of concreting and concrete compositions and many other factors.

A large number of domestic and foreign works are devoted to the study of the contact seam in composite concrete and reinforced concrete structures [1–6]. In recent years, a lot of researches have been carried out by many different scientific-research, design and educational institutions of the Republic of Belarus: Belarusian National Technical University, Brest State Technical University, Republic Unitary Scientific-research Enterprise for Construction “Institute BelNIIS”, Polotsk State University and others; some institutes in the CIS. Thanks to these studies, the following conclusions can be drawn:

1. The joint surface of the new concrete with the old one should be clean, so that the surface contamination does not create an interlayer or a film that prevents the concretion of concrete. When concreting, the film of cement grout must be removed together with the underlying thin layer of porous concrete.
2. Often the surface of the structure should be rough, as a smooth surface does not create good adhesion.
3. For monolithic concrete, when conducting construction with interruptions, it is recommended to treat the surface with a strong stream of water immediately after setting the concrete.
4. Concrete is laid on a damp, but not very wet surface, as excess water reduces the adhesion strength.

5. Care of concrete is also important. To do this, it is recommended to maintain humid conditions for the new concrete. It is also recommended to keep the conjugate surfaces of elements in a wet state.

6. There is quite conflicting information about the effect of the concrete class on the shear resistance of the contact joint. However, according to different researches, it can be concluded that the higher the class of concrete is, the greater the resistance to shear is.

7. The mobility of concrete is recommended to choose P2-P3, as the use of "liquid" concrete reduces the shear resistance of the contact seam.

8. Concrete shrinkage is one of the main factors influencing the shear resistance of the contact joint. The greater the shrinkage is, the lower the shear resistance of the contact joint is.

9. The use of various selected concrete compositions also has a positive affect on the shear resistance of the contact joint. For example, when modified additives are used in certain concentrations, such as C3, ATP, Stachament 2010, it is possible to reduce the mobility and shrinkage of concrete so that to increase the strength of the contact joint.

In modern economic conditions, with the increase in prices for basic building materials, shortage and high cost of energy, the problem of saving materials and resources, including in composite structures, is becoming more acute. That's why it is recommended to use the modified concrete, layers, impregnation [3-5].

Recently, modified concrete is widely used in new construction, during reconstruction and technical re-equipment, as they allow not only to reduce energy consumption and cement consumption, but also to reduce labour intensivity of placing concrete due to partial or complete exclusion of concrete consolidation. This is primarily due to the work in cramped conditions. The same concretes have also proved themselves in composite structures. So, in Polotsk State University, studies of modified concrete with the superplasticizer "Stakhament 2000M" were carried out. According to the results of the research, it is evident that the contact shear resistance has increased significantly (Fig.2.) [7]

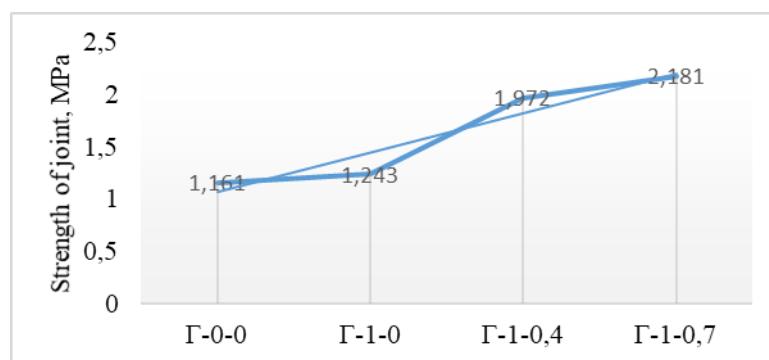


Fig. 2. The influence of the superplasticizer "Stakhament 2000M" on the joint (G-1-0 – 0% of additives; G-1-0,4 – 0,4% of additives; G-1-0,7 – 0,7% of additives)

Most modifiers are expensive, so it is more effectively to use them in layers. Thus, the modifiers "Stagement 2000 M" and C3 with the additive content of 0.7% can be added to a layer and new concrete requires the concentration according to the terms of the construction of [7].

The essence of interlayers is not only to save materials, but also to reduce shrinkage in the area of the contact joint. However, laying a thin layer 0.5 to 2 cm thick is very specific in construction and constant monitoring is required to perform a quality contact joint. Therefore, there is a question of using primers or impregnations, when the surface can be "impregnated" 2-4 times and to achieve an increase in the shear resistance of the contact joint. However, it is recommended to choose primers or impregnations carefully, since the application of them is different.

In connection with the above, Polotsk State University carry out the research on the possible use of primers to increase shear resistance of the contact joint. Tests of the "Typhoon Master No. 100" and "Ceresit ST19" primers have already been carried out. At present, there are researches of primers with dolomite powder and aluminum sulfate, which can increase the strength of the contact joint, by reducing shrinkage and increasing durability.

Conclusions:

1. Now there is a wide variety of types of joints of concrete and reinforced concrete structures, which differ in materials, connection technology and constructive solutions.

2. There are many factors that affect the resistance of the contact shear, starting from the state of the surface of the old concrete and ending with the mobility and shrinkage of the new concrete mix.

3. The use of modified concrete and interlayers can significantly increase the resistance of the contact joint and reduce the shrinkage of the concrete, but they are quite expensive, in particular, the interlayers require the control of laying, so that the technological processes are not compromised.

4. It is necessary to use primers, as less time-consuming and economical material.

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UDC 624.012.3

**CONTACT JOINTS SHEAR STRENGTH OF COMPOSITE CONCRETE STRUCTURES
LACED WITH STACHEMENT-2000M HYPERPLASTICIZER**

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The urgency of using composite concrete and reinforced concrete structures and the problem of solid adhesion of the element in the zone of the contact joint of composite concrete and reinforced concrete structures are considered in the article. The investigations of contact joints shear strength laced with STACHEMENT-2000M hyperplasticizer are carried out. Conclusions are drawn from the results obtained.

Combined action of composite concrete and reinforced concrete structures as well as its reliable service is impossible without ensuring the strength of the contact joint. The strength of the contact seam depends both on the technology and quality of the preparation and on the methods of concreting and concrete composition. Currently, there is a wide variety of adhesion types of concrete and reinforced concrete structures which differ in materials, connection technology and constructive solutions [1].

One alternative for ensuring a reliable connection of composite concrete and reinforced concrete structures in the area of the contact joint is the use of chemical additives in concrete. Plasticizers as well as super- and hyperplasticizers are especially popular over the past decades all around the world.

In Polotsk State University a study was carried out to test the strength (shear resistance) of contact joints of composite concrete structures using the STACHEMENT-2000M hyperplasticizer and to select the optimal dosage of the hyperplasticizer in the concrete mix.

The tests were carried out in accordance with the normative documents after the concrete strength was set to hardness under natural conditions. The experiment was close to real conditions [2, 3].

The analysis of the nature of the fracture shows that all the samples collapsed in contact zone between old concrete and new concrete. Destruction in all cases was sharp and fragile.

According to the results of the experiment it was found that in samples with the addition of the hyperplasticizer STACHEMENT-2000M the surface of old concrete had adhering concrete particles of new concrete, while in the non-additive samples the surface on which destruction occurred was relatively clean and smooth.

This is due to the fact that the hyperplasticizers contribute to the creation of a finer porous and homogeneous structure of concrete, thereby reducing the concentration of stresses in the contact zone. In its turn that led to an increase in the strength of the contact joint.

Proceeding from the results of the experimental shear strength of additional and non-additive samples, it can be concluded that when using the STACHEMENT-2000M hyperplasticizer in a new concrete the strength of the contact joint increases by 1.5 and more times compared to the no-additive concrete.

In the course of the experiment, studies were conducted on the selection of the optimal dosage of the hyperplasticizer, which would ensure the most reliable combined action of composite concrete structures.

Comparing the results of the experiment, it can be concluded that the optimum amount of additive to increase the strength of the contact seam is 0.7% of the mass of cement with a cone slump of 12 cm.

Based on the experimental data, a dependence of the shear strength of a composite structure for a series of samples designed to determine the effect of the amount of additive used in concrete was constructed (Fig. 1).

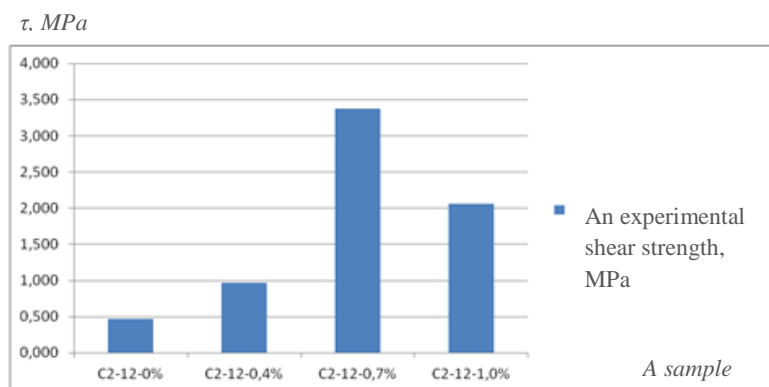


Fig. 1. A histogram

According to the histogram, it can be concluded that the use of the additive significantly increases the strength of the contact joint and improves the combined action of the two elements. The use of the STACHEMENT-2000M hyperplasticizer in an amount of 0.7% of the cement mass is optimal for achieving the best concatenation results of concrete.

A general view of the surfaces of new concrete after the destruction of some samples is provided in figure 2 [1].

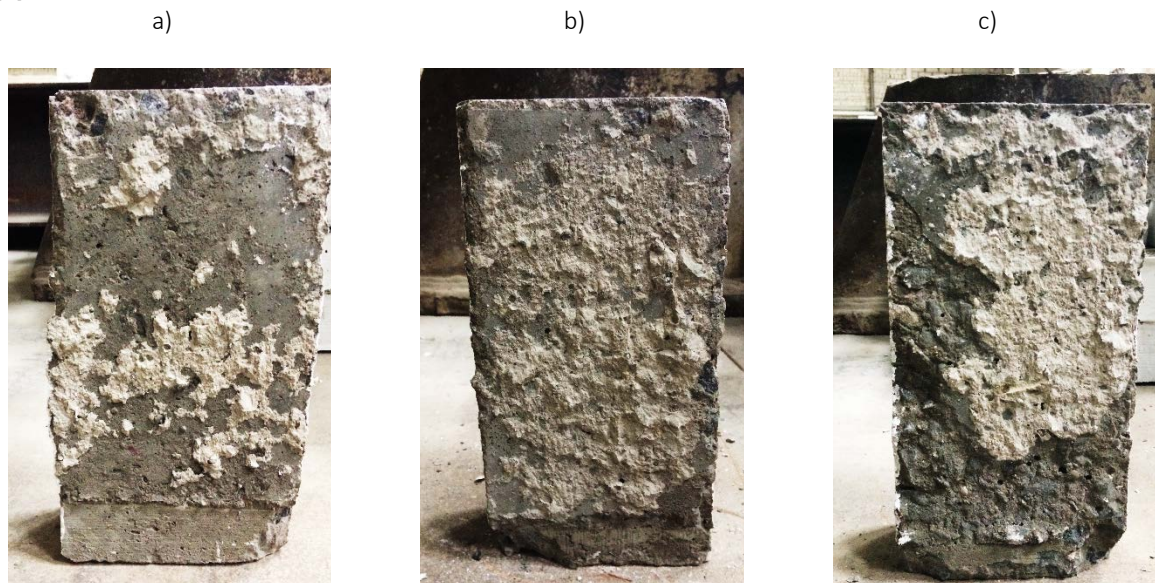


Fig. 2. A general view of the surfaces of new concrete after the destruction: a – a sample C2-12-0,4%, b – a sample C2-12-0,7%, c – a sample C2-12-1,0%.

According to the results of the research the following conclusions can be drawn:

1. Addition of modifiers in new concrete, in particular STACHEMENT-2000M additives, increases the strength of the contact joints in comparison with the non-additive samples by 1.5 and more times.

2. The optimum ratio of the use of STACHEMENT-2000M hyperplasticizer to the mass of cement is 0.7%. Shear strength of the contact joint increases by more than 4 times in comparison with the non-additive samples, and also by 1.5 and 3 times in comparison with the addition of a hyperplasticizer in an amount of 0.4% and 1.0%, respectively.

3. Addition of the STACHEMENT-2000M hyperplasticizer can allow to refuse such complex measures as the dowels placing, grooves with sufficient removal from the surface of only the cement film, i.e. creating a minimal surface roughness.

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UDC691.32

TRENDS IN THE IMPROVEMENT OF ROAD CONSTRUCTION AND DESIGN

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The development of economical cement-concrete road pavements, which possess high operational qualities and indicators of the modern technical level is an urgent task for road construction in the Republic of Belarus.

The strength of the foundation has a significant influence on the performance of road covering. The strengthening of foundation soils is carried out by binding materials, including production wastes that have as-tringent properties. The effective raw materials used in strengthening the foundations are spent casting mixtures of the foundry industry and cupola slag. With the optimal combination of prescription and technological factors the compressive strength of the mixture for the road foundation can be achieved immediately after compaction of 1,02 MPa [1].

One type of construction of rigid road coverings in the construction of cement concrete covers includes an intermediate layer of heavy concrete, which in turn lies on a sandy base [2, 3]. With this variant of coating, the middle layer perceives most of the loads.

A promising method of increasing the strength of a concrete base is reinforcement [4, 5]. Reinforcement allows to redistribute the stresses arising from the action of the transport load on a large area, and thereby contribute to the stable operation of pavement even in adverse climatic conditions [6].

The research object in this work is cement slabs reinforced with waste alkali-resistant glass mesh GMP-160(100)-1800/1800JSC «Polotsksteklovolokno» (fig. 1). The main characteristics of the grid: fiber length – 20-25 mm; nominal weight – 160 g/m²; breaking load – 1800H; chemical resistance – very high. The research subject is the strength of concrete for pressing on an elastic base.



Fig. 1. Waste alkali-resistant glass mesh

For the study samples of four species with different percentage of fiber from the mass of cement were molded: without fiber, 10%, 20% and 30%. Sample sizes: length – 140 mm, width – 120 mm, thickness – 30 mm. In all compositions the water-cement ratio was 0,4, cement consumption – 1000 kg/m³, cement CEMI42,5H. After molding the samples underwent heat and moisture treatment.

The finished samples were tested for pressing on a hydraulic press HCP-1000MG4. The plate was laid on a hard base, a metal round die with a diameter of 60 mm.

The data obtained during the test are presented below (table 1). The main indicators are the force and deformation of the samples.

Table 1. – Test results data

No Sample	Cement consumption, kg/m ³	Water flow rate, kg/m ³	W/C	Fiber content, %	Load P, kH	Deformations L, mm
1	1000	400	0,4	0	1,01	2,764
2	1000	400	0,4	10	0,11	0,012
2	1000	400	0,4	10	0,21	0,164
2	1000	400	0,4	10	0,33	0,302
2	1000	400	0,4	10	0,44	0,395
2	1000	400	0,4	10	0,54	0,469
2	1000	400	0,4	10	0,95	0,748
2	1000	400	0,4	10	1,22	0,829
2	1000	400	0,4	10	1,45	0,973
2	1000	400	0,4	10	1,74	1,117
3	1000	400	0,4	20	0,1	0,014
3	1000	400	0,4	20	1,06	2,007
4	1000	400	0,4	30	0,56	0,499
4	1000	400	0,4	30	1,27	1,207

According to the obtained data, a combined graph is constructed that reflects the load and the corresponding deformations of all the samples (Fig. 2).

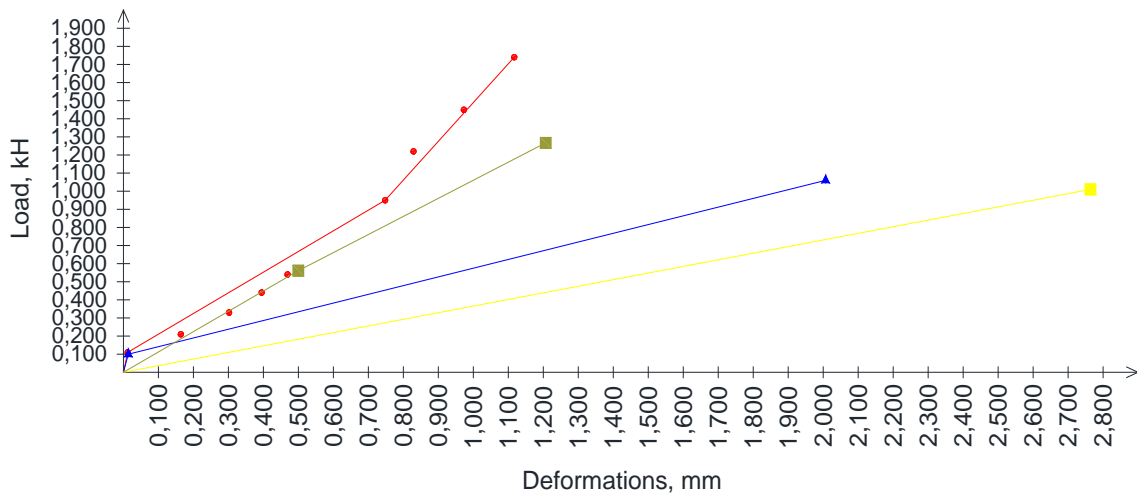


Fig. 2. Graph of load and deformation of the samples:
 yellow – without fiber, red – 10% fibers, blue – 20% fibers, green – 30% fibers

Then the samples were loaded before the beginning of the cracking. Separately, the forces in which cracks in the samples are revealed are tabulated (table 2).

Table 2. – Efforts and displacements during crack opening

No Sample	Fiber content, %	Load P, kH	Deformations L, mm
1	0	1,01	2,764
2	10	210,88	1,778
3	20	284,96	7,189
4	30	89,58	3,263

By the nature of the sample destruction it can be seen that without fiber fracture is brittle. The added fiber binds the sample from inside, which in turn prevents brittle fracture and does not scatter the sample under load. Even after opening the cracks the sample keeps its shape without breaking apart.

Analyzing table 1, it can be noted that the most optimal is the second sample, where the reinforcement is 10% of the cement mass. In sample number two, with the greatest load being equal to 1,74 kH – the least deformation, which is 1,117 mm.

According to table 2, it can be concluded that the second sample is also optimal, in which the cracking begins at a load 210,88 kH, and the deformation at this instant is 1,778 mm. It should be noted that in sample 3 cracking begins when crocheting 284,96 kH, which is higher than in the second sample, but with this load the deformation is several times higher and is 7,189 mm.

Thus, according to the data obtained during the test, it can be concluded that with the use of alkaline-wool glass wool as a reinforcing fiber it is possible to create the main middle layer in a multilayer road. Due to its application the force at which the destruction takes place increases and movements are significantly reduced. It is also worth noting that the use of fiber changes the nature of destruction, which is also important for concrete. The destruction ceases to be brittle, and after the opening of the cracks the sample is not destroyed due to the binding action of the fiber. Based on the test results it is advisable to mold products with the content of fiber as in the second sample, 10% of the fiber from the mass of the cement. This percentage of reinforcement gives the most optimal indicators of force, displacement and maximum force at which crack opening occurs.

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ABOUT THE DIFFERENTIAL EQUATION OF BENDING COMPRESSED-BENT BAR
 TAKING INTO ACCOUNT THE DIFFERENT MODULAS OF MATERIAL

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The article shows the synthesis of the differential equation of axis of the compressed-bent bar for a case when engineering material of a beam is characterized by various modulus of elasticity when stretch and compression. Using the method of initial parameters generalized formulas were received to determine parameters of the stress-strain state in an arbitrary section of bar.

Consider a rectilinear flexible bar which is loaded with a constant longitudinal force and transverse load, shown in Figure 1 below.

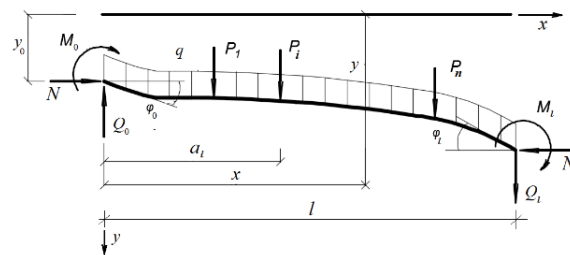


Fig. 1. The compressed-bent bar

The bar undergoes deformations of compression with bending under the action of the applied load. The stress-strain state of the bar at the origin is characterized by the quantities

$$y(0) = y_0, y'(0) = \varphi_0, M(0) = M_0, Q(0) = Q_0$$

which are, respectively, the deflection, the turning angle, the bending moment and the shear in the left section of bar, and are called the initial parameters.

The adopted that the bar is made of a differentmodulas material. The section of the bar is symmetrical of arbitrary shape (Fig. 2)

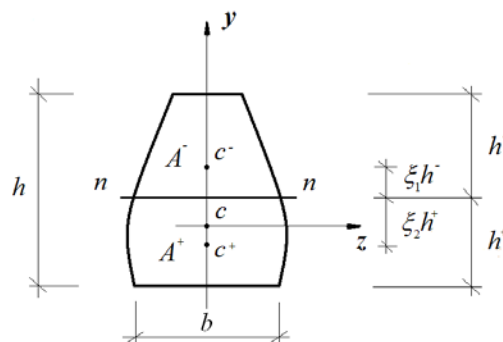


Fig. 2. Symmetrical transverse section of bar

where A^- – the area of the compressed part of the section with the center of gravity at the point c^- ; A^+ – the area of the stretched part of the section with the center of gravity at the point c^+ . The total area of section $A = A^- + A^+$.

To describe the deflections of the compressed-bent bar made from a differentmodulas material, we use the approximate differential equation of bent axis of such a bar [1]

$$\frac{d^2y}{dx^2} = -\frac{M(x)}{D(x)}, \quad (1)$$

where $M(x)$ – the bending moment in an arbitrary section; $D(x)$ – the bending stiffness of the transverse section of the bar, taking into account the differentmodulas of material.

The bending moment $M(x)$ entering into equation (1), for the considered load distribution of the bar is described by expression

$$M(x) = M_0 + Q_0x + N[y(x) - y_0] - \sum P_i(x - a_i) - \frac{qx^2}{2} \quad (2)$$

In determining the moment from formula (2) in some section, only those forces that are to the left of this section must be taken into account under the summation sign.

The quantity that enters into equation (1) $D(x)$, characterizes the bending stiffness of the transverse section, taking into account the influence of the differentmodulas of the engineering material. This value is related to the bending stiffness of the transverse section EI_z by the ratio [2]

$$D = \frac{EI_z}{\zeta} \quad (3)$$

where ζ – influence coefficient of the differentmodulas of the engineering material on the bending stiffness of the transverse section. For a symmetric transverse section of an arbitrary shape, it is described by expression

$$\zeta = \frac{I_z}{I^+(x) + \mu I^-(x)}$$

where $I^-(x)$ and $I^+(x)$ characterized by moment of inertia, respectively, compressed and stretched parts of the transverse section with respect to the neutral axis; $\mu = \frac{E^-}{E^+}$ – coefficient of differentmodulas of engineering material, characterizing the ratio of its modulus of elasticity during compression E^- and stretching E^+ .

Taking (2), (3) into account, the equation (1) takes the next form

$$\frac{d^2y}{dx^2} + \zeta \frac{N}{EI_z} y = -\frac{\zeta}{EI_z} \left[M_0 + Q_0x - Ny_0 - \sum P_i(x - a_i) - \frac{qx^2}{2} \right] \quad (4)$$

The resulting equation (4) describes the of the bent axis of the flexible compressed-bent bar, taking into account the differentmodulas of its material and is an ordinary inhomogeneous differential equation of order 2 with constant coefficients. With the value of $\zeta = 1$ equation (4) takes the form when the calculation of the compressed-bent bar is conducted without taking into account the differentmodulas of material.

Introducing the notation $n = \sqrt{\frac{N}{EI_z}}$, we obtain the general solution of equation (4) in the form

$$y(x) = C_1 \cos \sqrt{\zeta} nx + C_2 \sin \sqrt{\zeta} nx + y^*(x). \quad (5)$$

where C_1, C_2 – the arbitrary constants; $\cos \sqrt{\zeta} nx, \sin \sqrt{\zeta} nx$ -the partial solutions of the homogeneous equation obtained from equation (4) $y^*(x)$ - the particular solution of the inhomogeneous equation (4), which has the form

$$y^*(x) = y_0 - \frac{M_0 + Q_0x}{n^2 EI_z} + \frac{\sum P_i}{n^3 EI_z} \left[\sqrt{\zeta} n(x - a_i) - \sin \sqrt{\zeta} n(x - a_i) \right] - \frac{q}{n^4 EI_z} \left[\left(1 - \frac{\zeta n^2 x^2}{2} \right) - \cos \sqrt{\zeta} nx \right]$$

The arbitrary C_1, C_2 are determined from the boundary conditions at the left end of the bar

$$\begin{aligned} y(0) &= y_0 \\ y'(0) &= y'_0 \end{aligned}$$

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Using these conditions, we find

$$C_1 = \frac{M_0}{n^2 E I_z}, \quad C_2 = \frac{1}{\sqrt{\zeta} n} \left(\varphi_0 + \frac{Q_0}{n^2 E I_z} \right). \quad (6)$$

Substituting (6) into the general solution (5) we obtain the formula for deflections of a compressed-bent bar

$$y(x) = y_0 + y'_0 \frac{\sin \sqrt{\zeta} n x}{\sqrt{\zeta} n} + \frac{M_0}{n^2 E I_z} (\cos \sqrt{\zeta} n x - 1) + \frac{Q_0}{n^3 E I_z} \left(\frac{\sin \sqrt{\zeta} n x}{\sqrt{\zeta}} - n x \right) + y_p(x), \quad (7)$$

Differentiating successively (7), we obtain formulas for the turning angle, the bending moments and the transverse forces of the compressed-bent bar

$$\begin{aligned} y'(x) &= y'_0 \cos \sqrt{\zeta} n x - \frac{M_0}{n E I_z} \sqrt{\zeta} \sin \sqrt{\zeta} n x + \frac{Q_0}{n^2 E I_z} (\cos \sqrt{\zeta} n x - 1) + y'_p(x) \\ M(x) &= y'_0 \frac{E I_z}{\sqrt{\zeta}} n \sin \sqrt{\zeta} n x + M_0 \cos \sqrt{\zeta} n x + Q_0 \frac{\sin \sqrt{\zeta} n x}{n \zeta} + M_p(x) \\ Q(x) &= y'_0 E I_z n^2 \cos \sqrt{\zeta} n x - M_0 \sqrt{\zeta} n \sin \sqrt{\zeta} n x + Q_0 \frac{\cos \sqrt{\zeta} n x}{\sqrt{\zeta}} + Q_p(x) \end{aligned} \quad (8)$$

In formulas (7) and (8), which allow one to find the parameters of the stress-strain state in an arbitrary section of a compressed-bent bar, taking into account the influence of the different moduli of engineering material the quantities $y_p(x)$, $y'_p(x)$, $M_p(x)$, $Q_p(x)$ characterize the influence of the load in the span on the corresponding parameter of the stress-strain state and for the load shown in Fig. 1 are determined by the following formulas:

$$\begin{aligned} y_p(x) &= \frac{1}{n^3 E I_z} \sum_i P_i [\sqrt{\zeta} n (x - a_i) - \sin \sqrt{\zeta} n (x - a_i)] - \frac{q}{n^4 E I_z} \left[\left(1 - \frac{\zeta n^2 x^2}{2} \right) - \cos \sqrt{\zeta} n x \right] \\ y'_p(x) &= \frac{\sqrt{\zeta}}{n^2 E I_z} \sum_i P_i [1 - \cos \sqrt{\zeta} n (x - a_i)] + \frac{q}{n^3 E I_z} [\zeta n x - \sin \sqrt{\zeta} n x] \\ M_p(x) &= -\frac{1}{n} \sum_i P_i \sin \sqrt{\zeta} n (x - a_i) - \frac{q}{\zeta n^2} [\zeta - \sqrt{\zeta} \cos \sqrt{\zeta} n x] \\ Q_p(x) &= -\zeta \sum_i P_i \cos \sqrt{\zeta} n (x - a_i) - \frac{q}{n} \sin \sqrt{\zeta} n x \end{aligned}$$

The obtained differential equation (4) and formulas (7), (8) allow to obtain solutions to specific tasks of computation of compressed-bent bar, taking into account the different moduli of material.

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DETERMINATION OF THE STRESS-STRAIN STATE OF CONCRETE USING THE TENSOMETRY METHOD

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The article discusses the effectiveness of the use of load cells in the study of deformation characteristics of concrete. The technology of manufacturing deep sensors is described. The effectiveness of this type of sensor for the study of concrete deformation is being proved.

Ensuring the high reliability of the structures being created and optimizing the calculation parameters are largely determined by the availability of information on the physical and mechanical properties of the materials used. At present, a large amount of information on the standard mechanical characteristics of the behaviour of concrete of different strength has been accumulated [1].

The mechanism of destruction of concrete, as is known, is associated with the formation and development of micro- and macro-cracks under the action of a load. The cause of the appearance of the first microcracks is the concentration of stresses near the defects of the structure: pores, inclusions, dislocations. According to modern concepts, microcracks appear at low stress levels – $\sigma_c = 0,3f_{cm}$. Destruction of concrete begins with the development of cracks in the contact zone (matrix-aggregate) with their subsequent exit into the matrix. Contact cracks develop under the action of shear, and cracks in the matrix - tensile stresses [9].

All these cases are caused by expansion (pressure) or compression of the intraporous phase, leading to the deformation of the structure, then to stresses, at a critical value of which cracks appear in the structure [2].

In order to correctly determine the remaining life of structures, the initial data must be determined by the results of field tests and measurements. Unfortunately, for most constructions, obtaining reliable source data is difficult, which naturally reduces the correctness of calculations. The stresses occurring in the structures are usually taken as the result of formalized calculations, which does not reflect the actual operation of the structure. There is a need to seek reliable operational methods for obtaining initial data for calculations directly from full-scale structures. In this situation the way out would be the use of telemetric systems for monitoring the state of objects [3].

Load cells are used as primary sensors for obtaining information characterizing the loading parameters and stress state of the structure. The method of strain gauges, at the present moment, is one of the best developed in the measurement of mechanical stresses. Transformation of information from sensors into a form convenient for further coding does not cause fundamental difficulties and can be realized by any known method [5].

The algorithm of the system functioning assumes the following operations [3]:

1. Reading of the information of strain gauges fixed on a design for the operative formation of an array of initial data;

2. Coding information of each sensor and forming a group signal that allows to identify the number of each sensor and the number of the object on which the sensors are installed;

3. Transmission of information via radio channels from each object to the base station;

4. Analysis of the loading state of each of the N objects and the remaining resource on the basis of calculations.

Experimental studies of concrete deformation in conditions of a complex stress state with short-term and long-term load action are associated with great methodological difficulties. The main problem with such a study is the limited or total lack of access to the surface of a concrete sample, which makes it difficult to measure deformations with traditional measuring instruments. In addition, the measurement zone should be located as far as possible from the contact surface of the sample and the loading element [6].

For more detailed study of the development of deformations in concrete samples, it was decided to use deep sensors in [1, 8–10]. As shown by the studies [7], the application of this type of deep sensor (Figure 1) gives a good convergence of experimental and theoretical data.

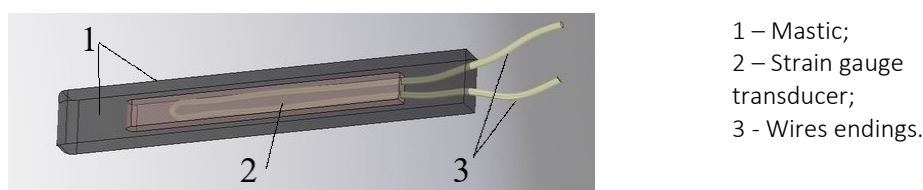


Fig. 1. Model of a deep sensor

Deep load cells are manufactured using the following technology [7]:

1) In a collapsible metal mold (the cell for making each sensor has a size of 100X10X5mm), greased with a synthetic oil, a layer of 2.5 mm thick mastic was laid. The mastic consisted of a mixture of glue BF-2 with cement in the ratio of 1: 2.

2) After the mastic dried (within 24 hours), strain gauges were pasted onto it, which, in turn, was covered with a second layer of mastic. Only the parts of the sensor head with leads remained free.

3) After the wires were soldered to the terminals, this part of the sensor was isolated.

4) After heat treatment in an oven at the temperature of 150 ° for 1 hour, the sensors were removed from the mold.

In the future, a similar experiment is planned to monitor the deformations of concrete samples using this type of deep-seated sensors.

The results of the studies described in [1, 8–10] testify to the promising application of the sensors considered for studying the stress-strain state of concrete. Their main advantages are simplicity, low cost of their manufacture and the possibility of using traditional measuring strain gauges [6].

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UDC 691.87

MODELLING OF TERMINAL CONNECTORS FOR TESTING
 AND OBTAINING PRESTRESSING FRP REINFORCEMENT

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The article presents the possibility of using terminal connectors with wedge grips. To determine the load-carrying capacity of the wedge grips, it is necessary to calculate the drag force on the surface between the FRP reinforcement and the slip. As a result, the friction force on the contact surface is supplemented with the drag force generated by plastic shear strain of the pipe body.

Modern views on the use of non-metallic reinforcement gained greater resonance, i.e., used in conjunction with metal designs. However, their physical and mechanical properties are much better. 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.

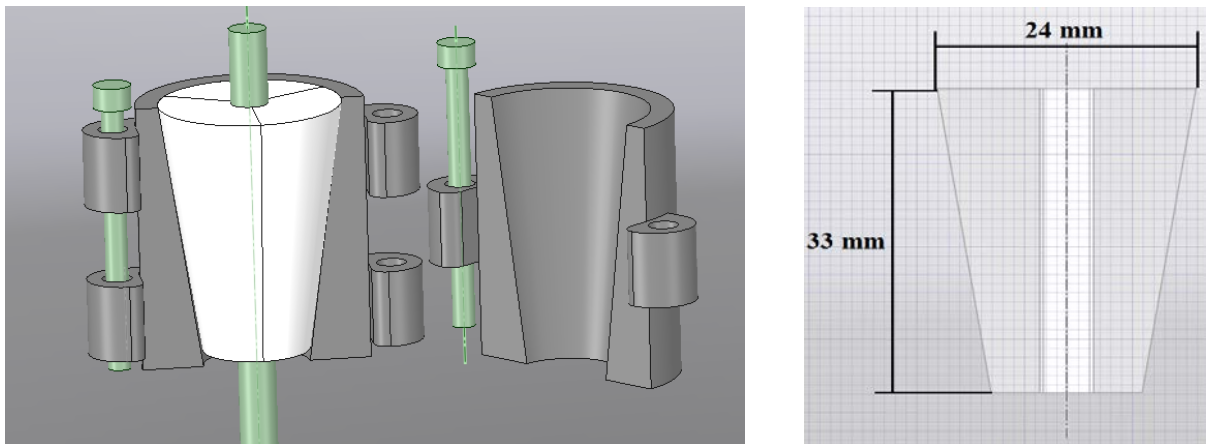


Fig. 1. Model of terminal connectors and dimensions of wedges executed in the software ANSYS SpaceClaim

A wedge clamp is used in devices where it is necessary to obtain a significant clamping force or change its direction. They allow to increase and change the direction of the transmitted force. To provide a restraining force, the surface of the wedge (Fig. 1) device must create the necessary resistance force on the contact surface resulting from the plastic deformation of the composite reinforcement when it moves relative to the wedges, which complements the frictional force.

Elastic and plastic analytic solutions. At the initial stage ($h \rightarrow 0$) of indentation of a wedge punch with a flat base, solution of the linear elastic problem of punch pressure with a rectangular base on half space [4, 5] can be used:

$$F = \frac{E}{1-\nu^2} \cdot \frac{\sqrt{wl}}{m} h \quad (1)$$

where $E=210 \text{ GPa}$ is Young's modulus, $\nu=0.3$ is Poisson's ratio, $w=0.024 \text{ m}$ is the truncated wedge base width, $l=0.033 \text{ m}$ is the truncated wedge base length, m is the parameter determined as the ratio of the base sides (if $l/w=1.375$ $m = 0.95$, Fig. 2). Eq. (1) was derived by generalization of the solution of the Boussinesq problem on the action of a normal concentrated force on the surface of elastic half-space. It should be noted that solution (1) was derived based on the assumptions of infinitesimal mechanics, where small strains are assumed and the differences between the actual and reference configurations are neglected. In this case, the form of the wedge side face is not crucial, only the truncated wedge base sizes are essential. The solution is true for very weak in-

dentation forces only and, therefore, for shallow penetration depths ($h \rightarrow 0$), when the plastic zone and contact on the side wedge faces may be neglected. When solution (1) was derived, it was assumed that contact pressure was evenly distributed, there was no friction and h was assumed as the average displacement value under the punch. Such conditions are not crucial as the difference from the solution for the rigid punch (constant displacements and variable contact pressures) is about 8% [4].

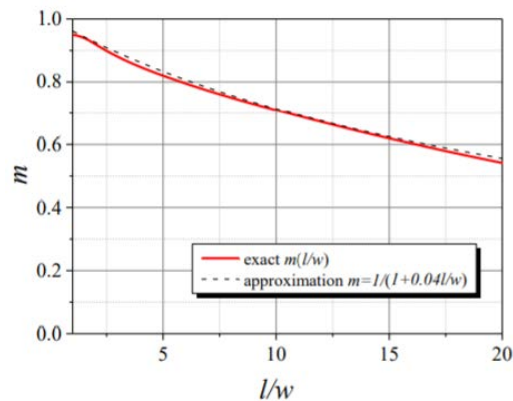


Figure 2. [3]. Parameter m in Eq. (1) vs. base side ratio $l/w=1.375$

$$F = \frac{210 \cdot 10^6}{1 - 0.3^2} \cdot \frac{\sqrt{24 \cdot 33}}{0.95} h = 6836N$$

A simplified analytical model was proposed to determine the indentation force of non-ideal (truncated) wedge punch with symmetrically sloped sides (20°).

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TECHNOLOGY, MACHINE-BUILDING, GEODESY

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DESIGN FEATURES OF INSTRUMENTS IN AUTOMATED PRODUCTION FACILITIES

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The article deals with designing cutting tools in automated production facilities and with their main features – interchangeability, versatility, high accuracy.

Introduction. Cutting tools of automated production facilities should provide minimum costs when using at a given stage of processing. Based on the features of the functioning of automated production facilities, there are following requirements for the tools:

1. High reliability;
2. High and stable cutting properties;
3. Satisfactory formation and removal of chips,
4. Quick change during replacement;
5. Interchangeability, ensured by adjustment to the size outside the machine;
6. Versatile application for typical machine surfaces of various parts on different CNC machines;
7. Increased accuracy of tools for CNC machines.

All these requirements fit into the three main features:

1. High performance;
2. Low power consumption of the cutting process;
3. Economical tool.

The ways of realizing the requirements 1–7 are basically the same as for tools in general are designed according to the same algorithm. However in the conditions of the automated equipment operation, the other ways of solving a number of problems are required.

Design. Creation of new designs of cutting tools and improvement of old ones, application of new tool materials (high-speed steel of increased wear resistance, fine-grained hard alloys, hard alloys, mineral-ceramics, superhard materials based on cubic boron nitride, etc.) and using scientifically grounded cutting modes are decisive factors in increasing the period of resistance of the cutting tool and labor productivity when processing parts from various materials. [1]

First of all, when choosing a cutting material, they tend to use a material of higher heat resistance and strength in order to increase the productivity and reliability of the tool. These requirements are not always compatible. Therefore, it is necessary to find an economically advantageous solution. In order to improve the versatility of tools, cutting materials in the form of multifaceted non-re-sharpened plates (MNP) are mechanically fastened to housings. As a result, such a tool can be quickly retrofitted with plates of another cutting material. [2]

The geometric parameters of tools with MNP are provided both by the parameters of the plate itself and by the inclined mounting of the plate in the tool body.

Tighter requirements for the reliability of the methods of chip formation led to the creation of MNP with shaped front surfaces, allowing chip breaking in a wide range of elements of the cutting regime (Figure 1).



Fig. 1. Non-standard plate produced by Sandvik Coromant

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Optimizing the pitch of the teeth of the prefabricated tools is reduced to finding ways to fasten the plates, which, under all other conditions, will ensure the minimum step value. Overstepping the optimum border in the direction of minimizing the step fails.

In solving the remaining tasks of the algorithm for designing the working part of the tools of automated machine building, there are no principal features. There are not any of them in the design of the guiding parts. The difference is only in the fact that fewer tools have guiding parts, since CNC machines provide precise positioning of the tool. For the same reason, in many cases there is no need for a movable tool joint with the machine spindle.

The design of the connecting part differs mainly in that it is necessary to provide a quick-change attachment of tools in the case of manual replacement.

The tools of modular constructions differ from the standard connecting part, as the standard elements of the connecting part of general-purpose tools are of little use. They do not provide the required accuracy of positioning and rigidity, which, along with the requirements for rapid tool replacement and their manufacturability, made it necessary to look for new design solutions for connecting devices. Now there are a lot of them.

The interchangeability of tools is provided by the introduction of compensators in the form of micrometric screws into their design, which allows to adjust the required tool size in advance, outside the machine.

Versatility of tools is achieved due to the modularity of structures. This is one of the promising areas for the development of designs of boring cutting tools. [3] Any instrument of a specific purpose can be obtained by rapid assembly from standardized modules. In such an original way (modularity of structures), the contradiction between universality and specialization of the instrument is solved (Figure 2).

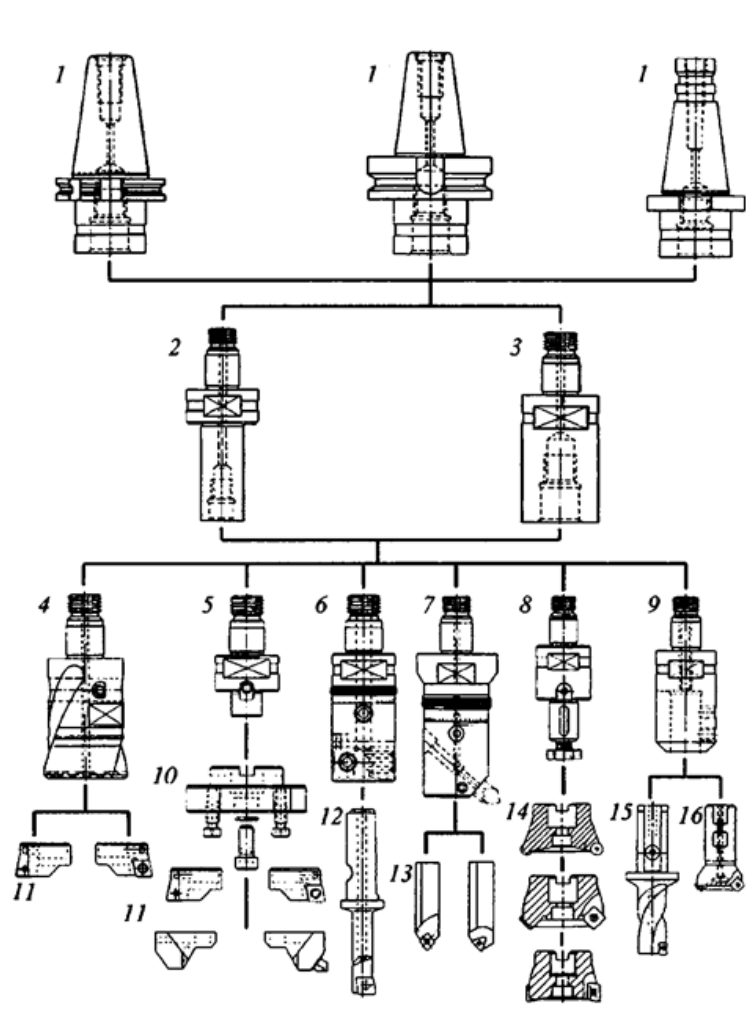


Fig. 2. Boring tool system based on cylindrical connection with axial puff

At the same time, specialized units make specialized units that results in low cost modules with high quality. The drawbacks of the assembly tools are their reduced stiffness compared to the solid tools. [4] However, this disadvantage also turns out to be a positive side: higher vibration resistance due to damping of the oscillations by the joints of the modules.

The high accuracy of the instrument depends on the accuracy of the manufacturing, as well as the choice of the optimal, in terms of accuracy, base surfaces, the methods of articulating the cutting tool with the auxiliary and with the machine tool. To maintain the accuracy of the positioning of the tool during operation, an important role is played also by the method of transferring the cutting forces from the machine to the tool.

The precision of the boring tools is provided by cutting inserts with micrometric extension of the insert, the so-called microboring. Analysis of their design and design features are described in [5-9].

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DIFFERENTIAL EQUATION OF HEAT CONDUCTIVITY AND ITS SOLUTION IN METALWORKING

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Introduction. In connection with constant updating types of structural materials, increasing of requirements to quality of machine parts and intensification processing modes the issues related to thermal processes in technological systems come to the fore.

To consider these processes when designing the process equipment, to be able to manage them, you need to know the heat transfer in the elements of the technological system.

Principal of heat transfer. There are three types of heat transfer: conduction, convection and thermal radiation. [1]

Conduction is the process of propagation of heat energy by direct contact of bodies or separate body parts, with different temperatures, for example, workpieces, tools and parts manufacturing equipment.

Convection is the process of moving volumes of liquid or gas in the space from one area to another, with different temperature.

Convection of heat is always accompanied by conduction, as the movement of liquid or gas means contacts of the particles having different temperatures.

A collaborative process of convection and conduction is called heat transfer.

Thermal radiation is the process of heat propagation in the form of electromagnetic waves with the mutual conversion of thermal energy to radiant and back again.

An example of the types of heat transfer during cutting is presented in figure 1, where C - conductivity, R - radiation, convection, CWF – convection with the fluid, CWA -convection with the air; ON, OL and OS – lots of heat from the deformation, the friction in the front and rear surfaces of the cutting tool.

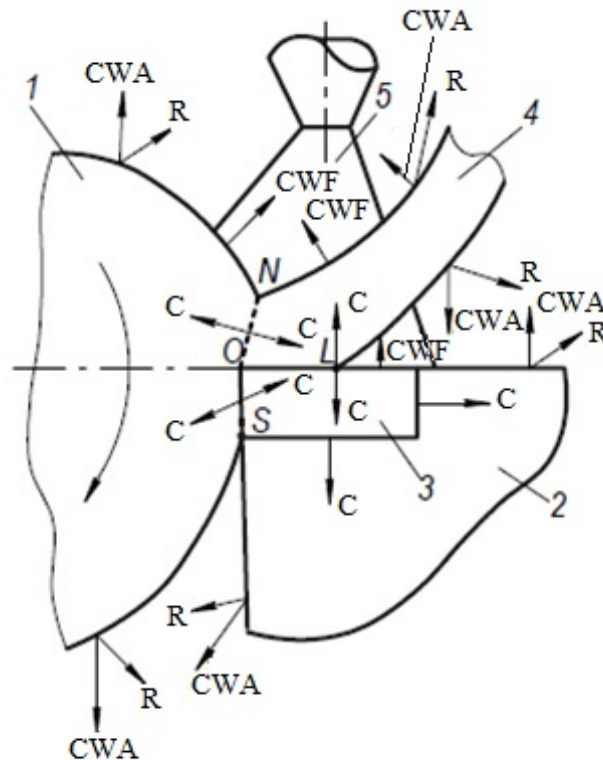


Fig. 1. Types of heat exchange in the cutting zone:
1 – workpiece; 2 – cutting tool; 3 – cutting insert; 4 – shavings; 5 – cutting fluid

The quantity of heat dQ flowing through isothermal surface with an area of dF for the time dt is proportional to the temperature gradient (figure 2):

$$dQ = -\lambda \text{grad}\theta F \cdot dt. \tag{1}$$

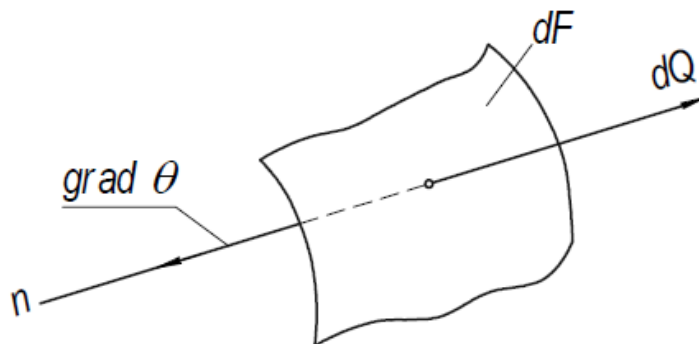


Fig. 2. The insulated element and surface heat flux

The amount of heat passing through unit area of the isothermal surface in unit time (heat flux density), is determined by the ratio:

$$q = \frac{dQ}{dF \cdot dt} = -\lambda \text{grad}\theta. \tag{2}$$

where λ - the coefficient of heat conductivity expresses the quantity of heat passing in unit time through unit area when the temperature gradient of one degree per unit length.

The thermal conductivity characterizes the ability of the material to conduct heat and depends on the composition of the substance, its structure, density, humidity and temperature. The minus sign in equation (2) shows that the vector of the heat flow directed in the direction opposite to the direction of the vector $\text{grad}\theta$. Expression (2) typically represents the basic law of heat conduction, or Fourier law stating that the heat flux density is directly proportional to the temperature gradient.

The differential equation of heat conduction. In unsteady mode the redistribution of heat is accompanied by a change in temperature of the separate elements of the body. The change in the temperature fields of solid bodies at non-stationary heat conduction is described by the differential equation. For the derivation of this equation in the body of the elementary volume $\Delta x \Delta y \Delta z$ (figure. 1) 100, the process of propagation of heat in it is considered in the direction of one axis, for example OX.

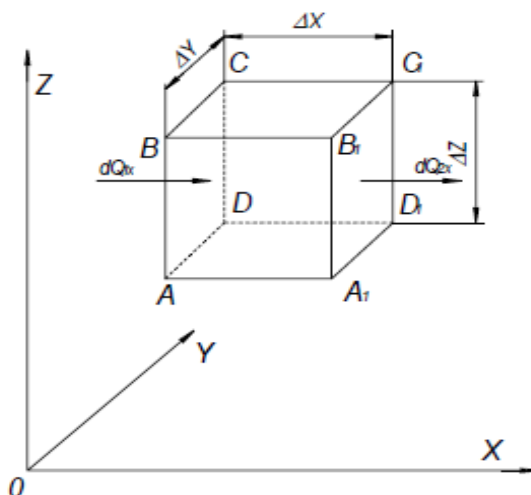


Fig. 3. Scheme to the conclusion of the differential equation of heat conductivity

Technology, Machine-building, Geodesy

The smallness of area $\Delta y \Delta z$, supposes that the temperature on each face of the body is distributed evenly. Let face $A_1B_1C_1D_1$ temperature is θ , and on the verge $ABCD - \theta' = \theta + \Delta\theta_x, \Delta\theta_x$, where the temperature change along the OX axis. The change of the heat flow from one face to another direction OX consider the body described by the expression:

$$dQ_{2x} = \lambda \text{grad}_x \theta \cdot \Delta y \Delta z \Delta \tau$$

or

$$dQ_{2x} = \lambda \frac{\partial \theta}{\partial x},$$

The temperature of the faces ABCD:

$$\theta' = \theta + \Delta x \frac{\partial \theta}{\partial x'},$$

then

$$\text{grad}_x \theta' = \frac{\partial \theta'}{\partial x} = \frac{\partial}{\partial x} \left(\theta + \Delta x \frac{\partial \theta}{\partial x} \right)$$

and heat flow

$$dQ_{1x} = \lambda \frac{\partial}{\partial x} \left(\theta + \Delta x \frac{\partial \theta}{\partial x} \right) \Delta y \Delta z d\tau.$$

as $dQ_{1x} > dQ_{2x}$, in the amount of

$$dQ_x = dQ_{1x} - dQ_{2x} = \lambda \frac{\partial \theta}{\partial x} \Delta y \Delta z d\tau + \lambda \frac{\partial^2 \theta}{\partial x^2} \Delta y \Delta z \Delta x d\tau - \lambda \frac{\partial \theta}{\partial x} \Delta y \Delta z d\tau = \lambda \frac{\partial^2 \theta}{\partial x^2} \Delta x \Delta y \Delta z d\tau$$

or

$$dQ_x = \lambda \frac{\partial^2 \theta}{\partial x^2} = dV d\tau, \quad (3)$$

Similarly, for the coordinate axes OY and OZ:

$$dQ_y = \lambda \frac{\partial^2 \theta}{\partial y^2} = dV d\tau, \quad (4)$$

$$dQ_z = \lambda \frac{\partial^2 \theta}{\partial z^2} = dV d\tau, \quad (5)$$

The change of the heat flow in the whole body will be described by the expression:

$$dQ = dQ_x + dQ_y + dQ_z = \lambda \left(\frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2} + \frac{\partial^2 \theta}{\partial z^2} \right) dV d\tau, \quad (6)$$

The amount of heat can also be determined using the heat capacity:

$$dQ = \rho \cdot c \cdot dV \left(\frac{\partial \theta}{\partial \tau} \right) d\tau. \quad (7)$$

where ρ – the density of the material;

c – mass heat capacity;

$\rho \cdot c$ – volumetric heat capacity;

$\frac{\partial \theta}{\partial \tau}$ – the rate of change of temperature of the body in time.

Equating the expression (6) and (7), we obtain the differential heat conduction equation of Fourier:

$$\frac{\partial \theta}{\partial \tau} = \omega \left(\frac{\partial^2 \theta}{\partial x^2} + \frac{\partial^2 \theta}{\partial y^2} + \frac{\partial^2 \theta}{\partial z^2} \right). \quad (8)$$

where $\omega = \frac{\lambda}{c \cdot \rho}$ – the thermal diffusivity characterizing the thermal inertia properties of the body.

This equation is general and valid for any body shape and any conditions of heat transfer.

Due to the given above assumptions, the conduction equation can be solved in one of the following methods: classical, operating, numerical, heat sources and modeling.

When using the classical method, the integration of the differential equation (8) is one of the well-known mathematical methods. Operating methods, for example, in the method of integral Laplace transform do not study the function we are interested in, and its modification is obtained by multiplying on an exponential function. When using numerical methods for differential heat conduction equation is solved by the finite difference method. It is based on replacing the derivatives in equation (8) by their approximate values, expressed by differences of the functions $\theta(x, y, z, \tau)$ in discrete points-nodes of the grid (after the body is split into elementary volumes of the correct form). The differential equation in this case is replaced by the equivalent ratio of finite differences, for the solution of which the algebraic operations are implemented on the computer. To determine the temperature at any point of the body in a given time is enough to know the temperature of the neighboring points at the previous time. If you know the initial temperature distribution in the body and on its boundary surfaces, then gradually, step by step, moving from one point of the body to another, or considering one time after another, the temperature field in the object can be calculated.

The most widely used method in various fields of engineering is the method for the heat sources. The essence of this method is determined by two main provisions:

1) temperature field arising in a heat-conducting body under the influence of a heat source of any shape, moving or stationary, when the current is alternating or continuous, can be obtained as the result of a particular combination of temperature field arising under the action of instantaneous point sources;

2) the process of propagation of heat in the body is in the form of the distribution of heat in the body of unlimited size by adding to the actually existing sources a system of fictitious sources or heat sinks.

If we assume that in the body, all points of which have the same temperature, and the heat exchange with the environment misses, with the broken or instantly extinguished point source contributing the q_T of heat, the solution of the differential equation (8) for these conditions can be written as:

$$\theta_T(x, y, z, \tau) = -\frac{q_T}{\lambda \sqrt{\omega} (4\pi\tau)^{3/2}} \exp\left[-\frac{(x_u - x)^2 + (y_u - y)^2 + (z_u - z)^2}{4\omega\tau}\right]. \quad (9)$$

where $\theta_T(x, y, z, \tau)$ – the temperature of any point of the body;

x, y, z – the coordinates of the point of the body;

x_u, y_u, z_u – the coordinates of the heat source;

τ – the duration of the source;

λ and ω – the coefficients of thermal conductivity and thermal diffusivity of the body material.

Modeling of thermal processes are carried out mainly in two types:

1) physical modeling when studying the heat transfer process in a real body is based on analysis of similar process of propagation of heat in the model;

2) mathematical modeling when studying heat transfer in a real body is based on the analysis of fundamentally different physical phenomena, different from the process of propagation of heat, but having a similar mathematical description.

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METHODS OF EXPERIMENTAL DETERMINATION
OF HEAT AND TEMPERATURE ELEMENTS OF THE TECHNOLOGICAL SYSTEM

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Experimental determination of heat and temperature in the technological system is necessary to solve heat problems empirically and to test theoretical calculations of temperature.

Methods of determining temperature are divided into *direct* and *indirect* [1]. To use *indirect* methods of estimation of temperature values for some of its indirect manifestations. For example, to change the component of the cutting force P_z , because the amount of heat is determined by the formula $Q = P_z \cdot u$. *Direct methods* are based on a relatively more accurate determination of temperature using temperature sensors. Direct methods further are divided into *contact* and *contactless*. The *contact methods* include methods and devices where there is no direct contact between the temperature sensor and the measurement object. The *contactless* methods are those ones in which the measuring sensor devices are located at some distance from the object which temperature is to be determined.

Contact methods

Thermometers, heat indicators, thermocouple are used for contact methods; radiation and other devices, optical, acoustic and pneumatic sensors are used for contactless methods. Due to the nature of the temperature measuring elements of the processing system thermometers (mercury gauge and mechanical) are mainly used to determine the temperature of liquids, melts and when calibrating. The use of heat indicators, which are further divided into chemical, thermal and melting, are also limited. Heat indicators are produced in the form of heat pencils, thermoablation, termotronic, heat-sealing and thermal paper. Heat indicators have a temperature measuring range from 20°C to 1500°C and a few color changes (from 1 to 6). Each color indicates a certain temperature. For example, a fluoride of cobalt in CoO_2 is orange in colour, and at the temperature of 85°C it becomes light pink.

Heat indicators in the form of fusible inserts are substances which in a certain temperature range, turn into the liquid crystalline state. Tin ($\theta_m = 231,9^\circ\text{C}$), cadmium ($\theta_m = 320,9^\circ\text{C}$), zinc ($\theta_m = 419,5^\circ\text{C}$), silver ($\theta_m = 960^\circ\text{C}$), copper ($\theta_m = 1083^\circ\text{C}$) are often used as such substances.

Direct methods are the most widely applied methods with using thermocouples, calorimeters and radiation pyrometers.

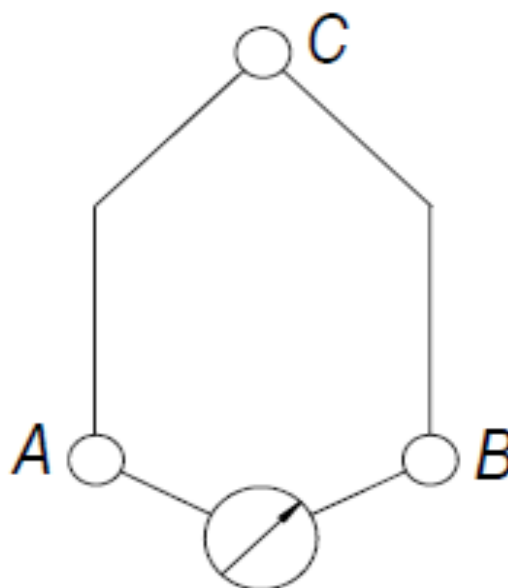


Fig. 1. Schematic diagram of the thermocouple

A *thermocouple* is the junction of two dissimilar metals, a common point called the hot junction, and all other dissimilar metals A and B in the circuit of the thermocouple, called cold junctions (figure 1).

Thermocouples are based on the phenomenon that in the closed circuit of two dissimilar metallic conductors an electric current or so-called thermal electromotive force (thermal EMF) is caused by heating one of the junctions. The thermocouple records the temperature difference between the hot and cold junctions. The cold junctions can be maintained at room temperature or zero temperature, which is achieved by locating the cold junctions in a vessel with melting ice.

Non-contact methods

Calorimetric method is the use of containers with liquid (water) and 1 for trapping flying off the chips 2, which are installed under the treatment area (figure 2, a).

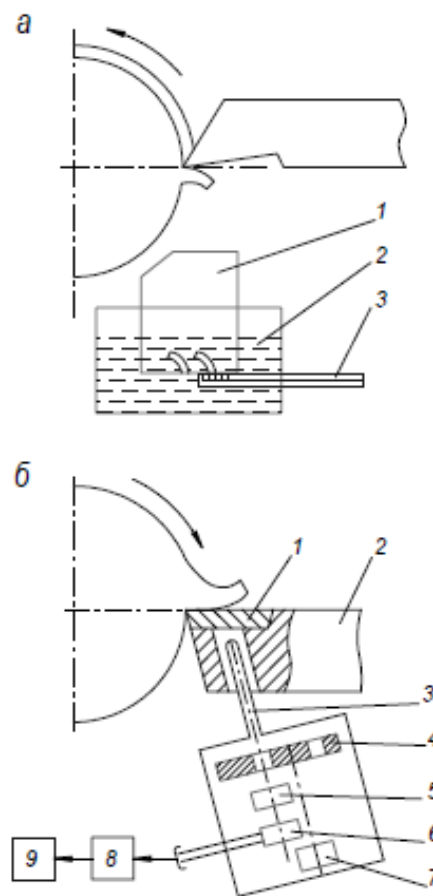


Fig. 2. Scheme of temperature measurement of cutting with a calorimeter (a) and radiation thermometer (b)

After getting chips in a calorimeter, the water is stirred to equalize the temperature. After stirring, the water temperature is measured, then the chips are weighed on an analytical balance, the temperature of the water in the calorimeter is calculated enthalpy of chips in calories and its volumetric average temperature:

$$\theta = \theta_{cm} + \frac{G_B(\theta_{cm} + \theta_B)}{c \cdot G} \quad (1)$$

where θ_{cm} – the temperature of the mixture (water after being hit by a chip);

θ_B – initial temperature of water;

G_B – the mass of water in calorimeter;

G – the mass of the chip or of the cutter;

c – the heat capacity of the shavings or cutter.

The radiation method is based on measurement of infrared radiation in the cutting zone radiation pyrometers (figure 2, b). Insert 1 cutter 2 needs to be transparent, for example, diamond, for the infrared rays, which through the light guide pads 3 fall to the modulator 4 and then through the filter on the radiation receiver 6. To drive the modulator 4 the micro 7 is used. Infrared radiation is amplified by an amplifier 8 and is recorded by the device 9. This method is effective, but its use during cutting is restricted to small areas of the zone of heat radiation and its closeness.

The results of experimental studies in determining the temperature of chips by calorimetric method have shown that at the stages of cutting and nursing its values are in the range of 410-460°C. When exceeding the permissible values of the blade wear chamfer (above 0,4 mm) and the tool speed of 12,000 min^{-1} , the chip temperature rises sharply up to the melting point of the processed material and is formed in the form of drops [2].

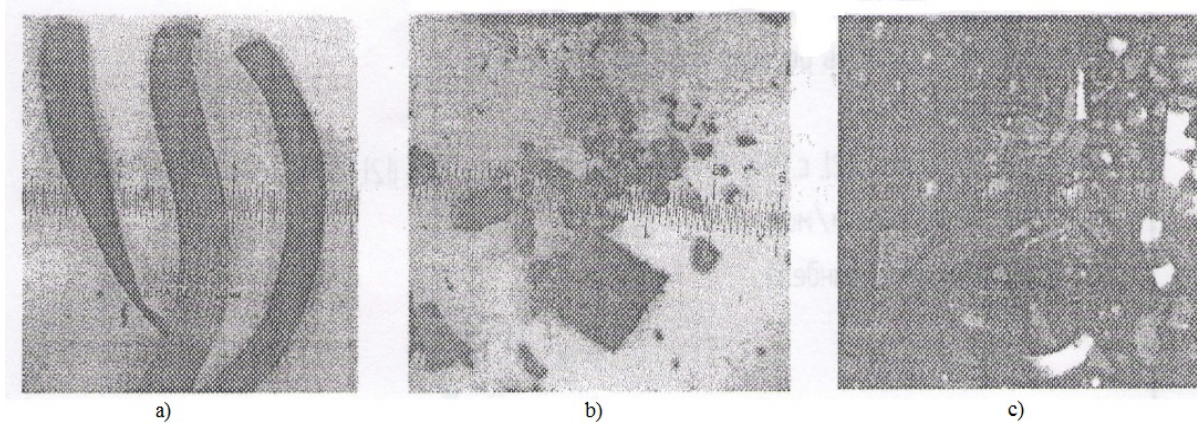


Fig. 3. a) at the stage of cutting; b) at the stage of nursing;
c) when working a blunt tool and the tool rotation frequency of $n_1 = 12,000 \text{ min}^{-1}$

The temperature of the part measured by the pyrometer varies depending on the rotation frequency of the tool and the work piece and their diameters from 30 to 120°C. A typical graph of the part temperature change from the processing time is shown in figure 4.

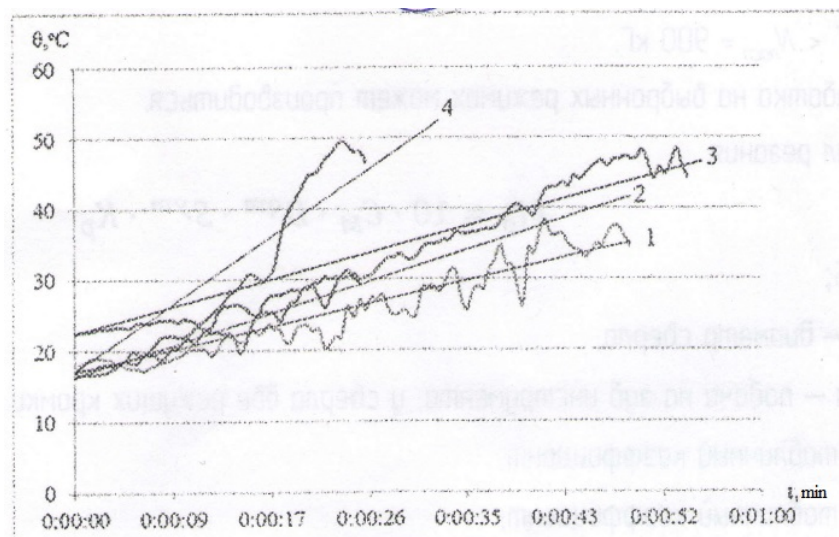


Fig. 4. The variation of the temperature of the work piece surface with a diameter of 35 mm on the time of treatment with the frequency of rotation of the work piece $n_2 = 200 \text{ min}^{-1}$ at:

- 1 - at tool speed $n_1 = 3150 \text{ min}^{-1}$ of cross feed $S_n = 1,61 \text{ mm/min}$;
- 2 - at tool speed $n_1 = 6300 \text{ min}^{-1}$ of cross feed $S_n = 2,25 \text{ mm/min}$;
- 3 - at tool speed $n_1 = 9000 \text{ min}^{-1}$ of cross feed $S_n = 0,853 \text{ mm/min}$;
- 4 - at tool speed $n_1 = 12000 \text{ min}^{-1}$ of cross feed $S_n = 1,543 \text{ mm/min}$

As it can be seen from the graphs, the higher the rotational speed is, the higher the temperature value is. The intensity of heat accumulation in the details is different and depends on the magnitude of the transverse feed - cutting depth. The greater the cross feed and less processing time are, the lower the intensity of heat accumulation in the part is by increasing the heat transfer into the chip.

As the wear chamfer increases on the back of the blade, the heat flows into the tool and the part increases, as evidenced by the increase in the heating temperature of the part to 120 degrees. At the same time, the influence of the transverse feed (cutting depth or section width of the cut layer), as a factor improving heat transfer into the chip, decreases.

Relatively low values of the heating temperature of the part (30–120°C) indicate that there are no significant structural and phase transformations in the surface layers of the part and the tool blade, which ensures high quality of the treated surface of the sphere.

In the study of tool blade wear, mechanical cutting and abrasive abrasion of irregularities on the blade surface with the formation of a wear chamfer of length l_ϕ and height h_ϕ along the auxiliary cutting edge and the adjacent back surface are observed. Moreover, the shape of the wear chamfer on the rear surface corresponds to the radius of the treated spherical surface.

Processing data of the measured value of blade wear showed that the permissible length and height of the wear chamfer is respectively $l_\phi = 2-4$ mm and $h_\phi = 0,1-0,4$ mm.

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THE APPLICATION OF SULFOCATHIONITE IN ALCYLATION

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This article is dedicated to the usage of organic ionits as catalysts. According to the modern idea ionits are characterized by insolvent highly moleculated acids and alkalis which are made from monomers by polymerization or polycondensation. The catalytic principle and the mechanism of ionits in the phenol alkylation by olefins are also overviewed here.

Introduction. There is the trend in the catalytic modernization field: liquid catalysts are changed into solids which have advantages in techniques, economy and regeneration.

There are some pivotal benefits of the organic ionits and mineral acids as catalysts:

1. Catalyst can be easily separated from the product by filtration or decantation. It can be used without any regeneration in the process over and over again (for 10 – 15 times). The process based on ionits can be carried out like an uninterrupted circuit.

2. The reaction products are subjected to catalytic both in a porous zone and the solution. Ionits are selective, and that is why adverse reactions are totally expelled. Because of that reason the method mainly matches the production of unstable compounds which are easily biodegradable.

3. Due to the product they are easier to be removed from the reaction zone, there is an opportunity to get a high yield of semi-products in the stepwise reactions. In fact, those semi-products are hardly obtained or none-picked out in a homogeneous catalytic process.

4. In some cases the ion resins application permits to change the way of reaction. Unlike the processes held in dissolved electrolytes (acids, alkyls), as ionits reaction happens with unequal velocity between small and large molecules in accordance to the penetration possibility of reactants throughout ionic porous.

5. Ionits almost do not cause corrosion. [1]

In the 60's a stormy exploration of the phenol alkylation in the presence of sulfocathionits begun. About 60% of alkyl phenol output was obtained by the usage of sulfophenol formaldehyde resins. The same outlet results were achieved with a modern sulfonated copolymer of styrene and divinyl benzene (KU-2) which showed the highest thermal and chemical stability in contrast with sulfonated phenol-formaldehyde resins.

The stationary and elevation bed of catalysts were worked out by Professor V. Izagulianz. The recommended temperatures are 120-130°C. Phenol: olefin ratio is varied from 1:2 to 8:1 mole/mole.

In the late seventies the developments of alkylation on macroporous sulfocathionite appeared. The elevation of the catalytic activity by putting medium or compound modification is widely used.

Organic ionit is employed in different reactions like etherification, acetal synthesis, condensation, alcohols dehydration, esters saponification, alcoholisis and acidosis of eaters.

Main body. In this article there is a review of phenol alkylation mechanism on cationits.

Phenol alkylation, as the alkylation of the others aromatics, goes with the removal carbocation substitution to sp^2 -C aromatic ring and carbocomplex formation (fig. 1).

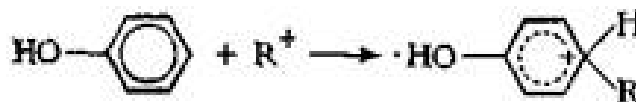


Fig. 1

It is considerable that the alkyl phenol formation has the same further transformation type like the substitution as a result of the proton σ -complex (fig. 2).

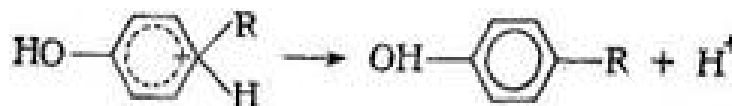


Fig. 2

However, such σ -complex is characterized by a high proton removal activity for hydroxy group. As a result there is a possibility of neutral further readjustment. An essential difference of substitution electrophilic reaction type from others is the transitional alkylcyclohexadiene (fig. 3).

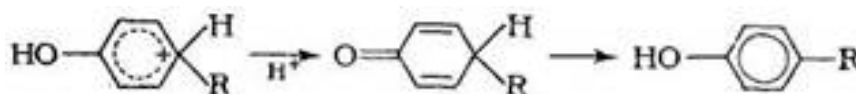


Fig. 3

Generally, phenol alkylation is limited to carbocation derivation. Cyclohexadienon and phenol nucleophile attacks are synchronized. If the synchronization breaks alkyl phenol esters will be derived. Esters are easily isomerized into alkyl phenols by acids.

The neutral pathway mechanism is stable for the account for reaction between olefin and the phenol molecule (fig. 4) [2].

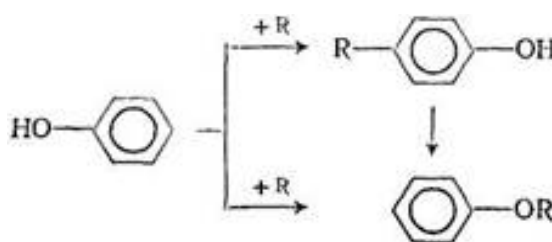


Fig. 4

The reaction pathway leading to direct p-benzenephynon is more energetically favorable than o-benzoquinone. That is the determining factor to faster p- substitution reason.

The major effect in velocity plays the olefin structure. Mono-di- and tri-alkyl phenol forms are coherently alkylations. It's known that hydroxy group interfacing effects cercal density of aromatic and leads to the increase in p-o-positions. Therefore, initial carbonic attack should be directed precisely to these positions. High yields of p-C-alkyl phenol is derived unlike o-C-alkylphenol. With the increase of catalytic activity the temperature and reaction duration of ortho- ratio will be promoted at 60-80% to 95% and more by isomerization.

By the adding of alkyl groups the first reaction step passes faster than the second and that one is faster than the third. Transalkylaton has an influence on the composition of compounds. With the increase of catalytic activity the temperature and the reaction duration of the yield of monoalkylphenol increases in the product. For mono-derive one uses equimolar or phenol excess in an initial mixture, for dialkylphenol derive – a mixture with olefin excess.

Conclusion. In alkylation there are some unacceptable and unavoidable reactions like:

- Phenol esters derive. In unbeneficial conditions the yield of which rises up to 50% per raw material.
- Olefin polymerization.

As the alkylation has the lowest energy potential (about 21 kJ/mole) the temperature reduction or olefin concentration lessen is prevented from the above reactions.

Thereby the velocity and selectivity of the phenol alkylation depends on the wide range of factors:

- the type and the activity of the catalyst;
- the olefin structure;
- the material ratio;
- the technological factors like the temperature, the duration, the presence of a solvent [3].

As F. Chernishou's experiments showed the phenol alkylation by hexadecane is 1 on Amberlyst - 15 (120°C) 100% alkenes conversion and 97% hexadecylphenol selectivity were reached [4].

Also A. Fakeeu and K. Sadouskaua in the LLK-Naftan laboratory worked out the other methods of the synthesis with cationic resins, the object was the improvement of the quality and recourse conservation.

Different catalysts were investigated: AMBERLIST 15DRY RESIN, 35 DRY RESIN, produced by DOW (France); АКВАСОФТ СФЕ 103 DR produced by «Transnov» SIA, Purolite CT 169, Purolite CT175, Puolite CT269 produced by Puolire S.R.L. (Romania), Lewatit K2649 produced by LANXESS (Germany).

According to the investigation made by Lewatit K2649 in alkylation increases the monododecylphenol yield up to 39% and phenol conversion up to 40%. The advantage of Lewatit K2649 is in temperature reduction and conversion increase [5].

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THE CHOICE OF A DESIGN OF THE DEVICE FOR PRODUCTION OF COMPOUND FEED

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In the work the analysis of the equipment and technology of its production for production of the granulated forages is carried out, it is shown that the most responsible element is the matrix. Ways of increase in its resource are planned.

One of the main objectives which face agriculture [1] is the possibility of consumption by the population by 2020 of meat products per capita more than 75 kg. The solution of this important economic task can be promoted by intensive development of a food supply. At the same time, the important part is assigned to production of formula-feed products – complex uniform mixes of different fodder means for full feeding of animals. Its growth in comparison with 2009 has to be 41,9%. It is possible to carry to the main advantages of use of compound feed: creation of a type of a forage with certain physicochemical properties; high nutritional value as in them different feeder components and additives are evenly distributed and concentrated (molasses, vitamins); mechanization and automation of distribution of forages is facilitated; expenses of forages as a result of decrease in losses of a mealy part of compound feed during the transporting and distribution are cut down. It will give the chance to provide balance of forages and to reduce their cost value. The conducted researches showed [4] that use of the balanced compound feeds increases productivity of animals on 10 ... 12%. Therefore, the researches directed to improvement of the equipment for production of formula-feed products have relevance.

The purpose of the work is the analysis of design features and results of researches of the equipment for production of the granulated forages taking into account requirements imposed to sterns and technologies of their production.

It is possible to carry on the main requirements which are imposed to the operation of cars for production of compound feeds: fineness of grind, size of a mass fraction of not ground seeds, a mass fraction of moisture, lack of the remains of packed compound feeds in the press for their production.

The carried-out analysis showed that the greatest contribution to development of production of compound feeds was made by prominent scientists A.P. Dmitrochenko, N.I. Denisov, S.S. Elenevsky, A.S. Yemelyanov, A.A. Zubrilin, P.D. Pshe-nichny, A.S. Solun, M.F. Tomme.

For the production of formula-feed products [2–7] two constructive versions of cars found distribution: extruders (with horizontal giving of components of compound feed) and grinders (with vertical giving of components of compound feed). The main part of an extruder – the screw, a special design rotating in the body which moves and compresses raw materials from the entrance feeder to a lattice matrix, and then to a die hole through which goes further on a technology chain. It should be noted that due to friction of the moved material about an extruder part temperature can reach 200⁰ C that corresponds to the lower bound of range of temperatures of the lower issue staly that also complicates operating conditions of parts of an extruder.

The most technology difficult in production and loaded is the matrix which represents the tempered disk (temperature of tempering 800 C with the subsequent cooling in water) made of steel 40X (σ_T of =395 MPas, HB 187-229, $K_{UV} = 1,2$ and $K_{UB} = 0,95$), equipped with a set of the through openings (diameter from 3 to 6 mm depending on matrix thickness) reamed on depth up to 5 mm executed on concentric circles with a certain step. Production of a matrix with ensuring exact coordinates of openings can be carried out, for example, by means of a dividing head on the vertical milling machine. At the same time it is reasonable to carry out drilling of openings with application of the conductor in the presence of cutting fluid. Such approach will allow to provide exact coordinates and high quality of the drilled openings.

When using grinders with vertical giving of components of compound feed for formation of granules the matrix on which the rollers crushing the arriving initial components are rolled is also used. At the same time the matrix will also be the most loaded element.

For the analysis of the intense deformed condition of a matrix it is reasonable to use a finite element method as which it is possible to use tetrahedral pyramids. It will allow to estimate most fully distribution of tension in volume of a matrix.

Thus, the carried-out analysis showed that for production of compound feeds it is possible to carry a research of the intense deformed condition of elements of cars with optimization of the choice of material of

parts of a press to the main directions of further researches of cars, improvement of manufacturing techniques of parts for a possibility of production of such device in small farms, the development of recommendations about decrease in the cost of production and to decrease in labor costs on their production.

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UDC 621.91.04

LABORATORY TESTS OF THE IMPROVED DESIGN OF THE BLOCK-MODULAR FACE MILLING CUTTER

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The results of laboratory tests of the advanced design of the block-modular face milling cutter are presented. Conclusions about the operability and tool life, based on the obtained wear values of the cutting inserts were made.

The analysis of the design of prefabricated face milling cutters by the world's leading manufacturers shows a tendency to use structures consisting of interchangeable structural modules. The interchangeability of structural modules is ensured by the unification of the basic connecting surfaces (cutting inserts in cutting blocks, cutting blocks in the cutting tools body, cutting tools for fixing in the spindle of the machine). It allows in a short period of time to assemble and adapt cutting tools to the production of new products and new technological processes. When using the modular principle, the flexibility of the plant's tool system increases, the productivity and reliability of the tool, and the operating conditions are improved through the use of optimal designs and the reduction of their variety. In addition, the modular design reduces the time and complexity of developing a new tool with the available standard unified modules.

On the department of technology and equipment of machine-building production, a block-modular face milling cutter with a unified cutter block was designed and manufactured [1, 2]. The efficiency and reliability of the developed design is considered in [3, 4]. At the same time, based on the results of the experimental research of the developed design of the block-modular face milling cutter, recommendations were given on the possible improvement of the tool design resulting in the design of a block-modular face milling cutter with cutting blocks "drowned" into the tool module to increase the rigidity and accuracy of the mill.

A variant of the design of the block-modular face milling cutter is proposed (Figure 1). The peculiarity of this design is that the cutting block 1 is "drowned" in the body module 3 and the block is installed on two cylindrical surfaces, which allows, firstly, to increase the rigidity of the block-modular face milling cutter during processing, and secondly, to increase accuracy of processing due to more accurate installation of the cutting blocks in the body module.

Laboratory tests of the experimental sample of the block-modular face milling cutter were carried out in accordance with the recommendations of GOST 23726 and GOST 26595 [5, 6].

At laboratory tests of the improved design of the block-modular face milling cutter, the following cutting conditions were used:

- feed $S_M = 210$ mm/min;
- depth of cut $t = 0,5..3$ mm (step change 0,5 mm);
- rotation frequency $n = 400$ мин⁻¹

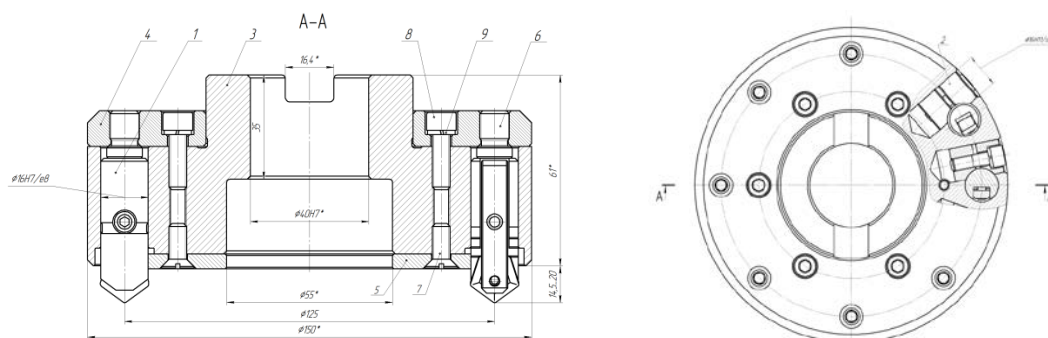


Fig. 1. The improved design of the block-modular face milling cutter

The tests were carried out on the vertical milling machine model 6R11, the material of the workpiece - steel 40H GOST 4543, the hardness of the workpiece - HB179 ... 229.

Technology, Machine-building, Geodesy

Methods of testing:

1. Carry out adjustment of the machine;
2. Install and fasten the cutting tool;
3. Set the cycle of the machine: depth of cut $t = 0,5$ mm, feed $S_m = 210$ mm/min, rotation frequency $n = 400$ min⁻¹;
4. Process the workpiece for 10 cycles on the modes of step 3 (if necessary, replace the workpiece);
5. Change the depth of cut by 0.5 mm;
6. Process the workpiece for 10 cycles with a changed cutting depth;
7. Repeat steps 4-6 until the depth of cutting is 3 mm inclusive;

Thus, when carrying out laboratory tests of the improved design of the block-modular face milling cutter with "drowned" blocks, the surface of the workpieces was processed during 60 passes of the tool, which can provide an indicative assessment of the operability and stability of this improved design.

After the end of the laboratory tests, the wear of the cutting inserts was measured. Figure 2 shows the wear values of cutting inserts.

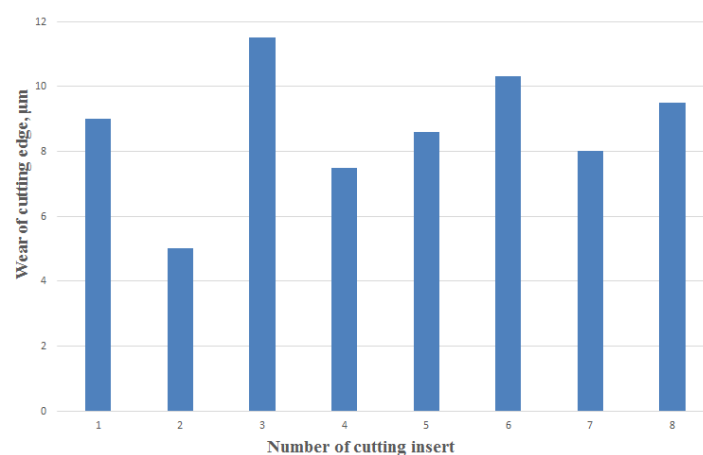


Fig. 2. The diagram of wear values of cutting inserts after laboratory tests

Analyzing the obtained values of wear of cutting inserts after laboratory tests of the improved design of the block-modular face milling cutter, it can be concluded that when machining on the cutting conditions specified in the methods of testing, this tool design remains operational for at least 130-150 minutes.

Conclusion. On the basis of experimental research, an improved design of block-modular face milling cutter has been developed and laboratory tests have been carried out. A feature of this design is that the cutting block is installed along a cylindrical surface with an stop in the bead, which increases the stiffness of the entire structure. The results of tests of the improved design showed its operability.

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UDC 533.697.5

**INVESTIGATION OF A SWITCH WITHOUT MOVING PARTS
FOR AN EJECTOR OPERATING IN A PULSATING MODE****ANTON LASHKOU, ELENA SAFRONOVA**
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The interest in the research of jet pumps is caused by their wide application in various industries; from automotive to oil refining. In oil refining, jet pumps are most often used in vacuum systems in various capacities and apparatuses, as well as for transport of various media. However, in the course of using jet pumps, a number of problems arise, for example as the need to treat wastewater in large quantities (with the use of vapor-jet systems for creating a vacuum), which is caused by the relatively high consumption of the ejecting agent due to the rather low efficiency of this type of pump. Consequently, research into the operation of jet pumps to increase their efficiency plays a very important role.

Hydro-jet pumps are devices designed to perform the process of mutual mixing of streams of active medium flow with a passive medium flow and their subsequent transportation. The passive medium can be a liquid, a gas or a slurry containing, in addition to the liquid, gaseous or solid dispersed impurities. Therefore, the external energy to hydraulic jet pumps is supplied by the working fluid.

In addition to the fact that jet pumps are characterized by high self-priming capacity, they can also pump liquids, gases, gas-liquid mixtures, slurries that can have solid impurities, aggressive media. The design itself is distinguished by the absence of movable parts, it is simple in the device, has small overall dimensions and weight and allows to be placed in hard-to-reach places, which is reflected in the operation and simplicity of feed and pressure control.

However, jet pumps, as a major problem, have a significantly lower efficiency than other types of pumps, they do not have a self-contained drive and require an extraneous source of pressure fluid to operate. In the course of operation, the jet pumps are irretrievably dumped large quantities of liquid used as an active medium.

These disadvantages can be solved by creating and using installations in which centrifugal and jet pumps are used together. Such facilities will have a set of indicators, which do not have a separate jet or centrifugal pump. This will expand the possibility of using centrifugal pumps.

Therefore, on the basis of joint application of jet and centrifugal pumps, installations can be created that will allow to change the range of performance of centrifugal pumps (that is, to increase several times the pressure or supply they create); increase the depth from which the liquid can be lifted by centrifugal pumps located above the reservoir (source); pumping slurries with solid or gaseous inclusions; create vacuum or pump out gases (jet vacuum pumps); create a gas pressure (jet compressors); to mix and dissolve liquid, solid and gaseous media and perform many other functions.

This versatile installation with jet paddle pumps will not only make full use of the advantages of jet pumps, but also will provide an opportunity to increase the efficiency of installations in comparison with the efficiency of jet pumps.

The efficiency of jet pumps has a limit, since it has losses when mixing active and passive streams. Therefore, an increase in the efficiency of installations with jet and centrifugal pumps can be achieved if a high-efficiency centrifugal pump performs a large amount of pumping work, and the jet pump performs only those technological functions that a centrifugal pump can not perform (self-priming, pumping gases or solid particles) [1].

However, there are scientific works that describe the functioning of the pumping unit in the regime of intermittent (periodic) supply of the active medium, which was air. When studying the operation of a jet pump in pulsation with liquid-gas media, the following results were obtained, namely the dependences, from which it can be seen that when pulsations are applied, the productivity by passive flow rate of the medium (air) increases. At the same time, the performance relation with different frequencies is not visible, but with a decrease in the ripple coefficient, the performance rises [2].

There was a need for a number of experimental studies, as well as a study of the effect of pulsations of jet pumps, which would reflect the confirmation of the positive results obtained, but liquid would be used as a passive medium.

The discovery in the history of the jet pump is attributed to the time of the first application of James Thompson in 1852 and the first theoretical development when mixing two Rankin fluxes in 1870 and Lorentz in 1910.

Transportation of media in various aggregate states is used more and more in industry.

In recent years, the jet pump, shown in the figure below, also known as the ejector, has grown in popularity as a different source for transportation systems. For example, hundreds of jet pump systems have been installed in industry around the world since the early 1970s [3]. The figure below shows the design of the ejector.

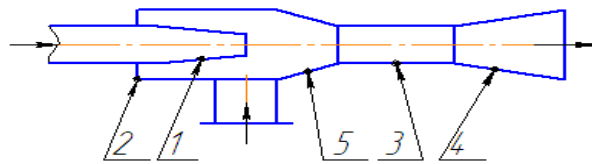


Fig. 1. General configuration of jet pumps:

1 – nozzle; 2 – the suction chamber; 3 – the suction chamber; 4 – diffuser; 5 – confuser

Jet pumps (ejectors) are among the most common. If we consider that ejectors, performing certain technological functions, and operate in hydraulic systems, as a rule, continuously and for a long time, even an insignificant increase in their efficiency leads to a significant saving of energy and the working environment.

The effective use of a jet pump in hydraulic systems requires a thorough knowledge of the hydrodynamics of the working process.

However, in most hydraulic systems, ejectors operate under non-stationary conditions, for example, when starting up the system or in the process of regulation.

For example, jet pumps use the driving flow of the active medium to increase the energy of the transported passive media. As shown in Figures 1 and 2, the jet pump consists of a nozzle to create a high-speed jet that feeds the active medium of the suction chamber associated with the raw chamber, the confuser and the mixing chamber (collector), the diffuser (sprayer) that communicate with the system [3].

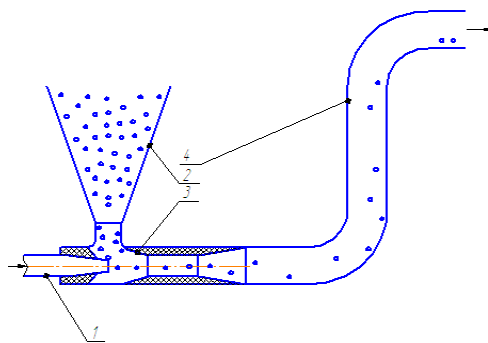


Fig. 2. Typical transmission scheme using a jet pump:

1 – supply of active medium; 2 – submission of passive medium; 3 – location of mixing flows;
4 – pipeline system of fluid motion

The principles of operation are based on fluid dynamics and are very different from other types of pumps (for example, a centrifugal pump): the jet of active (high-pressure) medium rushes from the nozzle into the working chamber and carries with it a passive (low-pressure) medium from the receiving chamber. In the working chamber, the active jet, mixing with the passive flow, transfers some of its energy to it. As a result, the total head (specific mechanical energy) of active molasses increases, while the active molasses decreases. In the diffuser, the dynamic head (velocity) is partially converted into static head. The diffuser reduces the speed and converts the kinetic energy, and at the output it provides less energy loss. Consequently, the flow is sucked out under the action of an active driving medium [4].

The jet - the working organ is the same as the piston in the piston pump and determines the processes occurring in the apparatus, as well as the efficiency of its operation. The peculiarity of the jet is its expiration into an air jet with a pressure below atmospheric pressure. This significantly affects the parameters of the jet (expansion angle, velocity distribution, length of the initial section).

The decisive role in the structure of the jet at the outlet from the nozzle is the air dissolved in it. Getting into the receiving chamber, where the pressure is much lower than the atmospheric pressure, the solubility of the gas in the liquid decreases, the compressed gas expands, which leads to the expansion of the jet - an increase in its diameter [4].

The passive medium can be a liquid, a gas or a gas-liquid mixture containing, in addition to the liquid, impurities of solid or gaseous particles. Mixed flows can be either phase-to-phase or single-phase, during the mixing process the state of media flows can remain unchanged, but it can also change. The flow entering the mixing process at a higher speed is called the working (ejecting) flow, and the flow entering the process at a lower speed is ejected [5].

The operating conditions of the ejectors depend also on the elastic properties of the interacting media. Under elastic properties, sills are understood as a significant change in the specific volume of the medium when its pressure changes.

As noted above, the efficiency of the jet devices increases significantly when they are operated in a pulsating mode, the pulsation mode can be realized by applying a unique switch without moving parts, which uses the Coanda effect as its operating principle.

The Coanda effect is a property of the jet to change the direction of motion due to adhesion to a nearby solid wall. The effect is as follows. A free jet, flowing out of the nozzle, carries with it particles of the environment, this leads to the formation of a secondary flow at the periphery of the jet, which additionally supports the trapped particles. If there are no walls near the jet, then the pressure throughout the stream flow region remains constant, and the jet does not change the flow direction. If a solid wall is placed near the jet, then the cross section of the jet from the side of the solid wall decreases. There is an increase in flow velocity and a decrease in static pressure near the wall. This leads to the deflection of the jet to the wall under the influence of atmospheric pressure, until the jet touches the wall and the equilibrium state arrives.

In the volume enclosed between the edge of the jet and the wall, a circulating region with a high secondary velocity and low pressure is formed. If a control signal is introduced into the low pressure region, this area begins to increase, the zone of sticking the jet to the wall will move along the stream, moving away from the additional channel.

When the control flow becomes equal to the switching rate, there will be a separation from the wall, which will ensure a change in the direction of its flow.

This happens as follows. In Figure 3, the jet P_n emerging from the nozzle 1 flows along the wall 4 in which there is a control channel 2. In the absence of a control pressure P_y in the channel 2, the jet of air flows along the wall 4 and enters the channel 3. With a gradual increase in the pressure P_y direction jet does not change. Then, at some increased value of P_y , the jet breaks away from the wall 4 and jumps to channel 5 abruptly.

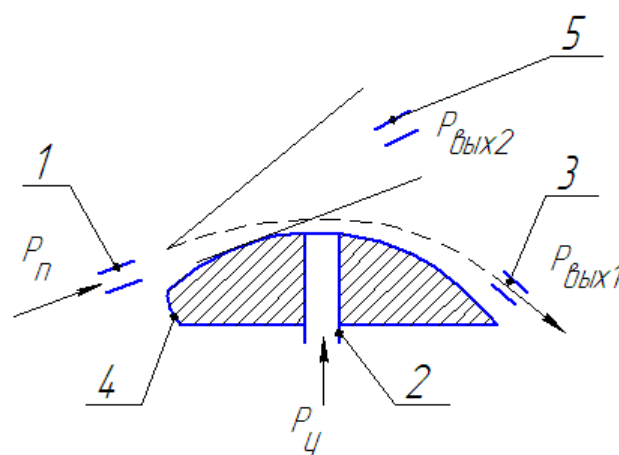


Fig.3. Jet Element with Jet Adhesion

Below is a simple description of the operation of a switch operating according to the Coanda effect principle [6]:

Step 1. The left channel is filled to the point 3, after which the flow switches to the right channel.

Step 2. Simultaneously, the following processes occur: the right channel is filled with liquid to point 2; liquid from the left channel during this time flows into the mixing chamber and creates a piston - call it a small piston; The liquid in the right channel continues to move to point 3 and switches to the left channel. While the liquid flows between points 2 and 3, an air bubble forms in the mixing zone.

Step 3. Simultaneously, the following processes occur: the left channel is filled to point 3, after which the flow switches to the right channel; the liquid in the right channel flows partially into the mixing zone, creating a regular piston; The previously created piston moves down. Between the pistons created by the liquid, air bubbles are created.

Step 4. Simultaneously, the following processes occur: the right channel is filled with liquid to point 2, the liquid from the left channel during this time flows into the mixing chamber, merging with the liquid from the right channel and creating a large piston; Previously created in the mixing zone, the pistons move lower; The liquid in the right channel continues to move to point 3 and switches to the left channel.

Next, steps 3 and 4 are repeated, creating a piston motion in the mixing zone. From the description it can be seen that the different lengths of the switch channels contribute to the formation of air bubbles in the mixing zone [6].

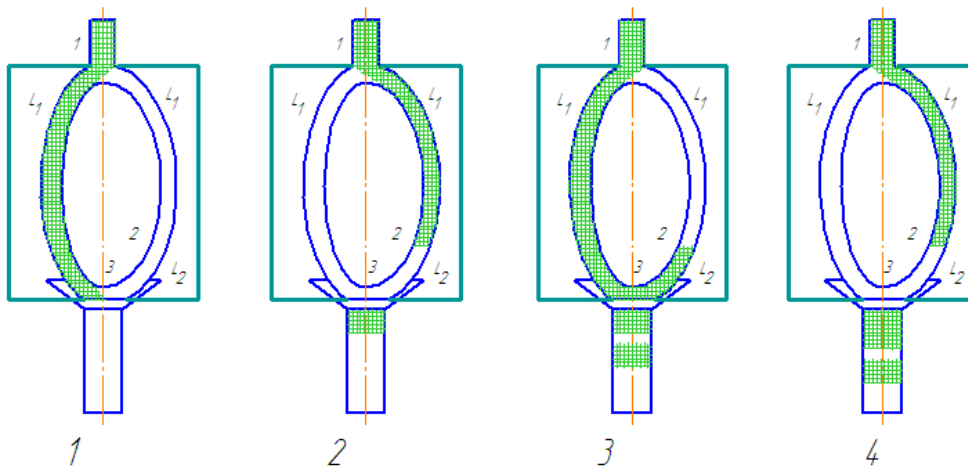


Fig.4. The simplest model of operation of the jet switch

Efficiency of the ejector is estimated mainly by means of the ejection coefficient, which is calculated by the following formula:

$$K_e = \frac{Q_{II}}{Q_A}$$

where Q_A is the volumetric flow rate of the ejecting flow (active), m^3/s ;

Q_{II} - volumetric flow rate of the ejected flow (passive), m^3/s .

The efficiency of the application of the pulsation regime in the process of ejection is described in the source [5]. The organization of the pulsation regime allows to increase the ejection coefficient by reducing the flow rate of the ejected flow at a constant flow rate of the ejecting flow, however, the complexity of the flow and the appearance of phase transitions due to physical processes during the ejection process complicates a fairly accurate simulation of this process.

In consequence of the above, it should be concluded that it is useful to study the application of the pulsation regime for the ejection process. The organization of the ejection process thus allows not only to reduce the consumption of sewage generated during the operation of vacuum-creating systems, but also to reduce the power of pumps used in conjunction with ejectors in the organization of technological processes. The use of such a switch has a wide practical significance, both from the ecological point of view and from the technological point of view.

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BROADBAND ANTENNAS

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This article shows the different types of broadband antennas, their main characteristics and disadvantages are also shown.

An antenna design is selected that most satisfies the broadband condition. Any radio engineering installation intended for radiation or reception of radio waves contains an antenna. The transmitting antenna can be defined as a device designed to emit electromagnetic waves. The receiving antenna is a device used to receive electromagnetic waves to use the information transmitted by these waves. The requirements for the antenna are different depending on the destination of the radio station [1]. Currently, there is a need for antennas for mobile communication, for navigation GLONASS Navstar, for communication with satellites, for communication with aircraft and other mobile objects. This requires the development of broadband antennas in the frequency range from the middle of the decimeter range (800 MHz) to the middle of the centimeter range (9 GHz).

In Fig. 1 shows one of the simplest broadband antennas – a broadband vibrator.

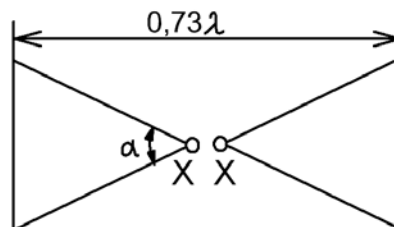


Fig. 1. Broadband vibrator

In this case we are talking about a wave vibrator which, due to the fact that its elements expand at the ends, has an extremely high bandwidth. Due to the increased influence of the edge capacitive effect the total length of the antenna is only $0,73\lambda$. The input resistance depends on the angle α . Sometimes broadband vibrators are placed one above the other or in front of the reflex grating, which provides additional focus radiation in the vertical and horizontal planes [3]. Lack of vibrator antennas – low efficiency.

Spiral broadband antennas are more effective Fig. 2. The spiral antenna differs from other antennas possessing directional radiation, primarily in that its radiation field has a circular polarization. In the case of using such antennas, it is necessary that both the transmitting and receiving antennas have a circular polarization of the radiation.

Circular polarization takes place when the conductor is wound in the direction of radiation in the form of a spiral, and it is necessary that the total length of the conductor in one turn equals 1λ , which corresponds to the coefficient of shortening of the diameter of the turn D equal to approximately $0,31\lambda$. It is assumed that at least three turns are used to obtain circular polarization, since the more turns the antenna has, the closer the polarization will be to the circular. A simple spiral antenna radiates in both directions in the direction of its axis. To obtain one-sided radiation and increase the antenna gain, a disk reflector is used.

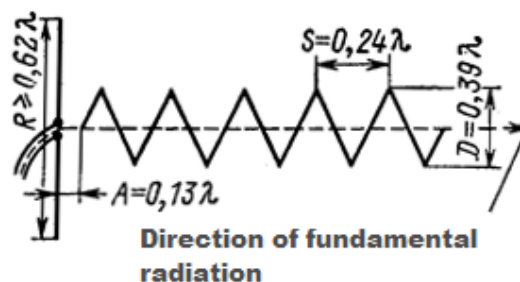


Fig. 2. Schematic representation of a spiral antenna

The spiral antenna has a wide bandwidth. With a distance between turns $S = 0.24 \lambda$ and the assumption of the maximum standing wave ratio in the power line ($VSWR = 1.35$) the ratio of frequencies within which the antenna operates satisfactorily is 1: 1.6 [3].

Logarithmic periodic antennas work best in a wide range of waves. Logarithmic periodic antennas are a relatively new design of broadband directed antennas. The greater bandwidth of the antenna combined with the significant gain is achieved due to the large consumption of structural materials, therefore the use of a logarithmic antenna only for radio amateur bands is usually impractical, but it is used as an all-wave antenna for television reception, including both amateur bands of 2 m and 70 cm. A characteristic of a logarithmically periodic antenna is that it consists of a plurality of elements connected in parallel [3].

The number of construction materials can be reduced using flat logarithmic spiral antennas. A flat logarithmic helical antenna is an electrodynamic system consisting of two flat curvilinear metal plates excited by a high frequency generator. The plates are called the shoulders of the antenna. The edges of each arm are defined by two identical logarithmic spirals, one of which rotates relative to the other by some fixed angle δ . This turn allows you to get a shoulder of finite width.

The equations of spirals for one arm in polar coordinates have the form:

$$\begin{aligned}\rho_1 &= \rho_0 \exp(\alpha\phi); \\ \rho_2 &= \rho_0 \exp[\alpha(\phi - \delta)]\end{aligned}$$

where ρ_1 , ρ_2 and ϕ – current polar coordinates; ρ_0 , α and δ positive constants.

The second arm of the antenna is identical to the first and rotated relative to it by 180° . The ratios of the radius vectors defining the edges of the shoulders are constant. Flat logarithmic spiral antennas belong to the class of frequency-independent antennas. To clarify this property, consider the curve that determines the shape of one of the edges of the antenna arm. We first note some features of the logarithmic spiral. The angle α formed by the radius vector ρ and tangent to any point of the helix is a constant value. Therefore, such spirals are also called conformal. As the angle ϕ is increased by one complete revolution, the radius vector ρ increases by a factor of $e^{2\pi\alpha}$. Thus, the dimensions of each subsequent turn of the logarithmic spiral differ from the previous only by a constant factor. The characteristics of the antenna remain unchanged if, with a change in the wavelength, all the dimensions of the antenna are proportionally changed. Influence of the shape and materials of which the antenna is made on its characteristics is shown in [4, 5]. The lower frequency of the working range of a logarithmic spiral is limited by the length of the helix arm, the upper frequency by the design in the region of the antenna feed points. In real antennas the ratio of these frequencies reaches 20. The large range of such antennas is explained by the following. The electromagnetic field along the antenna arms due to effective radiation rapidly decreases (by about 20 dB at a distance of one wavelength). As a result, with an increase in frequency, the active length of the shoulder decreases, a kind of automatic "cutoff" of the acting length of the shoulder occurs. This cutoff ensures the constancy of the relative dimensions of the radiating part of the spiral at different wavelengths and, consequently, the greater antenna range [1].

Conclusion. The characteristics of antennas operating in a wide frequency range are compared. The results of the comparison are as follows: vibrator antennas are low-efficient; spiral antennas are better, have an overlap factor = 2; Logarithmic periodic antennas require a large flow of structural materials; the most effective and economical are flat logarithmic spiral antennas with one-sided radiation, the overlap factor of which reaches up to 20.

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THE SPREAD FREQUENCY MODULATED SIGNALS TYPE OF ANISOTROPIC PLASMALIKE TYPE

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Introduction. The solution of the problems of interaction of electromagnetic wave (EMV) and hydrocarbon Deposit (UVZ), located on the background of heterogeneous and polyphase medium is due to the complex physical processes over hydrocarbon deposits, their occurrence conditions. Until recently, the electrodynamic description of the underlying inhomogeneity was reduced to its representation in the form of "a body with finite conductivity immersed in a medium with losses".

Currently, there are several physical models of hydrocarbon deposits, taking into account the migration of hydrocarbons in the environment above the deposits to the Earth's surface. In this case, the influence of electromagnetic signals on such formation can be described as single – resonance and multiresonance interaction [1–3].

In modern intelligence there is a tendency of emergence of new methods connected with complication of techniques and technologies which seek to reduce time of certification of the controlled surface and to increase quality of operational characteristics [4]. A greater number of proposed methods have no theoretical justification, sometimes contrary to the canons of physics. All this requires a thorough analysis of the physical processes occurring over the hydrocarbon field, concretization of its electrodynamic model to justify the interaction of EMF with the Deposit.

The aim of this work is to develop electromagnetic methods for searching anisotropic plasma-like media (ASPT) on the basis of the studied characteristics of the surface impedance of media in the mode of frequency-modulated (FM) signals.

The interaction of the computer with ASPT. Studies on this topic are presented in [5]. However, the peculiarities of interaction between EMV with UVZ in this mode impacts require further analysis.

The investigated carbon can be represented as an anisotropic inhomogeneity on the communication path [6].

In General, the spatial orientation of the external normal to the interface of the media and the wave vector \vec{k} EN is arbitrary (figure 1) and the process of interaction of the EMF with the local inclusion on the RRV path can be represented as a mode of inclined plane wave incidence with vertical polarization to a boundless surface with an anisotropic impedance (in the approximation of large characteristic sizes of inhomogeneity in comparison with the wavelength of the probing signal) [2].

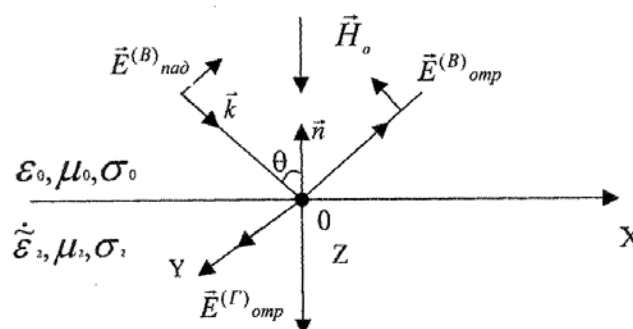


Figure 1. Geometry of the problem for EMV with vertical polarization of the field

Then the impedance boundary conditions give:

$$\begin{aligned}
 E_x &= -Z_0(\dot{Z}_{11}H_x - \dot{Z}_{12}H_y), \\
 E_y &= -Z_0(\dot{Z}_{21}H_x - \dot{Z}_{22}H_y), \\
 \dot{Z}_{11} = \dot{Z}_{22} &= -\frac{1}{j2\sqrt{\epsilon_R\epsilon_L}}(\sqrt{\epsilon_R} - \sqrt{\epsilon_L}), \\
 \dot{Z}_{12} = \dot{Z}_{21} &= \frac{1}{2\sqrt{\epsilon_R\epsilon_L}}(\sqrt{\epsilon_R} + \sqrt{\epsilon_L}),
 \end{aligned} \tag{4.2}$$

where $E_{-}(x,y)$, $H_{-}(x,y)$ – projections of the incident and reflected waves on the corresponding coordinate axes;
 Z_0 is the characteristic resistance of the medium surrounding anisotropic inhomogeneity.

Results of the study of surface impedance. With the help of Matlab software the analysis of frequency components of the surface impedance of the medium over UVZ is carried out at the change of parameters of PM, the variation of which extends the functional dependence of the resistance components on modulation modes and allows to increase the informativeness of the developed methods for searching UVZ.

The frequency dependences of the impedance boundary conditions on the segment from 105 Hz to 1010 Hz are investigated, the influence of the frequency modulation index and the modulating frequency on the surface impedance characteristics is considered.

Calculation of surface impedance components (4.2) was carried out on the basis of experimentally obtained data over hydrocarbon deposits: dielectric permeability of host rocks $\epsilon_r = 1$, specific electrical conductivity $\delta_r = 0,3 \text{ C/m}^2 / \text{m}$; effective frequency of collisions: electron-ion $u_e = [10^9]^{-1} \text{ c}^{-1}$ and ionic $u_i = 0,5 \cdot [10^7]^{-1} \text{ c}^{-1}$ [5].

Figures 4.2 and 4.3 show the frequency dependences of the component Z_{11} . To highlight the HS-levothrodi deposits in part of the impedance Z_{11} can recommend the following frequency: $1,15 \cdot 10^8 \text{ Hz}$ and $1,45 \cdot 10^8 \text{ Hz}$ ($At=0,5$).

For the frequency modulation index $b = 1$ the input impedance is characterized at frequencies of $9,8 \cdot 10^7 \text{ Hz}$ and $1,2 \cdot 10^8 \text{ Hz}$. When increasing the modulation index to $H = 10$ is offset from the points of extremum of the Z_{11} to the left. At a frequency of $9,8 \cdot 10^7 \text{ Hz}$ the module is 0,2, and at a frequency of $1,2 \cdot 10^8 \text{ Hz}$ the module is 0,25.

The increase in index world Cup leads to the fact that the extremum at frequencies of $0,54 \cdot 10^6 \text{ Hz}$ and $0,98 \cdot 10^7 \text{ Hz}$ vary insignificantly in comparison with the smaller values of the index of frequency modulation. The following frequencies of $1,1 \cdot 10^6 \text{ Hz}$ and $1,38 \cdot 10^8 \text{ Hz}$ (at $B = 15$) can be recommended for the allocation of hydrocarbon deposits on the impedance component $|Z_{11}|$. For the frequency modulation index $B=25$ at frequencies $0,50 \cdot 10^6 \text{ Hz}$ and $0,94 \cdot 10^7 \text{ Hz}$ and for the frequency modulation index $B=50$ there is an offset of extreme points $|Z_{11}|$ to the left.

At a frequency of $0,96 \cdot 10^7 \text{ Hz}$ the module is equal to 0,22, and at a frequency of $0,48 \cdot 10^6 \text{ Hz}$ the module is equal to 0,175. The increase in index world Cup leads to the fact that the extremum on the frequency is $0,94 \cdot 10^7 \text{ Hz}$ and $0,90 \cdot 10^7 \text{ Hz}$ vary insignificantly in comparison with the smaller values of the index of frequency modulation.

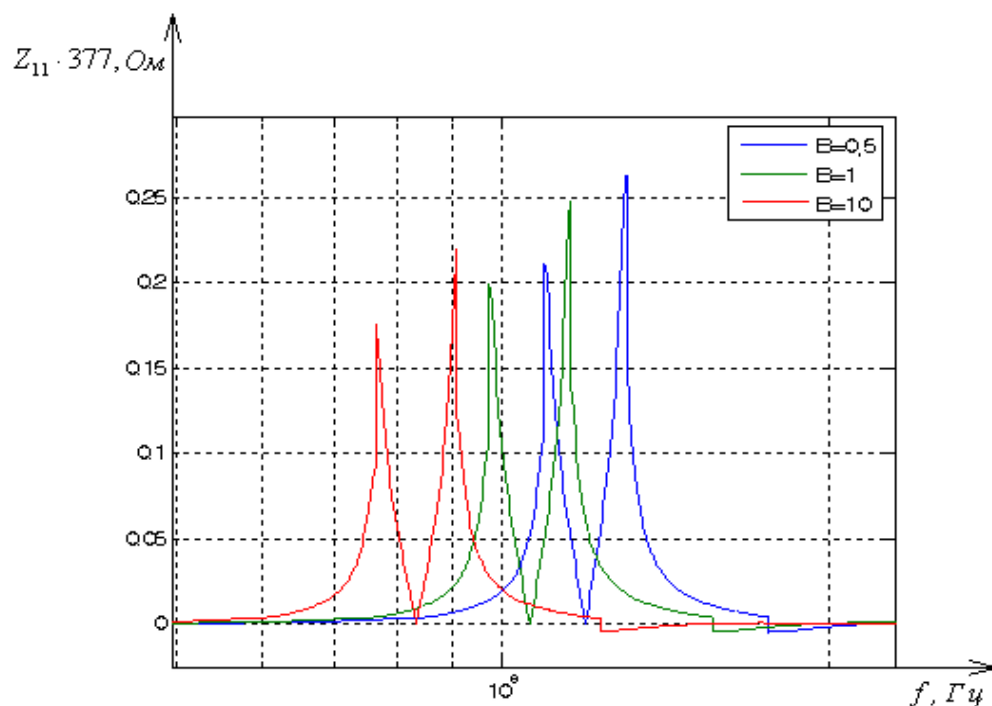


Fig. 2. Dependencies $Z_{11} = \psi(f)$: 1 – for $B=0,5$; 2 – for $B=1$; 3 – for $B=10$

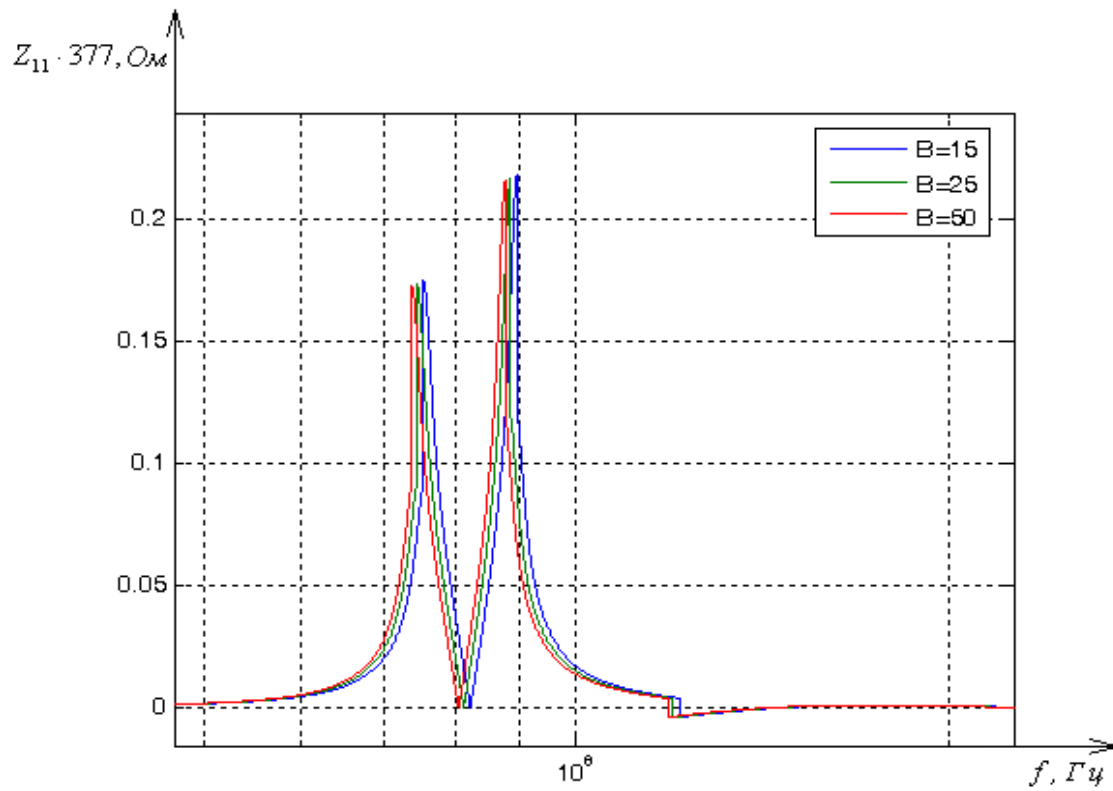


Fig. 3. Dependencies $Z_{11} = \psi(f)$: 1 – for B=15; 2 – for B=25; 3 – for B=50

The frequency dependences of the component Z_{12} are shown in figures 4.4 and 4.5.

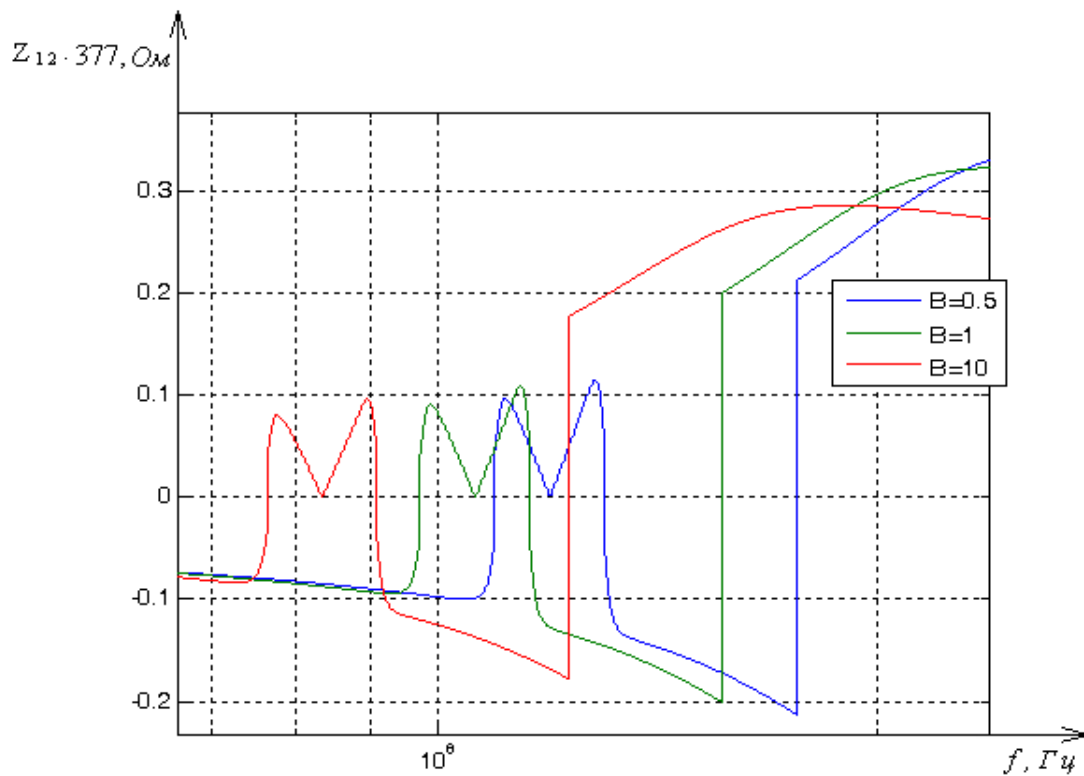


Fig. 4. Dependencies $Z_{12} = \psi(f)$: 1 – for B=0,5; 2 – for B=1; 3 – for B=10

The value of the component of the surface impedance Z_{12} is virtually unchanged in the frequency range from 105 Hz to 108 Hz. At a frequency in the range from 100 MHz to 180 MHz there is a sharp surge to values of 0.28-0.35. The variation of the index B in effect on the interval of frequencies from 100 KHz to 1 GHz. Lower values of index B correspond to higher values of Z_{12} and higher values of the frequency at which the growth of surface impedance is observed.

The value of the component surface impedance $|Z_{12}|$ / virtually unchanged in the frequency range from 105 Hz to 108 Hz (at $B = 15 - 50$). At a frequency of 300 MHz there is a sharp surge to the values of 0.17. The variation of the index B in effect on the interval of frequencies from 100 KHz to 1 GHz.

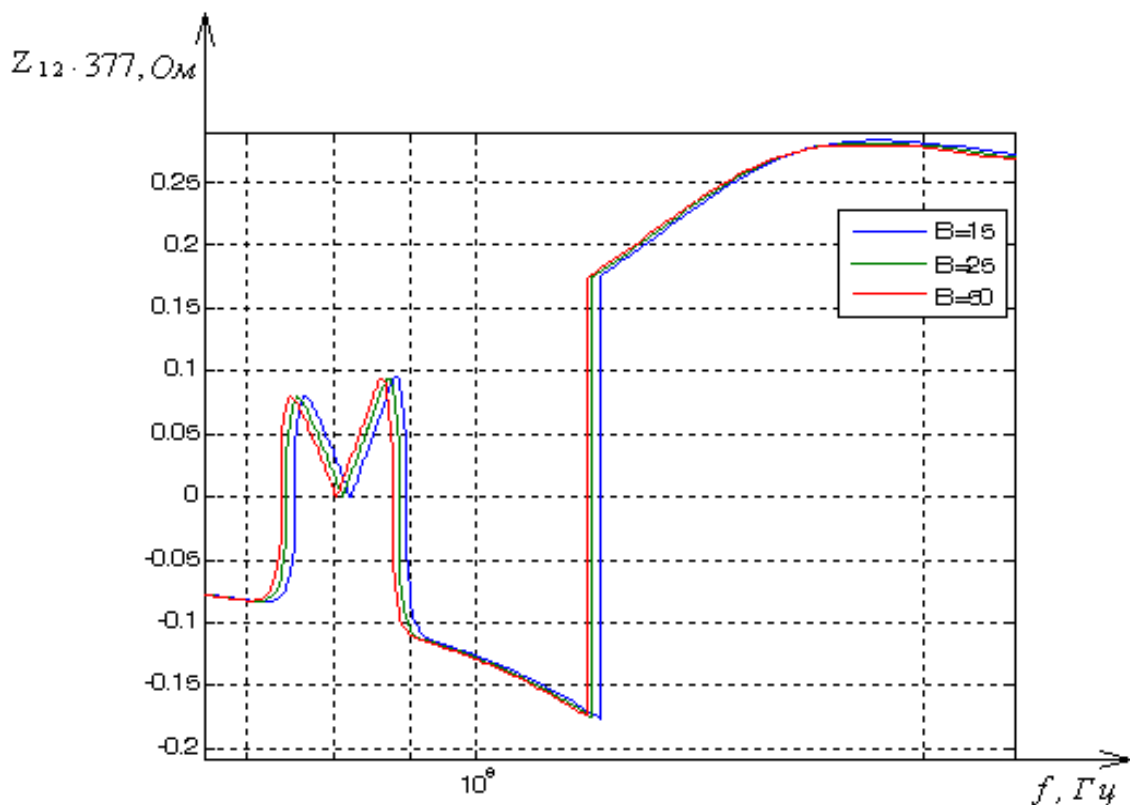


Fig. 5. Dependences $Z_{12} = \psi(f)$: 1 – for $B=15$; 2 – for $B=25$; 3 – for $B=50$

Lower values of index B correspond to higher values of Z_{12} and higher values of the frequency at which the growth of surface impedance is observed.

The impedance of the plasma-like layer under study is a complex value. Thus, the analysis is reduced to a separate study of the amplitude and phase characteristics of the surface impedance. The analysis of the amplitude characteristics of the surface impedance was carried out in this paper. The quantitative manifestations of these effects are determined by the physical and geological properties of oil and gas fields: chemical and mineralogical composition of the layers, structural and textural features of the skeleton, the nature of porosity and permeability, the percentage content of constituents, the characteristics of the mechanical properties of the skeleton, the amount of formation water in pores, its mineralization, etc., so in terms (4.2) it is necessary to take into account the amendments to these characteristics.

Conclusion. The paper identified the values of the components of the surface impedance of aspt, in which the Deposit of hydrocarbons was selected. The propagation of electromagnetic effects ' above the accumulation mode in the FM signal. The analysis is carried out in the impedance-frequency range of probing signals. Various modes of application of FM modulation are considered. The obtained results of interaction of PM signals with the environment over UVZ can be applied to the development of RTS of oil and gas deposits search and qualitative improvement of geological exploration performance.

The analysis of the surface impedance of the environment on the Uralvagonzavod, the largest of which can evaluate the characteristics of the antennas having a fixed position in space relative to the boundary line when you change the properties of the underlying surface, which gives the possibility to quantify the properties

of the medium, without resorting to the exact calculation of the changes of the electrodynamic parameters of the underlying surface.

The results of the study can be used to develop new electromagnetic methods for search and contouring of UVZ.

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UDC 544.725:66=111

STRUCTURES OF FILTER MEDIA AND MECHANISMS OF FILTRATION

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Separation systems are a vital part of most industrial processes. These systems account for a large fraction of the equipment and operating costs of industrial processes. Inorganic membranes have the potential for providing separation systems that can reduce both equipment and operating costs. Some optimistic thoughts will be given on how several industries can be operationally and economically revolutionized with inorganic membranes systems.

How efficiently a filter medium causes the separation of finely divided solids from a liquid or a gas depends on many variables. The first variable that usually comes to mind is the size of the pores in the medium. How important is a pore size? What do we mean by a pore size?

Some investigators have studied the efficiency with which a single fiber held in a gas stream captures particles from that stream. It follows that the more fibers you have, the greater the number of particles captured. Indeed, where fibrous mats are used to separate particles from a gas, the particles separated are much smaller than the distance between fibers. That is, the particles captured are much smaller than what we call pores.

The efficiency with which a filter medium separates particles from a fluid depends on the internal surface of the medium with which a unit volume of fluid comes in contact. Yet, given this surface-to-volume ratio, filtration efficiency also depends on the viscosity of the fluid and the temperature (independent of viscosity), the velocity of the fluid, and the affinity which the particles have for the material of the filter medium. This affinity, or repulsion, also depends on the material of the fluid.

With this list of variables, it should be clear that pore-size measurements cannot be made from filtration tests. The most obvious reason is seen in considering two media of the same material and the same pore-size distribution, but different thicknesses. In this situation the thicker medium will be a more efficient filter. The investigator who deduces pore sizes from filtration tests can be led astray.

There does remain the view, however, that under some conditions, filtration is a sieving operation, in this case pore size does loom high in interest. For example, a medium which is very efficient at filtering small particles from a gas is much less efficient at filtering those particles from a liquid, especially a highly viscous liquid. Liquid-borne particles, smaller than pores, when passing through the medium, tend to remain in the liquid stream, whereas in the less viscous gas stream, the particles are much more likely to find the pore wall. Once the particles touch the wall, where fluid velocity is nil - in laminar (viscous, or Poiseuille) flow - they fairly well stick there. Thus, where a filter medium is to separate small particles from a liquid, the pores must be smaller.

Sieving is the operation we have in mind when we want to make sure certain size particles or microbes are stopped, regardless of such variables as fluid velocity and viscosity.

The first thing to understand about fine filter media is that the length of the average-size pore is hundreds of times greater than the diameter. Of course, some media are relatively thin, being supported on a coarse (large-pore) support. But even then the length of the pore is greater than the diameter.

The present discussion is limited to those filter media composed of a random array of building blocks, specifically, three kinds: mats of fibers; sponge like membranes (manufactured by solvent-cast methods without surface skins); and membranes manufactured by stretching a solid plastic sheet so that as the sheet opens, it creates fibers emitting from clusters. Further, this discussion is limited to homogeneous media. That is, no matter where we inspect a plane in the medium (perpendicular to the flow of fluid). We see the same pore-size distribution.

The size of a pore in this plane is expressed as a linear measurement and generally means diameter. Yet that meaning depends on the method of measurement understanding that the pore is not a circle. For example, the measurement may be the square root of the cross-sectional area, or it may be the ratio of area to perimeter.

On moving from this Flatland (Abbott 1963), two-dimensional view, and moving into threedimensions to better address pore geometry, we see two concepts.

In the case of the spongelike membranes, Williams and Meltzer (1983) view the structure as skeletons of polyhedra. Where two skeletons touch with a common face, the opening in that face is a pore. The diameters of

the polyhedra are larger than the diameters of the pores. And, of course, there exists a distribution of both kinds of diameters.

The statistical view of a pore tunnel that passes through this filter medium is really not different from that of a tunnel in a fibrous mat. That is, the diameter of the tunnel varies along the bending length; and if we consider only sieving filtration, then we view this scenario:

A single particle (or microbe) approaching the face of the medium may be stopped on the surface if it hits the surface at a spot where there is no pore, or the pore is smaller. On the other hand, the particle may encounter a large pore, which it enters and then travels through to a depth before it is stopped by a choke point in the tunnel.

In the case of fibrous mats, or those stretched membranes resembling fibrous mats, a three-dimensional view is explained by considering that the medium is composed of many theoretical, thin layers, with some finite space between layers. The pore-size distribution in one layer is the same as the next; however, a large pore in one layer does not necessarily lie in the same spot on the next layer.

Both of these three-dimensional views allow us to understand somewhat how a fluid divides into many different-diameter streams when it flows through a filter medium. Of course, each stream likely divides and rejoins with itself or another stream. Yet, referring to what we said earlier, we can envision an average stream within the medium, so that we can speak of an average diameter and an average length.

The view of a pore-size distribution we obtain with a microscope, on inspecting the face of a filter medium, is the number distribution. We make a list or a plot of pore diameter versus the numbers of pores of each diameter. From that we deduce a number-average pore diameter. If now we consider the cross-sectional area of a pore (a function of the square of the diameter) and view each pore as having unit depth, we can deduce the volume-average pore diameter.

In conclusion, while some conditions of filtration may approach a sieving operation, most filtration processes consist of particles falling into the depth of the medium before they are stopped. This means that the efficiency with which particles are stopped depends not only on a pore size (whatever that means), but also on many other variables, such as the thickness of the medium, the velocity of the fluid, the viscosity, the temperature (independent of viscosity), and the affinity, or the repulsion, that particles (or microbes) have for the pore walls and for the fluid.

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UDC 912.4+94

STUDY OF RELIGIOUS AND OTHER OBJECTS ON HISTORICAL AND MODERN MAPS OF THE TERRITORY OF POLOTSK REGION WITH THE USE OF GEOINFORMATION SYSTEMS

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The article presents the results of continuing work on the formation of information layers of different objects (e.g. religious objects, inns, etc) on the territory of Polotsk and surrounding territories on historical and modern maps.

Introduction. Historical maps are a unique source of information about the natural and socio-economic conditions of a population of a certain historical period. Analyzing historical maps for certain historical dates, a series of different historical maps can help to assess the living conditions of the population and development of territories and their consequences, study the principles of settlement, the past of modern settlements, to estimate the rates of their development, to study known trends of historical periods on the example of a particular region.

Polotsk is the oldest city in Belarus and therefore is a very interesting target of historical research. At the same time, a number of historical cartographic materials are known to this territory. Among them are two plans of Polotsk from 1579, the plan of Polotsk from 1707, the reconstruction plan of the 16-17th centuries, the plan of 1779, the recovery plan of the city of 1778, two plans of the 18th 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 Bernardine depicting Polotsk of the middle of the 16th century [1-3]. This cartographic material allows tracing the development of the city and its environs for a long period, with a sequence of historical maps at fairly uniform time intervals.

Paper [11] presents general principles for analyzing historical maps on the territory of Polotsk and its environs, the procedure for the formation of a spatial raster base, the method of georegistration and transformation, the results of studying some changes in the area of Polotsk, etc.

One of the most time-consuming and critical steps is georegistration and transformation of the original raster data. The creation of a raster spatial base was performed earlier and presented in [11]. The presence of a spatial raster base - a series of georegistered historical maps – makes it possible to expand the research to study individual groups of objects, for example, religious objects (churches, cemeteries), inns, etc.

Methods of research. Current work involves historical maps for an area of approximately 500 km² (20 x 25 km) near the city of Polotsk. The maps of 1790, 1861, 1910, 1939, 1989 and 2015 as well as the plans of Polotsk of 1707, 1778, 1838 are used. OpenStreetMap [4] data as well as Public land-information map of the Republic of Belarus [5], Public cadastral map of the Republic of Belarus [6] are used as modern cartographic data. Historical maps are taken from the Internet [7–9]. Scale range of maps of 18 – 20 centuries is 1: 84 000 – 1: 200 000.

Current study involves the following steps. First of all, a spatial raster base is created. The work is carried out using QGIS software. Maps are registered in WGS-84 coordinate system. OpenStreetMap [11] data is used as a base map.

In the following step, digitizing of objects of interest is carried out. For this purpose, vector layers were created for the following raster maps: 1790, 1861, 1939 and 1989. The following vector layers are formed:

- polygonal (settlements, forest, hydrography),
- linear (road network) [11],
- point layers: temples and sacred objects and inns.

Then the joint analysis of multilayers, qualitative and quantitative data analysis are done.

Results. Religious objects (temples, prayer houses, churches) are subject to digitizing and accounting at the point layers "churches". There is a number of churches which were skipped.

Polotsk is constantly expanding its urban area. Therefore, it is impossible to avoid violating the cultural layer. So in the microdistrict "Airodrome" during the construction of communications the builders came across an old cemetery. The "Mikhailovskoye" cemetery, where St. Michael's Church was located, was previously in this place. During the First World War about five thousand soldiers and officers of the Imperial Army were buried here. In the 1920s the church and cemetery were demolished due to the expansion of the airdrome. This airdrome was established in 1916 during the First World War, next to the Mikhailovsky and military cemeteries. "To the north-west of the town between Zapalotse and Pahirshchyna a big cemetery was located. It derived its

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name from a cemetery church in honour of Michael the Archangel. The cemetery was Uniat. It is known that a timber church was already here in the XVII century. In 1811 stone church in a Baroque style was built. In the early XX century that was the biggest Christian cemetery in the town" [10]. (*the translation is ours - Dzmitry Kalugin, Maryna Valoshyna*)

In Ekimany there was a church of St. George the Victorious (1737-1950s).

The inn is a room for lodging with a courtyard for horses and carriages of travelers, usually with a tavern. The inns were usually located on the most important transport routes. In the vicinity of Polotsk there were several such yards too. In Figure 1 there is a fragment of the map of 1861. A circle with flags near the village of Kozyi Gorki shows the location of the inn existing at that time. In addition, on the fragment there are churches marked as a circle with a cross and a shaded circle with a cross, defining timber and stone churches respectively. Figure 2 shows the fragment of the map of 1861 with inns (marked with an asterisk) near Polotsk.



Fig. 1. Fragment of the map of the 1860s (Schubert maps)

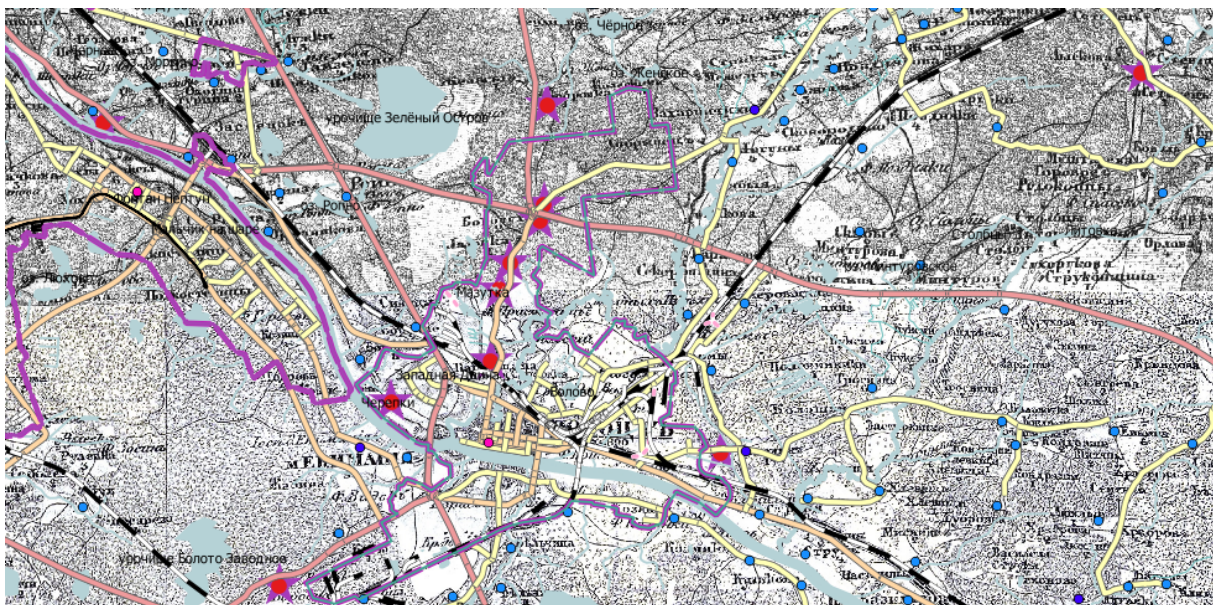


Fig. 2. Map of inns located near Polotsk

Discussion and conclusion. The system of symbols on historical maps allows performing an analysis of the availability and location of various objects. So, on the maps of Schubert there are settlements, grounds, temples and signs of sacred images, factory buildings, roads, road structures, water objects and structures on them, bridges, geodetic points, borders, etc. Types and categories of mentioned objects are also presented and therefore can be analysed.

When analyzing historical maps, it should be remembered that the map is the result of the work of a cartographer and has a subjective nature. In addition, the order of mapping, designing, generalization principles, projections, coordinate systems, symbols, manufacturing technology are significantly different for different historical periods and historical maps. And one should keep it in mind when reading a particular map and conducting joint analysis of maps of different historical periods.

Conversely, the analysis of different historical and modern maps makes it possible to study the principles of drawing up maps of a certain time period in more details.

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ANALYSIS OF FACTORS AFFECTING THE SIZE OF WATER DROPLETS IN THE EMULSION

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It is proposed to utilize oil-containing waste by preparing emulsions based on them and then using it as an anti-adhesion coating of the working surfaces of molds to produce reinforced concrete products or additives to the main fuel for boiler houses. The following things were analyzed: the influence of the size of an intact drop of water in the emulsion, the wavelength, the dimensionless wave number, the surface tension, the average flow velocity of liquids, and the density of media on the stability of the emulsion obtained by shock waves arising from the operation of a pneumatic radiator.

Introduction. About 100 thousand tons of automobile and industrial oils are consumed annually in the Republic of Belarus. The amount of waste generated from the using of oils is 80-85% of their original volume. Annually the enterprises of the country collect and process (without incineration) only 8,300 tons of used oils, which is less than 10% of consumption [1]. Meanwhile, the world collection of used oils is 15 million tons / year (about 50% of fresh production). That is, the Republic of Belarus currently lags far behind the most industrialized countries. Although, in Western Europe about 1.2-1.4 million tons / year of oils can either be illegally burned, or simply drained into the environment [2].

The accumulation of various oil-containing waste (OCW) in enterprises, including the chemical industry, is explained by the requirements that are imposed on spent oil products intended for regeneration, purification and use in exchange or along with other petroleum products. So, according to GOST 21046-86 mixtures of used oil products intended for use as a component of boiler fuel, should have a mass fraction of mechanical impurities not more than 1%, mass fraction of water not more than 2%, in addition, they should be free from contamination. To meet the requirements of GOST, it is necessary to have expensive specialized equipment at the enterprise. This in turn, combined with high transport costs for centralized reception points for most enterprises makes collection, recovery and utilization economically impractical.

For such enterprises, it is promising to find ways of using oil-containing waste directly at the enterprise or at the enterprises of the region, preferably with minimal expenses for cleaning and processing. Therefore, it is advisable to use OCW to prepare such commodity products, for which a high degree of purification from mechanical impurities is not required, and the presence of water in the OCW is more a positive property than a negative one.

One of the possible ways of such application is the production of emulsions and emulsols based on OCW with the help of shock waves arising from the operation of a pneumatic radiator. Such studies are conducted at the Polotsk State University [3-5]. Utilization of waste involves conversion into non-hazardous compounds by emulsification and the use of emulsions obtained both as anti-adhesion coatings of the mold surfaces for the production of reinforced concrete products and as an additive to the fuel of the boiler units. The first direction will allow refusing additionally from the use of expensive industrial emulsols and lubricants, and the second - to reduce the volume of nitrogen oxides and carbon emissions with flue gases into the atmosphere due to the controlled change in the combustion process of fuel [6-8]. A serious problem for the application of this method is the preparation of an emulsion with the required stability.

Task formulation is to investigate the factors influencing the stability of the emulsion.

Results and discussion. The stability of the emulsion (the ability to maintain its original properties over the entire volume over time) is determined by the volume of the released non-emulsified substance in percent of the total volume of the emulsion [9]. The stability of the emulsion is affected by its concentration, particle size and viscosity. The sedimentation rate of water droplets v in the emulsion is expressed by the Stokes formula

$$v = \frac{2(\rho_2 - \rho_1)r^2g}{9\eta}, \quad (1)$$

where ρ_2 – density of water, kg / m³;

ρ_1 – OCW density, kg / m³;

r – radius of a drop of water, μm ;

g – gravitational acceleration, m / s^2 ;

η – emulsion viscosity, $Pa \cdot s$.

Dependence (1) shows that the droplet sedimentation rate is proportional to the square of its radius. The smaller the droplet radius, the greater the stability of the emulsion. Stability increases with the viscosity of the liquid and the friction force of the droplet shift in the emulsion. On the other hand, the stability of the emulsion is affected by the number of possible recombinations, i.e. fusion of small droplets of liquid into larger ones.

Figure 1 shows the dependence of emulsion stability on the density of OCW ρ_1 and the size of water droplets r in the emulsion. It is seen that with increasing emulsion density and simultaneous decrease in the size of water droplets in the emulsion, the stability of the emulsion increases. We can not influence the density of the OCW of the site for disassembly and cleaning of equipment, but the size of the water droplets in the emulsion can be affected.

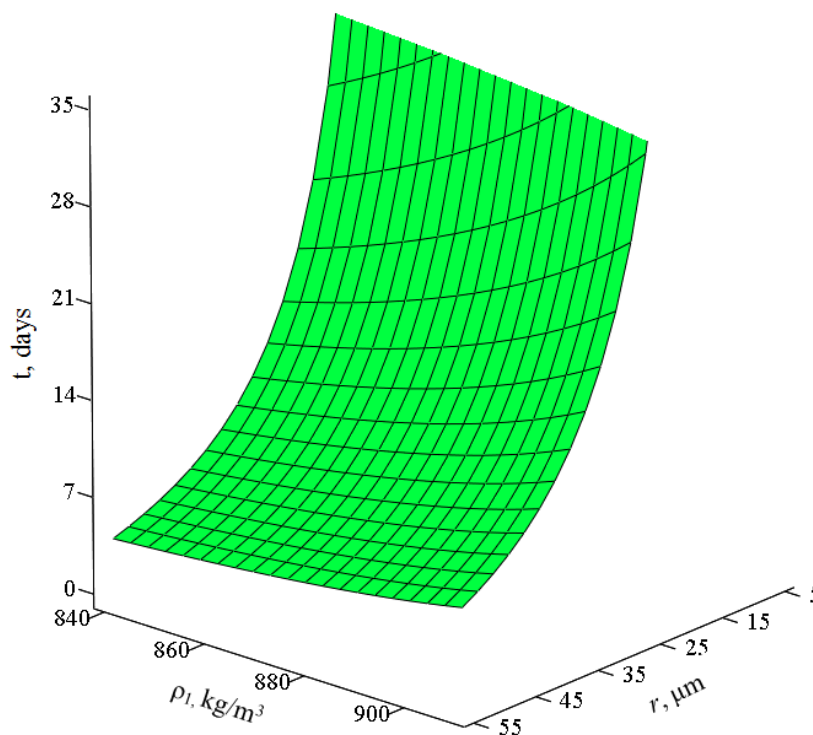


Fig. 1. Dependence of emulsion stability on density of oily wastes ρ_1 and size of water droplets in emulsion

The decay process depends on the viscosity, density and surface tension of the liquid, as well as the flow velocity and the amplitude of its pulsation. The influence of the driving force dramatically speeds up the process. The destruction of the interface occurs mainly at high fluid velocities in the turbulent flow regime. Generating shock-wave processes in a container with liquids by a pneumatic radiator, one can achieve an increase in the instability of the interface and its destruction. In the volume of the liquid, in addition to the wave phenomena near the shock-wave radiator, cavitation processes will arise with the formation of air cavities in the liquid, followed by their rapid slamming [10].

A droplet of radius $r = \lambda / 4$ opens from the surface of the liquid with a wavelength λ , and after the detachment of the drop, waves with an amplitude $\lambda / 8$ remain at the interface. These waves are initial perturbations for the subsequent detachment of droplets. That is, a decrease in the wavelength leads to a decrease in the size of the water droplets in the emulsion, and consequently to an increase in the stability of the water-in-oil emulsion made on the basis of oily waste [10].

Figure 2 shows the wavelength dependence of the emulsion preparation from the surface tension and the dimensionless wave number. Analysis of the results allows us to state that with a decrease in surface tension and a simultaneous decrease in the dimensionless wave number, the wavelength, and therefore the size of the water droplets in the emulsion, decreases, which leads to an increase in the stability of the emulsion.

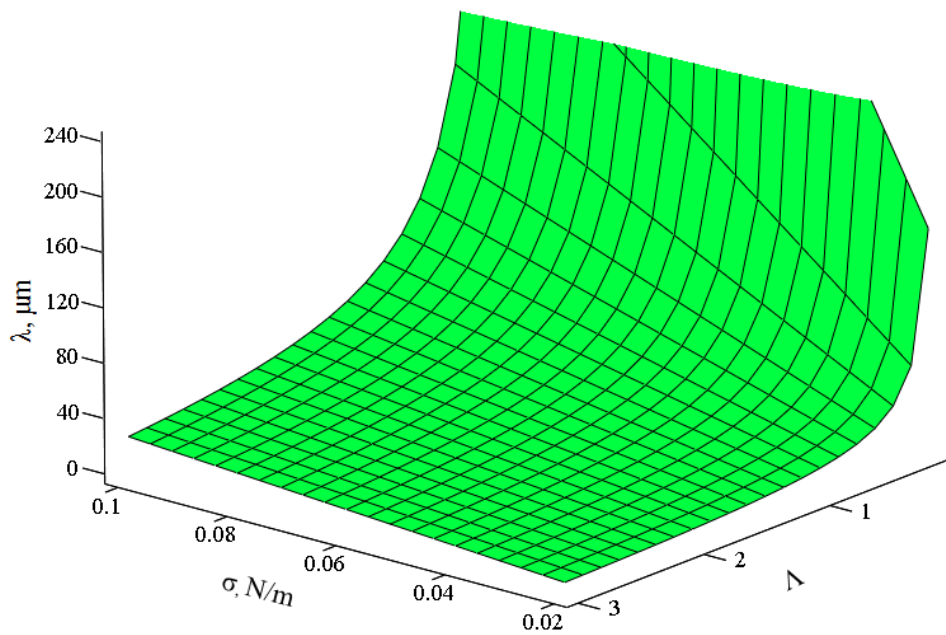


Fig. 2. Dependence of the wavelength λ from the emulsion on the surface tension σ and the dimensionless wave number Λ

Figure 3 shows the dependence of the wavelength dimension in the preparation of the emulsion on the average flow velocity of liquids and surface tension. It is established that an increase in the flow rate of liquids with a simultaneous decrease in the surface tension leads to a decrease in the size of the water droplets in the emulsion.

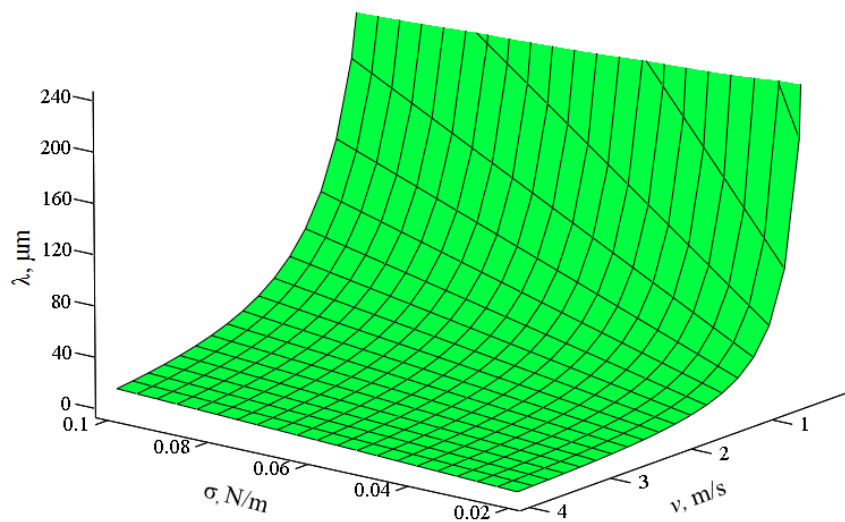


Fig. 3. Dependence of the size of the wavelength from the emulsion on the average flow velocity of liquids and surface tension

Figure 4 shows the dependence of the wavelength dimension when preparing the emulsion from the density of OCW and the average flow velocity of liquids. Analysis of the results of calculations allows us to state that with a simultaneous increase in the density of OCW and the flow rate of liquids, the size of the water droplets in the emulsion decreases.

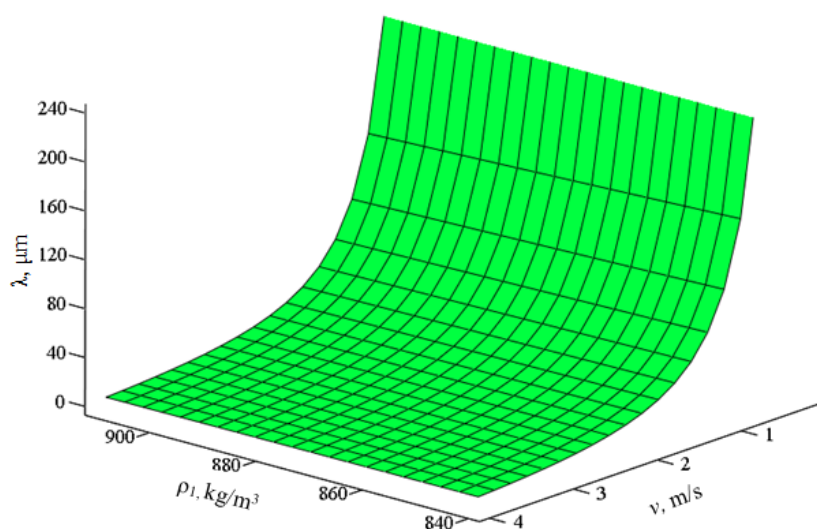


Fig. 4. Dependence of the size of the wavelength from the emulsion on the density of OCW ρ_1 and the average flow velocity of liquids v

Conclusion. The established dependences of the wavelength and size of the undisturbed droplet in the emulsion on the parameters of the dimensionless wave number Λ , surface tension σ , average fluid flow velocity v , and ρ_1 and ρ_2 media densities make it possible to significantly reduce the amount of experimental studies to obtain an emulsion based on waste oil containing products with a predetermined stability.

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REDUCTION OF OCCUPATIONAL RISKS FOR WORKERS OF THE OIL REFINERY BY INTRODUCING AN AUTOMATED SYSTEM FOR EVALUATION OF OPERATORS' PROFESSIONAL ABILITY**DZMITRY YUKHNO, YULIYA BULAUKA****Polotsk State University, Belarus**

An automated system for psychophysiological testing of operators of oil refineries is designed. The system helps to improve the accuracy of the assessment of operator proficiency and to reduce occupational risk.

Profession of the operator of technological oil refinery units is one of the most popular in oil-processing industry and the most responsible since an operator's wrong actions can lead to emergency. Introduction of modern industrial control systems, the systems of antiemergency automatic protection and remote control, and decrease in number of the technological parameters controlled by physical activity has significantly changed the nature of operators' work. This causes increase in requirements to speed of workers' reactions including actions in emergency situations and to the accuracy of measurements of a control system condition in a technological process, as well as increase in volume and the importance of production information.

It is authentically established that about 80% of industrial accidents at oil refinery and 30% of emergencies take place for the reasons connected with a human factor. The problem of decrease in frequency of accidents and injuries by regulating a human factor influence is important and relevant.

The successful solution of these tasks requires tension of memory and attention, operational thinking, speed and accuracy of reactions, maintaining self-control in emergencies, and other abilities connected both with specific features of a nervous system and with formation of qualities of an operator important for the profession. The discrepancy of a number of physiological and psychological parameters of the worker to requirements imposed by a profession, maybe, on the one hand, the overstrain reason that in turn will lead to development of occupational diseases and, on the other hand, can become the reason of industrial accidents and emergencies.

Therefore, the tendency to determine the professional abilities of a person develops. The methods of diagnosing special abilities are used, with the aim of predicting the future professional success of the applicant for the profession. The application of tests for professional selection will allow to ensure rapid inclusion of personnel in work, to cut costs of their training, to reduce the risk of accidents and injuries.

Professional selection is the determination of the degree of a person's professional suitability for a particular profession or position in accordance with regulatory requirements. There are four aspects of professional selection: medical, physiological, pedagogical and psychological.

1. Medical professional selection is made on the basis of medical procedures to measure the level of development and the formation of the human body and its individual functional systems.

2. Physiological selection takes into account the specific functional state of a person: the degree of fatigue and performance, susceptibility to stress factors, the ability to function effectively under risk conditions, night shifts, information uncertainty.

3. Pedagogical professional selection is aimed at assessing the formation of special knowledge in the employee, the development of his skills and practical professional skills.

4. Psychological selection is realized through verbal tests and questionnaires, instrumentation techniques, personal projective tests, interviews. Such a selection is aimed at identifying and assessing the individual's dispositions and abilities, its value orientations, professional orientation, motivation, interests and preferences.

The main goal of the selection is to attract employees with the necessary qualifications and the necessary personal qualities, capable of solving the tasks assigned to them as effectively as possible. At professional selection the conformity of opportunities and sights of candidates to conditions and features of work on a particular post is defined. The result of professional selection should be the choice of the most profitable worker (i.e., the most professionally relevant activity).

Now professional selection of potential employees in oil refinery is carried out generally by identification of medical contraindications to this profession and compliances of education level and qualification. Psychophysiological and personal qualities of candidates are not usually considered.

Introducing an assessment system of professional suitability of the operator of technological oil refinery units will bring both the social and economic effect which leads to the reduction of number of incidents caused by «human factor» and, as a result, will lead to decrease in professional risk.

Department of Technology and Equipment of Oil and Gas Processing at Polotsk State University is carrying out a research on identification of professionally important qualities of workers in an oil processing industry and on selection of the approved techniques of their assessment. The programme complex is developed for professional selection of operators of technological oil refinery units for an oil processing industry. Pilot studies are carried out with the use of a programme complex for professional selection of personnel of oil refinery among the staff at JSC “Naftan” and PSU students of major specialties.

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ANALYSIS OF THE BASIC METHODS OF TRIBO MODIFICATION

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The article is devoted to the analysis of tribo modification main methods and describing their advantages and disadvantages.

The wear resistance increase of a part depends largely on the dimensions of mating surfaces and conditions of the loading and lubrication regime.

The increase of the parts wear resistance is achieved by protecting them from abrasive action; the use of special lubricants and additives to lubricants, allowing the creation of a film on all rubbing parts; creating conditions for liquid lubrication by applying the thinnest film of powder mixtures to the parts; using the vibrating rolling, allowing to create an optimal roughness of rubbing surfaces of parts, etc.

Tribo modification methods include methods for reconstructing friction surfaces in a mode of continuous operation with the use of additives to lubricants containing dispersed natural layered silicates. The use of such additives can ensure the restoration of worn surfaces with the formation on the friction surfaces of metal-ceramic coatings which have increased wear resistance.

Technological methods for improving the tribotechnical properties of friction pairs and increasing the service life of tribo-joints by operating them in the presence of the lubricant containing nano-sized solid components, in particular, nano-sized diamonds, should also be referred to tribo technological methods. Solid nano-sized particles introduced into the lubricating medium have a complex effect on the tribo system, increasing its longevity.

This method of wear resistance increase is one of the most promising, so the purpose of this work is to analyze and study the basic methods of tribo modification.

Among the processes that positively affect the tribo system in the use of lubricants with nano-sized solid additives are: the formation of separation layers of increased bearing capacity, stabilization of rheological characteristics of the lubricating layer over a wide temperature range, the decrease in the roughness of the friction surface, and hardening of surface layers.

One of the factors affecting reliability and durability of machines is the run-in of mating surfaces of parts. The use of run-in preparations in the manufacture and repair of machines and mechanisms allows to integrate the run-in, thereby shortening the duration of the running-in phase and prolonging the zone of the steady wear regime. Due to this, the number of failures of machines and mechanisms during operation is reduced and their service life is increased.

Lubricant compositions containing solid components (diamond-graphite powder, carbides, silicon oxides, etc.), polymers are used as run-in compositions [1].

Running preparations based on nano-diamonds can reduce the running-in time and optimize the quality of rubbing surfaces. Diamond performs the role of abrasive material, due to which, the process of submicrometry of single microprotrusions takes place in the process of operation. That leads to a significant increase in the actual contact area of friction pairs.

Repair and recovery compounds (RVS) are used with the exhaustion of the repair and overhaul life of the friction pairs of machines and mechanisms. They form anti-friction anti-wear coatings of long-term action on friction surfaces. RVS use makes it possible to restore worn surfaces of tribo-conjugations to original parameters. Currently known RVS for the component composition, physico-chemical processes of their interaction with rubbing surfaces can be divided into three groups: remetalizants (metal-plating compounds), polymer-containing preparations and geomodifiers.

Metal-clad lubricants can be used for all types of friction units: frogs, tips of steering rods, bearings, gears, etc. Such lubricants include powders of metals, their oxides, alloys, salts, complex and other compounds. The mechanism of their action lies in the metal plating of rubbing surfaces due to the deposition of metal components that make up their composition in a suspended or ionic form.

At the same time microdefects are partially eliminated. The coefficient of friction decreases, the wear resistance of clad surfaces significantly increases, the interval between grease changes increases. They successfully work in heavily loaded friction units. However, for the existence of a metal-cladding layer, the constant presence of remetalizant in the oil is necessary.

At present, to improve the technical and operational characteristics of tribo-conjugations, the spectrum of input materials in the lubricating compositions used is expanding, and new methods for obtaining already known materials are being developed. For example, a metal-clad lubricant composition containing ultrafine copper powder obtained by electric wire exploding has been proposed.

The composition was developed on the basis of lithol using highly dispersed filler powder (zinc, bronze or lead), obtained by evaporation and condensation in the atmosphere of neutral gas in a vacuum installation, ensuring non-vanishing work of friction pairs in course of their operation and allowing the already worn friction surface to be restored while maintaining main technological parameters of lubrication [1].

The lubrication mechanisms of such lubricating compositions are largely determined by the type of additives or fillers introduced therein and the load-temperature conditions of their application, i.e. operating conditions of the friction unit. Most often, the main role in reducing the intensity of wear of rubbing parts is taken away from formation of metal films on the friction surface.

The main disadvantage of plastic greases with metal-clad components is the fragility of the disperse phase of the lubricant therefore the use of additives of metallic powders in antifriction plastic greases is limited. In order to decrease the effect of minimizing, the cladding components of the lubricant must have a stable nanoscale level. They should be placed in a special protective envelope to prevent their oxidation, and have a trigger mechanism for the interaction reaction with the friction surface during the operation.

Another method of increasing the life of tribo-joints due to the modification of friction surfaces is the use of metal-plating lubricants, in which dispersed ferromagnets are introduced. Transitional metals, as well as some of their intermetallic compounds, for example iron-nickel, iron-cobalt, are of practical importance. The most widely used magnetite. It has a good adsorption capacity with respect to surfactants, and is also capable of forming colloidal dispersions with high magnetization [2, 3].

To increase the reliability and economy of engines, polymer-containing preparations containing PTFE, surface activated fluoroplast-4, perfluoropropylene oxide, perfluoropolyether carboxylic acid (epilam), silicone and some other polymeric substances are used. These drugs appeared before the others and were originally used to ensure a short-term preservation of mobility of military equipment in the event of a serious damage to the oil system.

One of the ways to improve the quality and wear resistance of the working surfaces of parts at the stage of manufacturing (recovery) and during their operation is the use of FANT (Finishing antifriction non-abrasive treatment). The essence of FANT means that the steel or cast-iron parts after the traditional final machining of their surface are covered with a thin layer (1 ... 3 mm) of antifriction copper-containing coating by friction. In this case, the phenomenon of selective metal transfer during friction is used [4].

The advantages of using FANT process are: extremely low material consumption; low consumption of mechanical energy; harmless to the environment; short duration of coating (several seconds and minutes); stable and good quality coating; economic feasibility with a large and small number of products.

The main methods of FANT by a number of authors are conventionally divided into two groups:

1. application of metal coatings with a friction-mechanical method, a tool made of copper-bearing alloy (frictional brass, bronzing and copper plating); friction-chemical method (FANT in metal-plating media containing various surfactants and metal salts capable of restoring on the surfaces to be treated when exposed to rollers, discs, bars, brushes, tampons, etc. from non-metallic tool); friction coating of plastic alloys in metal-plating media.

2. application of layered solid lubricating coatings in the form of graphite, molybdenum disulphide and other compounds by contact spreading by various methods.

Application of FANT together with metal-plating compositions allows to increase service life of tribo-conjugations in 2-2,5 times. However, this is possible only with the constant presence of metal-plating compounds in the contact zone of friction surfaces [4].

The method of cladding by a flexible tool based on the use in standard grinding technologies as an instrument instead of abrasive wheels of disk wire brushes made of metals and alloys forming a metal-plating layer on the working surface of the workpiece allow intensifying the FANT, increasing productivity and improving the economic parameters of metal plating of friction units.

Conclusion. Analytical review of scientific literature and patent sources devoted to the methods of tribo technology have shown that these methods make it possible to increase their wear resistance significantly (up to 70%), technical and operational indicators in 1.5 – 2 times, shorten the duration and improve the quality of their running-in, reduce the temperature of working units (up to 15%), the noise and vibration level, which significantly affects the reliability and service life of machinery and machines.

The modification of plastic lubricants with nanoscale diamond-containing additives provides an increase in extreme pressure properties and has an additional effect due to an increase in the hardness of the contacting surfaces when the structure of the friction surface is grinded during intense plastic deformation of micro roughness under the action of solid diamond particles and as a result of dispersed hardening when diamond particles are introduced into the friction surface and contributes to the reduction of the coefficient of friction due to reduction roughness of the friction surface and partial replacement of sliding friction by rolling friction.

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UDC 621.91.02

KINEMATIC SUPPORT OF A REGULAR MICRO-RELIEF OF A SPHERICAL OF A WORKPIECE BY AN EMBRACING MILLING

GALINA GVOZD, NIKOLAI POPOK, RUSLAN KHMELNITSKY

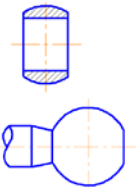
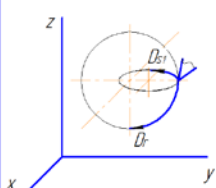
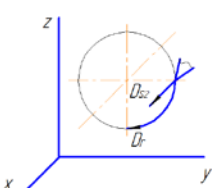
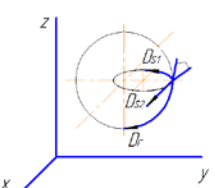
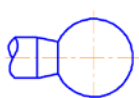
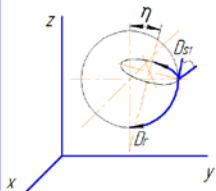
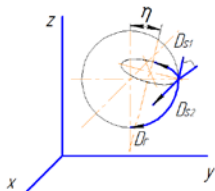
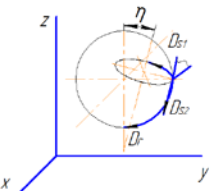

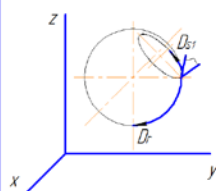
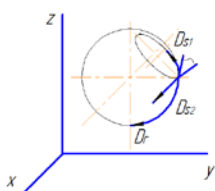
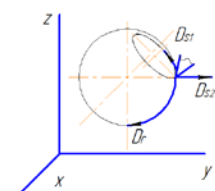
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The possibilities of modification of spherical surfaces by cutting and ion-plasma processing with the purpose of improving the quality of machine parts are considered. An analysis of the kinematic features of the treatment of spherical surfaces by a rotating tool at a high cutting speed and the formation of a cutting surface is given. The results of experimental studies of the physical characteristics of the shear layer, microrelief, and microhardness of the resulting surface of the component are presented, including after coating with TiN by an ion-plasma method on a vacuum installation, confirming a decrease in the height of irregularities to $Ra\ 0,6 \div 1,2\ \mu\text{m}$ and increasing microhardness in $1,5 \div 3$ times in comparison with the traditional methods of obtaining spherical surfaces.

Introduction. To the details contacting in the friction nodes on spherical surfaces, there are raised requirements for their wear and corrosion resistance [1]. In works [2,3, etc.], it is proposed to apply on their surface plastic deformation (rolling) and cutting (blade and abrasive treatment) of regular microrelief to improve the operational properties of such parts. In this work, a method of machining by cutting is used for these purposes. It is realized on universal and special machines equipped with a high-speed drive (rotation frequency of $10,000\ \text{min}^{-1}$ and more) [4], as well as ion-plasma treatment in vacuum [5].

Kinematic and geometric characteristics of combined treatment. The method is implemented according to one of the kinematic cutting schemes presented in Table 1.

Table 1. – Kinematic schemes of combined machining by cutting the spherical surfaces of parts

Shape of a spherical surface	Kinematic scheme of cutting		
	Finishing	Roughing	
 <p>Spherical belt</p>	<p>Two-element scheme</p> 	<p>Two-element scheme</p> 	<p>Three-element scheme</p> 
 <p>Spherical segment</p>	<p>Two-element scheme</p> 	<p>Three-element scheme with longitudinal feed (along the axis of the main motion)</p> 	<p>Three-element scheme with a transverse feed (at an angle η of the axis of the main motion)</p> 
 <p>Spherical segment</p>	<p>Two-element scheme</p> 	<p>Three-element scheme with longitudinal feed (along the axis of the main motion)</p> 	<p>Three-element scheme with a transverse feed (at an angle 45° of the axis of the main motion)</p> 

The spherical surfaces of non-complete shapes are machined - bounded by a plane from one or both sides. The kinematic cutting scheme can be two- (two rotational motions) and three- (two rotational and translational motions) element, the operations of forming the sphere on three transitions. At the first transition, the rotating tool is inserted into the rotating workpiece (roughing), and the direction of the translational movement of the infeed (feed) Ds_2 occurs along the axis of the main rotational movement of the tool Dr . The axis of the rotational motion of the feed of the workpiece Ds_1 is directed at an angle η to the axis of the main rotary motion, that is, the form of axial processing is simultaneously realized – the countersinking, since the tool has three or more blades, and the type of milling. At the second transition, the surfaces are groomed (semi-finished processing) and a two-element kinematic cutting scheme is realized with the main rotational motion of the tool Dr and the rotational movement of the workpiece feed Ds_1 . On the third transition, when the tool blades reach the required sphere size, smoothing (finishing) of the surface of the sphere is realized. On these transitions, along with the counter motion of Dr and Ds_1 , it is possible to realize their associated rotation, which will contribute to better surface smoothing.

With a two-element kinematic scheme, the cutting path is a cycloid turned on the circle of the sphere (Figure 1), and for a three-element cutting scheme, the trajectory of cutting is a cycloid turned on a circle of a sphere in a spiral (Figure 2). Due to the low velocities of the feed motions Ds_1 and Ds_2 , the shape of one turn of the cycloid can be regarded as a circle.

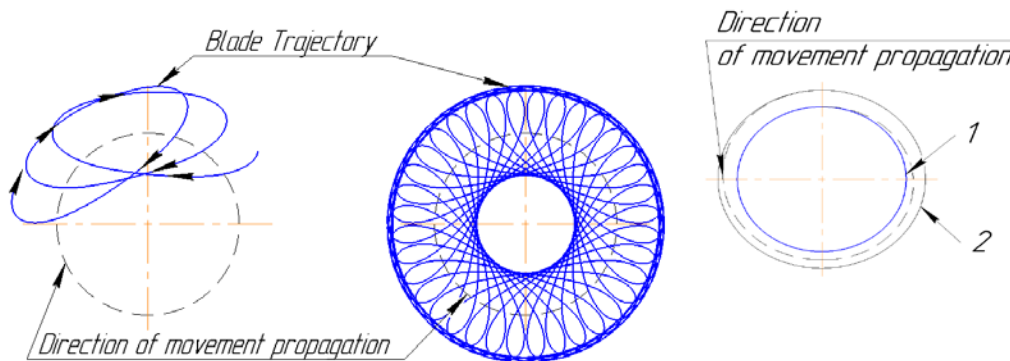


Fig. 1. Trajectory with a two-element cutting scheme

Fig. 2. Trajectory with a three-element cutting scheme: 1 – is the surface of the resulting spherical surface, 2 – workpiece surface

Figure 3 shows the development of the spherical surface of the part on a plane with the circumference of the circle πDs . The projection of the development of the circumference of the tool with the length πDs of the plane perpendicular to its axis for the transition of grooming. The directions of the vectors of the rotation speeds of the tool \bar{V}_r and sphere \bar{V}_{s1} are shown for the case of their opposite direction. If you change the direction of one of the rotations, a cut will be carried out. The linear velocity of rotation of the sphere in its various diametric cross sections varies from the maximum values at the largest diameter to zero at the poles of the sphere.

The cutting trajectories considered, the section of the cut layer and the kinematic angles of the blade determine the formation of the microrelief of the processed surface of the sphere. Figure 6 shows that the surface of the sphere is formed in the form of a "net" due to the intersection of the trajectories of the movements of the workpiece and the tool, and the direction of formation of uniform unevenness in the surface is determined by the angle of inclination of the axis of rotation of the workpiece relative to the axis of rotation of the tool and the value of the rotation speeds. The angle of inclination of lines with the same value of irregularities is in the range $65^\circ \div 75^\circ$ at an angle of $\eta = 15^\circ \div 25^\circ$. It is known [6, 7] that the use of steep-milling cutters (milling cutter) with an angle of inclination of the cutting edges of the blades within these limits, and also rotational tools providing a cutting angle of the trajectory of cutting $50^\circ \div 70^\circ$, contributes to a decrease in the roughness of the treated surface.

This conclusion is confirmed by the investigation of the spherical surface of a sample with an atomic-force microscope of model NT-206 (Figure 4).

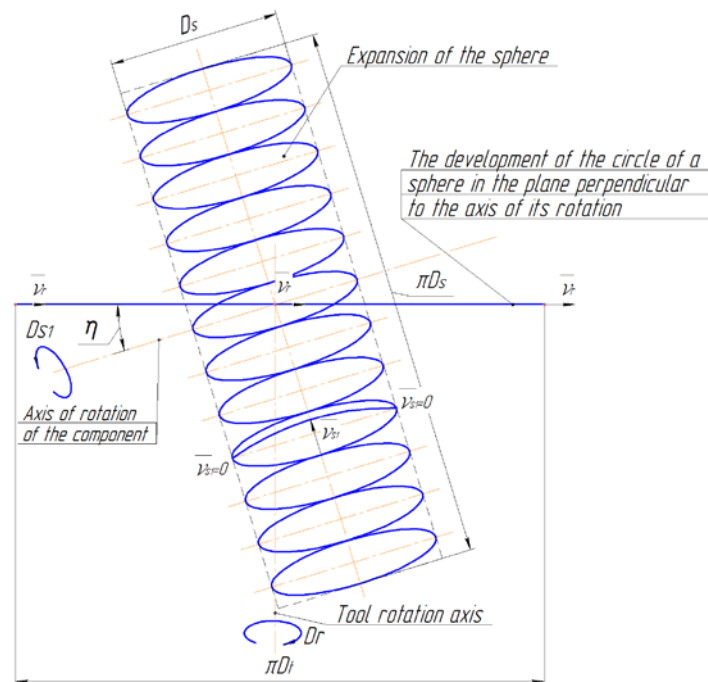


Fig. 3. Scanning the surface of the sphere and the tool circle to the plane

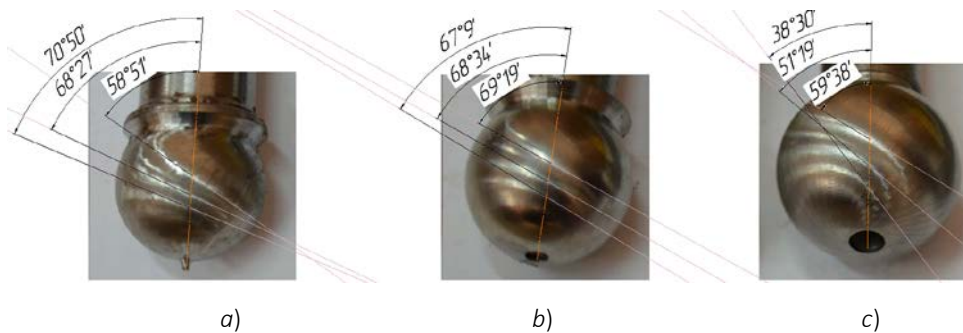


Fig. 3. Roughness of a spherical surface of a detail and angles of an inclination of lines of an equal roughness: *a* – R_a 1,3 μm at the tool rotation speed $n_1 = 3150 \text{ min}^{-1}$; rotational speed of the workpiece $n_2 = 20 \text{ min}^{-1}$ and diameter of the sphere 25 mm; *b* – R_a 0,6 μm at the tool rotation speed $n_1 = 3150 \text{ min}^{-1}$; the rotation speed of the workpiece is $n_2 = 20 \text{ min}^{-1}$ and the diameter of the sphere is 30 mm; *c* – R_a 0,7 micron at the tool rotation speed $n_1 = 6300 \text{ min}^{-1}$; rotation speed of the workpiece $n_2 = 180 \text{ min}^{-1}$ and diameter of the sphere 35 mm;

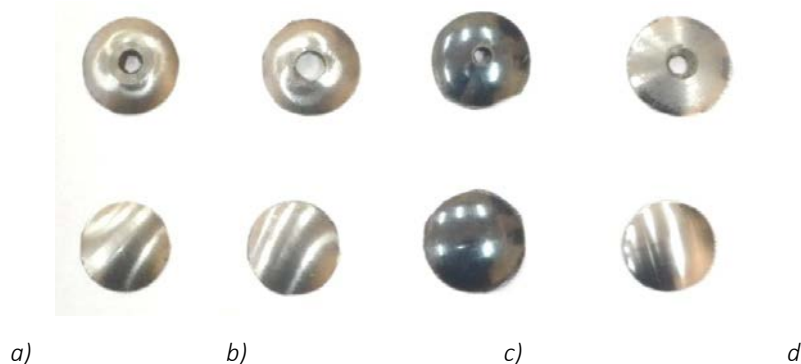


Fig. 4. Samples for study on an atomic force microscope: *a* – machining with tool rotation speed $n_1 = 3150 \text{ min}^{-1}$; rotational speed of the workpiece $n_2 = 20 \text{ min}^{-1}$, *b* – machining with tool rotation speed $n_1 = 6300 \text{ min}^{-1}$; rotational speed of the workpiece $n_2 = 180 \text{ min}^{-1}$, *c* – machining with tool rotation speed $n_1 = 12000 \text{ min}^{-1}$; rotational speed of the workpiece $n_2 = 20 \text{ min}^{-1}$, *d* – machining with the lathe on the lathe with a speed of $n = 1200 \text{ min}^{-1}$ and feed rate $S_0 = 0,2 \text{ mm / rev}$.

(the top row is the surface view near the axis of rotation (poles of the sphere), the bottom row is the surface view at the maximum distance from the axis of rotation (pole of the sphere)).

Figure 5 clearly shows unevenness and risk along the cutting path, which provides a low surface roughness between the risks-trajectories ($Ra\ 0,021 \div 0,64$).

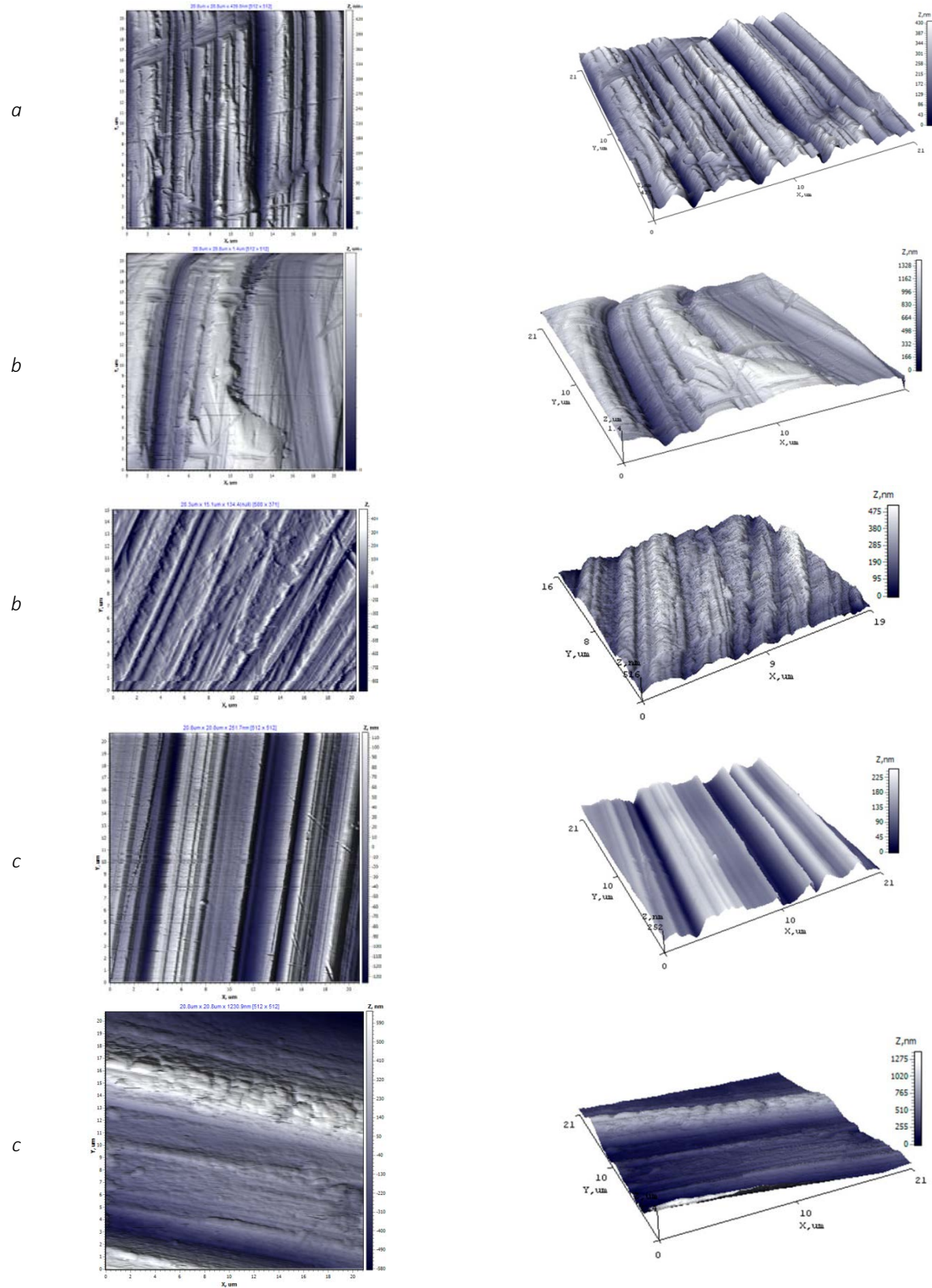


Fig. 5. Surface topography after treatment: a, b – a rotating tool; c – turning lathe

In this case, the microhardness of the surface is increased by a factor of 1,5 to 3 as compared with the base: an increase in the tool's rotation speed from 3000 to 6000 min^{-1} leads to an increase in the microhardness of the surface by 10-20% (Table 2).

Table 2 – The value of microhardness of sample surface

No test unit	Processing type	Machining rate	Microhardness, HV 0,025
test unit 1	By rotating tool	$n_1=3150 \text{ min}^{-1}$	625
test unit 2		$n_2=20 \text{ min}^{-1}$	750
test unit 3	By rotating tool	$n_1=6300 \text{ min}^{-1}$;	780
test unit 4		$n_2=180 \text{ min}^{-1}$	850 (support plate's hardness 282 HV 10)
test unit 5	By rotating tool	$n_1=12000 \text{ min}^{-1}$;	515
test unit 6		$n_2=20 \text{ min}^{-1}$	525
test unit 7	By lathe tool	$n=1200 \text{ min}^{-1}$;	565
test unit 8		$S_o=0,2 \text{ mm/rev.}$	390 (support plate's hardness 278 HV 10)

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INFLUENCE OF EXTERNAL CONDITIONS ON THE RESOURCE GAS CHANGE IN GAS TRANSMISSION SYSTEMS

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The algorithm of the gas reserve in the gas transmission systems is represented in the article. Estimation of the influences of environmental conditions is approached to assess the accuracy of specific example margin pipeline «Torzhok-Minsk-Ivantsevichy CS "Smolensk" – CS "Krupki"».

Introduction. The gas transmission system (GTS) is an important transport link integrated into the main pipeline network of the Russian Federation and the European Union (EU). It runs through the territory of the Republic of Belarus connecting gas flow from suppliers to consumers. Supervisory control of GTS registers a number of tasks; one of them is measurement of the transported gas amount and development of this problem - gas reserve management in the GTS. Practice shows that the operation of gas reserves calculation in the gas transportation system by balance method (i.e. based on accounting units of input and output data of the system even at relatively small intervals of time (calendar month)) leads to significant errors due to accumulation of measurement errors. In this regard, the PGU developed a software package that allows calculating and determining margin gas telemetry data on the basis of determination modes of GTS. As a result, this method solves the problem of errors accumulation during measurement.

Main part. The mathematical model of the GTS is a set of interconnected objects in accordance with the technological scheme; (linear portions (LP), compressor plant (CP), gasdistribution stations (GDS), gas reduction point, valves and regulators etc.). Active elements are allocated GTS, e.g. allowed to control quantities of pressure change and (or) temperature between their input and output (CP, gas reduction point etc.). During calculating the gas reserve regime, active elements of the hydraulic system of GTS is considered to be specified and taken into account when simulating known measurements of the input and output pressures and (or) gas temperatures at their locations in the circuit. This allows excluding from the calculation models of these objects.

Measuring the amount of transmitted gas in the GTS is an important dispatch task. The creation of a software package (SP) for the calculation of reserve gas in the gas transport system, which was implemented in the Belarusian section of the main gas-pipelines (GP), made it possible to improve the efficiency of management and the accuracy of data on the system of trunk gas pipelines that run through Belarus. The solution of this problem is a consequence of more general problems solution: determination the regime of transport gas by the gas transportation system under a number of criteria and parameters defined for each section GP based on the computational algorithm. At the same time it is necessary to take into account the dependence of some parameters to each other, the nature of these links and the overall structure of the GTS, which determines the physical configuration of the network due to the specificity of the subject area.

At the same time, be aware of the relationship of some parameters from each other, the nature of these links and the overall structure of the GTS, determine the physical network configuration, due to the specifics of the subject area.

GTS configuration is not continuous. If repair work is necessary, a stream of transported gas along branch can be transferred to a reserve one. Therefore, it's necessary to support various structural links between the nodes of the GTS. During calculating the mode of transport of gas, the actual structure of the gas transportation system should be used at a given time, that is, the actual state of the cranes should be taken into account. The following issues should be considered:

- gas reserve in operating linear sections (LU);
- unchanged gas reserve in the disconnected LP, gas temperature is taken equal to the ground temperature, and pressure is calculated from the condition of the unchanged reserve from the moment of disconnection;
- Change in gas reserves in LU, operating as a cylinder, i.e. connected on the one hand to the operating LU, while pressure is taken from the operating LU, and temperature is assumed equal to the ground temperature;
- change in the gas reserve, both during bleeding and when filling out the disconnected LU [2].

The application of the developed algorithms for search of the unknown parameters of GTS in the SP allowed producing simulations of stationary and non-isothermal gas flow throughout the GTS network, taking into account the structure of the gas transmission network and all the other criteria which are enough to

describe the transport of gas. Based on the simulation model, the SP determines all the unknown parameters of GTS that are necessary for the further calculation of gas reserve. Designed SP also provides the desired accuracy of the calculations results, the minimum value which does not exceed the precision used in the system of temperature sensors and pressure sensor that are specified by their nameplate data. It is also possible to change the number of displayed data existing objects, such as pressure, diameter, temperature, length, costs, stocks and names.

Based on the example of the pipeline Torzhok-Minsk-Ivantsevichy CS "Smolensk" – CS "Krupki" pipeline, an account of the amount of gas transported in the gas transportation system for external factors was carried out:

- The soil temperature;
- The soil moisture;
- The density of the soil;
- Wind speed;
- Thickness of snow;
- The thermal conductivity of snow.

Calculations were carried out for 3 soil types: sand, loam, and mixed type of soil.

As a result of the calculations, the factors that have the greatest effect on the change in the amount of gas in the gas transportation system have been identified. These main factors are the ground temperature. Dependences of the gas reserve on these factors are shown in Table 1 and Table 2.

Table 1. – Changing the amount of gas depending on the soil temperature

The soil temperature, °C	Sand	Loam	Mixed
0	21,15746	21,18741	21,21141165
2	21,04038	21,08009	21,11872447
4	20,93769	20,96316	20,98549885
6	20,84183	20,85047	20,89129941
8	20,6968	20,69607	20,82144254
10	20,60534	20,6207	20,64250751
12	20,46669	20,47323	20,5002083
14	20,30571	20,36103	20,35386013
16	20,18639	20,20605	20,19707245
18	19,99467	20,04438	19,96359833

The change in the amount of gas depends on soil temperature. At low temperatures the amount of gas is much higher than at high temperatures. From the calculations the temperature is changed by 18 degrees, the differences is excit:

- Sand \approx 1,687 million m³ (5.8%)
- Loam \approx 1,756 million m³ (5.7%)
- Mixed \approx 1,818 million m³ (6.25%)

Table 2. – Changing the amount of gas depending on the soil moisture

The soil moisture, %	Sand	Loam	Mixed
0	20,85959	20,93735	20,9328135
4	20,8993	20,96774	20,95339981
8	20,93276	20,9713	20,97569352
12	20,97862	20,9856	20,97730335
16	21,00701	20,99662	20,98545006
20	21,03526	21,01657	21,0036948
24	21,06233	21,03048	21,01660271
28	21,07589	21,09053	21,03927692
32	21,09526	21,09955	21,04243804
36	21,10477	21,11614	21,06511225

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Analyzing the change in the amount of gas depending on the soil moisture, the results show that at the higher humidity there is gas in the pipeline, but with absolutely low humidity (e.g. 0%), we see that we have a smaller amount of gas. The difference is:

Sand \approx 247 816 million m³ (1%)

Loam \approx 186 594 million m³ (0.74%)

Mixed \approx 155 422 million m³ (0.64%)

Other factors such as soil density, the wind speed, the thickness of the snow cover, and snow thermal conductivity do not greatly affect the amount of gas in the pipeline (a difference of a maximum of 0.08%) [1].

Conclusions. These calculations provide that the controllers should take into account such factors as temperature and humidity of the soil during the measurement of the gas amount in GTS. The final decision on the choice between the use of a mixed soil model and the behavior of accurate calculations based on a detailed study of data on the structure and condition of soils along the route of the gas-wire should be determined as a result of economic calculations of the feasibility of working on studying the composition of soils and developing a monitoring system for their state.

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UDC 665.775.625.85

PREPARATION OF BITUMINOUS MATERIALS BASED ON NEUTRALIZED ACID TAR

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The article presents the results of the study on neutralizing acid sludge from the production of sulphonate additives by the JLLC "LLK-Naftan" with dolomite flour and chemical water slurry obtained with the help of bituminous roofing hot mastics corresponding to the requirements of GOST 2889 on the basis of neutralized products. The proposed technology makes it possible to expand the raw material base resources for obtaining bituminous materials through the use of product waste and to reduce the cost for obtaining bitumen mastics.

Introduction. Acid tar is formed by sulfuric acid purification of mineral oils, by the production of sulfonate additives, in alkylation processes where sulfuric acid as a catalyst is used. This type of waste causes a serious environmental problem. Acid tar accumulates in dumps and open storage ponds where the acid is washed out by atmospheric precipitation and as a result SO₂ and SO₃ is released. This results in of water and air contamination. Acid tar is one of the most difficult products to waste dispose.

At the same time the acid sludge is a valuable secondary material resource for certain products including commercial petroleum products. The constant need for the commercial petroleum products such as road bitumen, roofing mastics and others with a relatively high cost necessitates the search for new ways of their obtaining, including the usage of less expensive components of raw materials, in particular, acid tar.

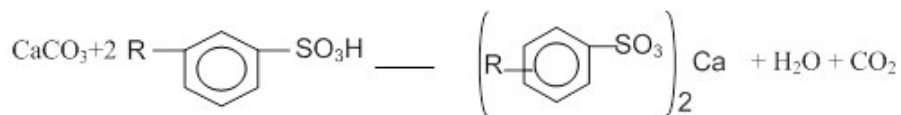
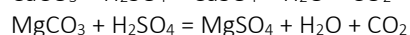
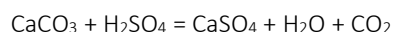
The analysis of certain studies has shown that there are various methods for processing acid sludge while producing bituminous materials. They involve the process of their neutralization with the help of an aqueous solution of alkalis, the process is accompanied by the formation of a large amount of sewage, what is more, alkalis is an expensive reagent [1]

The purpose of this study is to observe the process of the neutralization of the acid tar during the production of the sulfonate additives at JLLC "LLK-Naftan" with dolomite flour and chemical water treatment sludge at the CHP plant, produced on the basis of the neutralization products of bituminous materials.

Methodology. As a neutralizing agent one can use a natural mineral – dolomite flour, produced according to GOST 14050-93 of JSC "Dolomite", Vitebsk city (pH = 7.45). As a second neutralizing agent one can use a chemical water treatment slurry from Polotsk CPP (pH = 10.51) which has not found its qualified application until recently and is accumulated in dumps.

The treatment of acidic tar is carried out in two stages. At first stage, the acidic tar is heated to a temperature of 80-110 C and is mixed with neutralizing agents, dolomite flour and slurry are added at 5, 10, 15 and 20 wt. on tar. The neutralization time is 20 minutes.

The main reactions of neutralization of sour tar are the following:



The acid number is determined as follows: the sample of acidic tar is dissolved in the benzene-kerosene mixture, the distilled water is added and mixed, so that the soluble organic sulfonic acids are transferred into water. The resulting system is poured into a separating funnel and is left to rest for 24 hours before the emulsion is separated into two layers. The aqueous part is titrated with 0.1 N sodium hydroxide solution.

To determine the total acidity a method of direct titration is used, this method was proposed by B.M. Rybak and I.E. Blumin. The method consists of the following: the tar weight is dissolved in neutralized alcohol-benzene solution and is titrated with 0.5 N aqueous NaOH solution in the presence of phenolphthalein indicator. Total acidity is determined with the formula:

$$K = \frac{T_{a,n} \cdot 24.5 \cdot 100}{A \cdot C \cdot 20 \cdot 100}$$

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where K is the total acidity, %;

$T_{a,e}$ – titre 0.5 N solution of alkali, titre is 0.5 n solution of alkali, 24.5 is the weight 0.5 g-eq H_2SO_4 ;

A is a hinge of tar, g; C is the amount of extract taken for the titration, ml; 20 is the weight 0.5 g-eq. NaOH.

Results, discussion and conclusion. The characteristics of the initial sample are the following: acid sludge produced by the sulfonate additives of JLLC “LLC-Naftan” are presented in the table. Acid number, acidity, ring softening temperature as well as the ball and needle penetration depth at 25 ° C and the content of individual components are also determined. The starting sample is a black solid sticky mass with a sharp specific odor, by its consistency resembles clay.

Under the action of static loads it exhibits named properties of non-Newtonian liquids.

Table 1. – The main characteristics of acid sludge taken from the Sulphonate Additives Plant at JLLC “LLK-Naftan”

Rate	Implication
Acid number, mg NaOH/g	117,073
Inorganic acidity, %	11,339
Softening point on the ring and ball, °C by GOST 11506	45,5
The depth of needle penetration at 25 °C by GOST 11501	138,4
Rate of components, % mass.	
Sulphonic acids in terms of group $-SO_3H$	up to 25
Dipping acid	up to 4
Oil (I,II,III groups of aromatic and naphthenic-paraffinic hydrocarbons)	up to 60
Asphaltene	up to 10
Pitch	up to 15

The acid tar is neutralized with dolomite flour at various temperatures. It is established that the degree of change in the acid number is approximately the same at 80, 90 and 100 ° C and significant decrease in the acid number by more than in 2 times is relative to the initial value which is found upon neutralization at 110 C. This is probably due to the fact that during heat treatment of acidic tar at 110 ° C there is low-temperature decomposition. It consists in the interaction of sulfuric acid with resinous-oil and resinous-asphaltene substances of the organic part of acidic tar which acts as organic reducing agents. This process also helps to reduce acid number. Similar dependence is also established for the acidity index. Maximum reduction is established when it neutralizes with dolomite flour and heat treatment of acid tar at 110 ° C. With this temperature the residual acidity after neutralization is only 0.61% which indicates the absence of water-soluble acids.

Analysis of the change in the softening temperature of acid sludge after neutralization with dolomite flour at various temperatures has shown that the increase in the heat resistance and temperature of softening of tar is observed throughout the temperature range of processing. The highest values are recorded at a temperature of 110 ° C. The rate of increase in the change in the softening temperature increases with increasing processing temperature. Thus, with a 5% addition of flour for neutralization at temperatures up to 100 ° C the softening point increases by no more than 1.5 ° C, and at 110 ° C the softening temperature increases by 6 ° C. Probably, this is due not only to the influence of dolomite flour, but also to the chemical reactions of low-temperature decomposition. Thus, the percentage of addition of the neutralizing agent and the neutralization temperature has a significant effect on the target parameters.

Figure 1 shows the dependence of the change in the acid number of sour tar after neutralization with dolomite flour and chemical water treatment sludge at a temperature of 110 ° C. It can be seen that the neutralization process is more effective when one uses chemical water treatment sludge which correlates with the pH of the neutralizing agents.

The same dependence can also be traced from a change in the acidity of tar after neutralization with dolomite flour and chemical water treatment sludge. At the same time any almost neutral product can be obtained with the addition of a chemical water treatment slurry of about 10% by weight as well as the same acidity value only with a 20% additive of dolomite flour. Thus, chemical water treatment sludge is needed twice as much to neutralize acid sludge than dolomite flour needs.

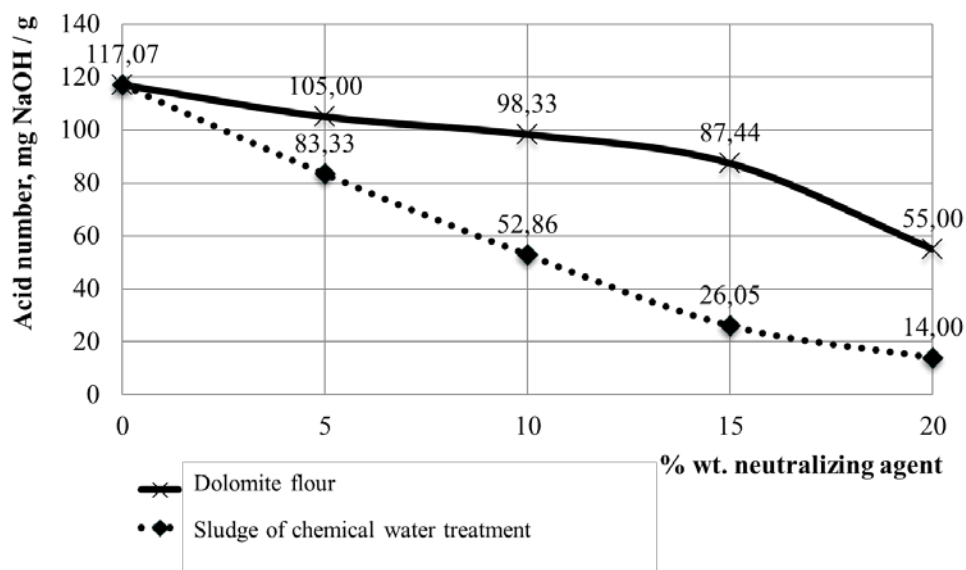


Fig. 1. The dependence of the acid number of acid sludge upon neutralization with dolomite flour and chemical water treatment sludge at a temperature of 110 ° C

The linear dependence of the change in the softening temperature according to the softening temperatures on a ring and a sphere acid sludge after neutralization with dolomite flour and chemical water purification slurry at a temperature of 110 ° C is determined (reliability of the approximation $R^2 = 0.9$ for dolomite flour and 0.94 for the slurry). It was found out that at concentrations of the neutralizing agent up to 10% by weight the softening point increases by almost 6-8 ° C, and at a higher concentration of more than 15% by weight heat stability is increased to a greater extent from slurry chemical water purification.

Based on the products of neutralization of acid tar it is proposed to obtain bituminous roofing bitumen according to GOST 2889 since various dust-like fillers and, in particular, fine-grained dolomites are used to produce this mastic.

As a bituminous binder for the preparation of mastics two samples are used: oil road bitumen 60/90 and bitumen of oil 90/10. For initial samples their softening temperatures are determined according to the softening temperatures on a ring and a sphere (for oil road bitumen 60/90: 53 ° C, for bitumen of oil 90/10: 110 ° C) and the penetration depth of the needle at 25 ° C (for oil road bitumen 60/90: 68.4 x 0,1 mm, for bitumen of oil 90/10: 15 x 0.1 mm).

As a component of the mastic, bitumen binder is added in concentrations of 10, 15 and 20% by weight. The product is neutralized by slurry chemical water treatment at a temperature of 110 ° C.

The analysis of the dependence of the penetration depth of the needle at 25 ° C for bituminous mastic after addition of the neutralizing acid sludge shows that the obtained additive has practically no effect on the penetration rate of bitumen of oil 90/10 with initially high content of asphaltenes but the addition of a neutral product to the road bitumen oil road bitumen 60/90 leads to a significant increase in its hardness for more than twice the penetration depth of the needle when 20% of the neutral product is involved. The reason is probably the increase in the content of asphaltenes.

The analysis of the dependence of the change in softening temperature of bitumen mastic after addition of the product of neutralization of acid sludge shows that the mastic softening temperature on the basis of oil road bitumen 60/90 is increased, since the neutral product with a softening point of 60 ° C is added and, probably, additional processes structuring and the heat resistance of the mastic based on bitumen of oil 90/10 deteriorates because a more fusible component is added to it.

For bituminous mastics, the temperature of brittleness in the freezer compartment is determined, flexibility and heat resistance according to GOST 2889, the results obtained are shown in Table 2, it is established that the obtained values do not exceed the normative values for Mastic bituminous roofing G-65 and Mastic bituminous roofing G-85.

Table 2. – The characteristics of bitumen mastics based on neutral acid sludge

Indicator name	Mastic bituminous roofing G-65 by GOST 2889	oil road bitumen 60/90 and 15% of the mass of neutral acid tar slurry (15% by weight, 110 ° C)	Mastic bituminous roofing G-85 by GOST 2889	bitumen of oil 90/10 and 15% of the mass of neutral acid tar slurry (15% by weight, 110 ° C)
1. Heat resistance for 5 hours, C°, not less than	65	65	85	85
2. Softening temperature by the "ring and ball" method, ° C°	68–72	74,5	88–92	102
3. Flexibility at temperature (18 ± 2) C° on a rod in diameter, mm	15	15 (resist)	30	30 (resist)
4. Filler content,% by weight: pulverized	25-30	up to 15	25-30	up to 15
5. Water content, % mass.	Trace	no	Trace	no
6. Temperature of embrittlement of bituminous binder, C° not higher	–15	lower –15	–12	lower –12

Thus, it can be concluded that the product of neutralization of acid sludge from the production of sulfonate additives by JLLC "LLK-Nathan" by chemical water treatment slurry from Polotsk CCP plant can be disposed of by mixing with bituminous binders and obtaining bitumen roofing hot mastics that meet the requirements of GOST 2889. For neutralization dolomite flour is used but with double volume for neutralization.

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ANALYSIS OF THE «RULES OF PROCURING INDUSTRIAL SAFETY OF THE EQUIPMENT OPERATING UNDER EXCESSIVE PRESSURE» APPLICATION AT BELARUSIAN OIL & GAS REFINERIES

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In this article the analytical results of the «Rules of procuring industrial safety of the equipment operating under excessive pressure» application at Belarusian oil & gas refineries are given. It has been identified that in the current redaction of the «Rules of procuring industrial safety of the equipment operating under excessive pressure» there is a wide range of contradictions that have to be worked up in details. Also it calls for introduction of essential changes in the document in order to transform impracticable formal requirements into operative industrial safety procuring of the equipment operating under excessive pressure.

Introduction. Type and construction variety of columns, reactors, heat exchangers, vessels, tanks, cisterns, etc. where, as a rule, liquid or gaseous hydrocarbons (generally toxic explosive hydrocarbons) are being kept under high pressure, nowadays form a principal part of modern oil & gas refinery. Questions on procuring industrial safety of equipment at oil refineries and chemical plants are obviously essential and have paramount importance [1-6].

Methods of research. The «Rules of procuring industrial safety of the equipment operating under excessive pressure» (here and after the Rules) had been introduced on the territory of Belarus since the 1st of March 2016 in accordance with the act № 7 since the 28th of January 2016 by the Ministry of Emergency Situations of Belarus. These rules have substituted previous «Rules of organization and procuring industrial safety of the equipment operating under excessive pressure» (the first edition in 1956). The radical renewal was made with the necessity to create the unified regulatory framework on the territory of the Eurasian Customs Union, where Belarus is one of the founding states.

It is generally accepted that the Rules is the significant document which is sufficient to provide safe, trouble free equipment functioning in case of strict rules observation, especially at oil & gas refineries. In particular, during practical application of the Rules at refineries some contradictions had appeared. These contradictions need to be analyzed, studied and discussed. The above problems determined the object of the research.

Results, their discussion and perspectives. We consider that the abolition of concept “supervising of technical condition of device on the part of owner” is the most important and doubtful Rules innovation. During the last period of USSR technical control group activity its actions had been regulated by “the standard technical supervision approved by the USSR enterprises of Minchimprom” affirmed in 1983, and “the provision of technical control group activity at Minneftechimprom enterprises of the USSR” affirmed in 1983. That means that some Acts, which identified in details and regulated technical control group activity functioned together with the Rules of organization and procuring industrial safety of the equipment valid in the USSR. Such requirements are found in Byelorussian national TNPA: “Rules of organization and procuring industrial safety of the equipment (vessels) operating under excessive pressure”, “Rules of organization and procuring industrial safety of the process pipeline”, “Rules of organization and procuring industrial safety of lifting cranes”, which established practical technical codes of tanks technical operation, ventilation system, industrial buildings and structures, “the provision of technical control group activity at Belneftechim organizations.

Requirements for the qualification and education level of specialists, demand for responsible specialists for supervision of certain types of technical devices had been specified by TNPA. In practice, appointed specialists were postgraduates or those who finished college. They had enough experience in maintenance, exploitation and repair of the equipment.

With reference to previously listed TNPA and in accordance with current law acts, in particular, requirements 4.4.3 TKP 506-2013 “Chemical plant and facility explosion. General requirements”, technical control group has functioned for more than 50 years at Naftan, which nowadays is guided by “provision of technical control group activity at Belneftekhim organizations”. Groups have been working from the very start-up at “Grodno Azot”, “Mozyr oil refinery plant”, “Mogilevchimvolokno”, Naftan, Polymir, etc.

At the same time, in the article 30 of the law of Belarus “About industrial safety” dated the 5th of January 2016 №354- the following basic rights of industrial safety specialists are noted:

Technology, Machine-building, Geodesy

- industrial safety inspection, compliance with requirements of industrial safety, consideration of document on issues of industrial safety;
- demand for written explanations from officials and employees who have violated the requirements of industrial safety;
- informative explanatory work with employees on industrial safety issues;
- advancement of proposals concerning industrial safety to the site manager to prevent accidents and incidents.

Here we need to pay attention that all above functions (from the act 30 of the Low) are determined and used by technical supervision specialists in accordance with "provision of technical control group activity at Belneftechim organizations and local enterprises".

For comparison, technical control group specialist gives prescriptions and monitors their implementation and technical supervision specialist, besides the monitoring of the equipment functionality during between - repair periods, carries out an equipment audit and tests, identifies defects, looks for technical solutions, controls defect elimination, and by his own signature and seal allows the operate equipment for the period indicated by the TNPA. In case of the equipment operating under excessive pressure, above functions are carried out by Gospromnadzor MES of RB experts. In addition to previously indicated responsibilities, the technical supervision head specialist has to fulfill preventive safety work on the equipment usage.

Moreover, it is important to note that there is no head to exercise control over the dangerous industrial facility during technical survey of the equipment operating under excessive pressure. Earlier these functions had been carried out by a person responsible for supervision, but in the renewed Rules edition, these duties are transferred to a person responsible for exploitation of the equipment operating under excessive pressure.

Based on the facts, there is the need and expediency to add the concept "technical supervision group" to the «Rules of procuring industrial safety of the equipment operating under excessive pressure» with the same formulation as in the general document in the industrial safety exploitation of the equipment operating under excessive pressure area.

The second and no less important Rules usage problem is connected with new equipment purchase and old equipment repairing, in particular with weld control. Earlier requirements and methods of control were strictly determined in "Rules of organization and procuring industrial safety of the equipment (vessels) operating under excessive pressure". In accordance with the Application 9 the vessel group was specified by pressure, temperature and working conditions. In the application 14 content of control process was defined. Today in Belarus there is no affirmed document to specify weld control details during the process of vessels producing or repairing. In the 157-th Paragraph of the renewed Rules edition it is written: "Control requirements for each type of equipment operating under excessive pressure are indicated either in project or in technical documentation". From our point of view the idea "indicated in project or technical documentation" is incorrect because project organization during documentation development is to take into account some TNPA requirements, nonexistent in Belarus,

It should be noted that the Rules are also applicable to equipment repairing without formulated project documentation. Here we have the following question: Where should the details of weld control process be taken from?

There is an example: the 1st group vessel by TR TS 032-2013 certification was bought, but in project documentation extent of weld control was established as 30%. Moreover there is an explosive fire hazardous mixture or a mixture of the 1st or the 2nd hazardous class as per GOST 12.1.007 in the vessel.

Earlier, for safety, 100% of welds were under control, but according to present Rules edition it's enough to control 30, 5 or 0% of all welds (as indicated in the project). Then it's necessary to enclose TR TS 032-2013 correspondence certificate and to provide standard application, which confirm accordance of TR TS. As a result, enterprises can face an unqualified equipment application at different dangerous production lines because of impossibility to have weld control requirements by TNPA. In this situation it seems logical to use volume control norms indicated in previous Rules editions.

The requirement for the red manometer line has remained unchanged in new Rules edition. According to the requirement of the 249 paragraph: "The red line has to be painted on the manometer scale the red line has to be painted at the division level corresponding the work pressure for the element, taking into account the additional pressure from the weight of the liquid column". Such requirement is realizable at enterprises with 5-10 pieces of equipment with manometers and with stable operation, and is useless at big enterprises like oil refineries. Here is an example of an air preparation unit: normal pressure for dried air is about 0.6 MPa. When air drying unit is switched on the system pressure falls to 0.4 MPa, due to additional hydraulic pressure resistance which is produced when air passes through absorbent.

Normal operation modes established by technological regulations are applied in both cases. Mode alternation can be made several times per day with pressure change. Here is the question: what pressure should be considered working and where should the red line be painted? In this situation the red arrow should be painted at the allowed pressure level for each vessel with the passport. There won't be any regime change dependence; the mode control will be carried out by automatic devices.

One more significant difference of the new Rules is the absence of requirements for calibration of safety valves established on the equipment. In fact, the safety valve is an important part, which prevents a vessel from breakdown in case of unexpected pressure rise in the system. In the previous Rules edition there was the requirement for calibration of safety valves at pressure not exceeding working one for the mentioned valve. In case of pressure rise by some reason in the system above specified limits, safety valve disruption happens. After the pressure decrease hermetic valve closure is sometimes impossible due to abrasives from working mixture, scavenge formations under the valve seat, that lead to process unit emergency stop. However, the general usage of the safety valve is to prevent a vessel from breakdown, not to control technological regime. For each vessel the calculated (for the new equipment) and allowed (for technically diagnosed equipment) pressure values are noted in the passport. Based on these pressure values the hydrotesting pressure calculation was made, under which the vessel is being tested before its exploitation. With the calibration of valves under calculated (allowed) pressure safety and stability of the vessel is guaranteed in emergency situation (the vessel stability under such pressure is confirmed by hydrotesting pressure which 1.25 times higher than the working one taking into account temperature coefficient), valve fault with pressure change in the system is excluded.

Conclusion. Hence, there are a few contradictions in the present edition of «Rules of procuring industrial safety of the equipment operating under excessive pressure», which require a detalization and changes in order to maintain safe work of the equipment operating under excessive pressure. In fact, there is some weakening of responsibility at a present time period for industrial safety control. It leads to some exploitation difficulties of the equipment operating under excessive pressure.

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DETECTION OF DANGERS IN A LIFE CYCLE OF MAIN PIPELINE TRANSPORT

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This article is devoted to identifying dangers at different stages of the life cycle of the main pipeline transport with the use of the process approach. The essence of the process approach is to identify processes and provide their interoperability. Preference in selection of process approach was based on the statement that the creation of quality and emergence of quality loss, and thus the security as a component of quality happen in processes. It was also proposed to use a graphical display of the processes in the technical normative legal acts because the presentation of processes becomes concise, well received, intuitive and at the same time meaningful and informative.

The activity of any organization can be graphically represented in the form of interrelations between personnel, processes, legal acts, raw materials. This allows us to visually see the scheme and understand the purpose of the organization's functioning, to identify and evaluate inefficient links. In this regard it is convenient to apply a process approach in assessing the effectiveness of the organization's activities. The essence of the process approach is the systematic identification of processes and ensuring their interaction.

The application of the process approach implies the consideration of company activities as a set of processes that use resources and transform inputs into outputs under the influence of control actions to achieve the organization's main goals. In this case the organizational units are viewed not as structural units with their separate goals but as participants in the process. When presenting the process of producing products or providing services in the form of a sequence of processes the structure of product value formation is better understood, it is possible to analyze the causes of the loss of quality and its constituent - safety from possible hazards. In its turn for the competent construction of a network of processes it is necessary to have information on their classification.

All processes of any activity can be divided into life cycle processes, management processes and resource provision processes [1].

As indicated in [2] the processes necessary for a quality management system should include management processes, support processes, life cycle processes and measurements. This classification of processes should be considered the most complete since it covers all the processes that are present in the activities of the organization. Considering that safety is one of the quality indicators in describing the network of processes to assess their safety it is advisable to use this classification of processes.

Management processes should include planning and analysis by management. A distinctive feature of this class of processes is the results which are the developed conditions under which the support processes, life cycle processes and measurement processes should function.

Processes for providing resources are auxiliary processes. They cannot be attributed either to managerial processes or to the life cycle processes. A distinctive feature of these processes is that the results of these processes are the resources that are used in the implementation of life cycle processes and resource management.

Life cycle processes can be divided into separate processes each of which corresponds to a certain stage of the product life cycle: planning, design, product development, procurement, production and maintenance. A distinctive feature of these processes is that the result of these processes is the product or service provided.

Measurement processes should include processes for monitoring, analyzing, measuring, managing inappropriate products and improving. A distinctive feature of these processes is the results which are indications that are aimed at improving the product or services provided and are used in the management, provision and life cycle processes.

An accurate and detailed description of the network of processes in the main pipeline transport requires the presentation of peculiar features as well as the processes and resources involved in it at all stages of its life cycle.

Among the features peculiar to the main pipeline transport in its functioning and distinguishing it from other types of transport the following features can be shown:

- as a result of the operation of the main pipeline transport products are not produced but a service is provided for the transportation of gas, oil and oil products from their production sites to the places of consumption;

- the main pipeline transport is a linear-extended type construction. Its main component is a linear part representing a continuous thread welded from individual steel pipes and laid along the route in one way or another;

- this type of transport is characterized by the possibility of its ubiquitous laying, so it can be used in a variety of topographic, geological, hydrological and climatic conditions;

- during functioning of this mode of transport a low cost of transportation is ensured in comparison to other types of transport;

- during transportation of hydrocarbon carriers by pipeline transport their quality is ensured due to the complete hermetic sealing of the pipe;

- during operation the automation of pouring, pumping, transporting and discharging of the energy carrier is maintained;

- the main pipeline transport is serviced by a small number of personnel

- in abnormal operation mode the main pipeline transport as a hazardous production facility becomes a source of a number of hazards accompanied by large negative consequences for the environment, personnel, population and other technical facilities.

In the life cycle of the main pipeline transport 7 main stages can be highlighted: design, construction, operation, reconstruction, overhaul, conservation, liquidation [3].

The interaction between the processes at each stage is organized sequentially, in parallel or in series-parallel which is connected with the possibility of performing the next process when one or several simultaneous processes arrive at its input.

Dangers can occur at each stage of the life cycle. Each stage is characterized by its inherent danger which happens due to the presence of individual material and information flow at each stage. Possible types of hazards that are inherent in this or that object of technical regulation and respectively the main pipeline transport are presented in [4] and consist of 11 species. The most interesting from the point of view of the origin and manifestation of hazards are such stages of the life cycle as design, construction, operation, reconstruction and overhaul. In the process of conservation and liquidation less hazards are observed.

Designing is a very important stage. Designing is the only stage of the life cycle where there is no manifestation of the dangers associated with the operation of the main pipeline transport. At this stage the basics for the operation of the main pipeline transport and the potential conditions that lead to the emergence of danger in the future are laid.

At the stage of construction of the main pipeline the quality of the installation works determines its failure-free operation in the future. Poor work performance during construction will contribute to the emergence of hazards and their transition to the next stage of the life cycle – operation. The interaction between processes on a given stage of the life cycle occurs predominantly sequentially. It should be noted that the processes and their results are subject to production, operational, inspection and author supervision. Each process during the construction of the main pipeline is a carrier of potential danger. To identify these processes on a more detailed level it is necessary to decompose the processes of the first level.

Visual detailed representation of the processes creates convenient conditions for further analysis of the possibility of a particular hazard occurrence. Comparing each process of the second level of decomposition to potential hazards it is possible to compile a list of the dangers inherent to processes at different stages of the life cycle. After considering each process at a lower level of decomposition and comparing possible hazards it can be concluded that the following types of hazards can occur at the construction stage: mechanical, fire, thermal, electric.

Operation is the longest stage of the life cycle in the main pipeline transport corresponding to the standard service life and even longer periods. It is during the operation that all the shortcomings of design solutions and construction are revealed. A distinctive feature of this stage is the simultaneous both sequential and parallel interaction between processes. While analyzing each process at the second level of decomposition for the appearance of danger it was revealed that at the operational stage the greatest number of hazards occur and they are related to the following types: mechanical, industrial, chemical, fire, explosion, thermal, electric.

Overhaul of the main pipeline transport is a complex of technical measures aimed at the full or partial restoration of facilities to design characteristics. Overhaul is carried out after elimination of the detected during diagnostics defects. Potentially dangerous defects are eliminated in the process of overhaul. Interaction

between processes is mainly sequential. The applied approach allowed to determine that at the given stage of the life cycle the following types of hazards can arise: mechanical, industrial, fire, explosion, thermal, electric.

Reconstruction of the main pipeline is a complex of measures for the reorganization or technical re-equipment of the main pipeline. In terms of the content of the works performed and the application of technical basic legal acts this stage of the life cycle is similar to construction. At this stage of the life cycle the following types of hazards can occur: mechanical, industrial, fire, explosion, thermal, electrical. Interaction between processes is mainly sequential.

Conservation of the main pipeline is a set of measures to protect the main pipeline facilities from adverse environmental impacts and other factors after the main pipeline is taken out of service. At this stage of the life cycle there may be such hazards as mechanical, fire, explosion, thermal, electrical. Interaction between processes is mainly sequential.

The liquidation of the main pipeline is the actions for dismantling, demolition or re-profiling of the main pipeline facilities and bringing the environment into a condition that is safe for life and health of citizens and suitable for further use. At this stage of the life cycle there may be such hazards as mechanical, fire, explosion, thermal, electrical. Interaction between processes is mainly sequential.

The presentation of the stages of the main pipeline transport life cycle at the second level of decomposition with the help of the process approach made it possible to compare the types of hazards to the stages of the life cycle.

Dangers in the main pipeline transport can originate at any stage of the life cycle. Among them the most important are designing and construction. The manifestation of hazards can occur at all stages of the life cycle with the exception of design. During the construction of the main pipeline, 4 types of hazards can occur, during operation – 7, during major repairs – 6, during reconstruction – 6, at liquidation – 5. Operation as the life cycle stage of the main pipeline transport is the most dangerous and responsible both in quantity of dangers and the scale of their manifestation.

Thus, from all stages of the life cycle operation requires the most thorough systematic assessment of hazards. Performing an assessment of the dangers must be carried out by focusing on the process approach because both quality assurance and loss of security are observed in the processes. The display of processes and the interrelationships between them in a graphic form facilitates the process of assessing hazards since such a graphical representation is concise, intuitive, well perceived and at the same time informative.

The proposed approach of mapping processes in graphic form is expedient for applying in the development of technical normative legal acts in the main pipeline transport. Currently the most of the technical regulatory legal acts are presented in text form. This is not always convenient for understanding because the text can poorly trace the sequence of processes and doesn't describe the inputs to processes and outputs from processes. Graphical display of processes with inputs, outputs, control actions will eliminate this disadvantage. Along with that this approach allows to take into account the maximum possible list of hazards arising in processes at various stages of the life cycle when developing technical regulatory legal acts. This feature is realized by decomposing the processes of the highest level to simple operations.

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**COMPARISON OF EQUIPMENT USED FOR REGULATION
OF WORKING CHARACTERISTICS OF THE MAIN PUMPS ON OIL PIPELINES****MANANNIKOV VITALY, ALIAKSEI VARONIN**

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The main goal of this article is to determine the most effective and reliable method for changing the characteristics of pumping units. Since during the operation of pumping units the consumption of hydrocarbon energy carriers by consumers is unstable, the question arises of reducing the energy costs for the electric motors input at pumping units. There are a number of methods for solving this problem. Here we will consider two basic and effective methods of regulating the performance that are currently used at the constructed pumping stations: the use of a frequency-controlled drive and a hydraulic coupling. A number of advantages and disadvantages of these methods are given and a conclusion is made as to which is more suitable both in terms of efficiency and reliability.

The condition for effective operation of pumping and compressor stations of main pipelines is continuous control of their performance. The performance control reduces energy costs and adapts the pressure and flow to the operating conditions of the transport system. So, with regard to the operating conditions of the oil transportation system seasonal fluctuations of oil consumption are unavoidable due to start-ups and stops of pump units and changes in oil flows through separate pipelines.

No pipeline works with the same capacity during the year. The reasons for work that differs from initially scheduled can be the following: insufficient amount of pumped liquid in the reservoirs, repairing works on the pipeline route without stopping pumping, organization of ground discharges, stop of the intermediate pumping stations or change in viscosity of the pumped liquid [1].

Regulation of the pump supply [2] and ensuring its operation at the required point is possible both by changing the resistance of the pipeline and by changing the characteristics of the pump. The pump speed can be changed in the following ways: either using variable speed motors or at a constant speed of the electric motor with an adjustable hydraulic clutch or a high-voltage variable-frequency drive.

The variable frequency converter (VFC) provides the ability to operate equipment at various speeds, which is realized by converting a general-purpose supply with a constant frequency and a constant voltage to a current with variable frequency and alternating voltage. Transformation is carried out electronically without moving parts and without side effects that are undesirable to the user. The efficiency of modern frequency converters ranged from 96.5% to 98.5%. One of the producers of this type of units is Danfoss which sells its production all over the world.

This method has the following advantages:

1) VFC allows regulating both minimum and maximum operating pressure at the inlet of the main pumping unit.

2) When using the VFC, no additional soft starter is required.

3) Frequency control reduces the number of replaceable pump rotors.

4) VFC can be used to redistribute oil streams when it is necessary to drop some of the oil to other directions, with the discharge being either permanent or variable.

5) Advantages of using VFC to maintain pumping modes are evident, associated with a sharp change in the rheological properties of the pumped medium (density, viscosity). For example, if one of the sections of the pipeline starts pumping oil with a higher density or viscosity, and this requires pressure increase - this is easily done by changing the speed of the pumping unit.

Above, the advantages of using VFC were compared with other frequency control methods. However, when installing an inverter, the following important aspects of its operation must be considered: significant increase in value and investment costs during operation. This type of device is also the source of electromagnetic interference.

A hydraulic drive is a set of devices designed to drive machines by means of a pressurized working fluid while performing control functions.

The adjustable turbine coupling produced by Voith is a hydrodynamic coupling. It transfers the energy coming from the engine due to the dynamic forces of the fluid flow circulating in the closed working cavity between the pump wheel on the leading (primary) shaft and a similar turbine wheel on the driven (secondary)

shaft. With a variable turbo coupling, the filling fluid can vary to any degree between the full and empty state. Due to this, infinitely variable speed control of the working machine is possible in a wide range when working with different load characteristics.

Voith company has considerable experience [3] of equipping of pumps and compressors of main pipelines with adjustable hydrodynamic drives, offering various types of hydraulic couplings for capacities up to 35 MW. One of the largest projects implemented with the participation of Voith Turbo in the CIS countries is the equipping of the East Siberia-Pacific Ocean-2 oil pipeline with the Voith hydraulic couplings.

The choice of hydraulic couplings as an adjustable pump drive is explained by a number of significant advantages:

- saving investment costs: not yielding to the frequency-controlled drive in the accuracy and speed of automatic control of the pump's performance, the hydraulic coupling has lower cost and does not require a whole series of additional investment costs.

- compactness: the hydraulic coupling occupies an area several times smaller than the frequency converter.

- high reliability and durability with minimal maintenance costs: the operating time without failures of the hydraulic clutches supplied for the ESPO-2 is 154,000 hours, and the running costs are reduced only to the replacement of oil (if the service requirements are met - every 5 years). Working for 30-40 years, the hydraulic clutch remains maintainable, while the frequency converter, due to the rapid change in the element base, becomes almost non-repairable in 8-10 years of operation.

- high adaptive ability of the hydraulic coupling for use in various designs, different operating conditions: adjustable Voith hydraulic couplings show the same technical readiness, both in the Arabian deserts and on offshore platforms of the North Sea or the Sakhalin shelf. They are suitable for operation in both high and low temperature conditions, high humidity and dust, high salt content in the air, etc.

Damping property is an important advantage [4] of the hydraulic coupling, which protects all drive elements from impact loads, thereby increasing the resources of the pump unit.

Another example of the application of hydraulic clutches for regulating the capacity of gas-pumping units in the main gas pipeline is the compressor station Cheboksarskaya (Russia) where hydraulic clutches were installed in 2005.

Nevertheless, hydraulic couplings have one drawback - it has a lower efficiency than the VFC.

Comparative characteristics of devices for regulating the speed of the VFD and the hydraulic coupling show that the first version (VFR) has large mass, several times larger than the size. This method has strict requirements at the installation site, and the time between failures is one fourth (40,000 h) of the operating time of the hydraulic clutches (160,000 h).

On the basis of the foregoing, it is obvious that the use of VFC is more effective, but is also more difficult to operate and maintain and less fault-tolerant.

Due to the high cost of the VDC equipment (about 3 times more than the cost of the hydraulic coupling) and the high cost of operating costs, the payback of the VFC relative to the hydraulic coupling during the operation period (40 years) is possible only if the oil is pumped constantly. Based on the presented criteria, it can be concluded that the hydraulic coupling is cheaper to maintain, more reliable and durable in operation.

Thus comparable analysis of equipment used for regulation of working parameters of the main pumps on oil pipelines showed that application of the hydraulic coupling is more preferable according to its operational capabilities and cost effectiveness.

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A METHOD OF REDUCING EMISSIONS OF HARMFUL SUBSTANCES INTO THE ATMOSPHERE BY BOILER PLANTS

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The article deals with harmful substances which are formed during boiler operation and their influence on people. An estimation of the dynamics of the change in the environmental tax on the emission of pollutants into the atmospheric air over the last ten years is given. The mechanism of formation of nitrogen oxides is considered. Recommendations are given on possible ways to reduce emissions of nitrogen oxides to the atmosphere that form during the operation of boiler houses. It is noted that using emulsions based on oily waste as an additive to the main fuel of boiler plants will allow not only to dispose of these substances, but will reduce emissions of nitrogen oxides into the atmosphere and consumption of the main fuel.

Introduction. At present, the problem of protecting the environment from harmful emissions from the use of fossil fuels, including natural gas, attracts the attention not only of scientists but of the entire world community. Acad. M.A. Strykovich notes [1] that in recent years, the anthropogenic impact of boiler plants on the atmosphere has become especially dangerous, the number of which increases every year. The annual emissions of the main toxic substances are: 150 million tons of sulphur dioxide, 300 million tons of carbon monoxide, 50 million tons of nitrogen oxides.

According to the data of prof. I. J. Sigala [2], Table 1 shows the effects of some toxic substances on the human body, confirming the relevance of work to reduce the hazards in combustion products of fuel.

Table 1. – Characteristics of exposure to harmful substances per person

Duration and nature of human exposure	Content in air, %		
	CO	NO _x	SO ₂
A few hours without noticeable action	0,01	0,0008	0,0025
Signs of easy poisoning	0,01–0,05	0,001	0,005
Serious poisoning is possible in 30 minutes	0,05–0,30	0,005	0,008–0,015
Danger of life if exposed for short periods of time	0,50–0,80	0,015	0,060

Objective – Having considered the mechanism of formation of nitrogen oxides, we propose ways to reduce emissions of nitrogen oxides into the atmosphere by boiler plants.

Results and discussion. Boiler installations, which many enterprises have, are both large consumers of fuel and energy resources and large sources of pollutant emissions [1, 2]. The pollutants formed during the operation of the boiler plants are classified in the following hazard classes: nitrogen (II) oxide (nitrogen oxide) – 3; nitrogen (IV) oxide (nitrogen dioxide) – 2; sulfur dioxide (sulfurous anhydride, sulfur (IV) oxide, sulphur gas) – 3; solid particles (undifferentiated by composition dust / aerosol) – 3; aromatic hydrocarbons – 2; aliphatic hydrocarbons C₁–C₁₀ – 4; aliphatic hydrocarbons C₁₁–C₁₉ – 4; carbon black (Soot) – 3; carbon oxide (carbon monoxide) – 4.

A company pays an environmental tax for these emissions. According to the Tax Code of the Republic of Belarus (Special part) of December 29, 2009 No. 71-3 (including changes and amendments, including the Law of the Republic of Belarus of January 9, 2017 No. 15-3), the environmental tax rate (rub) for emissions of pollutants into the air, in total for 1 ton substances currently constitute: the second hazard class – 769.97; third hazard class – 254.54; fourth hazard class – 126.48. Figure 1 shows the change in the environmental tax on the emission of pollutants of various hazard classes into the ambient air annually since 2008.

The dynamics of the growth of the ecological tax is vivid. Figure 2 shows the change in the ratio of the environmental tax rate for the emission of pollutants into the ambient air over the years to the rate applicable in 2008 for the second hazard class (for other hazard classes the ratio is almost the same). During 10 years the rate has increased almost 6 times. This should motivate enterprises to reduce emissions of pollutants into the air.

For many enterprises, paying an environmental tax for emissions of pollutants into the atmosphere is an important expense item and one of the reasons for switching boiler plants from fuel oil to natural gas. The use of natural gas as fuel in boiler plants excludes atmospheric pollution by sulfur dioxide and solid particles. At the

same time there is a continuous pollution of the atmosphere by combustion products of gaseous fuel (mainly nitrogen dioxide) [2].

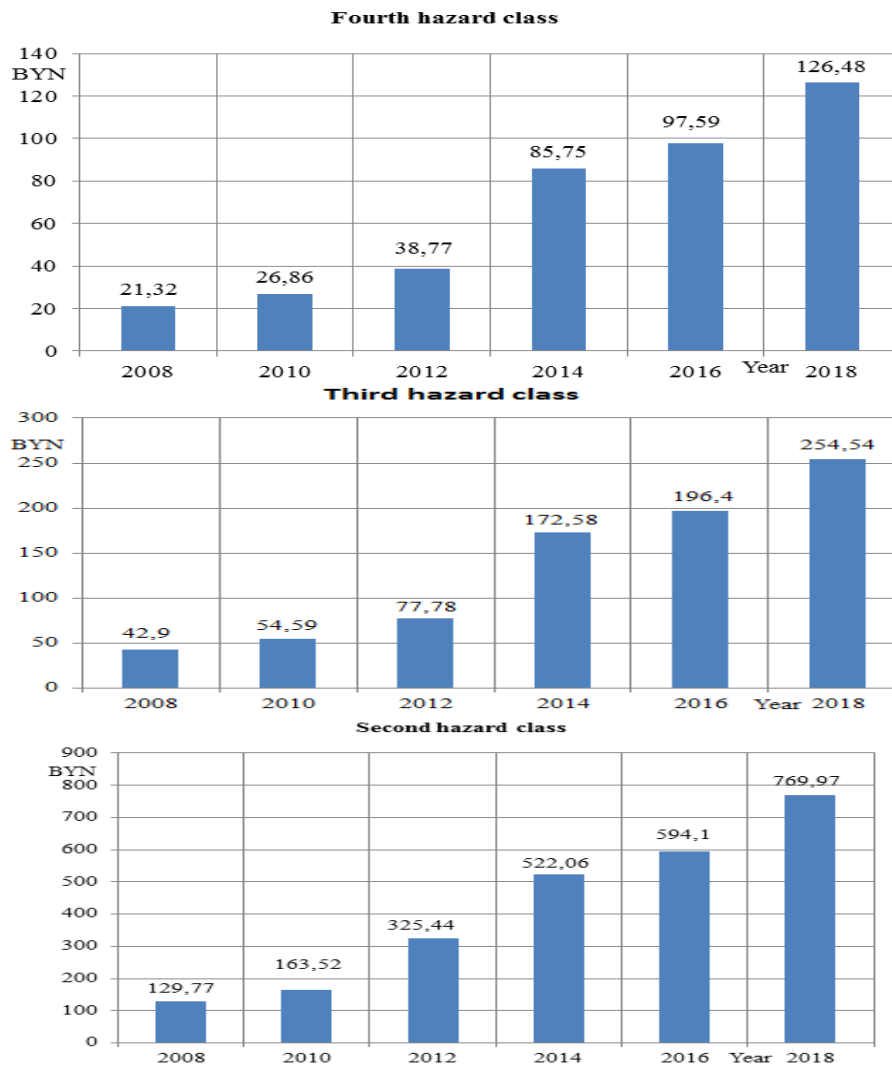
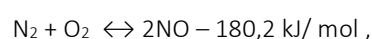


Fig. 1. Change in environmental tax on pollutant emissions of different hazard classes in the atmospheric air annually

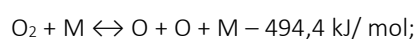
Formation of nitrogen oxides. Nitrogen oxides at high temperature form a number of thermodynamic stability: NO, N₂O, NO₂, N₂O₃, N₂O₄ [2]. Both nitrogen from the air and organic compounds of nitrogen with fuel take part in the formation of oxides [3]. The formation of nitrogen oxides is affected by catalysts - various compounds of mineral or mineral-organic constituents of fuel [2, 3]. Both the increase in the power of the burners and the boiler load, and the increase in the temperature of the medium in the furnace contribute to the increase of NO_x formation [2].

Nitric oxide is about 95% of the sum of all nitric oxides [2]. NO formation under high temperature oxidation of atmospheric nitrogen occurs by a radical chain mechanism with N and O atoms. The gross reaction of NO formation [3] can be expressed in the following form:



the complete chain diagram of this reaction is as follows:

initiation:



chains:

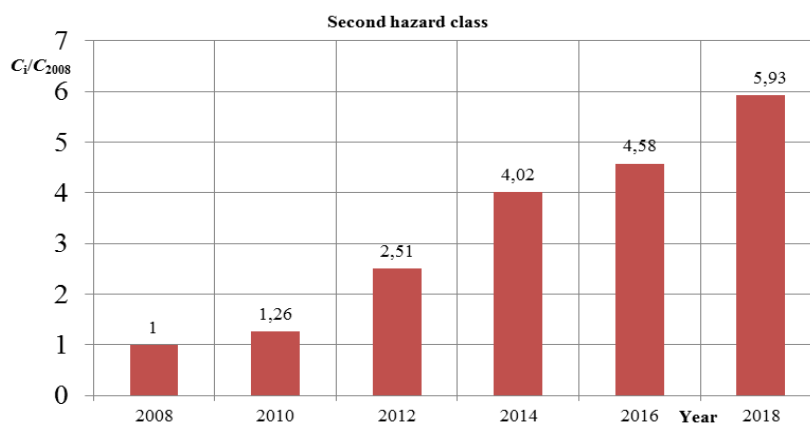
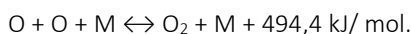


Fig. 2. Change in the ratio of the rate of environmental tax on the emission of pollutants into the air of the i -th year to the rate of 2008

chain termination:



Coming with flue gases to the atmosphere, NO is oxidized to nitrogen dioxide NO₂, reacts with atmospheric moisture and falls out with precipitation as a weak solution of nitric acid HNO₃, dissolving in water bodies. The formation of NO₂ at an excess air-content ratio of 1.1 and a flue gas temperature of 200 °C requires 35 minutes, so it is practically not formed in the gas path of the boiler. N₂O heminoxides are thermally unstable, and the proportions of the dimer of N₂O₄ dioxide and N₂O₃ trioxide are very small to take into account when studying toxic emissions of boilers [2].

The share of harmful emissions in the flue gas composition also includes nitrogen oxides formed from chemically bound nitrogen of the fuel. Fuel nitrogen through the radicals is partially oxidized to nitrogen oxides. The separation of nitrogen atoms from fuel elements consumes 1.5-4.0 times less energy than the dissociation of the nitrogen molecule from the air. The major part of the nitrogen oxides formed in the furnace of the boiler is due to the high temperature of the medium in the combustion zone and the presence of an oxidizer.

Oxides and nitrogen dioxide are formed by burning fuel in high temperature zones. Studies conducted under the supervision of Acad. J.B. Zeldovich [3] showed that reducing the burnup time of fuel droplets by two times leads to a decrease in NO_x concentration by 22% (Figure 3). Thus, the reduction in the residence time of the combustion products in the high-temperature zone of the boiler furnace leads to a decrease in the concentration of nitrogen oxides.

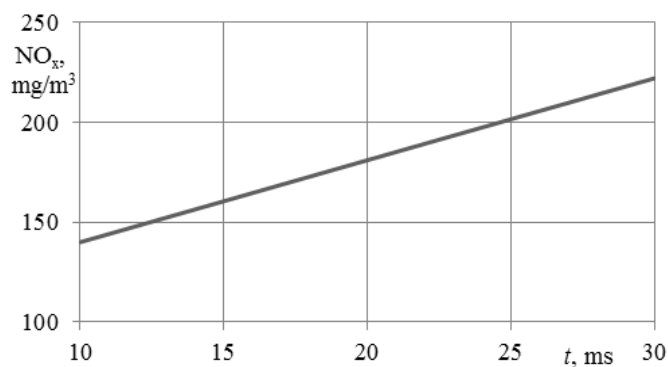


Fig. 3. Dependence of nitrogen oxides NO_x in flue gases (from burning oily emulsion) on the burnout time t in the boiler flare

To improve the environmental situation in the area of operation of boiler plants, it is necessary to strive not only to suppress the formed harmful substances, but also to a greater extent to the localization of their appearance [1-3]. One way to reduce the formation of harmful substances (oxides and nitrogen dioxide and carbon monoxide (II)) during the combustion of gaseous fuels is the injection of water or steam into the combustion chamber [2-5]. In prof. I.J. Sigala's opinion [2], the introduction of water or steam into the fuel-air mixture affects the combustion and formation of NO_x no less than the introduction of a similar volume of recirculating gases. Water vapour has a strong inhibitory effect on the synthesis of nitrogen oxides due to the effect of water vapour on the kinetics of NO_x formation. The prerequisite for this is the fact that water vapour affects the flame propagation velocity, and therefore the introduction of even a small amount of water vapour into the core of the combustion zone significantly affects the yield of nitrogen oxides.

However, on an industrial scale, this method is practically not used. It is due to the fact that, according to Acad. J.B. Zeldovich [3] and prof. I.J. Sigala [2], when the temperature of the flare decreases, the efficiency of the boiler decreases, which means that an additional volume of fuel is needed.

Polotsk State University is carrying out research to develop a technology for the preparation of emulsions based on oily waste [6-8]. Its use will allow enterprises to significantly reduce the capital and current costs for the separation of oily waste into petroleum products and water, since the emulsion includes water. One way to use such an emulsion is to use it as an additive to the main fuel of boiler plants [4, 5, 9].

Conclusion. Experimental studies have shown that burning emulsions based on oily waste (10-20% of water) with the main fuel with a uniform distribution of water throughout the volume of the material in the furnace of the steam boiler provides a reduction in emissions of harmful substances in the atmosphere compared to their quantity when burning dehydrated fuel. The reduction of carbon monoxide (II) by 43-59% and nitrogen oxides by 28-45% has been achieved. Using an emulsion based on OCW as an additive to fuel can reduce the consumption of the main boiler fuel by 3-5% [4, 5, 9].

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**THEORETICAL AND EXPERIMENTAL STUDY OF THE TEMPERATURE
IN THE WORKPIECE WHEN COVERING MILLING**

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A considered mathematical model for determining the temperature in a spherical workpiece, the calculation of the temperature of the spherical surface of the workpiece during processing with a rotating blade tool based on the method of point head sources, a graph of the temperature variation from the rotating angle of the workpiece.

With high-speed milling of spherical surfaces, it is important to know the temperature in the workpiece, since the temperature deformation has a significant impact on the accuracy and quality of the part [1].

For theoretical studies, known [2] mathematical formulas were used to calculate the temperature in the cylindrical and spherical bodies, since the workpiece in the case under consideration has the shape of a cylinder, and the finished part - the shape of the ball.

For the cylinder:

$$\frac{\partial \theta}{\partial t} = k \left(\frac{\partial^2 \theta}{\partial r^2} + \frac{1}{r} \cdot \frac{\partial \theta}{\partial r} + \frac{1}{r} \cdot \frac{\partial^2 \theta}{\partial \mu^2} + \frac{\partial^2 \theta}{\partial z^2} \right) + \varphi \frac{\partial \theta}{\partial \mu} \quad (1)$$

For the sphere:

$$\frac{\partial \theta}{\partial t} = k \left(\frac{\partial^2 \theta}{\partial r^2} + \frac{2}{r} \cdot \frac{\partial \theta}{\partial r} \right). \quad (2)$$

It is accepted that the heat source is fast-flowing, since the rotation speed of the cutter reaches 10 m / s and the Baking criterion $Pe > 10$:

$$Pe = 10 \frac{v(m/s) \cdot l_n(mil)}{K(sent^2/s)}. \quad (3)$$

The schematization of the heat source by [3] is adopted, which is shown in figure 1.

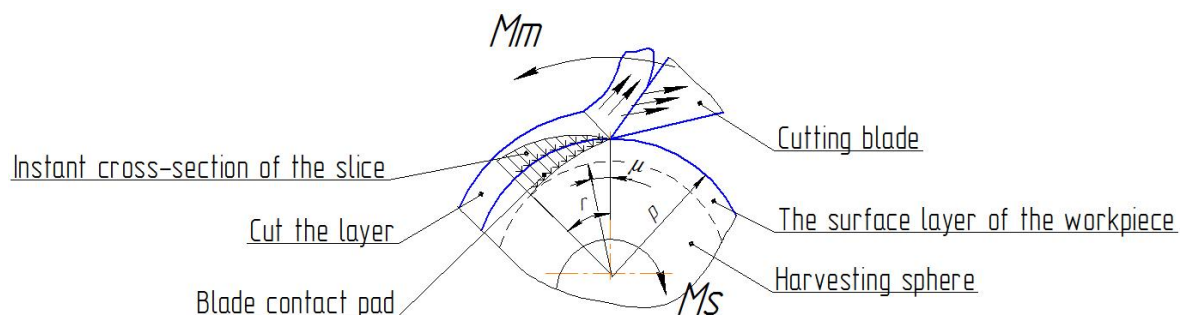


Fig. 1. Schematization of the heat source

We analyzed the results of studies on the kinematics of cutting, deformation, dynamics, thermal phenomena, surface roughness and precision, wear of cutting tools during the machining of the surfaces of the spheres cutting. Features and advantages of high-speed cutting for processing of spheres are revealed.

On the basis of the analysis of literary sources objects and directions of researches in the given dissertation are defined.

In the side Chapter describes and analyzes the possible kinematic cutting scheme obtained with the ratio of the circumferential velocity of the tool and the workpiece, and their impact on the roughness of the machined surface, the geometry of the tool blade and the cross-section of the cut layer in the cutting process.

The scheme of the combined treatment of the clamp spherical surface of the part is shown in figure 2 [3]. According to this scheme, the cutting tool 1 makes the main rotational motion of the M_r , and the workpiece 2 diameter D_{sph} is rotational motion of the supply M_{sr} . The workpiece is also reported forward motion M_{sn} , which provides rotation to a predetermined depth of cut. In this case, the cutting blades of the tool 1 are adjusted to the diameter D , and the workpiece 2 is installed relative to the tool at an angle to the axis of rotation η . The axes of rotation of the workpiece and the tool intersect at one point. The installation scheme provides an incomplete limited on one side of the spherical surface height H . Kinematic cutting scheme when inserting a rotating tool into a rotating

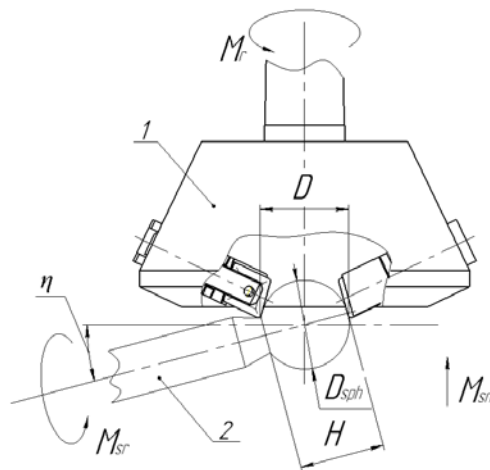


Fig. 2. Scheme of the combined treatment of the clamp spherical surface

workpiece is a three-element (M_r , M_{sr} , M_{sn}) and nursing (smoothing), when the translational motion is interrupted M_{sn} , goes into a two-element (M_r , M_{sr}). A complex cutting path is realized in the form of a cycloid bent into a spiral or circle and intersecting the latter.

Through platforms of contact in the form of "comma" thermal streams from a cutting zone direct in preparation, a shaving and a tooth of the tool. The contact length was determined by an empirical formula:

$$l_n = l \cdot \sin^{\chi_e} \tau, \tag{4}$$

where τ - contact angle;

l - the coefficient representing the soda value of the contact length at $\tau = 90^\circ$

$$l = \frac{c_e \cdot S^{ye}}{(v_w / v_t) \cdot z_e}.$$

The temperature from the point heat source according to [4] is described by the following equation:

$$\theta_{M.T.2}(r, \mu, z, t) = \frac{q_{M.T.2} \exp\left[-\frac{z^2}{4k(t-t_u)}\right]}{\pi \cdot R^2 \cdot \lambda \cdot \sqrt{\pi \cdot k \cdot (t-t_u)}} \cdot \left[1 + \sum_{n=-\infty}^{\infty} \cos n(\mu - \mu_u) \cdot \sum_{\alpha} \frac{\exp[-k \cdot \alpha^2 \cdot (t-t_u)] \cdot \alpha^2 \cdot \ln(\alpha r) \cdot \ln(\alpha r_u)}{\left(\alpha^2 - \frac{n^2}{R^2}\right) \cdot \ln^2(\alpha R)}\right], \tag{5}$$

where r, μ, z – the coordinates of the point of the cylinder;

r_u, μ_u, z_u – the coordinates of the heat source;

t – current time;

t_u – the duration of the heat source;

$q_{M.T.}$ – the intensity of the point heat source;

k – coefficient of thermal conductivity of the body;

λ – coefficient of thermal conductivity of the body;
 $\ln(x)$ – the Bessel function of the nth order of the first kind from a real argument;
 \sum_{α} - using the sum of the positive roots of the characteristic equation $\alpha \cdot \ln'(\alpha R) = 0$.

Entry conditions:

$$\begin{aligned} 0 \leq \mu < 2\pi; 0 \leq r \leq R; 0 \leq z \leq \infty, \\ t > 0; t|_{t=0} = 0; \end{aligned} \tag{6}$$

Boundary condition:

$$\frac{\partial \theta}{\partial r} \Big|_{r=R} = 0 \tag{7}$$

The formula for calculating the temperature in the workpiece when exposed to a temperature source in the form of a "comma" is obtained in the following form:

$$\begin{aligned} \theta_{n,2} = \frac{q_{n,2} \exp\left[-\frac{z^2}{4k(t-t_u)}\right]}{R^2 \cdot \lambda \cdot \sqrt{\pi \cdot k \cdot (t-t_u)}} \cdot \left[l \cdot \sin^{xe} \mu \left(R - \frac{1}{2} \cdot \sin^{xe} \mu \right) \right. \\ \left. + 2 \sum_{\alpha} \frac{\exp[-k \cdot \alpha^2 (t-t_u)] \cdot l_0(\alpha \cdot r)}{l_0(\alpha \cdot R)} \cdot \int_{R-l \cdot \sin^{xe} \mu}^R r_u \cdot l_0(\alpha \cdot r) \cdot dr_u \right]. \end{aligned} \tag{8}$$

If the source is valid for the time from 0 to t_u , then formula (8) is converted to the following form.

$$\begin{aligned} \theta_{n,2}(r, z, t) = \frac{2q_{n,2}}{R^2 \cdot \lambda \cdot \sqrt{\pi k}} \cdot \{ l \cdot \sin^{xe} \mu (2R - l \cdot \sin^{xe} \mu) \cdot \\ \cdot \left[2\sqrt{t} \cdot \exp\left(-\frac{z^2}{4kt}\right) - \frac{z\sqrt{\pi}}{\sqrt{k}} \cdot \operatorname{erfc}\left(\frac{z}{2\sqrt{k \cdot t}}\right) \right] + \frac{\sqrt{\pi}}{\sqrt{k}} \cdot \\ \cdot \sum_{\alpha \neq 0} \frac{\exp(-\alpha r) \cdot l_0(\alpha r)}{\alpha \cdot l_0^2(\alpha R)} \cdot \int_{R-l \cdot \sin^{xe} \mu}^R r_u l_0(\alpha r_u) \cdot \int_0^{\alpha \sqrt{kt}} \exp\left[-\left(\frac{z\alpha}{2x} - x\right)^2\right] dx \}. \end{aligned} \tag{9}$$

For quite a long time to work out the ($t \rightarrow \infty$) formula (9) is presented in the form:

$$\begin{aligned} \theta_{n,2}(r, z, t) = \frac{2q_{n,2}}{R^2 \cdot \lambda \cdot \sqrt{\pi \cdot k}} \cdot \{ l \cdot \sin^{xe} \mu (2R - l \cdot \sin^{xe} \mu) \cdot \\ \cdot \left[2 \cdot \sqrt{t} \cdot \exp\left(-\frac{z^2}{4kt}\right) - \frac{z\sqrt{\pi}}{\sqrt{k}} \right] + \frac{\sqrt{\pi}}{\sqrt{k}} \cdot \\ \cdot \sum_{\alpha \neq 0} \frac{e^{-\alpha z} l_0(\alpha r)}{\alpha \cdot l_0^2(\alpha R)} \cdot \left\{ \frac{R}{\alpha} l_1(\alpha R) - \frac{R - l \cdot \sin^{xe} \mu}{\alpha} \cdot l_1\left[\alpha \cdot R - l \cdot \sin^{xe} \mu\right] \right\} \}. \end{aligned} \tag{10}$$

According to the obtained formula (10), temperature calculations were carried out at different angles of contact of the cutter tooth with the workpiece and the following graphic dependence was obtained (figure 3).

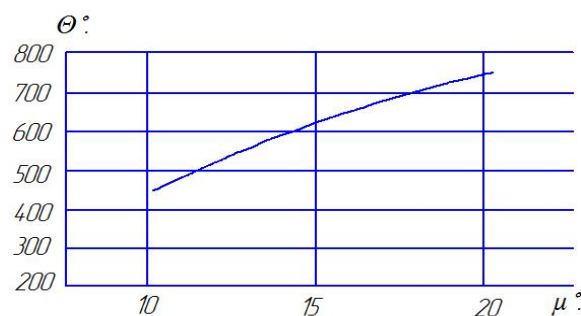


Fig. 3. Temperature calculations

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RECEIVING AN ANTIFREEZING AGENT FOR TRANSPORTING COKE BY RAIL

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The article presents the research findings of obtaining and analyzing the properties of antifreezing agent from products and semi-products of JSC Naftan to prevent sticking and freezing of coke to metal surface of open wagons during the transportation of petroleum coke from JSC Naftan to Belarusian Cement Plant in the wintertime.

Introduction. In autumn and especially wintertime, when coke, minerals and other loose rocks with high humidity are transported, there is sticking and freezing of a significant part of the solid mass to metal surfaces of wagons, and there is also freezing in a bulk cargo. In this regard, up to 50% of the bulk is not unloaded, which necessitates additional cleaning by means of excavators or manually and leads to a decrease in the productivity of quarry equipment by 15-20%. Accordingly, the cost of transportation increases by 20-25%.

To address the challenge of sticking and freezing of bulk cargo during transportation, there are various preventive means of oil origin, such as Nyogrin, Universin, Severin, produced by adding residual products of oil refining and petrochemistry. However, they all are produced in foreign countries and have a sufficiently high price. Due to a prompt commissioning of a delayed coking unit at JSC Naftan, there will be a problem of transporting petroleum fuel coke to Belarusian Cement Plant in Klimovichi at low temperatures.

The purpose of this study is to select component composition and to research the properties of Nyogrin-type preventive agents based on the residual products of JSC Naftan.

Preventive lubricants of petroleum origin should meet the following requirements [1, 2]:

- to have a low yield point;
- to lubricate a metal surface well;
- not to cause corrosion of metal surfaces;
- not to be toxic and fire-hazardous;
- to have a low cost;
- to be obtained in quantities necessary to meet the needs.

Methodology. A light vacuum gas oil with AVT-6 was chosen as the basic component of the preventive product from Naftan products and semi-products. For LVGO in the laboratory conditions, fractional distillation is performed. Density, kinematic viscosity, conditional viscosity, viscous flow activation energy, refractive index, flash points and surface tension are determined by Rebinder method.

High-molecular, heavy oil residues, such as: tar from VT-1, fuel oil with AVT-6, bitumen of oil building BN-90/10, semi-solid non-distilled residue of heavy pyrolysis resin, residual extract of selective purification of oils with phenol and residues from a Thermocracking unit are used as thickening, adhesive, anticorrosive and frost-proof additives to light vacuum gas oil. The content of asphaltenes is determined for high-molecular residues. The maximum content of asphaltenes in the form of a stable colloidal solution is characteristic of bitumen as the most severe residual product of oil refining. The minimum content of the residual extract is selective, which is associated with the preliminary removal of asphaltenes from tar, as it is deasphalted by propane. In addition to asphaltenes, crystals of high molecular weight, highly condensed aromatics, such as naphthalene, anthracene, and their derivatives, are formed in the pitch of the heavy pyrolysis resin.

Anti-freezing agents were obtained by mixing the residual products with a light vacuum gas oil and subsequent heat treatment at a temperature of up to 100°C for 1.5 – 2 hours by means of a mechanical paddle mixer. The residues were added in concentrations of up to 5% by weight to a LVGO.

Results, discussion and conclusion. Viscosity is an important indicator for preventive measures, at low ambient temperatures it should be low, which allows to apply the formulations on the surface of the transport equipment in a finely dispersed state using nozzles. Viscosity decreases relatively to the initial light vacuum gas oil when fuel oil and tar are involved, probably because the molecules of oil residues cause an increase in the compactness of dispersed particles and formation of nanoaggregate clusters.

For all samples, indicators such as flash temperature, an indicator characterizing the fire safety of the oil product and the refractive index are determined by which one can judge the prevalence of individual groups of hydrocarbons. The refractive index increases with increasing content of aromatic hydrocarbons. The flash point of petroleum products, depending on their volatility and vapor pressure when various additives were involved,

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was in all cases not lower than 125 ° C. According to this parameter, the obtained compositions are not inferior to the industrially produced preventive compositions Nyogrin and Universin, the flash point for which should not be lower than 75 and 80°C respectively. The obtained flash points meet the technical requirements, this is one of the main parameters, because the treatment of transport equipment with preventive measures should be carried out in open areas, or in closed rooms in compliance with fire safety standards.

The protective properties of preventive compositions in the presence of water are associated with the ability to create an adsorption-chemisorption membrane on the metal surface. The degree of corrosion on copper plates was determined by visual inspection of the surface of copper plates after 5 hours of testing them for corrosion. As a result of investigations, it was found that corrosion spots were not found on the surface of copper plates immersed in oil products. Corrosion degree 1a is established, which indicates insignificant corrosion for all test samples.

The analysis of the specific interfacial surface is performed on a spectrophotometer. The optical density of preventive agents increases in proportion to the increase in the concentration of the residue in the compositions. Molecules of oil residues cause an increase in the compactness of dispersed particles. Instead of a spatially loose structure, a finely dispersed compact structure is formed, which is accompanied by an increase in the specific interfacial surface.

Asphaltenes are strong surfactants that can adsorb at the phase interface and lower the surface tension. It was found that with a slight increase in the concentration of the residue, the surface tension of their solutions decreases sharply, further decrease in surface tension slows down with increasing concentration, and starting with the saturation concentration the new addition of the residue practically does not reduce the surface tension.

When heavy oil residues are mixed with gas oil fractions, the asphaltenes contained in them form mixed crystals with paraffins and cycloparaffins, which impedes their growth and the formation of a structural skeleton from solid hydrocarbon crystals due to the weakening of coagulation bonds between them. The nature of the curves for the change in the yield point of mixtures based on gas oil fractions is extreme. The extremum corresponds to 3% of the sediment concentration in the composition (the yield point is reduced by 29°C with tar involved and by 22°C when the fuel oil is involved), which corresponds to the optimum concentration of tar-asphaltene substances, at which the adsorption of the latter on the surface of all solid hydrocarbons available in the system.

The physicochemical properties of the antifreezing agent and industrial analogues are presented in Table 1.

Table 1. – Physico-chemical properties of the proposed antifreezing agent and industrial analogues

Antifreezing agent name	Yield point, ° C	Flash point, ° C	Conditional viscosity at 50 °C, ° VC	The content of H ₂ O, in a bulk %	The content of mechanical impurities, in a bulk %
Nyogrin-45	not higher -45	not less 40	1,0-3,0	no more 2,0	no more 1,0
University-40	not higher -40	not less 80	1,3-3,0	no more 0,5	no more 0,3
Severin-50	not higher -50	not less 80	1,1-1,5	no more 0,5	no more 0,2
Light vacuum gas oil with 3% tar mass (proposed product)	-29	148,8	1,49	0,01	traces

Simulation of the freezing process and adherence to the surface of open wagons was carried out under laboratory conditions with artificial coke watering in freezing chambers at a temperature of -25°C. A uniform thin layer of a chilled preventive agent was applied on the surface of pre-cooled metal trays (30 x 20 x 15 cm) with a brush, preventing the lubricant from flowing onto the metal surface. After 5-10 minutes after applying the preventive, an equal amount of bulk material was loaded into all containers. After using a pulverizer, the coal was moistured with water in amount of 5% to the bulk of coal. To create conditions that are as close as possible to loading conditions, after filling the containers with coke, an additional packing of loose rock was carried out. The filled trays were placed in freezing chambers for two days at a temperature of -25 ° C.

After the test time, the trays were emptied by overturning, then the metal surface of the laboratory open wagons was inspected, the degree of unloading of loose rock in percentage terms was estimated. For the tests, a sample of the antifreezing agent containing 97% of the light vacuum gas oil with 3% tar mass was taken. Laboratory tests showed that the processing of laboratory open wagons did not reveal a frozen product and no additional manual unloading was required.

Thus, the conducted researches made it possible to conclude that the antifreezing agent containing a light vacuum gas oil with 3% tar mass can be effectively used to prevent sticking and freezing of coke to the metal surface of open wagons. It is recommended for use in the transportation of petroleum coke from JSC Naftan to Belarusian Cement Plant in Klimovichi in winter.

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PROSPECTS OF USING COMPOSITE MATERIALS IN OIL AND GAS INDUSTRY

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In the world practice, composite materials are widely used in the oil and gas industry. In particular, fiberglass is used for production of field pipelines and reservoirs for storage of hydrocarbons, but this material has not been widely used in the Republic of Belarus, which raises questions, since glass-reinforced plastic (GRP) has a number of advantages compared to the metal of which the equipment is manufactured at present.

Composite material (composite, CM) is a structural (metallic or non-metallic) material which contains reinforcing elements in the form of threads, fibers or flakes of a more durable material. Examples of composite materials are plastics reinforced with boron, carbon, glass fibers, tows or fabrics based on them; aluminum, reinforced with steel and beryllium threads. By combining the volume content of the components, composite materials can be produced with the required strength, resistance to high temperatures and fire, modulus of elasticity, abrasion resistance, and also to create compositions with the necessary magnetic, dielectric, radio-absorbing and other special properties. By structure, composites are divided into several main groups: fibrous, laminated, dispersed, reinforced with particles, nanocomposites.

If we take a look at the oil and gas equipment used in manufacturing today, the main manufacturing material is steel. Steel is used for technical applications in mining, servicing, well overhaul, transportation and storage of raw materials. However, steel has a significant drawback, that is, a susceptibility to corrosion, due to both external exposure to the natural corrosive environment, and the chemical effect on the inside. Another significant drawback is the considerable weight of the equipment, which complicates the installation work and leads to the increase in cost, as well as the increase in transportation costs. In addition, using steel equipment leads to significant heat losses, which results in large energy costs to maintain the minimum temperature of the equipment. And it is typical for oil field equipment to operate in difficult operating conditions, especially for built-in equipment. Thus, for example, the operating time without failures of an electrical submersible pump unit depends on many factors. These include the angle of curvature of wells, intensity of curvature, presence of sharp bends of the trunk, composition of pumped liquid, pump descent depth, vibration impact, manufacturing technology, etc.

The solution of these problems is the usage of composite materials (fiberglass, reinforced thermoplastic). At present, in the oil and gas industry, the use of fiberglass pipes is widely developed, which are four times lighter than steel pipes with equal strength. They are not susceptible to corrosion, are resistant to chemicals, have a non-built-up smooth internal surface, which allows the use of pipes of smaller diameter in pipelines. They have low flammability, increased physical and mechanical properties, strength and resistance to overload. Fiberglass pipes are suitable for transportation of various liquids, gases, bulk materials, and can be used for drainage devices. Pipes are resistant to oil products, gas condensate, acids and alkalis. They do not require electrical protection against stray currents and are easy to install. One of the popular usages of composites is the production of vessels and tanks which are used in large quantities in oil production and storage of petroleum products.

Despite the obvious advantages of composite materials, in particular, fiberglass, it has not received wide application in the Republic of Belarus. One of the main reasons for that is the lack of an appropriate regulatory framework, because the production, use and maintenance of composite materials and structures made of them is regulated by technical standards (TNPA).

There are examples of current technical standards for products, which are made of fiberglass:

- Europe:

EN 13121-3-2016. GRP tanks and vessels for use above ground. Part 3: Design and workmanship;

- Russia:

GOST R 54559-2011. Pipes and parts of pipelines made of thermoset fibers reinforced with fiber. Terms and definitions;

GOST R 54560- 2011. Pipes and parts of pipelines made of fiberglass reinforced thermosets. - Specifications;

GOST R 54924, GOST R 54925, GOST R 54926, GOST R 55069, GOST R 55070, GOST R 55071, GOST R 55875, GOST R 55876 - Test methods;

GOST R 55072-2012. Tanks made of thermosetting fiber reinforced with glass.

- Belarus:

GOST 33123-2014. Pipes made of polymeric composites. Technical conditions - International standard; GOST 6943.3-79, GOST 6943.6-79, GOST 6943.8-79, GOST 6943.10-79, etc. Soviet GOSTs - Quality control of products.

The Republic of Belarus has a good background for the developing the market of fiberglass products (e.g., highly skilled workers, OJSC Polotsk-Steklovolokno). So, we need to develop a regulatory framework for the design and operation of structures made of composite materials, based on the international experience, as well as exploring the foreign technical standards.

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ANALYSIS OF CONSTRUCTIVE ELEMENTS OF HOUSING PARTS PROCESSED ON CNC MILLING MACHINE

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The constructive elements of housing parts processed on computer numerical control (CNC) milling machine have been considered. The analysis was made showing the frequency of usage of certain elements in the housing parts manufactured by OJSC "Izmeritel"

Housing parts make up to 20% in the general nomenclature of the parts manufactured in machine-building. The laboriousness of manufacturing these parts is 5-10 times higher than the laboriousness of manufacturing parts of other classes, due mainly to the widespread use of milling operations [1].

The use of CNC machines allows to reduce the amount of labor by dozens of times. When developing control programmes for these machines, it is necessary to have a classifier for the most frequently encountered constructive elements of bodies subjected to milling.

The housing part is a box-shaped part having one or more base holes with which other parts can be mounted inside the housing in a certain kinematic correlation, as well as the bodies of drive and distributive systems characterized by the presence of working apertures called basic [2, 3]. However, it should be taken into account that the housing part may not contain the base holes, nor be the case of the drive or distributive system.

In its turn, a constructive element (CE) of a part is local changes in its shape or surface in order to give it additional properties in the manufacture, assembly or exploitation [3, 4].

A wide variety of CE is used in housing parts. The most common constructive elements in parts are presented as follows:

1) A cavity is the internal space of the body intended for the location of impellers, guiding apparatuses and the passage of water, steam or gas. Also, this CE is often called "pocket" or "sample". It is worth noting that the cavity does not always have impellers and other elements specified in the definition.

2) A chamfer is the edge of a part cut on-the-miter. The chamfer angle is chosen based on constructive purposes, but often it is 45°.

3) A fillet is a smooth transition from one part of a surface to another along the specified radius. This CE is designed for removing sharp edges, facilitating assembly and giving aesthetic appearance.

4) A groove is a groove on a part surface of a different trajectory and often a square, rectangular or circular cross section. They are preferably designed for sealing rings and retaining lubricant (if a moving part is installed in the housing) in the body parts. Also a slit can be considered as a groove, that is a narrow groove cutting through the wall of the body.

5) A mortise is a groove in the part where a constructive element is located on the lateral surface or face. The grooves are of various types: open, closed, keyed, etc. They are used for moving joints of parts.

6) A boss is a protrusion on the surface of the cast piece designed to create a reference plane for the fasteners. Also, this CE is often used as a necessary technological element in the processing of parts. For example, when milling the first side of the body part, the workpiece is clamped in the vice by the boss.

7) A bead is a narrow ledge moving along the edge of a part. Beads are designed to limit the movement of one part along another, to make more dense and rigid assembly of this part with others, and in some cases for greater tightness.

8) A hole is the term according to GOST 25346 conventionally used to refer to the internal elements of parts (including non-cylindrical elements). A circular hole in the cross section is an opening in which any cross-section is a circle. There are stepped, deaf, threaded and other holes.

9) A thread is a relief surface formed on the cylindrical or conical surface of a part when cutting a groove of a certain profile along a screw line. There are various types of threads: metric, conical, tubular, trapezoidal, round, inch, pitched, single- and multi-thread, left and right.

10) A face is a surface having only two measurements, so that between any two points it is possible to direct a line that is completely soluble with this surface, or a subject that is a surface having a planar shape [5].

11) A ledge is a part of something that forms a step, a notch [6].

Presence of a particular CE has a great influence on the design process and creating a control programme for CNC machines.

The analysis of 26 parts produced by CNC milling machines at OJSC "Izmeritel" is carried out in order to determine the frequency of using the above-described structural elements in them.

The results of the analysis are presented in the form of a graph in Fig. 1.

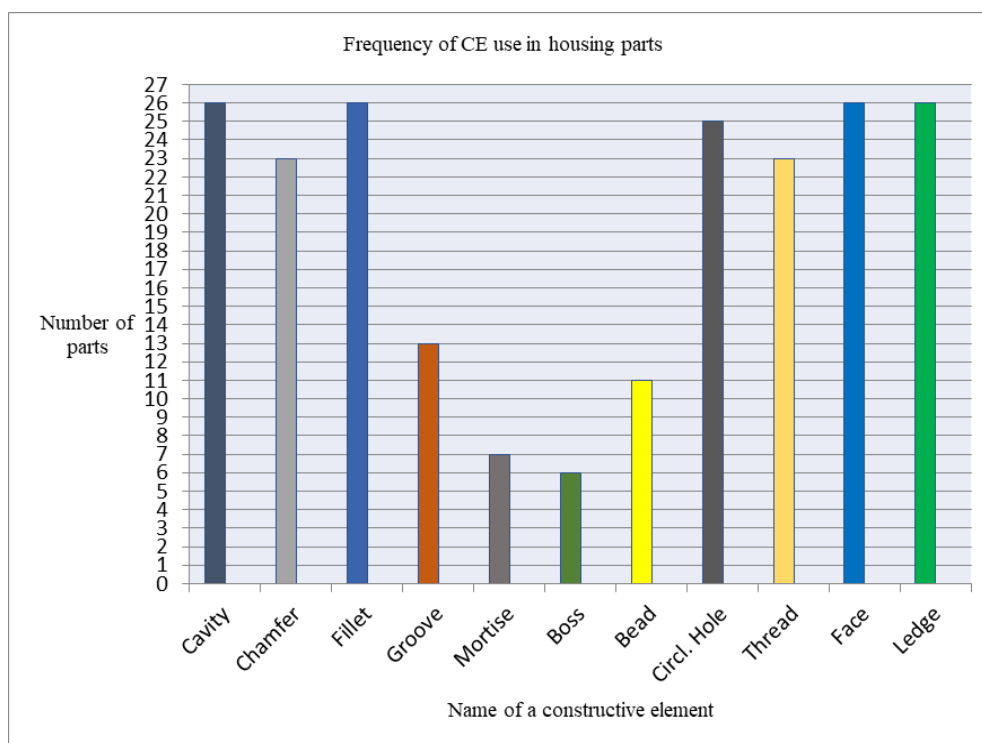


Fig. 1. Frequency of CE use in housing parts

As shown in the graph, in all the components there are 4 elements: a cavity, a fillet, a face, a ledge. Then there are holes with a circular cross section, thread and chamfer - 96% and 88% respectively (in threaded holes presence of a chamfer is mandatory). Grooves are present only in 50% of the parts, beads - 42%, and mortises and bosses – 27% and 23% of the parts.

Conclusion

The face as a constructive element is present in all the parts, and not only in the hull, since it is the main CE. The presence of the cavity, ledge and fillet in all the parts analyzed in this article suggests that they are the basic CE for this type of product. Presence of other CEs (grooves, mortises, bosses, etc.) is conditioned, first of all, by the requirements presented in this part, as well as by the functions that it performs.

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MOTOR OILS: TREND OF DEVELOPMENT, CHARACTERISTICS OF DOMESTIC LUBRICANTS

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We consider trends of improving the performance characteristics of motor oils, the most popular brands and the characteristics of domestic lubricants in this article.

Introduction. The development of engine building, the improvement of their design and the tightening of the environmental requirements are impossible without the use of progressive and modern lubricants.

Special attention is paid to the growing environmental problems associated with cars which can lead to the change in the requirements for the car engines design and a significant improvement in the performance of exhaust gas cleaning systems. This is reflected in the requirements for engine oil. According to the European legislation, all motor oils must comply with environmental standards. In order to meet the standards the engine oil should be compatible with the units of the gas cleaning system, and its chemical composition should be limited for this. In particular, sulfur and phosphorus which are active elements of anti-wear and antioxidant additives "poison" the catalysts. That is why their content in the oil should be low.

Main body. The production of new gasoline engines with direct injection or turbocharging is the main stimulating factor for the development of the new ACEA 2016. The new specification introduces a new category ACEA C5. A key feature of this specification is particulate filters. In the near future not only diesel, but also gasoline engines with direct injection will be equipped with soot filters [1].

The requirements for the category C5 are presented in Table 1.

Table 1. – The requirements for the category C5 according to ACEA

HTHS @ 150°C	$\geq 2,6 < 2,9$ mPa·s
HTHS @ 100°C	Report
Shear stability	Stay in grade
NOACK	$\leq 13\%$
TBN	≥ 6.0 mgKOH/g
Sulphur	$\leq 0,3$ %m/m
Phosphorus	$\geq 0,07 \leq 0,09$ %m/m
Sulphated ash	$\leq 0,08$ %m/m
Chlorine	Report
Fuel economy	$\geq 3.0\%$ (M111FE)

There is definitely a clear tendency to limit the content of phosphorus and sulfur for compatibility with modern systems of neutralization of exhaust gases and compliance with the Euro-6 standards. According to the API classification, the most modern oils are oils SP and CK-4 in 2018. Having analyzed the requirements for new standards and the trend of changing requirements for oils we can assume the following changes in the characteristics of oils of classes SP and CK-4 according to the API and C5 specifications for ACEA in comparison with the previous classifications:

- 1) Lessened sulfate ash (requires to use magnesium sulfonates);
 - 2) Lower sulfur and phosphorus content;
 - 3) Greater resource economy;
 - 4) Better compatibility with seals;
 - 5) Increased protection against oxidation of oil;
 - 6) Better anti-wear properties;
 - 7) The best detergent properties;
 - 8) Better dispersing properties;
 - 9) Better anti-foam properties;
 - 10) Better resistance to evaporation.
- These properties are achieved by using additives with improved properties.

To obtain high-quality oil it is necessary to pack the additives and then introduce the resulting additive package as a concentrate into the base oil.

To obtain oils according to the ACEA API and C5 API and CK-4 specifications it is necessary to use low-ash magnesium sulphonates (multifunctional additives), antiwear additives, antioxidant additives, anticorrosive additives, antifoam additives, antifriction additives, detergent and dispersant additives, thickening agents additives and depressant additives some properties of which can be combined in multifunctional additives.

For synthetic oils antioxidant additives play the most important role.

All components included in the engine oil are supplied as a balanced additive package in which the component ratio is clearly fixed, tested for compatibility and provides the best performance for each type of engine oil with specified requirements. It is for this reason that the majority of manufacturers of machinery and lubricants are strictly prohibited to use additional additives in oils. Additive packages are mixed according to a clearly defined formula with base oils for the production of motor oils [2].

In the market of motor oils there is a huge number of brands and each in its own way surpasses the rest and is more popular in certain circles of automakers and consumers. The most popular companies producing motor oils among the CIS countries are Zic, Xado, G-Energy, Liqui Moly, Shell, Castrol, British Petroleum, Mobil and others.

The Republic of Belarus has its own progressive enterprises which produce high quality lubricants that meet all modern requirements. Leading companies in this area are JLLC "LLK-Naftan" and JSC "Naftan".

"LLK-Naftan" investigates and develops additives as well as produces additive packages for motor, transmission and marine oils that are capable of ensuring those oils comply with current API and ACEA requirements. This is the largest producer on the post-Soviet territory. Today more than 95% of LLK-Naftan products are exported.

The Belarusian Chamber of Commerce and Industry recognized LLK-Naftan as the best exporter in the nomination "Oil refining in 2014, chemical and petrochemical industry". The Association of Oil Refiners and Petrochemicals (Russia) recognized the products of JLLC "LLK-Naftan" as the best in the CIS in the field of import substitution of additives for lubricating oils [3].

JSC "Naftan" produces modern hydrocracked motor oils HC4 and HC7 corresponding to the Group III of API oils. This trend is promising in the context of the growing tendency of the Group II and III API oils throughout the world and also because of the approach in composition and properties of hydrocracked oils to the Group IV synthetic oils. All-season motor oil "Naftan Guarantor" produced by JSC "Naftan" corresponds to SJ / CD classification, and "Naftan Prime" to SL / CF [4].

Hence, the development and improvement of the performance characteristics of motor oils are an integral part of improving the design of ICE and improving the environmental situation in the world and the production of lubricants produced in the territory of the Republic of Belarus is modern and competitive.

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MODERNIZING THE TECHNOLOGY OF PRODUCTION OF PARTS USING BORING CUTTING TOOLS

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Increasing the efficiency of production of cutting, auxiliary tools and technological equipment is closely linked with the development of technology, technique and organization of the main production of the enterprise. It is very important that the tempos of technical progress of instrumental production don't lag behind, but correspond or even outstrip the pace of the technical development of the main production. Tool production promotes the introduction of advanced technologies in the enterprise, being its technical base [1].

The main directions of development of instrumental production lie in the spheres of activity related to the process of designing the newest tool designs, the tool selection system for a given technological process, with a qualitative choice of the technological process of manufacturing the tool, the optimal conditions for its operation. In this connection, it is possible to single out the following main directions [2-4]:

1. Increase the requirements for the accuracy of form-building and auxiliary tools. It's necessary to revise the existing normative documentation for the accuracy of tooling, according to which the designer assigns accuracy parameters in the design, as well as increasing the accuracy of the tool making, which requires improvement of instrumental technology, the use of new high-precision modern equipment and monitoring tools.

2. Increasing the requirements for the durability of cutting tools in high-speed processing with an increase in the cutting speed of blade tools to 30 m / s, grinding - up to 150 m / s. This requires the use of new instrumental materials, such as highly dispersed and alloyed hard alloys, complex and powder high-speed high-temperature steels, carbide steels and super hard materials. Increasing the durability is largely provided by wear-resistant coatings of the working part of tools and cutting plates to them.

3. Creation of new designs of cutting and auxiliary tools for high-speed machining. Such tools should have beating of cutting edges not more than 0,010 ... 0,003 mm, balancing devices for minimizing vibrations, new fixing methods (for example, clamping devices), new high-strength and vibration-resistant materials for the execution of hull parts of cutting tools and auxiliary tools.

4. Development of designs of prefabricated and block-modular tools with replaceable polyhedral plates from hard alloys, including such tools as drills, counter bores and sweeps. To this end, it's necessary to develop new designs for cutting and supporting plates, to increase their precision in manufacturing, to reduce the roughness of the surfaces of blades, to create new ways of fastening the plates, to develop new recommendations on their geometry and to increase their flexural strength. As an example, carbide-tipped plates with a special front surface shape can be cited providing the chip breaking process, taking into account the material of the part, the type of machining and the cutting modes.

5. Creation of new designs of grinding tools, such as grinding wheels with an oriented arrangement of cutting grains, high-alloy wheels, circles with cutting grains from new super hard materials and synthetic diamonds. Development and application of new ligaments, increasing the durability and stability of the circle. It's also necessary to increase the requirements for accuracy and non-equilibrium of circles capable of providing high-speed processing.

6. Equipment of technologies based on non-traditional methods of processing, new tools and devices. To such methods it is possible to carry ultrasonic processing of materials, including drilling, turning, reinforcing the work on machine tools with CNC; high-speed turning of steels and alloys of high hardness (HRC 70), including the imposition of vibrations from the hydraulic slide and ultrasonic head; final (finishing) treatment instead of grinding with a blade tool equipped with a hard alloy, monocrystalline diamond, natural and artificial; vibration milling; vibration; vibroabrasive processing; vibration-hardening treatment with the use of a vibratory slide and an ultrasound head; high-speed laser cutting of sheet material up to 3 mm thick (up to 30 m / min); precise laser cutting of steel billets up to 25 mm thick; laser drilling holes up to 0.2 mm in diameter; laser welding.

7. Development of computer-aided design tools (CAD-I) systems based on modern computers and graphic systems with the development of simulation of projected objects in virtual mode, which allows to provide visualization of the design process, achieving design optimization, high accuracy of profiling. For this, such systems are used as solid-state modeling, geometric-kinematic method for running-in of tools, the method of

aligned sections for threading tools and in the processing of screw grooves with constant or variable pitch and etc.

An example of intensive development, including instrumental production, is MAZ, which has won recognition of its products not only in Belarus, but also far beyond its borders. Within the framework of the practice held at this enterprise, it was proposed to modernize the technological process for manufacturing the MAZ-9506 car lift body (Figure 1).

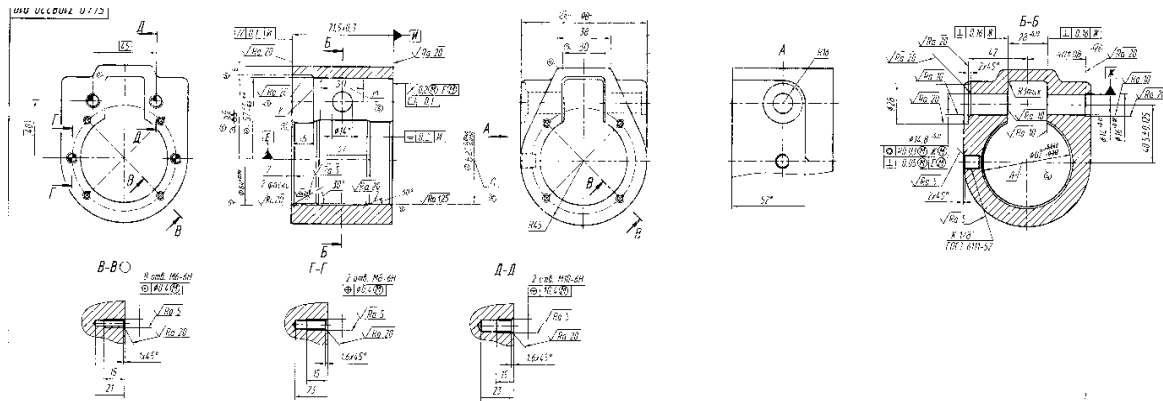


Fig. 1. The body of the MAZ-9506

MAZ 9506 is a two-axle semitrailer truck, which is designed for transportation of a wide range of loose goods as part of a road-train with a truck-tractor equipped with hydraulic equipment, on all types of roads. One of the proposals for modernizing the technological process was to reduce the cost of the coordinate-boring operation for boring the exact main hole $\varnothing 62^{+0.042}_{+0.012}$. It was proposed to replace the existing cutting tool – the boring cartridge of a foreign company Sandvik Coromant (Sweden) by much cheaper analogue existing in Belarus. Having considered various options, a boring cartridge was proposed which was developed in the framework of the regional scientific and technical program "Innovative Development of the Vitebsk Oblast" by the educational institution "Polotsk State University" in conjunction with the open joint-stock company "Orsha Tooling Plant" (JSC "OIZ") (Figure 2) [5].

Interchangeable composite inserts with super-hard tool materials can be used as a cutting blade in the boring chuck, consisting of a holder and a cutting blade fixed by soldering or gluing. Basically, these incisors of the insert correspond to GOST 25487 "Boring cutters with carbide inserts with cylindrical shank for coordinate boring machines". It should be noted that the opening of the mechanism for installing the boring tool must be maximized in terms of setting the range of the tool to be installed. Smaller sizes can be installed by using adapter cylindrical bushings, the outer diameter of which corresponds to the diameter of the hole in the boring chuck and the inner diameter of the connecting cutter.

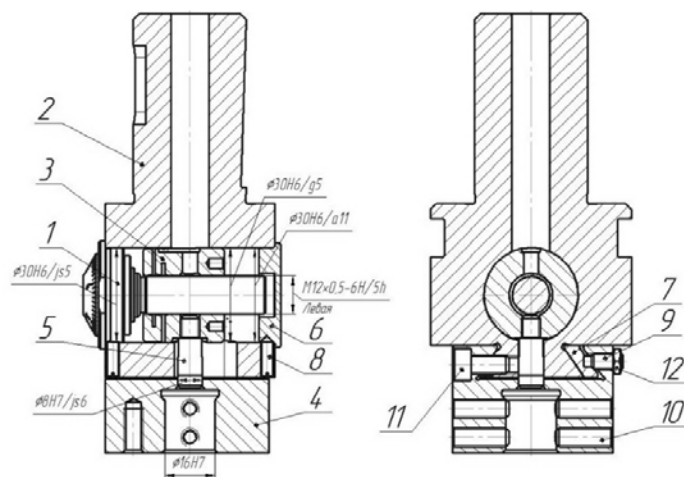


Fig. 2. Boring chuck

Technology, Machine-building, Geodesy

The movement mechanism of the tool in the boring chuck in the holder includes an accurate closed on both sides groove that provides precise orientation in space relative to the axis of the base mandrel. The design of the tool moving mechanism should have minimal dimensions, accurate and rigid fixation in the direction of the acting cutting forces, which leads to the complication of the structures of individual structural elements, due to overlapping and overlapping functions of various parts of the boring cartridge.

At present, JSC "OIZ" produces various technological equipment, including boring cartridges. But competition with leading Western firms forces the plant to transform and find new ideas to reduce the cost of producing cutting tools, which leads to a reduction in costs for the products of the main production of MAZ. To do this, it was proposed to improve the existing technological process of processing the basic component "Tool slide" of the boring cartridge (Picture 3).

The technological route for the workpiece "Tool-slider" includes the following operations:

- 005 Lathe
- Lathe model 16K20
- 010 Milling
- Vertical milling machine model 6R10
- 015 Coordinate-boring
- The machine of coordinate-boring model 2421
- 020 Sanding
- Surface grinding machine model 3G71
- 025 Sanding
- Grinding machine model 3D756

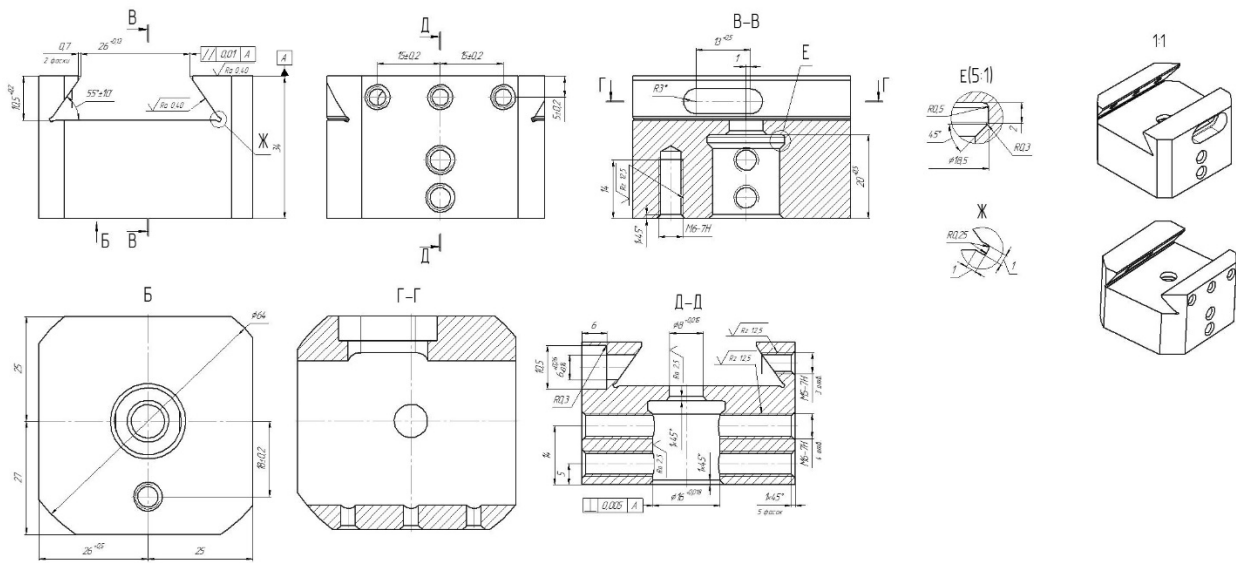


Fig. 3. Slide tool

Modernization of the technological process in comparison with the existing one consisted in reducing the number of used equipment, reducing the main time, and as a result of the reduction of the total labor intensity and the price of the products. Replacement of three universal machines: screw-cutting lathe 16K20, vertical milling 6P10 and coordinate-boring 2421 to the machining center ROBODRILL α-LiB series allowed to reduce the laboriousness of manufacturing the part and reduce the price of the boring cartridge as a whole.

The use of a domestic boring cartridge in the manufacture of the hoist housing reduces the cost of the tool, improves the accuracy and quality of the processing

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ITC, ELECTRONICS, PROGRAMMING

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EXPERIMENTAL STUDY OF VIDEO SIGNAL MASKING METHOD
FROM LEAKAGE ON TECHNICAL CHANNELS

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A new way of masking a video signal from leakage through technical channels with adaptive video noise frames has been experimentally investigated. The article represents the results of masking proposed test video frame with dynamic white noise and adaptive masking frames, where the video frame reconstruction was realized by synchronous accumulation of video frames. Experimental studies have confirmed the advantages of a new method of masking a static video frame with adaptive video noise frames.

Introduction. Video display modules are the source of electromagnetic emissions, which can be intercepted and restored, forming a data leakage channel in this way. This signal emission corresponds to the image displayed on the screen, generated by the computer's video card [1]. The static video image on the monitor screen can be received periodically with the frame update period f_k .

The restoration of a video signal in this case is possible, if accurate timing parameters are known for allocating video frames and their successful synchronous accumulation. If we use additive addition with dynamic noise as the signal accumulates, its amplitude grows linearly, depending on the number of accumulated frames, and the noise accumulates according to the root-mean-square law [2]. Thus, the improvement in the signal-to-noise ratio (SNR) will be proportional \sqrt{n} .

Justification of the method of masking video information. In carried out studies [3], the effectiveness of masking a video signal by a chaotic impulse sequence (CIS) is substantiated. It is demonstrated that for the most complete destruction of information, the masking signal must have a certain shape of the spectrum. Its structure needs to have more energy in the low-frequency range, and lower – in the high-frequency range. This is a consequence of the typical form of the video signal spectrum, in which the energy of the spectral components falls with increasing frequency, and they themselves concentrate near the harmonics multiples of the line frequency of the video image. CIS has a spectrum of a similar shape that allows it to mask video information much more efficiently than white noise.

Images of real objects contain large-scale and small-scale components, which in the frequency representation of the correspondence between low- frequency and high-frequency region. As the test frame for this experiment, the image of the aircraft was selected (Fig. 1). The clear contrasting contour of the aircraft against the background of uniform sky is well recognized as a large-scale structure. Details of the aircraft, such as chassis, lighting, engines and fairings of the mechanism for closing closed shows are small-scale information.



Fig. 1. The airplane image as a test frame

Existing white noise generators, such as «ГНОМ-3» [4] and others, are able to mask only the high-frequency range satisfactorily, and also do not take into account such features of the video signal as synchronism based on the principle of measuring sync pulses and uneven distribution of the amplitudes of the spectral components.

The proposed method takes into account these features of the video signal, and offers more efficient distribution of the spectral masking signal components due to its formation based on the masked video frame itself. Realization of this method consists of obtaining the spectrum of masked video signal in a digital form and constructing, on the basis of its line harmonics of the envelope. This envelope modulates uniform noise, which after this operation acquires a characteristic shape. Thus, with extra addition of the original and masking signal, most of the spectral components are suppressed by noise (Fig. 2–3).

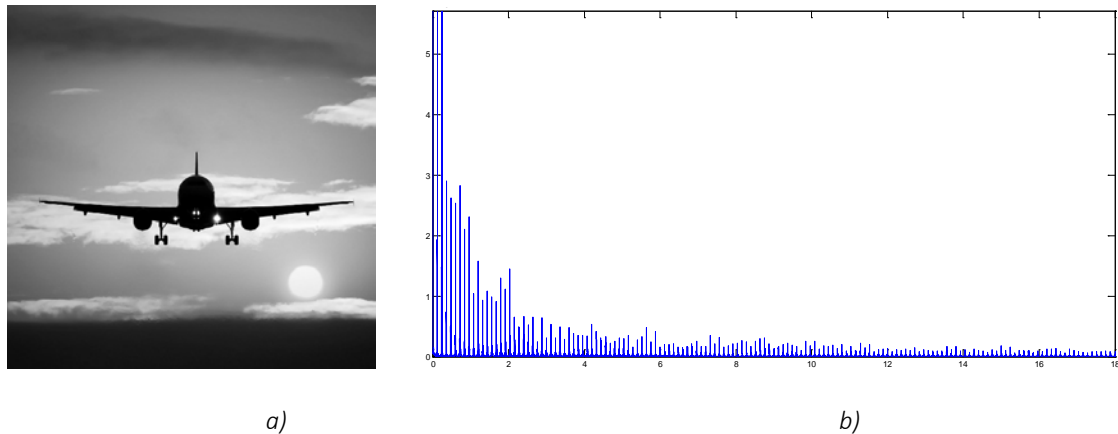


Fig. 2. Test video frame and its spectrum: a) original image; b) spectrum of the image

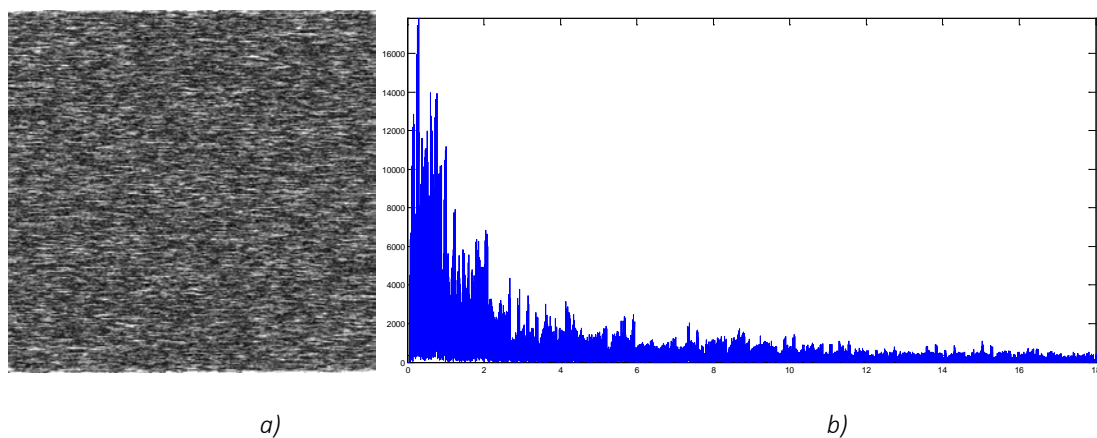


Fig. 3. Masking video frame and its spectrum: a) resulting masking image; b) spectral representation of masking image

Experimental investigation of video masking. Experimental study of the proposed method of masking a video image demonstrates its effectiveness with respect to white noise and CIS. The evaluation of increasing video signal security consists of masking it with a dynamically changing masking frame, dynamic white noise, and generated synchronous masking frames.

The experiment results on synchronous accumulation of a camouflaged test video frame with a video signal duration of 30 seconds are presented in SNR = 1/15 (Figure 4), with SNR:

$$SNR = \left(\frac{A_{signal}}{A_{noise}} \right)^2 \quad (1)$$

where A_{signal} – RMS signal amplitude;

A_{noise} – RMS noise amplitudes.

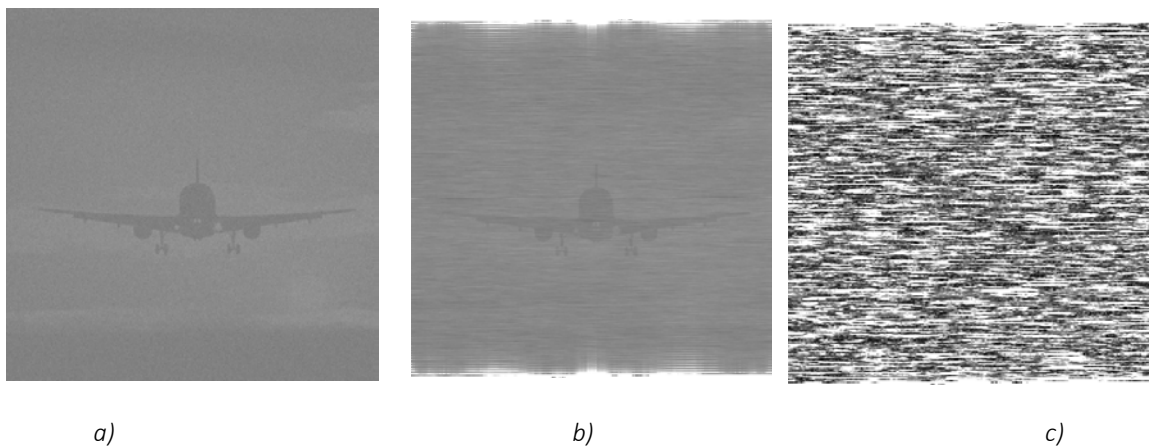


Fig. 4. Reconstructed synchronous accumulation of test video frame (video signal duration 30 s):
 a) noisy with dynamic white noise; b) noisy with dynamic masking frame;
 c) noisy with synchronous adaptive video noise frames

As a result, the conducted experiment confirmed the efficiency of masking video frames in the proposed way with respect to white noise with the same SNR of noisy video signal.

In figure 4a, it is easy to distinguish the airplane contour and all the above-mentioned small-component components. In addition, it is possible to distinguish the background details, such as the shape of clouds and the sun, without clear contours. In Figure 4b, a large-scale object can still be identified, but small details are already difficult to distinguish. In Figure 4c, the image is completely destroyed.

Figure 5 shows the change dependence in the security of masked video frames with duration of up to 750 frames, which corresponds to 30 seconds of video at the rate of 25 frames per second, synchronous accumulation during masking with dynamic white noise and dynamic adaptive video noise frames.

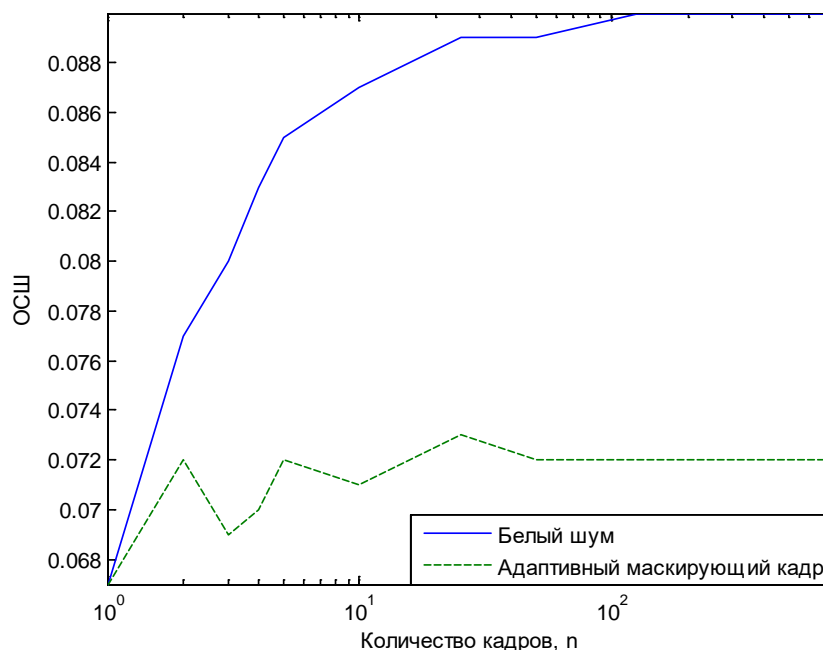


Fig. 5. Dependence of the SNR of the camouflaged video image on the number of frames in synchronous accumulation

Figure 5 demonstrates that the proposed masking method does not significantly improve the SNR of the masked signal in synchronous accumulation (dotted line in Figure 5) compared to the white noise masking method (solid line in Figure 5).

Conclusion. Experimental studies have demonstrated the advantages of the proposed method of adaptive masking of video information for static and dynamic video frames. Masking the test video frame with adaptive video noise frames during synchronous accumulation of video frames provides the best quality of masking and does not allow significant improvement of SNR compared to dynamic masking frame and dynamic white noise.

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NEURAL NETWORKS AND FACE RECOGNITION OF PEOPLE USING NEURAL NETWORKS

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The article considers artificial neural networks and some of their architectures. The process of recognizing people by their face with their help is considered. Areas of application of this technology are determined.

Introduction. At all times a person tries to simplify his life. In the pre-computer era, this was expressed in the improvement and invention of new devices. Now the human is trying to create artificial intelligence, to completely exclude the participation of man in a variety of spheres of life. However, artificial intelligence has not yet been created. But artificial neural networks through which developers are trying to create artificial intelligence are now used to solve many problems.

What is a neural network? The neural network is a sequence of neurons connected by synapses. The structure of the neural network has come to the programming world straight from biology. Thanks to this structure the machine is able to analyze and even memorize various information. Neural networks are also able not only to analyze incoming information, but also to reproduce it from their memory. In other words, a neural network is a machine interpretation of the human brain, in which there are millions of neurons transmitting information in the form of electrical impulses.

What are neural networks for? Neural networks are used to solve complex problems that require analytical computations like those that the human brain does. The most common applications of neural networks are:

Classification – the distribution of data by parameters. For example, the entrance is given to a set of people and you need to define those of them to give credit to and those whom not. This work can be done by a neural network analyzing information such as age, financial solvency, credit history, etc.

Prediction is an opportunity to predict the next step. For example, the increase or decrease of shares based on the situation on the stock market.

Recognition is, at present, the widest application of neural networks. Used in Google when you are looking for a photo or in camera phones, when it determines the position of your face and highlights it and much more.

What is a neuron? A neuron is a computing unit that receives information, performs simple calculations on it, and passes it on. They are divided into three main types: input (blue), hidden (red), and output (green). There is also a displacement neuron and a contextual neuron, which we'll talk about in the next article. In the case where a neural network consists of a large number of neurons, the term layer is introduced. Accordingly, there is an input layer that receives information, n hidden layers (usually there are not more than 3 of them) that process it and an output layer that outputs the result. Each of the neurons has 2 basic parameters: input (input data) and output data (output data). In the case of the input neuron: input = output. In the rest, the total information of all neurons from the previous layer gets into the input field, after which it is normalized using the activation function (so far, just imagine it $f(x)$) and gets into the output field.

It is important to remember that neurons operate with numbers in the range $[0,1]$ or $[-1,1]$. And how then, you may ask, to handle the numbers that come out of this range? At this stage the simplest answer is to divide 1 by this number. This process is called normalization and it is very often used in neural networks.

Areas of practical application of artificial neural networks. In each subject area, upon closer examination, one can find problem statements for neural networks. Here is a list of individual areas where the solution of such problems has practical importance right now.

- **Economics and business:** forecasting time series, automatic trading, assessing the risks of credit default, prediction of bankruptcies, real estate valuation, identifying overvalued and undervalued companies, rating, optimizing commodity and cash flows, reading and recognizing checks and documents, security of transactions on plastic cards.

- **Medicine and health care:** patient diagnosis, treatment of medical images, cleaning of instrument readings from noise, monitoring the patient's condition, predicting the results of different treatment methods, analyzing the effectiveness of the treatment.

- **Avionics:** trained autopilots, recognition of radar signals, adaptive piloting of heavily damaged aircraft, unmanned aerial vehicles.

- **Communication:** compression of video information, fast coding / decoding, optimization of cellular networks and packet routing schemes.
- **Internet:** associative information search, electronic secretaries and autonomous agents on the Internet, filtering and blocking spam, automatic columnning of messages from news tapes, targeted advertising and marketing for electronic commerce, captcha recognition.
- **Automation of production:** optimization of production process regimes, product quality control, monitoring and visualization of multidimensional dispatch information, prevention of emergency situations.
- **Robotics:** recognition of the scene, objects and obstacles in front of the robot, laying the route of movement, manipulator control, maintaining balance.
- **Political and sociological technologies:** predicting election results, analyzing polls, predicting the dynamics of ratings, identifying significant factors, clustering the electorate, researching and visualizing the social dynamics of the population.
- **Security, security systems:** face recognition; identification of a person by fingerprints, voice, signature or person; recognition of car registration numbers, monitoring of information flows in a computer network and detection of intrusions, detection of counterfeits, data analysis from video sensors and various sensors, analysis of aerospace images.
- **Input and processing of information:** recognition of handwritten texts, scanned postal, payment, financial and accounting documents; recognition of speech commands, speech input of the text into the computer.
- **Exploration:** analysis of seismic data, associative methods of searching for minerals, evaluation of resources of deposits.
- **Computer and board games:** the creation of neuro-players in drafts and chess (confirmed by playing with people's ratings - at the level of masters and international masters), winning in Go from European and world champions, on average better than a man, the passage of almost fifty old classic games with Atari.

The application of neural networks for face recognition. Currently there are about a dozen types of neural networks. One of the most widely used options is a network built on a multi-layer perception, which allows you to classify the input image / signal in accordance with the pre-setting / learning network.

Neural networks are trained on a set of learning examples. The essence of training is reduced to tuning the weights of inter-neural connections in the process of solving the optimization problem by the method of gradient descent. In the process of training neural networks the key features are automatically extracted, their importance is determined, and the relationships between them are constructed. It is assumed that the trained neural network will be able to apply the experience gained in the learning process to unknown images due to generalizing abilities.

The best results in the field of face recognition (based on the analysis of publications) were shown by Convolutional Neural Network or convolutional neural network, which is a logical development of the ideas of such neural network architectures as cognition and neocognition. The success is due to the possibility of taking into account the two-dimensional topology of the image, in contrast to the multilayer perception.

Distinctive features of a convolutional neural network with them are local receptor fields (provide local two-dimensional connectivity of neurons), common weights (provide detection of certain features anywhere in the image) and hierarchical organization with spatial sampling (spatial subsampling). Thanks to these innovations the convolutional neural network provides partial resistance to scale changes, displacements, rotations, angle and other distortions.

Testing with convolutional neural networks on the basis of ORL data, containing images of individuals with small changes in lighting, scale, spatial turns, position and various emotions, revealed a 96% recognition accuracy.

The convolutional neural networks were developed by DeepFace, which was purchased by Facebook to recognize the faces of users of its social network. All the features of the architecture are of a closed nature.

Disadvantages of neural networks: adding a new reference person to the database requires a complete retraining of the network on the entire set available (a sufficiently long procedure, depending on the sample size from 1 hour to several days). Problems of a mathematical nature associated with training: getting into the local optimum, choosing the optimal optimization step, retraining, etc. It is difficult to formalize the stage of choosing the network architecture (the number of neurons, layers, the nature of the connections). Summarizing all of the above, we can conclude that the neural network is a "black box" with hard-to-interpret results.

The conclusion. This article presents a brief description of neural networks. Also the use of neural networks for face recognition is described. Despite some disadvantages, they can be eliminated by changing the approach to the use of neural networks in face recognition.

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UDC 621.396

THE USAGE OF A SYSTEM ON A CHIP FOR THE SYNTHESIS OF RADAR

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Most developers who work with DSP tasks face the problem of lack of computing resources for implementing hardware solutions for image processing or synthesis. One way to accelerate computing is to use specialized hardware that has significant computing resources.

One of the priority tasks of the world community at present is to ensure global monitoring of the Earth. Considering the fact that the territory of the Republic of Belarus 70% of the time in a year is covered with clouds, for continuous monitoring of the earth's surface, radar monitoring is very actual, realized at any time of the day and under any meteorological conditions.

Advantages of radar sounding are that they are a means of detecting physical properties of objects in microwave ranges of waves and a measuring tool with the possibilities of using phase information, applying a wide range of survey modes and algorithms for data processing. This allows us to significantly expand the scope of applied problems in scientific and economic spheres, monitoring of disasters and emergency situations, and ensuring state security.

The problem of the formation of the earth's surface radar image (RI) in real time remains one of the urgent tasks in solving the problems of remote sensing of the Earth (ERS).

One of the basic requirements for the hardware of the RI formation is high performance. To achieve high computation speed is possible with the help of parallel calculation methods, which in most cases are realized by means of specialized integrated circuits (ICs), such as FPGA.

A promising trend in improving computing performance in recent years is the usage of systems on a chip (SoC). SoC is an IC containing a processor, some memory, a number of peripherals and interfaces, and FPGAs. The main feature of SoC is the usage of the processor system as a device for controlling the process of information processing, which is implemented on FPGAs.

The algorithm for accelerated preprocessing of input signals for RI implementation obtained on SoC is shown in Fig. 1.

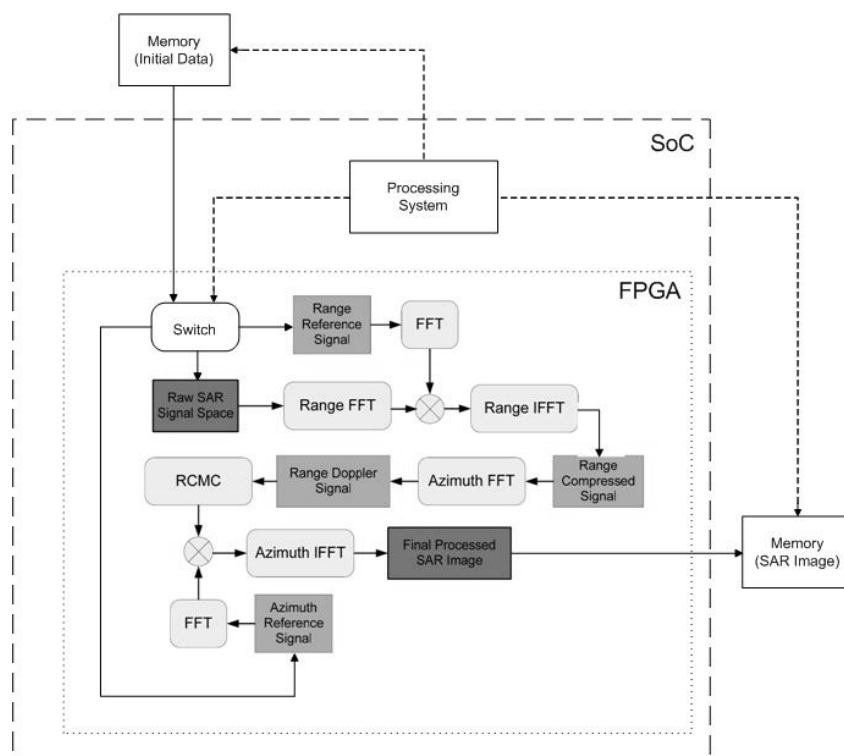


Fig. 1. The algorithm for accelerated preprocessing of input signals for RI implementation obtained on SoC

The original data is transferred from the memory to the switch, which splits this data into groups to form the filter reference functions and synthesize the image.

The two-dimensional signal is first analyzed as a series range time signals for each azimuth bin. Each range time signal undergoes matched filtering in the range frequency/azimuth time domain through range FFTs applied to the range time signals. After each signal is transformed back into the range time/azimuth time domain, the result is the range compressed signal as the matched filtering which is performed in the range frequency domain. In order to obtain azimuth compression, azimuth matched filtering must be performed. The range compressed signal is then composed into a series of signals with respect to azimuth time at different range bins. Each azimuth signal is Fourier transformed via an azimuth FFT and RCMC is performed before azimuth matched filtering in the range-Doppler domain. After azimuth matched filtering of each signal and azimuth inverse fast Fourier transforms (IFFTs), the final target image is obtained [1]. The resulting image is stored in memory.

Control is carried out by a processor system.

Data received by the spacecraft are presented in memory in the format of CEOS (Committee on Earth Observation Satellites).

To represent the ERS radar data in the CEOS format, a structure of four files is used (Fig. 2): Volume directory file, Leader file, Data set file, Null volume file. Each file contains records with the first 12 bytes of the same structure and include information on the sequential number of the record (from the first to the fourth byte), the type of the write code for its identification during processing, located from the fifth to the eighth byte (CEOS code), and the length records (from the ninth to the twelfth byte).

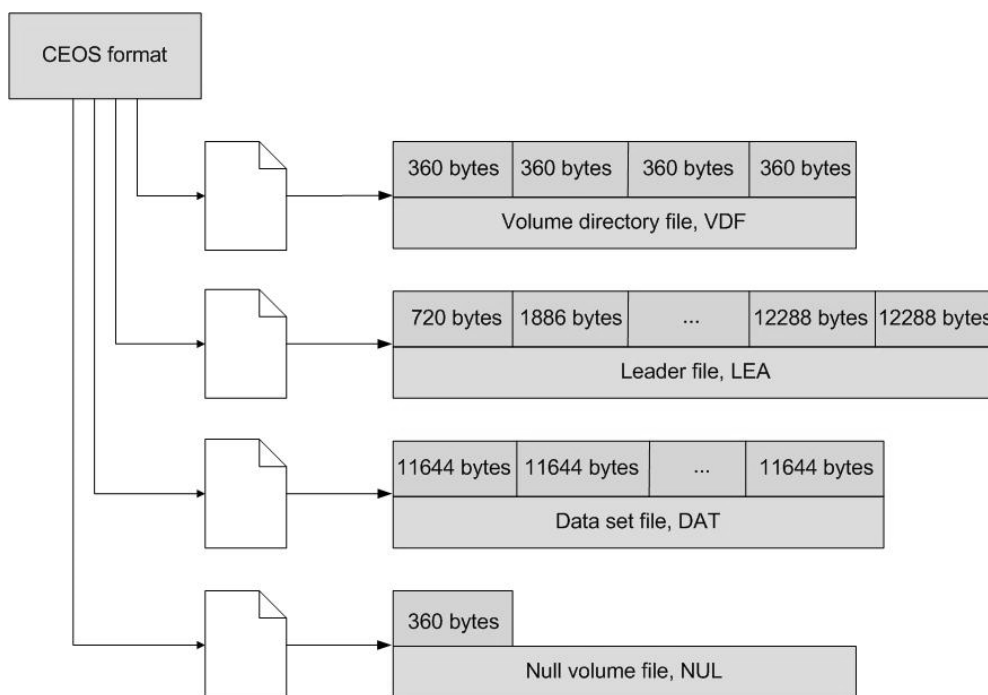


Fig. 2. Presentation of ERS radar data in CEOS format

The volume directory file contains a record of its description, a record of the pointer to the header file, a record of the pointer to the data file, a text entry.

The header file includes a description record, a record of raw data, a record with raw platform position data, a general-type data record for the radar, and a qualitative-type data record for the radar.

The data set file includes a record of the file description and a set of raw data records.

The null volume file contains a description of the file that includes the physical and logical volume identifiers, the number of volumes, their sequence numbers, date, time, country, volume creation organization [2].

Conclusion. The usage of SoC based on FPGA gives a wide range of possibilities for the implementation of complex projects requiring significant computational costs. The processor system of SoC can perform interface organization, load coefficients and other operations that are difficult to implement in hardware. Also, a single

processor core can manage several hundred DSP-blocks of FPGA that continuously process the input data stream.

This approach makes possible to use more modern adaptive algorithms for digital processing of the trajectory signal and image, which will solve the problem of the formation of a qualitative radar image.

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**METHODS AND ALGORITHMS FOR EVALUATING
THE RELIABILITY OF BUILDING STRUCTURES BASED ON PROBABILISTIC MODELS OF DYNAMIC LOADS**

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In this paper, we consider the basic models and types of dynamic loads on building structures, as well as the types of distributions for generators of random variables used to construct these models.

Modern approaches to assessing the reliability of buildings and structures in their design, survey, design of amplification and reconstruction recommend the use of new calculation methods based on probabilistic models. Today we observe the lack of knowledge about the variability of certain parameters of building structures, loads, and indirect influence of environmental parameters. At this stage of building science development, probabilistic models can serve as tools for simulation modeling in the calibration of the coefficients of semi-probability methods of calculation.

In the construction of models different random number generators are used to obtain the most approximate values of existing systems. Software generators of uniformly distributed numbers calculate each new number based on one or more preceding numbers in accordance with a given mathematical formula. Thus, the resulting numbers are completely deterministic and it is possible to repeat the run with the same sequence of values obtained.

Random number generation can be done for different kinds of distributions.

UNIFORM DISTRIBUTION

A uniform distribution is a continuous random variable that has a uniform distribution law if its density $f_X(x)$ has the form:

$$f_X(x) = \begin{cases} \frac{1}{b-a}, & x \in [a, b] \\ 0, & x \notin [a, b] \end{cases}$$

A uniform distribution can be used for generating almost any random variable. Figures 1 and 2 show the graphical characteristics of this distribution.

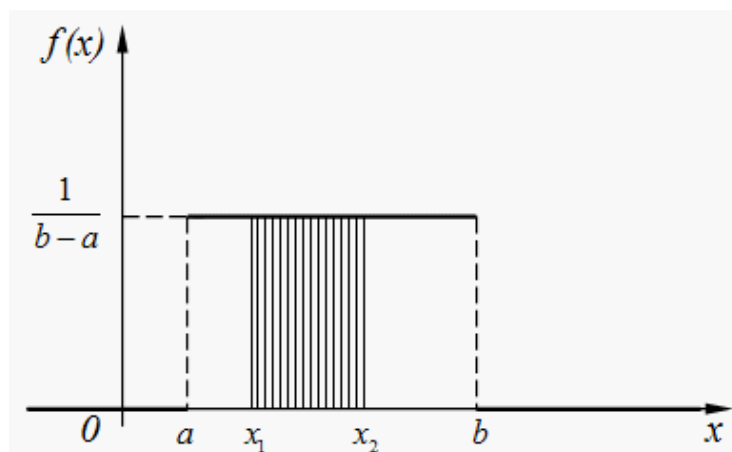


Fig. 1. Graphical characteristics of a uniform distribution of random variables

In the case of a simple random choice, it is assumed that each number is extracted from the general population, uniformly distributed in the interval from 0 to 1.

The mathematical expectation of a uniform distribution:

$$\mu = \frac{a+b}{2}$$

The dispersion of a uniform distribution:

$$\sigma^2 = (b - a)^2 / 12$$

The standard deviation of a uniform distribution:

$$\sigma = \sqrt{\frac{(b - a)^2}{12}}$$

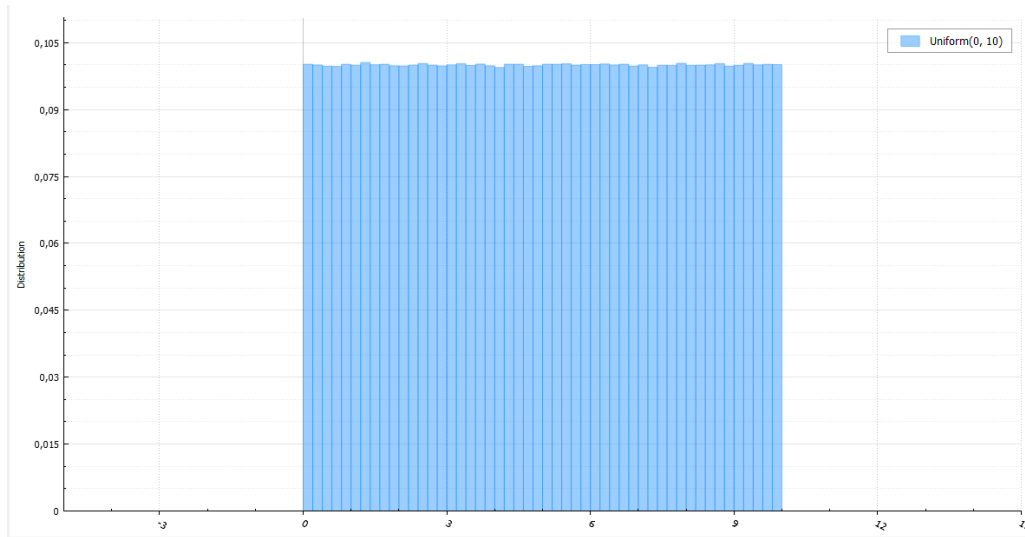


Fig. 2. Graphical characteristics of a uniform distribution of random variables

NORMAL DISTRIBUTION

A normal distribution (or Gaussian / Gauss-Laplace distribution) is the probability distribution, which in the simultaneous case is given by a probability density function that coincides with the Gaussian function:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Figure 3 shows the graphical characteristics of this distribution.

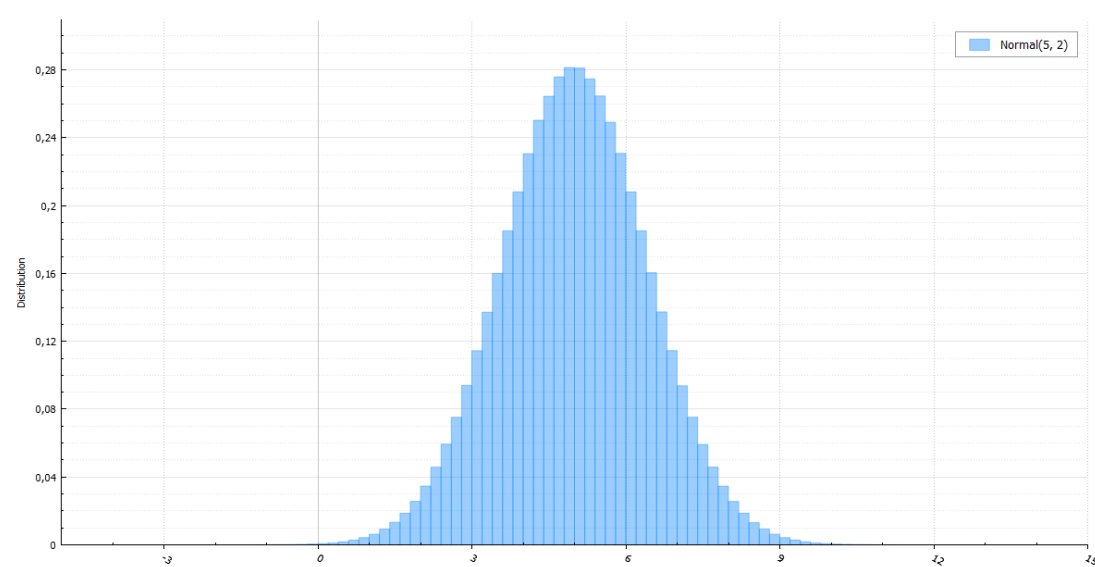


Fig. 3. Graphical characteristics of a normal distribution of random variables

The normalized randomly distributed random variable is obtained from the formula:

$$Z = (X - \mu) / \sigma$$

The expectation of a normal distribution is zero, and the standard deviation is unity. The density of a normal distribution can be obtained by substituting the formula of a random variable into the density formula:

$$f(X) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\frac{x^2}{\sigma^2}}$$

This distribution is used in many fields of science, for example in mathematical statistics and statistical physics. If the result of observation is the sum of many random weakly interdependent quantities, each of which makes a small contribution with respect to the total sum, then as the number of summands increases, the distribution of the centered and normalized result tends to normal.

A normal distribution is often found in nature, for example: deflection in shooting, measurement errors and certain characteristics of living organisms.

WEIBULL DISTRIBUTION

The Weibull distribution is a two-parameter family of continuous distributions having the parameter σ - the shape parameter and λ - the scale parameter. The probability density of a given distribution has the form:

$$fX(x) = \begin{cases} \frac{k}{\lambda} \left(\frac{x}{\lambda}\right)^{k-1} e^{-\left(\frac{x}{\lambda}\right)^k}, & x \geq 0 \\ 0, & x < 0 \end{cases}$$

The graphical characteristics of this distribution is shown in Figure 4.

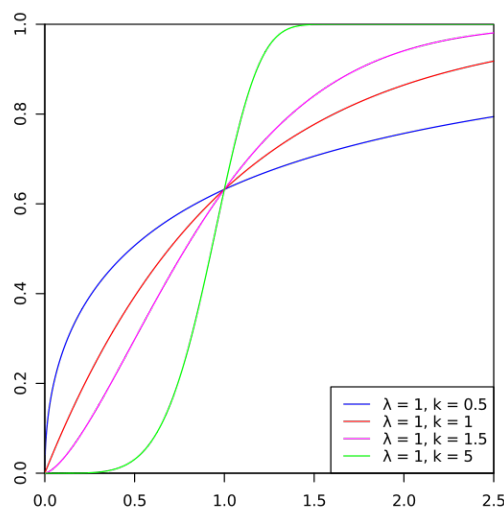


Fig. 4. Graphical characteristics of Weibull distribution

This distribution is used in: survival analysis, pullback reliability and analysis, in electrical engineering for representing overvoltage in electrical circuits, in weather forecasting, in predicting technological changes.

DISTRIBUTION OF GUMBEL

The Gumbel distribution (the double exponential distribution) is the probability distribution of a continuous random variable X with a distribution function:

$$f(x) = \exp(-e^{-y}),$$

where $-y < x < y$, $y = (x - a)/b$ and the parameters $-y < a < y$, $b > 0$.

The distribution functions and the graphical representation of the realization of random numbers with the Gumbel distribution are shown in Figures 5 and 6.

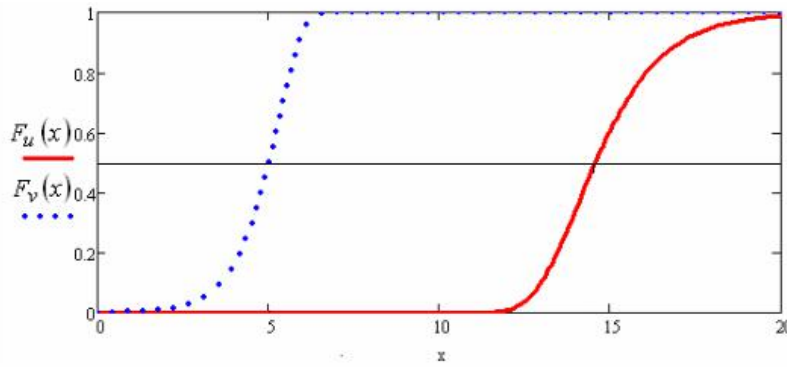


Fig. 5. Gumbel distribution functions: 1 – maximum values; 2 – minimum values

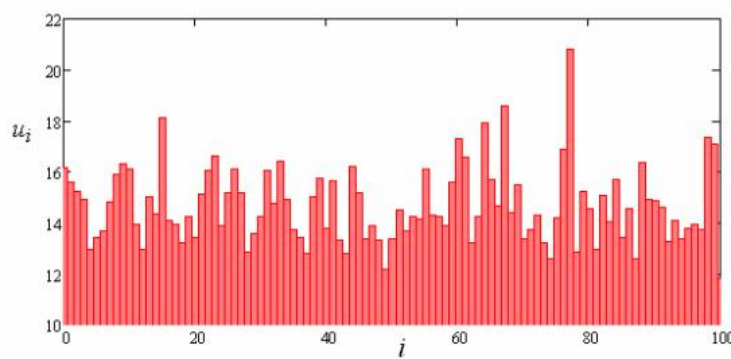


Fig. 6. Graphical representation of the realization of random numbers with the Gumbel distribution

This distribution is used mainly in the statistical analysis of snow and wind loads on structures.

LOGARIFICALLY NORMAL DISTRIBUTION

This distribution is a two-parameter family of absolutely continuous distributions. If the random variable has a lognormal distribution, then its logarithm has a normal distribution. The density of a given distribution has the form:

$$f_X(x) = \begin{cases} \frac{1}{x\sigma\sqrt{2\pi}} e^{-(\ln x - \mu)^2 / 2\sigma^2}, & x > 0 \\ 0, & x \leq 0 \end{cases}$$

where $\sigma > 0, \mu \in \mathbf{R}$. Then we say that X has a lognormal distribution with parameters μ and σ .

The density and distribution functions with the parameters $\mu = 0, \sigma = 0.7$ are shown in Fig. 7.

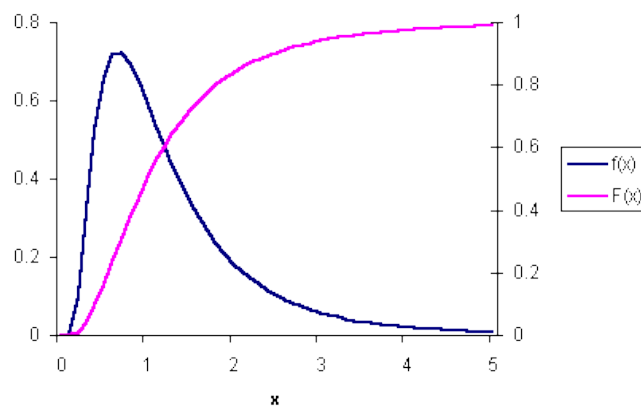


Fig. 7. Graph of the density and functions of the lognormal distribution

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Lognormal distribution is used, for example, in the modeling of variables such as income, permissible deviation from the standard of harmful substances in food and the like.

To construct probabilistic models of dynamic loads, examples are given for Gumbel, Weibull, and Lognormal distributions.

Load plays a major role in calculating the reliability of building structures. Loads are of several types: permanent and dynamic. Depending on the type of load, different models are built for calculation.

Constant loads are loads that do not depend on external factors. These loads include the weight of the structures, stationary equipment, prestressing forces and indirect effects due to the rheological properties of materials and uneven precipitation. The variability of the load due to its own weight is influenced by the uncertainties in size, density, additional loads from the nodes and connections of the structural elements, possible changes in the process of reconstruction and / or repair, and the level of construction works quality control. The most valid can take into account the influence of uncertainty in size and density.

Dynamic loads are loads that depend on time and space, sometimes representing a random function. Payloads, snow loads and wind are referred to dynamic loads.

Useful loads are loads that represent a kind of temporary loads, the nature of which is related to the operational (functional) designation of building structures.

Snow loads are loads that depend on the amount of snow. To describe and create a probabilistic model of snow load, statistical parameters of the snow load on the earth's surface and the statistical parameters of the model error, the coefficients of the "transition" from the load on the surface of the earth to the snow on the surface are needed. Coefficients of "transition" take into account: the form of the roof; snow poured from inclined surfaces; snow transport, resulting in uneven deposition over the surface of the cover and the removal of some of the snow that has fallen from the cover; melting snow on the heat-dissipating coatings heated in winter. To approximate the snow load, the first limiting Gumbel distribution, the lognormal distribution, and the Weibull distribution are most widely used. To analyze the reliability of structures characterized by very small probability values, the use of the Gumbel law is safer. The error in the model of this type of load is determined by the variability of the "transition" coefficients. The statistical parameters of coefficients from the load on the surface of the earth to the snow load on the surface have not been sufficiently studied. In most works, probability models of coefficients are adopted according to the recommendations of the Joint Committee of Structural Safety (JCSS). The recommended probabilistic models of snow load are presented in Table 1.

Table 1. – Recommended probabilistic models of snow load

Variable	distribution	μ_x/S_k	V_x
Snow load on the surface of the earth by districts:	Gumbel		
I		0,87	0,22
II		1,01	0,21
III		1,02	0,2
IV		1,10	0,2
Generalized (averaged) model of snow load on the surface of the earth		1,02 – 1,04	0,20 – 0,21
Snow load error	Logarifically normal	1,00	0,1 – 0,15

Wind loads. To describe wind impact models, you need:

- Statistical characteristics of the actual wind speed;
- Basic high-speed head wind;
- Coefficients of "transition" from the base wind speed to the wind profile;
- Coefficients of "transition" from wind speed to wind impact on the environment;
- Errors in the models of the determination of wind influence.

The recommended probabilistic models of wind impact are presented in Table 2.

Table. – Recommended probabilistic models of wind load

Variable	Distribution	μ_x/S_k	V_x
Velocity pressure	Gumbel	1,00 – 1,04	0,13 – 0,15
Wind impact model error	Logarifically normal	0,7 – 0,8	0,28 – 0,3
Wind impact (include model error)	Gumbel	0,7 – 0,8	0,31 – 0,34

With these loads in mind, you can perform the task of constructing a probabilistic model. However, this task must be divided into two important subtasks:

- 1) Construction of a probabilistic model for modeling based on the results of a technical condition survey.
- 2) Construction of a probabilistic model at the design stage.

When carrying out the first subtask, the data on the variability of the parameters of materials, loads, structural elements and structures as a whole will be obtained as a result of statistical processing of a small amount of measurement data.

When performing the second, for modeling probabilistic characteristics, large volumes of data on variability will be used, which are formed at the stage of production and construction.

When determining the parameters based on the results of the survey, the sampling data is processed. Each sample value is considered as an independent random variable having a corresponding distribution law with the same parameters.

To perform statistical processing in constructing a probabilistic model of a structural element, it is necessary:

- 1) Obtain the measurement data;
- 2) Verify the consistency of the data obtained by a certain distribution law;
- 3) Identify the distribution parameters of the general population from the received sample data with a given security. Identification is performed in accordance with the chosen distribution law;
- 4) Determine the regulatory characteristics from the identified distributions.

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WEB ASSEMBLY – THE WAY TOWARDS THE NEW HORIZONS OF PERFORMANCE

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We consider two sets of implementations of the algorithm to find Fibonacci numbers. One of them is represented by usual JavaScript functions, the second one is written in C and converted into the WebAssembly module. This will compare the performance of wasm and JS in solving similar tasks.

We will explore three approaches of finding the Fibonacci numbers. The first uses a cycle. The second uses recursion. The third is based on the technique of memoization. All of them are implemented in JavaScript (Fig. 1) and in C (Fig. 2).

```
function fibous (num) {
  var a = 1, b = 0, temp;
  while (num >= 0) {
    temp = a;
    a = b + a;
    b = temp;
    num--;
  }
  return b;
}

const fibousRec = (num) => {
  if (num <= 1) return 1;
  return fibousRec(num - 1) + fibousRec(num - 2);
}

const fibousMemo = (num, memo) => {
  memo = memo || {};
  if (memo[num]) return memo[num];
  if (num <= 1) return 1;
  return memo[num] = fibousMemo(num - 1, memo) + fibousMemo(num - 2, memo);
}

module.exports = { fibous, fibousRec, fibousMemo };

```

Fig. 1. Javascript functions implementation

```
int fibonacci(int n) {
  int a = 1;
  int b = 1;
  while (n > 1) {
    int i = a;
    a = b;
    b = i;
  }
  return b;
}

int fibonacciRec(int num) {
  if (num <= 1) return 1;
  return fibonacciRec(num - 1) + fibonacciRec(num - 2);
}

int memo[1000];
int fibonacciMemo(int n) {
  if (memo[n] != -1) return memo[n];
  if (n == 1 || n == 2) return 1;
  else {
    return memo[n] = fibonacciMemo(n - 1) + fibonacciMemo(n - 2);
  }
}

```

Fig. 2. C functions implementation

We will not discuss the details of implementation here, we have another main goal. Before proceeding to a practical example, let us elaborate on the features of technologies relevant to the research.

WebAssembly is an initiative to create a safe, portable and fast to download and use a code format suitable for the Web. WebAssembly is not a programming language. This is the compilation target, which has text and binary format specifications. This means that other low-level languages, such as C / C ++, Rust, Swift, and so on, can be compiled into WebAssembly. WebAssembly gives access to the same API as browser JavaScript, seamlessly integrated into the existing stack of technologies. This distinguishes wasm from something like Java applets. The architecture of WebAssembly is the result of teamwork of the community, in which developers of all leading web browsers took part. Emscripten is used to compile the code into the WebAssembly format.

Emscripten is a compiler from the LLVM bytecode in JavaScript. That is, using it you can compile into JavaScript programs written in C / C ++ or any other languages, the code on which you can convert to LLVM. Emscripten offers a set of APIs for porting code in a format suitable for the web. This project has been around for many years, mostly it uses to transform games into their browser versions. Emscripten allows you to achieve high performance due to the fact that it generates code that meets the standards of Asm.js, which is lower, but recently it was successfully equipped with WebAssembly support.

Asm.js is a low-level, optimized subset of JavaScript that provides linear access to memory using typed arrays and supporting annotations with information about data types. Asm.js makes it possible to improve the performance of solutions. This is also not a new programming language, therefore, if the browser does not support it, Asm.js-code will be executed as normal JavaScript, that is, it will not be possible to get performance gains from its use.

Let's turn the program written in C into a wasm format. In order to do this, use the option to create standalone WebAssembly modules. With this approach, the output of the compiler is only a file with the WebAssembly code, without additional .js files.

This approach is based on the concept of additional modules (side module) Emscripten. It makes sense to use such modules, since they, in essence, are very similar to dynamic libraries. For example, system libraries do not automatically connect to them, they are some self-contained blocks of code issued by the compiler.

After receiving the binary file, we need only upload it to the browser. In order to do this, the WebAssembly API provided a WebAssembly level object, which contains the methods needed to compile and create an instance of the module.

ArrayBuffer. The buffer contains initial binary data of fixed length. You can not execute them directly, which is why in the next step the buffer is passed to the WebAssembly.compile method, which returns WebAssembly.Module, an instance, in the end, you can create using WebAssembly.Instance.

Let's use our wasm-module to test its performance and compare it with the speed of JavaScript. The number 40 will be fed to the input of the functions under study.

Testing results: • JS x 8,605,838 ops / sec ± 1,17% (55 runs are selected) • JS recursive x 0.65 ops / sec ± 1.09% (6 samples) • JS memoization x 407,714 ops / sec ± 0,95% (sampling of 59 runs) • Native loop x 11,166,298 ops / sec ± 1,18% (sample 54 samples) • Recursive recursive x 2.20 ops / sec ± 1.58% (sample of 10 runs) • Primary memorialization x 30,886,062 ops / sec ± 1,64% (56 runs are selected) • Fastest: Collecting Memory • Slowest: JS recursive

It is noticeable that the wasm-code obtained from the C programs (in the test output it is designated as "Native") is faster than the similar code written in ordinary JavaScript ("JS" in the test output). At the same time, the fastest implementation was the wasm function of searching for Fibonacci numbers, which uses the technique of memoization, and the slowest is the recursive function in JavaScript.

Research Outcomes: • The best performance in C implementation is 375% faster than the best implementation on JS. • The fastest option on C uses memoization. On JS is an implementation of an algorithm using a loop. • The second highest performance in C is still faster than the fastest version on JS. • The slowest implementation of the algorithm in C by 338%

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UDC 004.4

IMPLEMENTATION OF THE SERVER PART OF THE MOBILE MMO-GAME IN SPACE STYLISTICS

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The paper formulates the requirements for the server part of the mobile MMO-game in space stylistics. It offers architectural solutions for implementing a network model, storing data, segmenting the system, which meet the requirements for the server part of the project.

Introduction. At present, computer games, especially multiplayer games, are becoming an important part of people's lives. They are played at home, in public transport, and even at work. This popularity is due to the fact that games can be addictive, can help to spend time with pleasure, to communicate with other people in the virtual world and to find new friends. Moreover, some types of computer games can also help in learning, enhancing memory, can improve attention to detail and analytical skills.

In multiplayer games people struggle to defeat real human opponents or cooperate to complete difficult game missions in the virtual universe. Massively multiplayer online (MMO) games have to manage large numbers of players at the same time and synchronize them efficiently in real time.

Multiplayer online games and games in space stylistics games showed their relevance to the example of popular games for personal computers (World of Warcraft, EVE Online, Star Wars: The Old Republic, Stellaris, Galactic Civilization, Space Rangers) and are in demand at the moment. Therefore, the space MMORPG with the elements of the quest and arcade can gain popularity among users of mobile devices.

The game takes place in a certain galaxy, consisting of many star systems, and those in turn represent a certain number of inhabited/uninhabited planets. The character controlled by the player is the captain of the spaceship, which can be repaired, improved, equipped with equipment and team members for in-game currency. Each player when creating a character must choose one of the three existing races, each has the corresponding characteristics. Inhabited planets give the player the opportunity to take quests, buy/sell goods, upgrade/repair equipment. For performing tasks and participating in battles, players gain experience that is used to improve the characteristics of their characters. The battle between players takes place in turn-based mode, the essence of which is to alternately carry out any specific action, such as the use of weapons, repair droid, etc. The characters of the players interact with each other within the same system, and if necessary move into other systems of the galaxy.

To the main gaming mechanisms that provide the server part, it is necessary to include:

- client connection on the mobile internet or Wi-Fi network, which requires saving of consumed network traffic;
- multi-user work in real time affecting the state of the game world;
- storage of data about players and state of game world;
- registration and authorization of players;
- processing of messages and updating of true state of game world;
- joint or single-player game tasks;
- communication and battles between players;
- chatting;
- upgrading the characteristics of character and ship;
- progress in quests;
- turn-based battles;
- in-game currency and the acquisition of property.

Network interaction model. The protocol UDP (User Datagram Protocol) was chosen to organize the network interaction. UDP allows for continuous synchronization of the game world without delay. This protocol is unreliable and can cause problems when a game needs to send data that is important to all the players in the game. Therefore, there is a need for own implementation of the reliability system with sorting the data by importance [1].

Another important design decision was to utilize a client-server model. In a client-server model clients only communicate with the game server and not between each other, like in a peer-to-peer application [2].

Approach to implementation of network model was based on ideas that are described in articles «The DOOM III Network Architecture», «Quake 3 Source Code Review», «The TRIBES Engine Networking Model». The network model should allow to reduce data traffic, minimize packet loss and maintain the reliability of the UDP protocol.

Layers of networking implementation:

- a Connection Layer that deals with notification and delivery of packets between client and server;
- a Stream Layer which provides packet stream management. This layer employs different stream managers to deal with events, object replication, input move management and others;
- a Simulation Layer which manages all objects in the simulation of game world.

The main components of this network model are illustrated in figure.

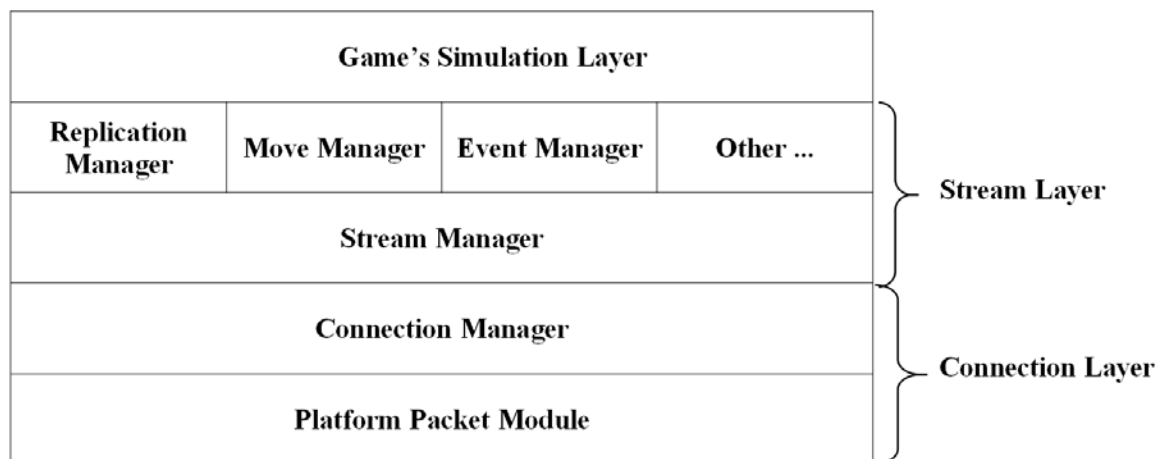


Fig. The main components of the network model

Platform Packet Module – is the lowest layer of the system. This layer is a wrapper for the standard socket, it constructs and sends various packet formats.

Connection Manager – it is to abstract the connection between two computers over the network. It receives data from the layer above it and transmits data to the layer below it, the platform packet module. Connection Manager does guarantee a delivery status notification. In this way, it is possible for the level above the connection manager (Stream Manager) to know whether or not particular data was successfully delivered.

Stream Manager – it is to allocate and transmit packets to the Connection Manager. To control bandwidth, each Stream manager has a packet update rate and size. Since other upper level systems will ask the stream manager to send data, it is also the duty of the stream manager to prioritize these requests. The move, event, and replication managers are given the highest priority when in a bandwidth-bound scenario. Once the stream manager decides on what data to send, the packets are dispatched to the connection manager. In turn, the higher-level managers will be informed by the stream manager regarding the status of delivery.

Replication Manager – it is to storage or replicate of duplicates (ghost) of dynamic objects that are deemed relevant to a particular client. In other words, the server sends information about dynamic objects to the clients, but only the objects that the server thinks the client needs to know about. Replication Manager must give the client the maximum number of relevant objects. It's very important that the ghost manager guarantees that the most recent data is always successfully transmitted to all of the clients. When an object becomes relevant, the ghost manager will assign some information to the object, which is appropriately called a ghost record. For transmission of the ghost records, the objects are prioritized first by status change and then by the priority level, after that Replication Manager determines the objects that should be sent, their data can be added to the outgoing packet.

Move Manager – it is to transmit player movement data as quickly as possible. Quick movement updates can be an important way to reduce the perception of latency on the part of player. The thread manager with the appearance of the movement data must add them to the outgoing packets first place, since this data has the highest priority. Each client is responsible for transmitting their move information to the server, where the simulation of the game world is performed. The client will be sent a confirmation of receipt of information about the movement, and the remaining clients will receive a new state of the world.

Event Manager – it is to maintain a queue of events that are generated by the game's simulation. These events produce functions on connected clients. After performing an action by one player, the server receives information about this event, checks its correctness and performs the appropriate simulation. Event Manager also prioritizes events and tries to keep a record of the maximum number of high priority events in the package.

Other Systems – support systems, which are not so important for understanding the overall architecture, but are involved in the implementation of game concepts.

Game's Simulation Layer – it is to process incoming commands and events, simulate the only true state of the game world. This layer has little to do with the network model. The server simulates the game in discrete time steps called ticks. During each tick, the server processes incoming user commands, runs a physical simulation step, checks the game rules, and updates all object states. After simulating a tick, the server decides if any client needs a world update and takes a snapshot of the current world state if necessary [2].

Data storage. Efficiently store and process data allows an approach that consists in the simultaneous use of two types of DBMS: In-Memory Database for operational work with dynamic data of the game world; Document-Oriented Database to store important, the loss of which would be critical for a player (improvement, money, quests), static and rarely changed data. Dynamic data should also be recorded for important with certain periodicity, and when a client logs out of the game.

Server partitioning. It allows to reduce the load, partially distribute it to servers, and reduce the amount of data that is transferred to each game client. This campaign is implemented by servicing each system of the galaxy by a separate server. When a player moves between systems, his data is replicated between the corresponding servers [1]. The processes of transition between systems, authorization and registration of the game are performed by the master server, which coordinates the operation of the entire system.

Conclusion. It provided a description of the game, on basis of which the main tasks for the implementation of the server part of the multiplayer online game were formulated. To solve the set tasks, architectural solutions were proposed, in particular, the approach to implementing the network interaction of the server and clients was considered. The network model describes ways to maintain the reliability of UDP protocol, reduce amount of data traffic and minimize packet loss.

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PROJECT MANAGEMENT SYSTEM WITH AUTOMATIC EXECUTION STATUS CONTROL

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The article is focused on a project management system with automatic execution status control. Its main advantage is the automatic tracking of the task, which simplifies the forecasting of risks and monitoring the work on the project online as well as reduces time and money expenses.

Project management systems do not only organize work and schedule projects. They are also applied in running a successful business, scaling growth, motivating teams. In fact, a project management system is intended to help you achieve higher productivity and better project results by centralizing and simplifying project management. Project management systems are vital today as they help us to avoid derailed projects, missed project deadlines, over-budgeting and lack of competitiveness.

You do not have to carry the painful legacy of running projects with difficult tools and ineffective processes anymore. There are beautiful solutions out there! Here are five defining business problems that a project management system will be focused on:

- Trouble managing stakeholder expectations. When you can't surface competing priorities, resource availability and scope changes, stakeholders are going to set down their own deadlines and demands—and then lose trust in your team when the project doesn't turn out as planned.

1. Lack of visibility. When project leads do not have access to a live schedule, time is wasted corralling updates from team members; and, there is no way to see incoming risks that let you plan ahead, and alert stakeholders before disaster strikes.

- Missed deadlines. When projects are tied to single-point deadlines or ones that are mandated by an executive with no idea how much work is involved, success is a pipedream. And, when the scheduling software doesn't show how resources are allocated, people get overworked even while blowing past proposed finish dates.

- No single source of truth. When project teams don't have a central location for project work, documents go missing, conversations get lost and hours are spent on work that was last week's top priority.

- Not adapting to change. When you don't have a schedule that updates in real time, there's no way to quickly assess the impact of all the constant changes occurring and alert stakeholders before it is too late.

When choosing a project management system in most cases, we prioritize online systems because they are cross-platform and allow you to be aware of the work on the project. Let's consider some of these systems.

Wrike, Inc. develops and delivers on-demand project management and collaboration software. It offers business management software that includes project planning, marketing project management, scheduling software, task management, add-in for Microsoft Outlook, and time tracking software solutions. The vendor offers a great free trial plan so there is no problem with trying out the key capabilities of the software first. To start, it offers a load of useful features including: task management, task prioritization, real-time newsfeed, interactive timeline (Gantt chart), and workload management. These tools help both distributed and co-located project teams to work speedily and efficiently.

JIRA helps you to assign tasks and prioritize your work. This app is recommended for application developers as it covers all aspects from initiation to launch. The cloud version of JIRA is easy to set up and maintain as all updates are automatic. You can utilize Scrum and Kanban workflows for project success. With the application's advanced workflow engine you can easily create a fitting process for your team.

The unique aspect of Clarizen is its links project management with social engagement in an effortless manner. The tool is widely adopted as it is fast to deploy and easy to use. With this app, you can connect projects, tasks, and conversations. Plus, the platform automatically prioritizes projects, tasks, resources, budgets, and portfolios, and ensures important resources and information are managed appropriately. Main features include: templates, personal calendars, project portfolio management, version control, and support for multiple languages and currencies.

Asana is a recommended task and project management app for teams that wish to communicate and collaborate efficiently and effectively. It's another strong contender on our list of 10 best project management software tools. You can leverage this platform to create projects and then tasks within the projects. Then, you

can track the progress of the tasks from any internet-ready device and browser. Top features include: multiple workspaces, real-time updates, activity feed, email bridge, and notifications and reminders.

Having considered a huge number of project management systems, one drawback was highlighted. They lack automation execute status control. The project management system with automatic execution status control is a new stage in project management systems. Its main advantage is the automatic tracking of the task, which simplifies the forecasting of risks and monitoring the work on the project online as well as reduces time and money expenses.

One of the options for automatic tracking of the task is the use of tests. This method is based on TDD. Together with the task, the supervisor also compiles the test to check the job automatically. This solution will speed up the execution of the project, since you often have to wait for the task manager to verify and approve the task. The main visible drawback of this system is the time spent on compiling tests, as well as the availability of relevant knowledge and skills for the manager.

In this article, project management systems were considered, and a solution to one of the problems of these systems was proposed.

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GAME MONETIZATION: THE MOST IMPORTANT GAME SUCCESS PERFORMANCE INDICATORS

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The advantages of Life Time Value in comparison to Cost Per Install were considered and the most significant game metrics when starting the game application were defined. The cost of involvement of one user in a game for smartphones was analyzed. Forecasting of the first results of the advertising company were carried out. A set of actions for achievement the maximum indicators of Life Time Value were established.

Introduction. Someone starts to develop new game products to get new experience, someone likes the game industry and wants to realize himself as a successful game developer and someone pursues the aim to make a popular product and to earn on it primarily. However, as practice shows, participating in the development of such projects, regardless of the initial goals, everyone sooner or later faces the problem of monetizing their game software.

The purpose of the study is to identify the most important financial indicators of the designed game application.

Monetization of the game is a set of activities and game mechanisms aimed at generating revenue by selling within the game content to users.

Let's consider the most popular cases of game creation among beginners and we shall analyze the weakest points in this particular approach. Figure 1 shows schematically the development plan for a game application by a junior developer.



Fig. 1. Game development plan by a junior developer

It looks good, but in practice, such approach is absolutely not viable. In this case, the developer does not consider all risks associated with the monetization of the game, does not adjust the game mechanics itself to the possibility of its competent and successful monetization. The developer tries to inject into the already finished game elements that do not fit into the original game design. That is why most of the games by junior developers contain built-in advertisements instead of reliable and successfully working mechanisms, such as pumping characters, opening chests, using energy, special offers and other modern elements of the gameplay.

During the game development, it should be understood, that publishing the game in application stores, such as the App Store [2], Google Play [3], Amazon Store [4] and others, at best case makes nothing but 30-50 installations, which would be made by your friends. Support from the application store is an excellent push for the application, but these stores are the business project of their creators and they are working primarily to make a profit. To be featured on the main page in stores, as a rule, you need to provide Apple or Google statistics of your application and in case of good financial performance, the game can be supported by application stores to get the strongest push to positioning in the top in its category.

Let's analyze which kind of statistics and which indicators everyone is interested in. There are many different characteristics, but it all comes down to a single - payback. To calculate the payback of the application, there is a formula (1),

$$LTV > CPI \quad (1)$$

LTV (Life Time Value) – the average profit from the user;
CPI (Cost per Install) – cost per installation.

In plain language, the application becomes profitable from the moment when the cost of involving one player into the game is less than the average profit received from one player. If this ratio works, the developer

will have the opportunity to expand the game audience, attracting more and more players into the game, returning all the costs of their involvement. Having these indicators, any application stores and investors will be happy to provide you the opportunities to attract new users, because on the basis of calculations they can observe clearly that the investment is returning and they can not be afraid to invest into promotion.

LTV is a characteristic that depends fully on the efforts of the developer and his team. To achieve maximum performance, several important rules are required:

- monetize everything you can monetize;
- attract only relevant categories of users which are the target audience of this game and their LTV is maximum;
- analyze user's behavior and correct weaknesses pleases of the game;
- investigating the reasons players leaving the game and try to add new elements in those moments to the constant maintenance of interest;
- make A \ B testing [5] of all promotional material (icons, all images and advertising banners), icons and any ideas that the development team brings into the game;
- run only the most successful and working ideas in the global version;
- constantly update your application and add new game content.

According to these principles, you can achieve the good metrics. But what exact numbers need to be achieved? This information is not confidential and up-to-date data can be found quickly and easily on the sites of the services that sell advertising. Based on Chartboost's data, which is one of the market leaders, the cost of attracting one player to the US market is \$ 2.32 [5]. This means that for the successful promotion of the game on the US market, it is required to pawn about \$ 2.3 for each player. It sounds scary, because it means that out of four users at least one must buy something about \$ 10. For comparison, figure 2 presents a table with the cost of attracting one user to the game (CPI), i.e. one installation in different countries.

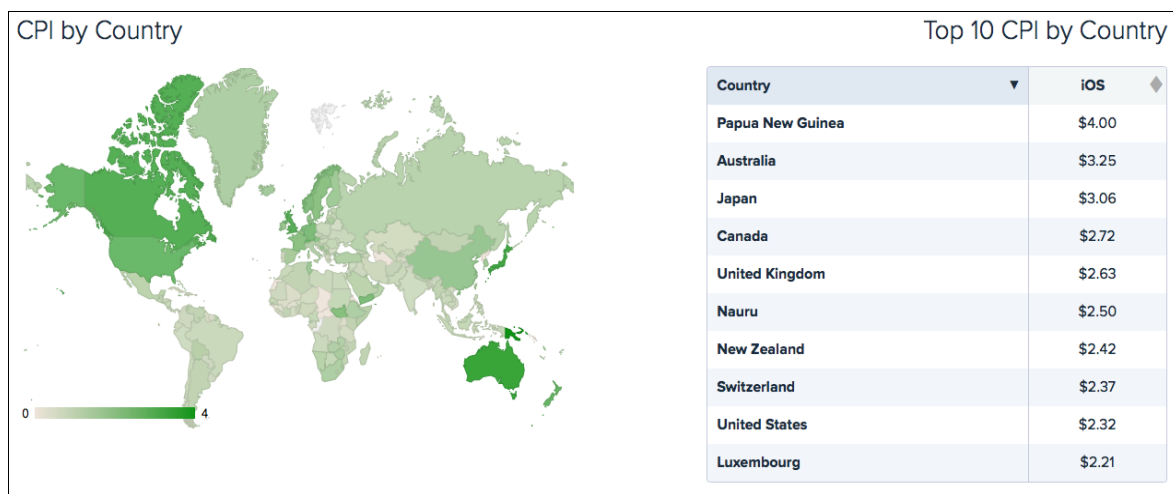


Fig. 2. The approximate cost of attracting one user to the game (CPI)

The cost of attracting a single user is high that is why you need to approach monetization issues with all responsibility. At first, select the way of game monetization, which, according to analysts' forecasts, will be relevant at the time the game is released. Then the idea of the game is adapted for the chosen way of monetization. If the game does not get worse after that, but on the contrary, the life cycle of the game increases, then you can proceed to further development.

But how to determine that your LTV is good enough to start investing into the game? After all, the process of the game can last for a long time, and money for attracting users are required in advance. There have already been a lot of research on this subject, based on what it is considered to be the 48th day as a reference point. If on the 48th day your daily profit covers the first day of expenses for attracting users, then the ratio represented in formula (1) is reached. Figure 3 shows a graph of the approximate income from one player for one year [1].

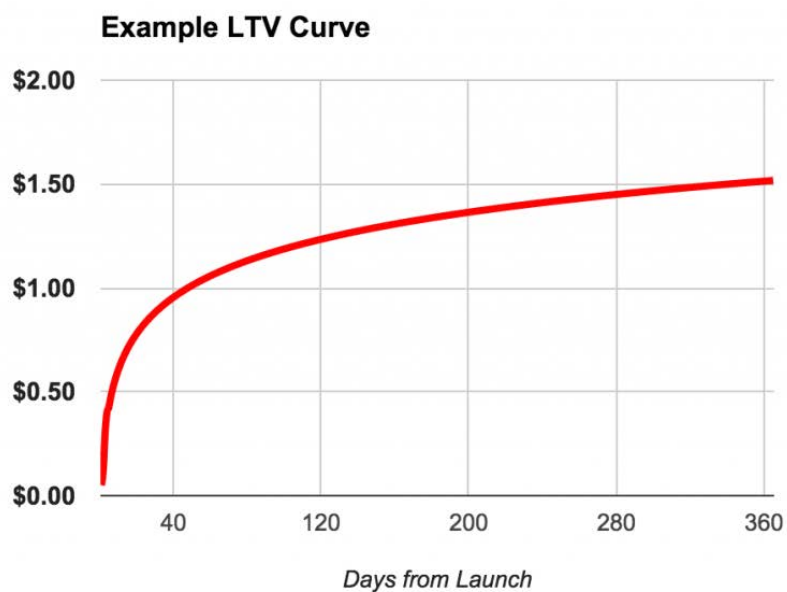


Fig. 3. Graph showing the annual LTV

The graph in Figure 3 shows that the income from one player is \$ 1.52 by the end of the year. And approximately 65% of the revenue comes during the first 40 days after the user installs the game, and the remaining 35% -- during the following year. Thus, on average, the first positive financial metrics appears only on the 50th day of the advertising campaign.

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**PROBLEMATICS OF THE CONTROL SYSTEM
AND THE POSSIBILITY OF THEIR SOLUTION WITH NEURAL NETWORKS**

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This article describes neural networks, their creation and possible ways of using. Also, the possibility of using a neural network is described in more detail.

In order to automate a system, it is necessary to remove a person either at some stage or from the entire system. In order to achieve this, you can use different possibilities. However, in this paper, we will consider the possibility of automating a system, or any process, with the help of neural networks.

To understand why neural networks were chosen to solve automation tasks it's essential to understand that they exist, how they function now, why they are the most suitable option for solving automation problems, and where neural networks are still possible.

First of all, neural networks as a mathematical model, as well as their software or hardware implementation, are built on the principle of the organization and functioning of biological neural networks - networks of nerve cells of a living organism. This concept arose when studying the processes occurring in the brain, and when trying to simulate these processes. After the development of learning algorithms, the resulting models began to be used for practical purposes: in tasks forecasting, for pattern recognition, and also in control tasks. [1] In this description, it can be seen that this type of software has evolved as an attempt to create a system that can act in the likeness of the human brain and can also be decision based on the incoming data.

Now neural networks are used for pattern recognition, as well as for classification. Both of these tasks, if solved, together with a small upgrade, can serve as the basis for automation. As an example, consider the 2 systems in which the computer has already replaced a person. One of such systems is a face recognition or fingerprint recognition system. Previously, in order to find a person by fingerprint, a team of specialists was used, who alternately compared the fingerprints from the file cabinet with the necessary print sent for comparison. As a result, it took a huge amount of man-hours to compare and reveal to whom this or that fingerprint belonged. Now a special joint system from the Gabor filter, the five-level Daubechies wavelet transform and the multilayer neural network are used to perform this task. The use of these principles allows you to recognize and classify fingerprints. [2] The general scheme of the work of classification of a fingerprint can be viewed in Figure 1.

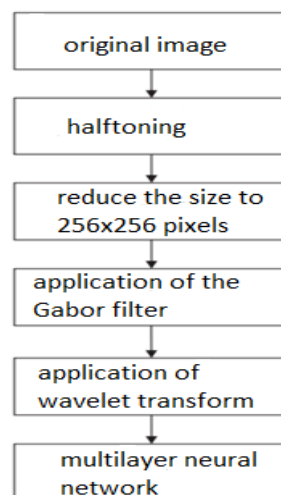


Fig. 1. General scheme for the classification of fingerprints

As described above, automation of the system with software is an attempt to remove the human being from the system or some part of the system. So this is an attempt to delegate the decision making process to the machine. Since a person makes decisions with the brain, it is logical to assume that to solve the problem of au-

tomating a certain process, it is necessary to use something that will act as the human brain. And this means that to solve such a task the neural network that will act as a human being is best suited, but unlike a human, it will not make human mistakes. So, for example, the percentage of error of any neural network can be known in advance. And if the percentage error is not satisfactory, the neural network can be modified to meet the requirements. Thanks to the fact that the neural network can replace a person at the proper level, neural networks have automated and replaced a person on a large number of industries.

Since the neural network should ideally act as the human brain and make decisions, it is worth creating a complex system that will act like a human being. A typical multi-variable system is driving a vehicle or controlling an unmanned vehicle using a control panel. In this report, we will consider the possibility of automating the motion of unmanned objects using the neural network.

At the moment, there are already systems that allow unmanned objects to be managed independently. Such systems can include robots vacuum cleaners and squares for the delivery of goods. However, it should be noted that both these systems are fairly simple and do not take into account more complex options. So, robots vacuum cleaners just move around the room and avoid obstacles if they rest on them, and the squares move in a straight line, simply bypassing the largest buildings. This means that both systems take into account a small number of obstacles on the way. This problem can be identified if we run a robot vacuum cleaner in a labyrinth or run a squarchoop of delivery in the forest and do not let it rise above tree trunks. So to automate such a thing as managing an unmanned vehicle in a complex environment, you will have to develop a system that can make a decision with a lot of obstacles. To make the system look like a person, the system should see obstacles just before itself (so the system can act as well as a person choosing from the options that are in front of it at the moment). Suppose that we want our unmanned vehicle to be controlled by itself, for this we need to do the following: first, we create a neural network that will control the unmanned vehicle and avoid obstacles. We achieve this by selecting appropriate inputs / outputs and careful training of the neural network. We transmit the network distance to the nearest obstacles around the apparatus, imitating the sight of a person. At the output, we get acceleration and turns for the unmanned vehicle. We also need to train the network on a variety of I / O strategies. The drone moves bypassing obstacles minimum for motion, the rest can be added for the system depending on what the system needs to do.

The network can be compared to a "function". There are many entrances. An entrance to the entrance is an obstacle array. These data are processed by the neuronet as a function and the response of the neurons is an exit from the function. The function $f(x) = y$ converts the value of x (one dimension) to y (one dimension). We use a neural network back propagation.

This neural network performs the work most quickly with several inputs. Since we have to work with several inputs and outputs, this system is the most suitable. When a neural network consists of only a few neurons, we can calculate the weights necessary to obtain an acceptable result. But as the number of neurons increases, the complexity of computations increases. A network of backward propagation can be trained to establish the necessary weights. We simply need to provide the desired results with their corresponding inputs. After training, the neural network will respond and produce a result close to the desirable result when submitting a known result and "guessing" the correct answer at any input not corresponding to the instructor. [3]

To train the neural network, we will use the backward propagation of the error, as well as training with the teacher. For training a neural network with the teacher, it is necessary to input the possible combinations of the inputs of the outputs. After training, the network will be able to make decisions according to what data it has received. This type of training was used in connection with the fact that it gives the smallest error in the calculations when learning a neural network.

Now that we've looked at how the "brain" works, we need to understand how to determine the inputs and outputs of the neural network. The neural network does not by itself do anything if we give it information and do not give the network response to the vehicle controller.

An obstacle matrix is fed into the neural network, this matrix contains the notation whether there is an obstacle in front of the movement or not. The matrix must contain elements, each of which must be zero or one, zero means that there are no obstacles in this cell and you can move there, if there is one in the cell, it means that there is an obstacle there and it is impossible to move there. Each cell represents the area in front of the drone, these areas are divided into N parts and numbered from the top left edge to the left to the right, top to bottom [4].

On the output from the neural network we can enter the choice: either the angles of rotation of the unmanned vehicle or the number of the cell where it is necessary to move.

From all that has been said, we can conclude that even such a complex action as driving a vehicle in a complex environment can be shifted to managing by neural networks, which will help to remove the human fac-

tor and human errors. In addition, it will help in economic terms, since neural networks do not require constant cash injections and are limited only to purchase and, in case of change in some factors, modernization.

To implement the neural network, the network was divided into 2 neural networks, each of them was trained using its own algorithm. To train the first neural network, Hebb training is used. Since the first neural network uses training without a teacher (Hebb method), some shortcomings have been identified in the development process. The main disadvantage is that the neural network is not always properly trained. In order to remove this drawback, the network was trained. After the tests, the appropriate weights for the neural network were chosen and they remained as standard. Due to this, errors related to incorrect learning of the neural network were eliminated. The training itself can be seen in Figure 2.

```
20 public void education(boolean right){
21     Vector<Vector<Double>> w = this.getW();
22     Vector<Double> input = this.getInput();
23     Vector<Double> output = this.getOutput();
24     double a = getAlpha();
25
26     if(!right){
27         int x = getWinner();
28         if (x >= 0) {
29             Double y = null;
30             for (int i = 0; i < w.get(x).size(); i++) {
31                 y = w.get(x).get(i);
32                 y -= a*input.get(i)*output.get(x);
33                 w.get(x).set(i, y);
34             }
35         }
36     } else {
37         Double x = null;
38         for(int i = 0; i < w.size(); ++i){
39             for (int j = 0; j < w.get(i).size(); ++j){
40                 x = w.get(i).get(j);
41                 x += a*input.get(j)*output.get(i);
42                 //if (x < 0.001) {
43                 //    x = 0.001;
44                 //}
45                 if (10*getAverage(i, j) < x){
46                     x /= 3.0;
47                 }
48                 w.get(i).set(j, x);
49             }
50         }
51     }
```

Fig. 2. Training of the first neural network

The second neural network is trained using the method of back propagation of the error; the implementation of this method can be seen in Figure 3.

```
393
394
395 public void education(boolean right){
396     //
397     //
398     InputLern inLern = new InputLern();
399     for(int k = 0; k < epohe; k++){//количество проходов по массиву
400         for(int mas = 0; mas < inLern.inVect.size(); mas++){//берём некую строку из массива
401
402             Vector<Double> inVect = inLern.inVect.get(mas);
403             Vector<Double> outVect = inLern.outVect.get(mas);
404             setInput(inVect);
405             calculate();
406             for(int i=0; i<w.size(); i++){
407                 Vector<Double> v = w.get(i);
408
409                 Double er=error(output.get(i),outVect.get(i));
410
411                 Double chis = output.get(i) - outVect.get(i);
412
413                 Double wDel = weightsDelta(er, output.get(i));
414                 for(int j=0; j < v.size();j++){
415                     Double inVectDobl = inVect.get(j);
416                     Double reb = v.get(j) - inVect.get(j)*wDel*learningRate;
417                     v.set(j, reb);
418                 }
419                 w.set(i, v);//получили новые веса для i выходного нейрона
420
421             }
422         }
423     }
424     //System.out.println(">>"+w.toString());
425 }
426 };
```

Fig. 3. Realization of training of the second neural network

Thus, the work examined the possibilities of a library using neural networks. Various ways of using the library were considered. In addition, a concrete example of using the library was considered in detail to simplify the performance of some tasks.

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DESIGNING THE GRAPHIC INTERFACE FOR IOS

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The article discusses the development principles of the graphical user interface in the mobile application for iOS using various technologies.

Introduction

Each operating system has its own principles of UI building. iOS uses XML-files – also called Storyboards, or code markup creation. Location of objects. The arrangement of objects is formed through the setting of the frame, coordinates and size of the interface elements, or using the Autolayout system, which specifies mutual indentation.

This article describes UI creation technologies for iOS in detail.

Main body

MVS (Model-View-Controller) pattern is usually used in application development for iOS. The main idea of this pattern is simple – duty separations: the controller processes user's activity (clicks on the buttons, server's requests etc.); the model provides data that the user needs; theView provides data presentation from the model. [1]

Storyboard is a markup file that provides a developer with a convenient set of tools for building a graphical interface. [2] Despite the fact that the file uses XML markup language, the programmer does not need to know it, because the principle of operation is based on dragging items onto the desktop of the file and specifying the properties of this object through the menu.

This technology has its own advantages:

- Layout visibility and simplicity
- Simple creation of transitions
- All that you need to know is the identifier of the transition (segue id)
- SizeClasses – the ability to specify the location of the elements for different device screens

However, there are some disadvantages:

- Complexity when working in a team, these files are very difficult to merge
- Most of the animation code cannot be inserted into these files
- Huge load in case of the increase in a project size
- Limited selection of layout elements

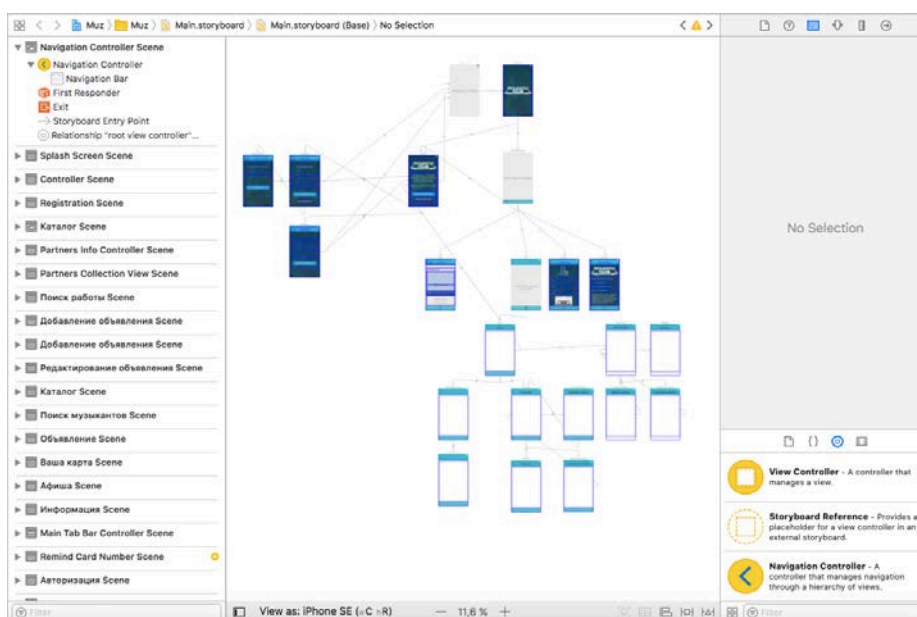


Fig. 1. Storyboard markup file

ITC, Electronics, Programming

All segues are represented by arrows between screens, each transition has its own identifier to access them. In the bottom righthand corner there is a menu with a selection of available elements, however their list is limited. [3]

Manual marking is prescribed in the Controller files and the View. However, you can do this in two ways:

- Via frames
- Via Autolayout system

Working with frames is the direct indication of the location coordinates of the interface elements, as well as their sizes. This method is not the best solution, because it does not provide sufficient flexibility; When you change the orientation of the screen, the interface cannot rebuild itself. However, this method works faster with resource-intensive elements than Autolayout.

Autolayout is a GUI system that dynamically calculates the position and size of elements based on certain constraints assigned to these elements. The advantage of this system is its flexibility. There is no need to fit the sizes and positions of the elements for different screens and states. To facilitate the work with Autolayout, there are many open frameworks: SnapKit, PureLayout and other. [4]

The advantage of manual markup before marking through Storyboard is as follows:

- Flexibility
- Speed
- You can work with the arrangement of elements in the process of working with the application
- It's easier to work with animation
- No restrictions in the choice of elements, because you can write your own and use the readymade ones.

However, the use of manual markup does not provide clarity, the application gets more coding. An example of manual markup is shown in Listing 1.

```
class VKCheckbox: UIView
{
    var line = VKCheckboxLine.Normal
    var button = UIButton()
    var checkmark = VKCheckmarkView()
    override init(frame: CGRect) {
        super.init(frame: frame)
        self.setupView()
    }
    required init?(coder aDecoder: NSCoder) {
        super.init(coder: aDecoder)
        self.setupView()
    }
    func setupView() {
        self.backgroundColor = UIColor.clear
        self.cornerRadius = 8
        self.borderWidth = 3
        self.borderColor = UIColor.darkGray
        self.color = UIColor(red: 46/255, green: 119/255, blue: 217/255, alpha: 1)
        self.checkmark.frame = self.bounds
        self.checkmark.autoresizingMask = [.flexibleWidth, .flexibleHeight];
        self.addSubview(self.checkmark)
        self.button.frame = self.bounds
        self.button.autoresizingMask = [.flexibleWidth, .flexibleHeight];
        self.button.addTarget(self, action: #selector(VKCheckbox.buttonDidSelected), for: .touchUpInside)
        self.addSubview(self.button)
    }
    override func layoutSubviews() {
        super.layoutSubviews()
        self.button.bounds = self.bounds
        self.checkmark.bounds = self.bounds
    }
}
```

Conclusion.

This article discusses the main ways to design a graphical interface for mobile applications for the iOS operating system, as well as their pros and cons. The examples of work with each of the systems are presented.

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MULTY-DIMENSIONAL INTEGRAL TRANSFORM WITH
THE CONFLUENT HYPERGEOMETRIC KUMMER FUNCTION IN THE KERNEL
AND INTEGRAL EQUATION OF THE FIRST KIND

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Multy-dimensional integral transform involving Kummer function in the kernel is studied on the space of summable functions on a finite domain $[a_1, b_1] \times \dots \times [a_n, b_n] \subset R^n$. Mapping properties such as the boundedness are given, and the inversion formula is established. Integral equation of the first kind with the Kummer function in the kernel is also considered. The solution of the investigating equation is established, and conditions for its solvability in the space of summable functions are given.

Consider the integral transformation on the left-hand side of (1)

$$(I_{\mathbf{a}^+}^{\alpha, \beta, \lambda} f)(\mathbf{x}) \equiv \int_{a_1}^{x_1} \dots \int_{a_n}^{x_n} \frac{(\mathbf{x} - \mathbf{t})^{\alpha-1}}{\Gamma(\alpha)} F(\beta; \alpha; \lambda(\mathbf{x} - \mathbf{t})) f(\mathbf{t}) d\mathbf{t} = g(\mathbf{x}), \quad \mathbf{x} > \mathbf{a}, \quad (1)$$

here $\mathbf{x} = (x_1, \dots, x_n) \in R^n$; $\mathbf{t} = (t_1, \dots, t_n) \in R^n$ – vectors; $\mathbf{x} \cdot \mathbf{t} = \sum_{k=1}^n x_k t_k$; $\mathbf{x} > \mathbf{t}$ means $x_1 > t_1, \dots, x_n > t_n$;

$\lambda = (\lambda_1, \dots, \lambda_n) \in R^n$, $\lambda_i > 0$, $(i = 1, \dots, n)$; $\beta = (\beta_1, \dots, \beta_n)$, $\alpha = (\alpha_1, \dots, \alpha_n) \in R^n$, $0 < \alpha_i < 1$ ($i = 1, \dots, n$); $\mathbf{a} = (a_1, \dots, a_n) \in R^n$; $k = (k_1, \dots, k_n) \in N^n$ – index with $k! = k_1! \dots k_n!$ and $|k| = k_1 + \dots + k_n$;

$D^k = \frac{\partial^{|k|}}{(\partial x_1)^{k_1} \dots (\partial x_n)^{k_n}}$; $d\mathbf{t} = dt_1 \dots dt_n$; $(\mathbf{x} - \mathbf{t})^{\alpha-1} = (x_1 - t_1)^{\alpha_1-1} \dots (x_n - t_n)^{\alpha_n-1}$; $f(\mathbf{t}) = f(t_1, \dots, t_n)$. Function

$F(\beta; \alpha; \lambda(\mathbf{x} - \mathbf{t})) = \prod_{j=1}^n {}_1F_1(\beta_j; \alpha_j; \lambda_j(x_j - t_j))$, where ${}_1F_1(a; c; z)$ is the Kummer function [1, §1]:

$${}_1F_1(a; c; z) = \sum_{k=0}^{\infty} \frac{(a)_k}{(c)_k} \frac{z^k}{k!} = \lim_{b \rightarrow \infty} {}_2F_1\left(a, b; c; \frac{z}{b}\right), \quad |z| < \infty, \quad (2)$$

here $(a)_k$ – the Pochhammer symbol: $(a)_0 \equiv 1$, $(a)_k = a(a+1)\dots(a+k-1)$ ($a \in C; k \in N$), ${}_2F_1(a, b; c; z)$ – Gauss hypergeometric function [1, §1]. The domain of integration of the transformation operator on the left-hand side of (1) is a rectangular parallelepiped with opposite vertices $\mathbf{x} = (x_1, \dots, x_n)$ and $\mathbf{a} = (a_1, \dots, a_n)$. In this paper, the transformation (1) is studied in space $L_{\bar{p}}(\mathbf{a}, \mathbf{b})$, $[\mathbf{a}, \mathbf{b}] = [a_1, b_1] \times \dots \times [a_n, b_n] \subset R^n$, $-\infty < \mathbf{a} < \mathbf{b} < \infty$, $\bar{p} = (p_1, \dots, p_n)$, $1 \leq \bar{p} < \infty$, functions $f(\mathbf{x}) = f(x_1, \dots, x_n)$ that have a finite norm [1, § 24.4]:

$$\|f\|_{\bar{p}} = \left\{ \int_{a_n}^{b_n} \dots \int_{a_2}^{b_2} \left[\int_{a_1}^{b_1} |f(x_1, \dots, x_n)|^{p_1} dx_1 \right]^{p_2/p_1} dx_2 \dots \left[\int_{a_n}^{b_n} dx_n \right]^{p_n/p_{n-1}} dx_n \right\}^{1/p_n} < \infty.$$

Expressions

$$(I_{\mathbf{a}^+}^{\alpha} \varphi)(\mathbf{x}) = \frac{1}{\Gamma(\alpha)} \int_{a_1}^{x_1} \dots \int_{a_n}^{x_n} \frac{\varphi(\mathbf{t})}{(\mathbf{x} - \mathbf{t})^{1-\alpha}} d\mathbf{t} \quad (\alpha > 0, \mathbf{x} > \mathbf{a}),$$

$$(D_{\mathbf{a}^+}^{\alpha} f)(\mathbf{x}) = \frac{1}{\Gamma(1-\alpha)} \frac{\partial^n}{\partial x_1 \dots \partial x_n} \int_{a_1}^{x_1} \dots \int_{a_n}^{x_n} \frac{f(\mathbf{t}) d\mathbf{t}}{(\mathbf{x} - \mathbf{t})^{\alpha}} \quad (0 < \alpha < 1, \mathbf{x} > \mathbf{a})$$

are called respectively (left-sided) mixed fractional integral and mixed Riemann-Liouville fractional derivative of order α [1, § 24.2].

We introduce the space of functions

$$I_{a_+}^{\alpha}(L_{\bar{p}}(\mathbf{a}, \mathbf{b})) = \{f : f = I_{a_+}^{\alpha} \varphi, \varphi \in L_{\bar{p}}(\mathbf{a}, \mathbf{b}), -\infty < \mathbf{a} < \mathbf{b} < \infty, 1 < \bar{p} < \frac{1}{\alpha}, 0 \leq \alpha < 1\}.$$

The space $I_{a_+}^{\alpha}(L_{\bar{p}}(\mathbf{a}, \mathbf{b}))$ plays the same role for equation (1) as the space $AC([a, b])$ of absolutely continuous functions for the classical Abel integral equation [1, §2.2].

Based on the representation of the kernel transform operator (1) through the series (2) and using the formula [1, formula (1.56)], we write the following formula, which reflects an operator structure (1):

$$I_{a_+}^{\alpha, \beta, \lambda} = I_{a_+}^{\alpha} (E - \lambda I_{a_+}^1)^{-\beta}, \quad (3)$$

where E is the identity operator.

On the basis of [1, Theorem 25.2, 37.1] we obtain.

Theorem 1. The operator on the left-hand side of (1) acts boundedly from the space $L_{\bar{p}}(\mathbf{a}, \mathbf{b})$, $\bar{p} \geq 1$, onto the space $I_{a_+}^{\alpha}(L_{\bar{p}}(\mathbf{a}, \mathbf{b}))$, $1 < \bar{p} < \frac{1}{\alpha}$; $0 \leq \alpha < 1$, $\lambda > 0$, $-\infty < \mathbf{a} < \mathbf{b} < \infty$.

If in (1) $\mathbf{a} = 0$ or $\mathbf{a} > 0$, but the function is further defined by zero on the interval $0 < \mathbf{t} < \mathbf{a}$, then we apply the multidimensional Laplace transform [1, formula (24.49)] to the left side of (1), we obtain

$$(L I_{0_+}^{\alpha, \beta, \lambda} f)(s) = s^{-\alpha} (1 - \lambda s^{-1})^{-\beta} (Lf)(s) \quad (s = (s_1, \dots, s_n) > 0; \lambda = (\lambda_1, \dots, \lambda_n) > 0). \quad (4)$$

As formula (3) and (4) show, the Laplace transform $(Lh)(s)$ of the kernel $h(\mathbf{x})$ of operator (1) and the corresponding reversion $[(Lh)(s)]^{-1}$ of it have the same form, differing only in the values of the parameters. In the simplest case of the fractional integration operator $I_{0_+}^{\alpha}$, which corresponds to the $(Lh)(s) = s^{-\alpha}$ with the condition $\operatorname{Re}(\alpha) > 0$ [1, formula (24.50)], for the Laplace transform s^{α} of the kernel of the inverse operator $D_{0_+}^{\alpha}$, the condition $\operatorname{Re}(\alpha) > 0$ forces us to represent s^{α} in the form $s^{\alpha} = s^n s^{-(n-\alpha)}$, where $\operatorname{Re}(n-\alpha) > 0$, and the operator $\left(\frac{d}{d\mathbf{x}}\right)^n = D_{0_+}^n$ corresponds to the value s^n [1, equality (18.12)]. Such operations we use for the conversion of the operator (1).

Using formula (4) and formula [2, formula 6.3 (7)], we obtain

$$\begin{aligned} f(\mathbf{x}) &= \left\{ (I_{a_+}^{\alpha, \beta, \lambda})^{-1} g \right\}(\mathbf{x}) = I_{a_+}^{-\alpha} (E - \lambda I_{a_+}^1)^{\beta} g(\mathbf{x}) = \\ &= \frac{1}{\Gamma(1-\alpha)} \int_a^{\mathbf{x}} (\mathbf{x} - \mathbf{t})^{-\alpha} {}_1F_1(-\beta; 1-\alpha; \lambda(\mathbf{x} - \mathbf{t})) \frac{dg(\mathbf{t})}{d\mathbf{t}} d\mathbf{t}. \end{aligned} \quad (5)$$

Theorem 2. Consider the equation (1): $(I_{a_+}^{\alpha, \beta, \lambda} f)(\mathbf{x}) = g(\mathbf{x})$. Let $0 \leq \mathbf{a} < \mathbf{x} < \mathbf{b} < \infty$, $0 < \alpha < 1$, $\lambda > 0$; function $g(\mathbf{x})$ is given on the $[\mathbf{a}, \mathbf{b}] \subset R^n$; $f(\mathbf{x})$ - the required function (in the case $\mathbf{a} > 0$ it is assumed that $f(\mathbf{x}) = g(\mathbf{x}) = 0$ for $0 < \mathbf{x} < \mathbf{a}$), then the unique solution f of the equation (1) exists in the class of functions $L_{\bar{p}}(\mathbf{a}, \mathbf{b})$, $\mathbf{b} < \infty$, if, $g(\mathbf{x}) \in I_{a_+}^{\alpha}(L_{\bar{p}}(\mathbf{a}, \mathbf{b}))$, $\bar{p} \geq 1$. In the case $\bar{p} = 1$ the solution can be represented by the formula (5), if additional conditions $g(\mathbf{x}) \in I_{a_+}^{\alpha}(L_{\bar{p}}(\mathbf{a}, \mathbf{b}))$ and $g(\mathbf{a}) = 0$ are satisfied.

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WAYS TO PROTECT A USER'S EMAIL

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This article describes the process of mail attacks (phishing), because this is how most cyberattacks begin, and technologies that help protect your mailbox.

When creating the Internet, initially there was no way to check the identity of the sender. During the development of the basic e-mail protocols, the costs of processing power, implementation and ease of use were balanced with the risk of fraud. It was hard to imagine that 84% of all e-mail in the future will have a malicious load and be phishing or spam.

The result is that the headers of letters, including the "From:" and "Reply-to:" fields, are very easy to forge. In some cases, it's as easy as typing "john@company.com" in the "From:" field. Combining this with unsuspecting content, convincing graphics and formatting, it is possible to deceive people who thought that the message in their mailbox really came from the bank, the Federal Tax Service, the head or the president of the United States.

Taking into account the widespread distribution of e-mail, you are aware of the basis of our current information security crisis. The weakness in e-mail led to a lot of phishing attacks aimed at getting people to click on malicious links, downloading and opening malicious files, sending a W-2 form (analogous to a 2-NDFL in the US), or transferring money to criminals' accounts.

More recently, Coupa, a Silicon Valley company, has been the focus of attention after sending data on the wages of all 625 employees to the scammer. Russian hackers managed to distribute malware-infected PDF files by sending emails impersonating Harvard's Kennedy School. And last year, one of Europe's biggest companies lost \$45M when an employee mistakenly wired the money to a fraudster's account in response to a bogus email. The FBI estimates that one type of phishing attack, the Business Email Compromise (BEC), costs U.S. companies \$3 billion per year. [1]

On databreaches.net, a list of facts of phishing form W-2 was compiled. Work on the list this year indicates that the number of cases since 2016 are growing and at the moment it consists of 204 reports. Under the list, you can understand that there are cases of theft of these thousands of employees and this kind of fraud is very common.

HOW AN ATTACKER CAN FORGE AN UNPROTECTED E-MAIL

In fact, the fake address in the "from" field is the basis and the initial stage of most attacks. Why worry about falsifying e-mail with conditional "company.com", when it is possible to simply register a similar fake domain (for example, c0mpany.com) and use it? Or create a Gmail account (randomaddress1347356@gmail.com), assign it a friendly name that looks like the name of the CEO of the company? Because, in fact, to forge sending a letter from a real person's address is even easier than registering a fake domain or creating a Gmail account.

Three simple ways:

On the Internet, you can easily find sites that allow you to send fake emails. There are dozens of them, just a couple of examples: spoofbox.com and anonymailer.net. Many of them are free, some cost money, these services are positioned as legitimate, and the main purpose of use is the drawing of friends.

The algorithm for using is simple. It is only necessary to enter the e-mail address of the recipient in the field "To:", put any desired e-mail address in the "From:" field and after the message is created, confirm the sending. Under the terms of the user agreement, the responsibility for the damage lies entirely with the customers of the service.

The next method is sending using the UNIX command line. If you have a computer with a configured mail service, just type this command: mail -aFrom:whatever@anydomain.com

As a result, you receive a message in which the "From" field will contain "any@anydomain.com". Entering the subject line and the rest of the message, after pressing Ctrl + D, the message is sent to the recipient. The working capacity of this idea depends on how your system is set up. Nevertheless, it works in many cases.

Using PHP, you can create an email with a few lines of very simple code:

```
<?php
$to = 'nobody@example.com';
$subject = 'the subject';
$message = 'hello';
$headers = 'From: webmaster@example.com' . "\r\n" .
'Reply-To: webmaster@example.com' . "\r\n" .
'X-Mailer: PHP/' . phpversion();

mail($to, $subject, $message, $headers);
?>
```

In fact, these are lines of code used as an example in the online guide for the function of sending mail with additional headers / header.

These spoofing tools are greatly simplified. To make messages more realistic, it will take a little more work and, of course, social engineering skills. But the main technical component is very simple. The only thing that really prevents spoofing is the authentication of e-mail by sharing the SPF record, DKIM signature and DMARC. Next, we will describe how these technologies work and how. They are not new, but fortunately for scammers, most domains on the Internet are not yet protected. For example, only about 4% of .gov domains use authentication. What about the other 96%? Attackers can send emails in the guise of outgoing mailboxes of these domains at any time.

According to the source, one of four letters from .gov domains is fraudulent. Domains like justice.gov. House.gov. Senate.gov. Whitehouse.gov., and also domains like democrats.org, dnc.org, gop.com, rnc.org. And DonaldJTrump.com – all of them can be easily used for spoofing by mail scammers.

Methods of protection against spoofing:

The above-described ease of use of non-authenticated e-mail vulnerabilities and the widespread use of these methods as the initial stage for the largest cyberattacks, focuses the attention of the IT community on the need to use e-mail authentication technologies. By implementing email authentication, you can ensure that any user - employee, client or partner receiving an email, will be able to determine whether an email has been sent by a legitimate representative of the company. In addition, you can get transparency and control over who sends e-mail on your behalf.

The importance of this has increased dramatically due to the rapid growth of cloud services (SaaS), more than 10,000 of which send e-mail on behalf of their customers on the topic of sales, marketing, customer support, HR, accounting, legal and other services. Due to forced authentication, you can block anyone who tries to send a message on your behalf - spammers, phishers and even "gray" senders, which may be legitimate, but not listed in the list of allowed.

E-mail authentication standards allow the mail server to verify that an email with your domain in the "From:" field was allowed to be sent on your behalf. Before the message reaches the Inbox of the recipient, the mail server can check:

- Using the SPF record, does the sending server have the right to use the domain name (or names) specified in the message headers?

- If a cryptographic DKIM [2] signature is attached to the message, using an open version of the key in the DNS domain record, you can decrypt the headers of incoming messages and find out whether the message is actually from the claimed sender.

- Due to DMARC [3] configuration, domain owners can create mail processing rules that came from domains that have not been authorized and check whether the headers match with each other (for example, the From: and Reply-to :) fields. The rules include instructions on what the receiving server should do with messages that have not been authenticated, for example, do not skip them, put them in a spam folder, or mark them as potentially dangerous. Authentication by email gives the domain owner global control over what happens to messages sent on their behalf by anyone and anyone. For example, if you represent a mail-sending domain and publish a DMARC record requesting information, you will receive from all recipient domains that also support DMARC statistics about all mail messages that come with a return address from your domain. Statistics comes in XML and contains the IP address of each sender that is subscribed by your domain, the number of messages from each IP address, the result of processing these messages in accordance with the DMARC rules, the results of the SPF and the results of DKIM

WHY DO YOU NEED THE SHARED USE OF THESE TECHNOLOGIES?

In a simplified sense, SPF [4] allows you to create a whitelist for IP addresses. If the mail server with an IP address that is not on your list tries to send an email using your domain, the SPF authentication test will not be passed. However, a big problem with SPF is that the domain specified in the Return-Path field for authentication is used, and not the From field that people are actually reading.

Worse, phishing scammers can set up an SPF record for their own domains. They can then send emails that appear to come from a trusted company or brand, but the domain of that company will be displayed in the From field, and the domain of the fraudster in Return-Path. Such letters will be authenticated by SPF. The additional use of DMARC solves this problem by allowing the domain owner to require an "equalization", which means that the return and outbound addresses must be the same.

SPF records are text, but the syntax is quite complex. It is easy to make typos that are difficult to detect. In doing so, they will make the SPF record useless. An analysis of the SPF [5] records of all 62 sponsors of the RSA 2017 conference showed that only 58 published SPF, while 17 sponsors of the Cybersecurity Conference had errors in the recording. Companies that do not have much experience in the IT field often find SPF even more difficult.

Also, DKIM is not particularly effective against fraud without the use of DMARC. To stop phishing, the most important address is the domain in the From field. However, checking only the DKIM signature does not say anything about the domain in this field. The domain used to sign the message may be completely different from the domain specified in the From field. In other words, hackers can create messages that are signed through DKIM [6] using the domain they control, but the "From" field will contain your bank's email. Most people do not intend to dig into the headers of all incoming messages to make sure that the DKIM signature data is legitimate. It is also worth considering a large number of legitimate e-mail services that can make mailings on behalf of the sender and the problem of secrecy of the private key used to sign messages.

These two early standards, although important, contain important gaps. DMARC [7] is based on them and supplements. DMARC significantly increases the credibility of the email you send, regardless of whether emails from your own mail servers or cloud services that you authorize to send e-mail.

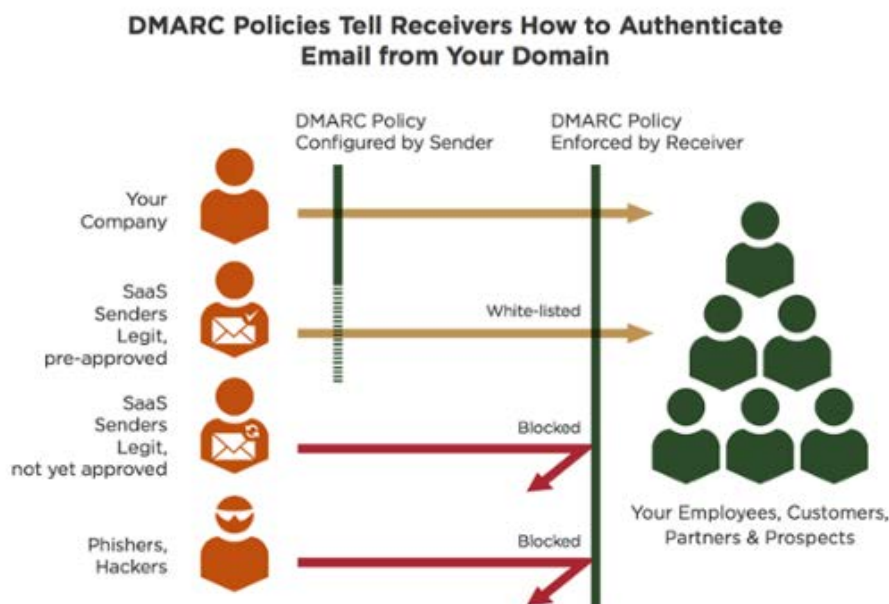


Fig. 1. Diagram of DMARC operation

The main contributions of DMARC are:

1. Configuring a policy that tells receiving e-mail servers what to do with e-mail messages that are not authenticated (nothing, quarantine or failure),
2. providing a reporting mechanism.

Having a policy and a feedback mechanism is what makes it work.

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MODERN APPROACHES TO ANDROID APP ARCHITECTURE: MVVM, MVP, VIPER

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Choosing the right approach to application architecture is an important and responsible solution that affects all subsequent application development; it needs to keep code clean and organized. The article describes some of Android app architectures.

During Google I/O, Google introduced architecture components which include LiveData and ViewModel which facilitate developing Android app using MVVM (Model-View-ViewModel) pattern. This article discusses how these components can serve an android app that follows MVVM. MVVM is one of the architectural patterns which enhances separation of concerns, it allows separating the user interface logic from the business (or the back-end) logic. Its target (with other MVC pattern goals) is to achieve the following principle "Keeping UI code simple and free of app logic in order to make it easier to manage".

MVVM has mainly the following layers:

– Model. Model represents the data and business logic of the app. One of the recommended implementation strategies of this layer, is to expose its data through observables to be decoupled completely from ViewModel or any other observer/consumer.

– ViewModel. ViewModel interacts with model and also prepares observable(s) that can be observed by a View. ViewModel can optionally provide hooks for the view to pass events to the model. One of the important implementation strategies of this layer is to decouple it from the View, i.e, ViewModel should not be aware of the view which it is interacting with.

– View. Finally, the view role in this pattern is to observe (or subscribe to) a ViewModel observable to get data in order to update UI elements accordingly [4].

LiveData. As said above, LiveData is one of the newly introduced architecture components. LiveData is an observable data holder. This allows the components in your app to be able to observe LiveData objects for changes without creating explicit and rigid dependency paths between them. This decouples completely the LiveData object producer from the LiveData object consumer. In addition to this, there is also a great benefit in LiveData, LiveData respects the lifecycle state of your app components (activities, fragments, services) and handles object life cycle management which ensures that LiveData objects do not leak.

As per Google Docs, If you are already using a library like Rx or Agera, you can continue using them instead of LiveData. But in this case, it is your responsibility to handle object allocation and de-allocation per Android components life cycle.

Since LiveData respects Android Lifecycle, this means it will not invoke its observer callback unless the LiveData host (activity or fragment) is in an active state (received onStart() but not received onStop() for example). In addition to this, LiveData will also automatically remove the observer when the its host receives onDestroy().

ViewModel is also one of the newly introduced architecture components. Architecture components provide a new class called ViewModel, which is responsible for preparing the data for the UI/View. ViewModel gives you a good base class for your MVVM ViewModel layer since ViewModel and AndroidViewModel extending classes are automatically having their holding data retained during configuration changes. This means that after configuration changes this ViewModel holded data is immediately available to the next activity or fragment instance [2].

MVP (Model View Presenter) pattern is a derivative from the well-known MVC (Model View Controller), which for a while now is gaining importance in the development of Android applications. The MVP pattern allows separating the presentation layer from the logic, so that everything about how the interface works is separated from how we represent it on screen. Ideally the MVP pattern would achieve the same logic and might have completely different and interchangeable views. The first thing to clarify is that MVP is not an architectural pattern; it's only responsible for the presentation layer. In any case it is always better to use it for your architecture than not using it at all [5].

In Android we have a problem arising from the fact that Android activities are closely coupled to both interface and data access mechanisms. We can find extreme examples such as CursorAdapter, which mix adapters, which are part of the view together with cursors, something that should be relegated to the depths of

data access layer. For an application to be easily extensible and maintainable we need to define well separated layers. What do we do tomorrow if, instead of retrieving the same data from a database, we need to do it from a web service? We would have to redo our entire view. MVP makes views independent from our data source. We divide the application into at least three different layers, which let us test them independently. With MVP we are able to take most of logic out from the activities so that we can test it without using instrumentation tests.

There are many variations of MVP and everyone can adjust the pattern idea to their needs and the way they feel more comfortable. The pattern varies depending basically on the amount of responsibilities that we delegate to the presenter. Is the view responsible to enable or disable a progress bar, or should it be done by the presenter? And who decides which actions should be shown in the Action Bar? That's where the tough decisions begin.

The presenter is responsible to act as the middleman between view and model. It retrieves data from the model and returns it formatted to the view. But unlike the typical MVC, it also decides what happens when you interact with the view.

The view, usually implemented by an Activity (it may be a Fragment, a View... depending on how the app is structured), will contain a reference to the presenter. The presenter will be ideally provided by a dependency injector such as Dagger, but in case you don't use something like this, it will be responsible for creating the presenter object. The only thing that the view will do is calling a method from the presenter every time there is an interface action (a button click for example).

In an application with a good layered architecture, this model would only be the gateway to the domain layer or business logic. If we were using the Uncle Bob clean architecture, the model would probably be an interactor that implements a use case. For now, it is enough to see it as the provider of the data we want to display in the view.

VIPER is a clean architecture mainly used in iOS app development but now we can implement the same in Android environment. It helps to keep the code clean and organized, avoiding the Massive-View-Controller situation. VIPER stands for View Interactor Presenter Entity Router, which is a class that has a well-defined responsibility, following the Single Responsibility Principle [1].

MVVM makes a lot of sense if you use it alongside data binding. But as projects grow, the presenter can become a huge class with a lot of methods, making it hard to maintain and understand. This happens so because too many responsibilities are to be taken care of by presenters like UI Events, UI logic, business logic, networking and database queries. This type of working is a direct violation of Principle of Single Responsibility, something that VIPER can fix. To overcome this issue in big Android apps, MVP+ and VIPE were used in Android apps basically moving some of the responsibilities from the Presenter to the Interactor.

The presenter handles UI events and prepares for data that comes from the Interaction to be displayed on View. The business logic and fetching of data from DBs or APIs are then done by the Interactor. Interfaces for linking the modules are used. In that way, they can't access methods other than the ones declared on the interface. This allocates a single responsibility of each module by clearly defining the structure. The developer can work with a free mind and will not commit mistakes like putting the business logic in a wrong place.

In fact, the modules are created and linked together on startup. When the Activity is created, it initializes the Presenter, passing itself as the View on the constructor. Then Interactor is initialized by a presenter. UIViewController or Storyboard handles this in an iOS project and later they club all the modules together. But on Android we don't create the Activities ourselves: we have to use Intents, and we don't have access to the newly created Activity from the previous one. This helps to prevent memory leaks, but it can be a problem if you just want to pass data to the new module. The Presenter can't be put on the Intent's extras because it would need to be Parcelable or Serializable.

VIPE had almost resolved all the MVP's problems, splitting the responsibilities of the Presenter with the Interactor. However, the View isn't as passive as the iOS VIPER's View because an additional task of regular view and routing to other modules has to be performed on Android.

Here are the differences between VIPE and VIPER. Now we move the view routing logic to the Router. It only needs an instance of the Activity so we call it startActivity method. It is still not as powerful as in iOS apps but still the single responsibility feature can be met.

After working on MVP and then doing a project using VIPER, I can surely say that the architecture does work on Android and it's worth it. The classes become smaller and more maintainable. It also guides the development process, because the architecture makes it clear where the code should be written. I am planning to use VIPER on my new projects, so that I could have better maintainability and clearer code. Of course, this is an evolving adaptation, so nothing here is carved in stone.

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UDC 005

A/B TESTING METHODS

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A / B testing is a powerful marketing tool for increasing the efficiency of the Internet resource. With the help of A / B tests the conversion of page guidance can be increased, optimal ad networks can be increased, and search quality can be improved.

In web analytics, A/B testing is a controlled experiment with two options, A and B. It is a form of statistical hypothesis testing or "two-sample hypothesis testing" as termed in the field of statistics. In online settings, such as web design, the goal of A/B testing is to identify changes to web pages that increase or maximize an outcome of interest. Formally the current web page is associated with the null hypothesis. A/B testing is a way to compare two versions of a single variable typically by testing a subject's response to the variable A against the variable B and determining which of the two variables is more effective [1].

A/B testing is used to consider how small differences in a marketing campaign might influence customer behaviour. This might be the title of a newsletter or an email, the text for a banner advert, the text on a call-to-action button or the layout of a web page. The idea is to run two variations of the campaign with a controlled group of customers to see which version is the most successful. You can repeat the tests numerous times to fine-tune your content and improve the effectiveness of your marketing communication.

When setting up a test you first need to think about all the metrics of your business and how you define the success of your marketing campaigns. This might be the number of sales, click-throughs, sign-ups, downloads etc. You then set up your marketing campaign with two variables (version A and version B). Don't be tempted to vary more than one thing at a time or you will never know which one has made the difference. To measure which is better you trial them simultaneously, in identical circumstances, and select the more successful version for use.

If you are testing a web site page use the existing version as the control point and set up a second for the test. Then split your traffic equally between the two. If you don't have the technical knowledge to do this yourself there are a number of free tools on the market that will help you, for example Google Analytics Content Experiments. There are also plenty of organisations specialising in conversion rate optimisation (CRO) that will run your A/B testing for you and make recommendations for your marketing.

If you are sending out an email or a newsletter you will need to put some effort in advance to prepare your test groups. The two groups need to be identical – or as similar as possible. Firstly, you will need an equal number of contacts and, ideally, you will want to have equal numbers of men and women. If you have the data available, consider age ranges, geographic locations and any other factors that might contribute. Choose a small percentage of your database to run the test, maybe 10%, and make sure you send them letters simultaneously so you minimise any variance [2].

You will also need to determine up front how long you are going to run the test for and how many responses you need to count the results. Use past data as a guide but be careful not to cut it off too soon or to run it for too long as this may mean other factors have affected the result. If you are testing low volumes you will need to determine for which period you can realistically wait and whether the test result will be reliable.

A/B tests most commonly apply the same variant (e.g., user interface element) with the equal probability to all users. However, in some circumstances, responses to variants may be heterogeneous. That is, while the variant A might have a higher response rate overall, the variant B may have an even higher response rate within a specific segment of the customer base [3].

Many companies use the "designed experiment" approach to making marketing decisions with the expectation that relevant sample results can improve positive conversion results. It is an increasingly common practice as the tools and expertise grows in this area. There are many A/B testing case studies which show that the practice of testing is increasingly becoming more popular with small and medium-sized businesses as well [4].

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UDC 004[005]

DATABASES ARCHITECTURE OPTIMIZATION FOR IMPROVING RELIABILITY AND SPEED OF WORK

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This article discusses the technologies and techniques for implementing the fault tolerance of the server part of the application and increasing the response speed of the database.

The main problem when working with a large amount of data is often a poorly organized part of the application that is responsible for data storage. Modern technologies often require increased attention to the back-end part of the application. And the development of the back-end begins with a database. Databases, their device and architecture, play a key role in the appropriate usage of the application and the integrity of user data.

There are two fundamental approaches to the organization of database interaction architecture in the application: shading, replication.

Let's consider the principle of replication. Replication allows you to create a complete database duplicate. So, instead of one server, there will be several servers in the product being developed. Most often use the master-slave scheme:

1. Master is the main database server, where all data is being received. All changes to the data (addition, update, deletion) must occur on this server.

2. Slave is an auxiliary database server that copies all data from the master. From this server should read the data. There can be several servers of this type.

Replication allows you to use two or more identical servers instead of one. Data read operations (SELECT) are often larger than data modification operations (INSERT / UPDATE). Therefore, replication allows you to unload the main server by transferring read operations to the Slave.

To organize replication technology, two database connections must be declared in the product code of the product. One for the master and one for the Slave. An example implementation is provided in Listing 1.

Listing 1

```
<?  
$master = mysql_connect('10.10.0.1', 'root');  
$slave = mysql_connect('10.10.0.2', 'root');  
$q = mysql_query('INSERT INTO users ...', $master);  
$q = mysql_query('SELECT * FROM users WHERE...', $slave);
```

Replication is usually supported by the DBMS itself (for example, MariaDb) and is configurable regardless of the application.

It should be noted that replication itself is not a very convenient scaling mechanism. The reason for this is the data dissynchronization and delays in copying from Master to Slave. But this is an excellent tool for providing fault tolerance. You can always switch to a slave if the master breaks and vice versa. Most often, replication is used in conjunction with shading, for reasons of reliability.

The second approach to organization of the structure is shading. The essence of the shading is in dividing the database into separate parts so that each of them can be carried to a separate server. There are several types of shading - vertical and horizontal.

Horizontal shading is the separation of one table into different servers. This should be used for tables that store impressive amounts of information and do not fit on a single server. The division of the table into pieces is done according to this principle:

1. Multiple servers create the same table (only the structure, without data).
2. The application selects the condition by which the desired connection will be determined (for example, even for one server, and odd ones for another).
3. Before each access to the table, the desired connection is selected.

Suppose that there is an application that works with a highly loaded table that stores user's photos. There are also two servers (usually called shards) for this table. A possible usage scenario is for odd users to store and retrieve information using the first server, and even the second. Thus, on each of the servers there will be only a part of all data about the photos. An example is shown in Listing 2.

Listing 2.

```

<?
$image_connections = [
    '1' => '10.10.0.1',
    '2' => '10.10.0.2',
];

$user_id = $_SESSION['user_id'];
$connection_num = $user_id % 2 == 0 ? 1 : 2;
$connection =
mysql_connect($image_connections[$connection_num], 'root', '');
$q = mysql_query("SELECT * FROM images WHERE user_id = ' . intval($user_id), $connection);

```

The result of the operation $\$user_id \% 2$ is the remainder of the division by 2. That is, for even numbers - 0, and for odd ones - 1.

Horizontal shading is a very powerful tool for scaling data.

Vertical shading is the allocation of a table or a group of tables to a separate server.

In order to apply such a kind of shading, as vertical, it is necessary to use the appropriate connection to work with each table. An example is shown in Listing 3.

Listing 3.

```

<?
$users_connection = mysql_connect('10.10.0.1', 'root', '');
$image_connection = mysql_connect('10.10.0.2', 'root', '');

$q = mysql_query("SELECT * FROM users WHERE ...", $users_connection);
$q = mysql_query("SELECT * FROM images WHERE...", $image_connection);

$q = mysql_query("SELECT * FROM albums WHERE...", $image_connection);

```

Unlike replication, we use different connections for any operations, but with certain tables.

Do not apply the technique of shading to all tables. The right approach is a step-by-step process of splitting up growing tables. You should think about horizontal shading, when the number of records in one table is a significant factor in the performance of the application. Shading and replication are often used together. An example of such an implementation is presented in Listing 4 below.

Listing 4.

```

<?
$image_connections = [
    '1' => [
        'master' => '10.10.0.10',
        'slave' => '10.10.0.11',
    ],
    '2' => [
        'master' => '10.10.0.20',
        'slave' => '10.10.0.21',
    ],
];

$user_id = $_SESSION['user_id'];

$connection_num = $user_id % 2 == 0 ? 1 : 2;
$connection = mysql_connect($image_connections[$connection_num]['slave'], 'root', '');
$q = mysql_query("SELECT * FROM image WHERE user_id = ' . intval($user_id), $connection);

$image_id = 7;

```



```
$connection_num = $user_id % 2 == 0 ? 1 : 2;  
$connection = mysql_connect($image_connections[$connection_num]['master'], 'root', '');  
$q = mysql_query("UPDATE images SET views = views + 1 WHERE image_id = ' . intval($image_id), $con-  
nection);  
'2' => '10.10.0.2',
```

This scheme is often used not only for scaling, but also for providing fault tolerance. So, if one of the shard servers fails, there will always be a spare one.

In this paper, we can highlight the fact that we have considered some possibilities for the competent re-organization of databases in order to improve the optimization and increase the fault tolerance.

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DEVELOPMENT OF THE INTERNET SHOP MANAGEMENT SYSTEM,
INTERACTION OF THE SYSTEM WITH THE USER

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The article presents a practical way to create a simple and intuitive control system for an online store. The aim of the work is to write an application to simplify the interaction of the user with the database when working with the filling of the online store, to simplify the use of the online store itself, as well as to create a simple and understandable management interface and to develop protection against an unauthorized access from the outside. This task was solved using the PHP scripts language.

Introduction. Currently, people are trying to digitize as much information as possible, which will provide access to it from any digital device anywhere in the world, with only access to network resources.

This allows you to make the most common and usual actions more quickly. For example, to make purchases. But few people have thought that behind the system dealing with sales there is a complex logic of order processing and demonstration of goods. The management system is engaged for orders management and filling of the store. This means that this system operates with large amounts of data, including payment data, customers personal data, as well as data of the store itself and data about the goods. This implies that this system must meet some of the security requirements and provide access to a narrow circle of people.

In view of the growing demands of the population, the requirements to the interfaces of the products being developed are also increasing. As in any web application, the method allows you to get the required information in an acceptable way.

Choice of technologies. This part of the application is an integral part of the online store, hence it is also a web application. That's why the development was carried out in the PHP language. This language implemented work with the access to the information in database. This language allows to establish a quick connection to the database.

Such languages as Javascript and CSS were used in addition to the PHP language to improve the appearance of the interface: CSS is a formal language for describing the appearance of a document written with the use of a markup language. It serves mainly for creating cascading style sheets. Javascript is a programming language that gives interactivity to pages. It serves for creating applications and application parts.

Interface design. For convenience of use, there was used a method of grouping tasks into certain theme blocks, when developing the interface. This type of grouping allows to simplify and speed up blocks search, and also to organize the data on the screen, for better readability and understanding.

Comparison of access through the system and through the database. To add information to the online-store directly through the database, the user sometimes needs to add links and descriptions to a large number of tables (Fig. 1)

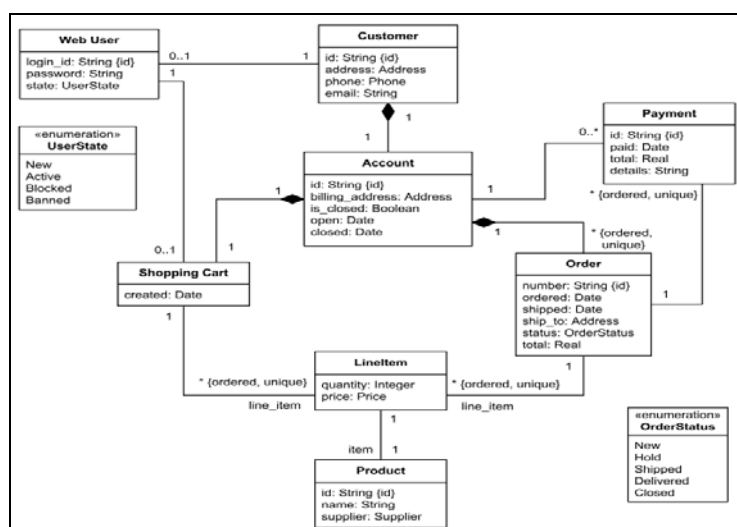


Fig. 1. Number of tables in the online-store database

Figure 1 shows that you need to use a large number of tables to add information. Also, when placing an order, you will have to search the necessary information in all the tables, when it requires an update. This significantly complicates the work with the filling of the online-store, and the very process of working with it. It is for this purpose that the content management system of the online-store is being developed (fig. 2).

The image shows a web-based 'Sales Form' interface. At the top left, it says 'Sales Form' with a gear icon. Below this, there are several input fields:

- Date:** A text box containing '13-APR-2011' with a calendar icon and a placeholder '[dd-MMM-yyyy]'.
- Name *:** A text box containing 'Maxwell Schwartz'.
- Region:** A dropdown menu showing 'West'.
- Product Category:** Three radio buttons: 'Furniture' (unselected), 'Stationary' (selected), and 'Grocery' (unselected).
- Product *:** A text box containing 'Standard Label'.
- Sales:** A text box containing '2000' followed by 'USD'.
- Cost:** A text box containing '1600' followed by 'USD'.

 At the bottom of the form, there are two buttons: 'Add to Zoho Reports Database' and 'Update'.

Fig. 2. Adding information to the database via the interface

In Figure 2 you can see that the same process of adding data becomes much easier and faster by using the control system. Simplicity is achieved by the fact that all links are set in advance through the program code, and the user does not need to keep track of all the tables for the availability of data, the system will do everything itself. The user only has to enter the data necessary to add, or select the data that needs to be changed. Access directly through the database is very complicated, and even if the user has all the necessary data about the structure of the database, this process still remains quite long. No one is immune from human errors and usual inattention, which can lead to loss of data, and as a result - to a possible loss of profit from the online store.

Data protection against an unauthorized access:

Since this system operates with all the data that is in the database: user data, accounts, card numbers, passwords – a lot of problems can emerge, if you lose this data. Proceeding from all this, it can be concluded that the data is subject to protection. The closure of direct access to the system, so that no one can access the data, can be the simplest method of protection. But then arises the following situation when the right of access should be given to a certain group of people who can work in the system. The solution to this problem is to create a user group that has been granted an access to work with this system. This allows you to restrict access to third parties, and to provide access to the system to a selected circle of people. But sometimes this may not be enough, and outsiders can take possession of the rights to access the system. This will require a second stage of protection, which is to encrypt passwords and card numbers, so that no one can see the "open" data on passwords and card numbers. The system itself can be a protection stage as well, because it's not the user himself who interacts with the database, but the system itself. Data protection with the help of the system is explained by the fact that the user can enter incorrect data, while interacting with the database, which, as a minimum, will result in the presence of incorrect data, and as a maximum, in cleaning, or even deleting the database itself. The system must check the input data for correctness and request a data re-entry, or perform editing on its own.

Interaction with the user:

The system must interact with the user to facilitate information retrieval and to increase productivity. If the system allows the execution of orders, the user must see that the order has arrived. The system must notify about this. In this case, the user does not have to look through the data himself in search of the order, the system must do it itself, automatically. This is an example of a complex interaction with the system, but there are

simpler examples as well. The system has blocks describing the data from the database tables, and the user intuitively understands, which part of the system he is working with at the moment. Interface availability plays an essential part in interaction with the user, as it provides a convenient and understandable process of work in the system itself.

Conclusion. The development of a management system is an integral part of creating an online store, because it allows not only to simplify and speed up the work in the system itself, but also to protect the data of the user, customers, and the data of the store itself. The development of the interface greatly simplifies the understanding of the system elements, which also facilitates further work.

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UDC 004.912

PLAGIARISM DETECTION**DZMITRY DZIOKIN, YURY PASTUHOV**

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The article is dedicated to plagiarism problem in terms of modern world. Classification of computer-assisted plagiarism detection methods is given.

Introduction. The problem of plagiarism became more serious with the advent of the Internet. Any piece of information that appeared on the Internet just once becomes a public domain. Therefore, it becomes very hard (sometimes even impossible) to observe copyright. It is hard to define original author as well. Impetuous development of the Internet promotes penetration of plagiarism in different spheres of human activity.

Plagiarism is a crime. It often misleads a reader, causes some problems for the author. Mostly, plagiarism is found in universities, where documents are usually a kind of reports or essays. Though, plagiarism can be also found in other fields such as novels, some scientific papers and even source codes.

Plagiarism detection. The process of searching and locating instances of plagiarism within a particular work, paper or document is called plagiarism detection.

Detection of plagiarism can be either manual or software-assisted. Manual detection requires substantial effort and excellent memory, and it is impractical in cases where too many documents must be compared, or original documents are not available for comparison. Software-assisted detection allows vast collections of documents to be compared thus making successful detection much more likely. [1]

Taking into account the power of present computers, the usage of computer-assisted plagiarism detection becomes very effective. This detection mechanism is an information retrieval task, which is widely supported by specialized information retrieval systems (like Google, Yandex and etc.).

In common words, plagiarism detection mechanism is simple: a suspicious document is compared with a collection of authentic documents. Based on a chosen document model and predefined similarity criteria, the detection task is to retrieve all documents that contain information that is similar to the text in the suspicious document. [2] The figure 1 represents classification of computer-assisted plagiarism detection methods from technical point of view.

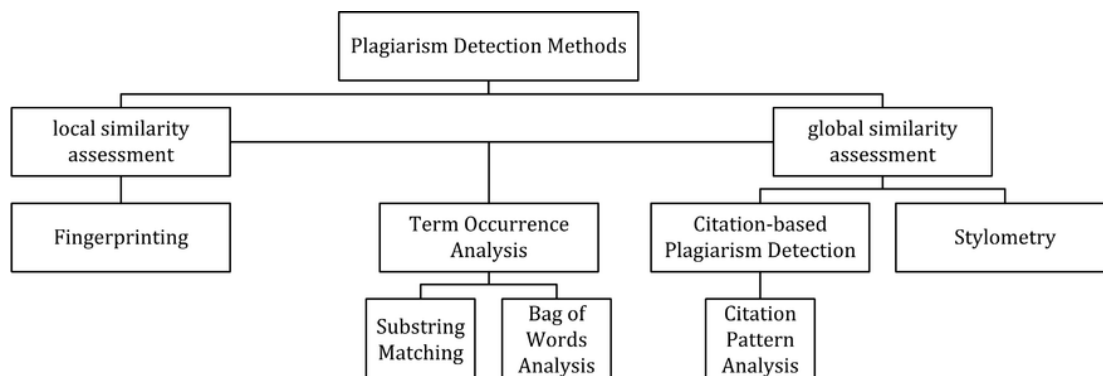


Fig. 1. Classification of computer-assisted plagiarism detection methods

Let's consider these methods:

- **Fingerprinting**. This is the most widely applied method of plagiarism detection nowadays. This method forms representative digests of documents by selecting a set of multiple substrings (n-grams) from them. The sets represent the fingerprints and their elements are called minutiae [3]. A suspicious document is checked for plagiarism by computing its fingerprint and querying minutiae with a precomputed index of fingerprints for all documents of a reference collection. Minutiae matching indicates shared text segments and suggests potential plagiarism if a chosen similarity threshold is exceeded. [4]

- **String matching**. Rather spread method which is used in computer science. Checking a suspicious document in this setting requires the computation and storage of efficiently comparable representations for all doc-

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uments in the reference collection. [1] These representations are further compared pairwise. Suffix trees or suffix vectors models are used for this task. However, it is worth noting that this approach is expensive in terms of computing: the algorithm takes $2h$ comparisons in general, where h is the length of a string where the search is going.

- Bag of words. It is the adoption of vector space retrieval where documents are represented as one or multiple vectors, e.g. for different document parts, which are used for pair wise similarity computations. Similarity computation may then rely on the traditional cosine similarity measure, or on more sophisticated similarity measures. [5][6][7]

- Citation analysis. This approach is suitable for scientific texts, or other academic documents that contain citations. Similar order and proximity of citations in the examined documents are the main criteria used to compute citation pattern similarities. Citation patterns represent subsequences non-exclusively containing citations shared by the documents compared. [8]

- Stylometry uses statistical methods for quantifying an author's unique writing style and is used for authorship attribution.

All detection approaches rely on textual similarity (except for citation pattern analysis). Generally, these mechanisms are analysis stage of the Culwin and Lancaster's four stages of detecting plagiarism. They are collection, analysis, confirmation and investigation. Detection mechanisms depend on some authentic collection of documents, it is very important to have up-to-date and large collection of documents and constantly refresh it.

Conclusion. In the age of information technologies plagiarism has become more actual and turned into a serious problem. The problem of plagiarism is described in this article. Basic approaches of plagiarism detection are reviewed. The most useful and popular methods of computer-assisted plagiarism detection such as fingerprints, string matching, bag of words, citation analysis and stylometry are described.

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**EVALUATION OF THE POSSIBILITIES
OF THE PYTHON PROGRAMMING LANGUAGE FOR SOLVING GEODETIC TASKS**

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There are tasks in geodesy and related sciences that require a significant amounts of computational work involving the mathematical apparatus of Ordinary Least Squares. In this paper, we consider a problem of solving the system of normal equations that are composed from the results of re-leveling of the geodynamic polygon. The system of normal equations is solved by the formula (1) [1].

$$X = (A^T P A)^{-1} A^T P L \quad (1)$$

where X – vector of unknown parameters; A – matrix of coefficients of the error equations; P – matrix of the weights of measures, where the i -th diagonal element is calculated by the formula $p_i = \frac{C}{S_i^2}$, where C – weight coefficient, S_i – length of the i -th measured line; L – vector of free terms of the error equations.

Matrices used as data source may have considerable dimensions. For each leveling point as many error equations are composed as many cycles of leveling was made.

The algorithm used for solving the system of normal equations includes matrix operations. Matrix multiplication is an operation with computational complexity about $O(n^3)$. The description of methods for optimization of this algorithm is beyond the scope of this paper.

The most popular software products for operating with matrices among explorers in the field of geodesy are Microsoft Office Excel and Matlab.

According to the author, operating with matrices in Microsoft Excel requires increased concentration of attention and takes much time. Displaying big matrices is difficult.

Matlab provides a large number of functions for matrix operations, but this environment isn't suitable for developing big programs, functions of integration with other software products are limited. Matlab programming language is weakly typed, the speed of execution of cyclic algorithm is low, the support for sparse matrices is incomplete, object-oriented programming in Matlab is difficult. The installation package has a size of about 10 Gb [3].

Python programming language first appeared in 1991, nowadays it is included in the worlds' top-five programming languages (according to PYPL and TIOBE indices, that are based on queries in search engines, independent researches of such popular IT-portals as Stack Overflow and GitHub) [2, 5, 8, 9].

Python is a multiparadigm language (it supports different styles of programming: structural, object-oriented, functional, reflective, imperative, aspect-oriented etc.). In its reference implementation – CPython – the language is interpreted or compiled into byte code. Other implementations have the possibility of compilation into MSIL (IronPython), Java byte code (Jython). Unlike the previously mentioned Matlab and Microsoft Excel, Python interpreter is distributed under the terms of permissive license. In fact, it doesn't limit the freedom of users' and developers' action. The installation package of Python interpreter has the size of about 35 Mb. Additional packages and libraries are installed by standard utilities if the Internet connection is available.

The following Python libraries seem the most useful for solving geodetic and geodynamic tasks:

- NumPy – tools for big data, including matrices and arrays processing.
- SciPy – tools for scientific and engineer calculations, e. g. maxima and minima of the function, integral calculations, solution of ordinary differential equations, polynomial approximation etc.
- Matplotlib – library for graphical representation of numeric data, charts plotting.
- Networkx – library for networks and graphs processing. It seems to be promising to use in geodesy and related sciences, because any network can be represented as a graph for solution of different tasks, as, for example in research [4]. There is the function of importing networks from formats supported by all modern geoinformational systems (for example ESRI shapefile), so the library is also useful for solving tasks of routing and allocation.

In our research the Numpy library was chosen for geodetic and geodynamic solutions. It isn't included into the standard library, but can be installed without any trouble by PIP utility. Algorithms included into the library were implemented in C and optimized for big data operations. There is the possibility to integrate Python

programs with C/C++ programs. According to a number of studies programs with Numpy run faster than those on pure Python and even faster than on C [6].

In pure Python matrices are represented as a two-dimensional list. This format is convenient for calculations, because there is the possibility to take arbitrary elements, add, remove, edit them. In Numpy library matrices are represented as an instance of `numpy.matrixlib.defmatrix.matrix` class, that can be initialized by `numpy.matrix()` method with a list as an argument. Inverse transformation is performed by `.tolist()` method. Matrix multiplication and addition are performed by binary operators `*` and `+` respectively. Transposition is performed by `.transpose()` method, inversion of the matrix – by `.I` property. Here is a fragment of a source code of software developed in our research, in that solution of normal equations with Numpy is performed [7].

```
# вычисление неизвестных методом линейной аппроксимации
self.N_linear = self.A_linear.transpose()*self.P*self.A_linear
self.Q_linear = self.N_linear.I
self.free_members_vector_linear = self.A_linear.transpose()*self.P*self.L_np
self.vector_of_solutions_linear = self.Q_linear*self.free_members_vector_linear
solutions_list_linear = self.vector_of_solutions_linear.tolist()
```

Matplotlib library allows to plot such images as line plots, histograms, three-dimensional plots, stream-plots and others. Different coordinate systems are supported. Matplotlib allows to create interactive images, that refresh operatively in time, embedding plots into windows of other software developed in Python. Navigation toolbar allows to scale and scroll the plots.

The possibility of plotting contour maps, e.g. spatiotemporal charts of movement of the leveling points is of interest for geodynamics. The result is below (fig. 1). This chart was made on the basis of re-leveling on Polotsk geodynamic polygon from 2004 till 2015. The function of plotting such charts is planned to be embedded into the developed software.

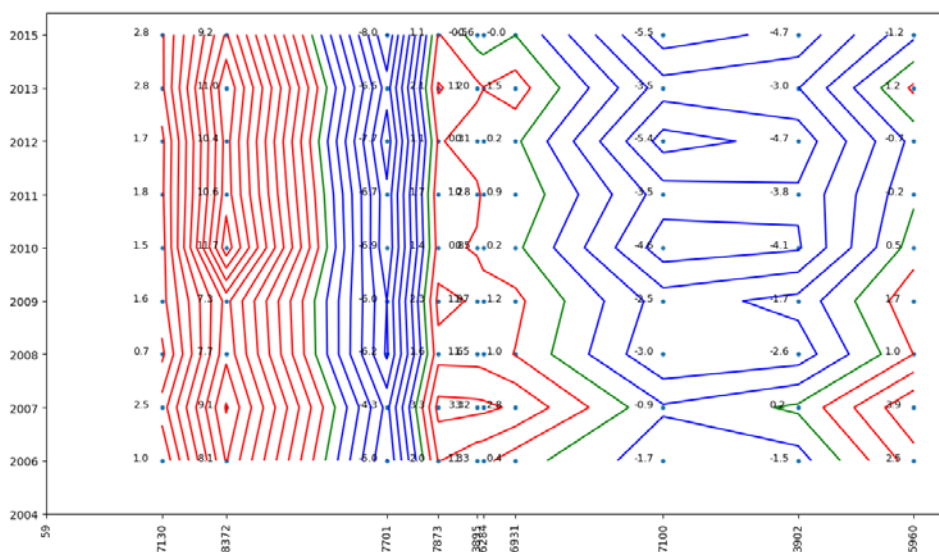


Fig. 1. Spatiotemporal chart of movement of the leveling points on Polotsk geodynamic profile

We made an attempt to represent the leveling network graphically by Networkx library. The problem is complicated by the fact that the horizontal coordinates of the leveling points are unknown. Networkx library offers several methods of graph visualization. In our case the closest to the real view of the network was obtained by the spectral method. The function of network visualization is planned to be embedded into the developed software to give the user an opportunity to get an idea about the network topology.

Developed software product is based on PyQt5 framework, which allows the developer to create a simple and user-friendly interface (fig. 2).

We shouldn't forget about the entry threshold. The lower it is, the less difficulties in studying the language a beginner has. Python has one of the lowest entry thresholds. This fact combined with the variety of

functions of standard and additional libraries makes Python the most perspective language for data analysis, scientific and engineering calculations, development of scientific and applied software. Furthermore, as practice shows, professional geodesists who studied programming independently develop higher quality software than professional programmers. As an example we can name the programs of professor V. I. Mitskevitch. His software was developed in FORTRAN but didn't lose its relevance even nowadays.

Thus, having considered the possibilities and features of Python programming language, we can highlight the following advantages of this programming language in solving problems of geodesy and related sciences:

- Interpreter, additional packages and libraries are distributed under terms of free license, installation and extension of the interpreter is performed by simple actions;
- The language has a good functionality and performance to solve most problems that arise in geodesy and related sciences;
- The language is easy to learn, may be learned in a short time by a non-professional programmer without losing its relevance and popularity in the world.

#	#	расстояние	2004	2006	2007	2008	2009
59	7130	1,8	5,4037	5,40475	5,40617	5,40443	5,40532
7130	8372	1	1,2478	1,25484	1,25444	1,25482	1,25352
8372	7701	2,5	7,6095	7,5964	7,59606	7,59558	7,59616
7701	7873	0,8	1,7062	1,71326	1,71388	1,71402	1,7145
7873	3895	0,6	-1,7911	-1,79182	-1,79119	-1,79114	-1,79154

Fig. 2. Main window of the developed software product

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CSS FRAMEWORKS TOOLS

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A CSS framework is a pre-prepared software framework that is meant to allow for easier, more standards-compliant web design using the Cascading Style Sheets language.

The CSS Front-End Frameworks are very popular with web developers. These are particular collection of HTML, CSS and JavaScript components that makes website development easier and faster. With framework you can easily design a fully responsive and modern layout of any website. Most of frameworks are using grid system for layout in spite of some differences. The main goals of all frameworks are to provide basic and common layout structure so that web developers do not have to design a website layout each time from scratch.

As there are too many Frontend frameworks available and each framework has its own strengths and weaknesses. So it is not necessary that the most popular framework work for your project, the less popular can be more suitable. So it does totally depend on your project to choose the right one. For example, if your project is simple, then there is no need to use a complex framework.

CSS frameworks are fast becoming extremely popular starting points for a lot of developers. If you have never used one, a CSS framework is a set of default CSS and HTML files that provide a great code base to build upon. Commonly included in CSS frameworks are CSS resets, buttons, and common layouts that are aimed towards saving developers time by not having to reinvent the wheel with every project.

When it comes to adding visual style and layout of a website, CSS frameworks can help add a little fineness to it. The most popular CSS Frameworks that will be helping development community:

Pure. A minimal CSS framework, Pure is known for its simplicity and style. Being smaller in size, it offers a better choice for all development needs where responsiveness is of utmost choice.

Materialize. Materialize is based on Google's Material Design featuring specific design pattern. This framework lets you do a lot of visual styling to impress users. It looks professional and saves a lot of developers' time. It is a perfect style if users want uniqueness and exclusiveness in their project.

Bootstrap. Certainly not a lightweight framework, but absolutely most popular framework with developers. It is one of the oldest frameworks which is going to enjoy its fame for longer. Due to an easy to use nature a number of developers are using it for their projects. Bootstrap has become an obvious choice for adding responsiveness to any website.

Kube. Modern day developers have developed a liking towards Kube for the fantastic characteristics that it exhibits – support for all modern browsers, light in weight, appealing templates and styles, etc. It is also based on Flexbox which offers many interesting features and added functionalities for layout.

Bulma. Free, open-source, Flexbox-based CSS framework – Bulma – provides many reasons to web designers and developers to choose it. It is fully responsive and modular, and offers a wonderful desktop and mobile-viewing experience.

The positive sides: A. They can help you learn CSS. You might just literally not know how to pull off a solid multi-column layout. A framework may be a good place to get your feet wet understanding how CSS works;

B. They provide code that you just don't need to write from scratch every time, like resets. All these frameworks start with brilliant resets that cover all the bases and will have you covered for years to come;

C. They relieve cross-browser concerns. We have all felt the burn of finding out our sites are buried in some browser. Frameworks are built to bring their functionality to all browsers;

D. They encourage grid based design. They just help you achieve better readability, scanability, balance visual weight, flexibility, expandability, and just overall page cohesiveness;

E. They come with documentation. If you need help getting started, framework generally comes with some support files. This can be particularly nice if you are designing a site you will be handing off to a client. You can just let them know what framework you used and refer them to that documentation for support requests.

The negative sides: A. Since a framework has a standard set of grids and selectors and other codes, it restricts your design. So for every new kind of design idea you would want to implement, you would have to learn a new framework

B. It changes the way you write your HTML. Developer wrapping websites in a div called "page-wrap". It's called "container" in logics. You write markup based around some frameworks predetermined class and id names

C. They can be bloated. There may be CSS styles set up in a framework to accommodate tons of different layouts that you'll never use. If you are concerned about every byte of a web page, you are going to end up doing a lot of stripping away of used code. The extra code comes up from the list of predefined codes that come with the framework.

These frameworks are required for the completion of website development. Additionally, these different preprocessors cater for the divergent requirements of individual projects. Depending on the requisites, it is advisable to select from the varied available frameworks.

It is also essential to bear in mind that some frameworks are ideal for new, fairly experienced, or proficient developers. Therefore, the expertise level is also another factor to consider during the selection process of the framework-kinds.

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SEMANTIC FRAMES: INFERENCE ENGINE FOR KNOWLEDGE EXTRACTION

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This article describes a process of designing an inference engine for extraction of knowledge from preprocessed sentences in English, which uses semantic frames as a mean for representation of both the production rules and the acquired information.

In order to engineer an *inference engine* (IE) [1] for knowledge extraction two conditions must be met. First – the sentences being passed to the engine must be already lexically, grammatically and syntactically analyzed. Second – the result of this preprocessing must be represented in a unified way. The best approach would be to pass it as a group of interlinked objects of certain types which provide methods for requesting needed information.

We will start off by defining two primitive classes (Fig. 1): *<base-node>* encapsulates a type of a node, *<text-node>* contains a string representing an individual word.

<base-node>	<text-node>
#type: string = nil	#text: string = nil
+get-type-expr(): string	+get-text(): string

Fig. 1. Top-level classes

Now we proceed to define two intermediate classes (Fig. 2). *<node>* is a generic class that describes a node's syntactic role and holds a reference to its parent node. *<compound-node>* is intended to represent constructs, consisting of several nested simple or compound nodes.

<node>	<compound-node>
#role: string = nil	#children: list = nil
#parent: <base-node> = nil	+nth-child(index:integer): object
+get-role(): string	+repr(margin-0:string): string
+get-parent(): <base-node>	+get-text(): string

Fig. 2. Middle-level classes

Note that *<compound-node>* is not directly derived from *<text-node>*, but still responds to *get-text*. That is, it returns a string obtained by merging results of calling *get-text* on its children.

Having established a set of basic types, we can then design the actual classes necessary to represent the result of sentence analysis (Fig. 3–4).

<lemma>	<word>
#properties: alist	#properties: alist
+get-list-of-lexical-categories(): list	#lemma: <lemma>
+has-lexical-category?(lexical-category:string): boolean	+get-lemma(): <lemma>
+get-list-of-grammatical-categories(lexical-category:string): list	+has-attr?(attr-name): boolean
+has-grammatical-category?(lexical-category:string, grammatical-category:string): boolean	+get-attr(): object
+get-grammatical-category(lexical-category:string, grammatical-category:string): string	+repr(margin-0:string): string
+repr(margin-0:string): string	+get-shallow-tree-expr(): string
	+get-deep-tree-expr(): string

Fig. 3. Classes for representation of simple nodes

<phrase>	<sentence>
+repr(margin-0:string): string	+repr(margin-0:string): string
+get-shallow-tree-expr(): string	+get-shallow-tree-expr(): string
+get-deep-tree-expr(): string	+get-deep-tree-expr(): string

Fig. 4. Classes for representation of complex nodes

Relations between all previously mentioned classes are shown in Fig. 5.

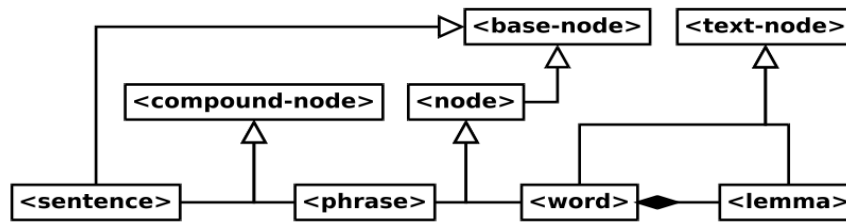


Fig. 5. Generic class diagram

Since we will implement our IE in *Common Lisp* [2], there is no need to introduce any additional abstract classes (interfaces) as a containers for methods *repr*, *get-shallow-tree-expr* and *get-deep-tree-expr*, because we have a powerful mechanism of *generic functions* [3] at our disposal to deal with this.

Every invocation of IE must supply two required parameters: one is an instance of *<sentence>* class and another is a pool of *semantic frames* (SF) [4][5] which provides the essential knowledge – *production rules* [6]. These rules are generated on-the-fly from a *S-expression* [7] based representation. The general layout of both extraction and subsumption rules, defined using *EBNF* [8], is the following:

```

rule list      = pool spec;
pool spec     = '(pool', pool name, shared data, {frame spec}, ');
pool name     = node name;
shared data   = '(', {binding}, ');
binding       = '(', data id, data, [data type], ');
data id       = SYMBOL | KEYWORD;
frame spec    = '(frame', [frame reference], frame name, frame classifiers, {slot spec}, ');
frame reference = node reference;
frame name    = node name;
frame classifiers = node classifiers;
slot spec     = regular slot spec | shared slot ref;
regular slot spec = '(slot', [slot reference], slot name, slot classifiers, slot data spec, ');
shared slot ref = '(slot-ref', slot reference, ');
slot reference = node reference;
slot name     = node name;
slot classifiers = node classifiers;
slot data spec = data spec | data ref spec | reference spec | frame spec;
data spec     = 'data', data, [data type];
data          = VALUE;
data type     = KEYWORD;
data ref spec = 'from', data id;
reference spec = 'node', reference;
reference      = KEYWORD;
node reference = KEYWORD;
node name     = STRING | NIL;
node classifiers = '(', {classifier}, ');
classifier     = SYMBOL.
  
```

An extraction rule is a *RELATION*-frame consisting of one or many *CONDITION*- and *ACTIVITY*-slots, as well as an arbitrary number of sub-relation slots (without classifiers). The format of the corresponding symbolic expression obeys the following syntax:

```

rule frame      = frame head, '(relation)', {relation attribute}, {node condition slot}, {node activity slot}, {subnode relation slot}, tail;
frame head     = '(frame', name;
  
```

ITC, Electronics, Programming

<i>slot head</i>	=	'(slot', name;
<i>name</i>	=	<u>STRING</u> <u>NIL</u> ;
<i>tail</i>	=	');
<i>relation attribute</i>	=	slot head, '(attribute) data', <u>VALUE</u> , tail;
<i>node condition slot</i>	=	slot head, '(in condition', [condition negation], tail, condition slot data node condition frame, tail;
<i>node condition frame</i>	=	frame head, '(condition', [condition negation], condition modifier, tail, {condition slot}, tail;
<i>condition quantifier</i>	=	'necessary' 'possibly';
<i>condition negation</i>	=	'not';
<i>condition modifier</i>	=	'and' 'or' 'xor' 'imp' 'eqv';
<i>condition slot</i>	=	slot head, '(condition', [condition quantifier], [condition negation], tail, condition slot data node condition frame, tail;
<i>node activity slot</i>	=	make instruction slot {name instruction slot} [data instruction slot] {classifiers instruction slot} {clarifiers instruction slot} {export instruction slot} {import instruction slot} compound instruction slot;
<i>export instruction slot</i>	=	'(slot "export" (out activity) data (' , entity selection, {target context level}, ')), tail;
<i>import instruction slot</i>	=	'(slot "import" (out activity) data (' , entity selection, {source context level}, ')), tail;
<i>entity selection</i>	=	':frame' ':slot';
<i>target context level</i>	=	context level;
<i>source context level</i>	=	context level;
<i>context level</i>	=	'top' ':top' '0' <u>POSITIVE INTEGER</u> ;
<i>make instruction slot</i>	=	'(slot "make" (out activity) data ' , make instruction ((' , {make instruction}, ')), tail;
<i>make instruction</i>	=	':frame' ':pslot/frame' ':cslot/frame' ':pframe/slot' ':cframe/slot';
<i>name instruction slot</i>	=	'(slot "name" (out activity) data (' , target context level, entity selection, text source, [text filter], '));
<i>text source</i>	=	':form-text' ':lemma-text';
<i>text filter</i>	=	f-expression;
<i>f-expression</i>	=	<u>STRING</u> ;
<i>data instruction slot</i>	=	'(slot "data" (out activity) data (' , target context level, text source, [text filter], '));
<i>classifiers instruction slot</i>	=	'(slot "classifiers" (out activity) data (' , target context level, entity selection, entity classifiers, '));
<i>entity classifiers</i>	=	{ <u>SYMBOL</u> };
<i>clarifiers instruction slot</i>	=	'(slot "clarifiers" (out activity) data (' , target context level, entity selection, entity clarifiers, '));
<i>entity clarifiers</i>	=	{f-expression};
<i>compound instruction slot</i>	=	'(slot nil (out activity) (frame nil nil ' , {node activity slot}, '))'.

The inference process has a top-down depth-first direction, i.e. it starts with top-level nodes and for each of them: checks the node itself, recursively checks its children and only then selects the next one on the same level. IE iterates over all rules (in order they are defined) and if some relation holds for the current node (i.e. conjunction of evaluated conditions equals TRUE), then IE executes its instructions sequentially. For a compound node IE will also try to apply sub-relations (if they are present) to its children. When any particular relation holds and it has an attribute «once-only» set to TRUE, IE would stop the iteration and would not attempt to apply remaining rules to the current node.

Conditions are a fundamental part of decision-making strategies. They allow to pick important pieces of a sentence and reject other insignificant or redundant information. Every condition name is associated with a corresponding function that retrieves a specific node's attribute. Evaluation of a condition involves invocation of such a function with the current node as an argument and comparing the result with a regular expression, stored in the slot. Table 1 provides short descriptions for all possible conditions.

Table 1. – Conditions

Name	Description
type	Node's type expression
stree	Node's shallow tree expression
dtree	Node's deep tree expression
role	Node's role expression
text	Node's text
has-misc-attrs	List of node's miscellaneous attributes
has-attrs	One or list of node's grammatical categories
attrs	List of node's grammatical categories and their values
lemma-text	Lemma's text (words only)
lemma-has-type	One or list of lemma's lexical categories (words only)
lemma-has-attrs	Lists of lemma's lexical plus grammatical categories (words only)
lemma-type	Lemma's lexical category (words only)
lemma-attrs	List of node's grammatical categories and their values for a given lexical category (words only)
dir-parent-type	Type of a direct parent node
top-parent-type	Type of a top-level parent node
dir-parent-stree	Shallow tree of a direct parent node
top-parent-stree	Shallow tree of a top-level parent node
dir-parent-dtree	Deep tree of a direct parent node
top-parent-dtree	Deep tree of a top-level parent node
dir-parent-role	Role of a direct parent node
top-parent-role	Role of a top-level parent node
dir-parent-text	Text of a direct parent node
top-parent-text	Text of a top-level parent node
sentence-type	Sentence type
sentence-text	Sentence text

For every sentence node being processed IE creates a separate context with two unset references – for a frame and for a slot; and two links – to a parent context and to the node itself. Because all contexts are connected all the way to the top, it is possible to define relations between frames using «*make*» instruction (and cross-references using «*import*»/«*export*» commands). The behavior of this instruction can be controlled by specifying one or several of symbolic constants described in Table 2.

Table 2. – Arguments to «*make*» instruction

Literal	Description
frame	Create a new frame and assign it to the reference in the current context
pslot/frame	Create a new frame and assign it both to the reference in the current context and as data of a slot in the parent context
cslot/frame	Create a new frame and assign it both to the reference and as data of a slot in the current context
pframe/slot	Create a new slot of a frame in the parent context and assign it to the reference in the current context
cframe/slot	Create a new slot of a frame in the current context and assign it to the reference in the current context

After the extraction of knowledge is completed, the pool of newly-created frames is passed further to the subsumption procedure which performs normalization of relations and updates the existing knowledge base.

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SEO AUTOMATION TOOL

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SEO automation means making the search engine optimization process automatic through the use of tools, software and other programs that reduce human labor. The article considers programs for SEO automation. Their positive and negative sides are shown.

Anyone who has been in the search engine optimization (SEO) for more than a few days knows that earning your website a place in search results is difficult.

To date, there is a need to carefully plan and execute your strategies, and there is also a need to be on the lookout for changes in algorithms and market trends.

But the fact that SEO requires in-depth knowledge doesn't mean that it doesn't need to use tools and software to simplify the process, especially when you work with several large websites.

The entire SEO process is far too complicated for all of it to be automated but there definitely can be certain aspects of SEO. And this can free up considerable time for other creative and administrative work.

The key here is to understand what can be automated and what cannot or should not. For example, such tasks as site monitoring and data collection should be automated so that information is collected on the go. A professional then has to make decisions based on the data collected.

However, the SEO processes like content creation and organic link building should not be automated because the result of the work would not only end up with low-quality content, but also with the possibility to get penalized for building spammy links.

It is better to find a combination of tools and software that help get the work done in minimal time.

So if you are thinking of automating your SEO, here are some of the best tools that can help you with specific areas.

SEMrush for advanced keyword research and tracking. Keyword research is the foundation of any good SEO program. After all, the goal is to have the audience to find you through search. While a free tool like Google Keyword Planner is a great place to start, SEMrush is the tool that would save a lot of time and effort when it comes to keyword research.

With SEMrush keyword research tool, you can identify competitor's best keywords, observe position changes in domains, uncover long tail keywords for your own site and for PPC campaigns.

Combining the Keyword Magic tool and Keyword Analyzer allows to carry out keyword research faster than a combination of tools would. There appears an opportunity to easily sort through thousands of keywords and uncover long tail keywords without multiple spreadsheets.

The keyword analyzer sorts selected keywords according to volume, KD, and click potential. Using the Keyword Magic Tool, you can select a combination of phrases and the tool will suggest long tail combinations with the exact phrases people search for.

As for the work with clients, then the SEMrush Report builder comes in handy for creating custom reports. All you need to do is to select widgets relevant to report and customize the settings. The report builder automatically updates the information whenever there is a need to generate a report.

You can also schedule the reports, or use them as templates for future reports.

Cyfe for all-in-one monitoring. One of the pains of SEO is that there is always so much information to track.

Cyfe is an all-in-one business dashboard that allows to keep track of important marketing metrics including SEO and SEM metrics. Cyfe's strength lies in its ability to pull in data from several sources into one dashboard.

Cyfe's pre-built widgets allow for easy monitoring of any metrics one may want to track. With the Moz widget, for example, you can monitor a website's authority in search without a paid Moz account.

By adding a widget to Google Search Console, you would receive updates on a site performance in Google search. You could also monitor a site's performance across different search engines.

Another application of Cyfe is competitor tracking. With Cyfe competitor dashboard and RSS feeds, you can monitor competitor's content, email and social media strategies at a glance.

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Once you have configured all of dashboard widgets, you can set up rule-based SMS alerts, allowing to continue with business as usual. You will get a mobile push notification when anomalies that demand human attention arise.

Screaming Frog SEO spider for site crawls and audits. The bottom line in SEO is knowing what to fix on a site to boost performance in search. That needs an excellent site audit process, especially one that can be put on repeat. For this, Screaming Frog SEO spider is a great choice.

Screaming Frog is a web crawling tool that checks for broken links, audits redirects, analyses page titles, meta data and discovers duplicate content. It can also generate XML sitemaps and integrates with Google Analytics, and can even set it up for regularly scheduled crawls.

Ahrefs for backlink analysis. The best way to jumpstart SEO effort is to get backlinks from reputable websites. Ahrefs is the tool that can help keep an eye on how well efforts are paying off. The tool crawls 6 billion web pages daily and has an index of 3 trillion known URLs, making it the perfect option for backlink analysis.

With Ahrefs, you can automatically set the tool to monitor how well are ranking in search, using the recently rebooted Rank Tracker tool. You can also get alerts for new keywords, new/lost backlinks and brand mentions.

Keeping an eye on the competition is also easy, as you can find content attracting the most backlinks in niche and spy on competitors to know where their links are coming from.

SEO is difficult. To get the best results, you will still need to invest the required time and effort. But you can use excellent tools that make the job easier and faster.

The SEMrush keyword research tool is a great option for intelligent keyword research while Ahrefs helps track down backlinks effortlessly.

Screaming Frog SEO Spider helps stay up to date with site performance through in-depth crawling, and for monitoring all site metrics in one place, you can rely on Cyfe.

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UDC 005

SERVICE VERSIONING IN MICROSERVICE ARCHITECTURE

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Microservice architecture is all about integration and contracts. API versioning is extremely important to control compatibility of different parts of system and provides completed business features. There are different versioning techniques and it is important to select the most suitable for your project.

Microservices is a variant of the service-oriented architecture (SOA) architectural style that structures an application as a collection of loosely coupled services. In a microservices architecture, services should be fine-grained and the protocols should be lightweight. The benefit of decomposing an application into different smaller services is that it improves modularity and makes the application easier to understand, develop and test. It also parallelizes development by enabling small autonomous teams to develop, deploy and scale their respective services independently. It also allows the architecture of an individual service to emerge through continuous refactoring. Microservices-based architectures enable continuous delivery and deployment [1].

The microservice architecture is not a silver bullet. It has several drawbacks. One of the most important – is integration complexity. Many different services work together in continuously changing environment to provide completed business feature. The probability of failure rapidly increases with number of service integration points, so it is extremely important to have a possibility to control compatibility of different parts of the system [2]. One of the most popular technique for that – is service versioning.

Service Versioning is the approach followed by service developers to allow multiple versions of the same service to be operational at the same time. To give an analogy, any re-usable software API library has multiple versions used by different applications. The same analogy applies to services [2].

The most popular versioning scheme today – is Semantic Versioning 2.0.0. It proposes a simple set of rules and requirements that dictate how version numbers are assigned and incremented. These rules are based on but not necessarily limited to pre-existing widespread common practices in use in both closed and open-source software. For this system to work, first need is to declare a public API. This may consist of documentation or be enforced by the code itself. Regardless, it is important that this API be clear and precise. Once public API identified, every service change will trigger specific increments to its version number. Consider a version format of X.Y.Z (Major.Minor.Patch). Bug fixes not affecting the API increment the patch version, backwards compatible API additions/changes increment the minor version, and backwards incompatible API changes increment the major version [3]. Before the service firstly published to production, major version may be zero, and in this case, minor and patch bump-up rules may be ignored.

Semantic versioning is very suitable for libraries, but in case of microservice architecture, classical semantic versioning Major.Minor.Patch format should be interpreted as Breaking.Feature.Fix API change. For a live production system, it is actually need to worry about making breaking changes to services (the first SemVer number). If developer wants to be able to make a breaking change to a service, he must provide a way of making that change while still supporting the old version of the contract. Feature part of version is also important to indicate left border of supported API versions for the consumer. As for the patch/fix part, it is internal service implementation detail, which not affects contract between the service and its consumer.

Breaking changes are any change to the contract, which is provided by the service, which is not backward compatible. There are many different types of changes, which could have the potential to be breaking. The most common places for breaking change are transfer schemas and endpoints. The transfer schema is the structure of the data you will either receive or emit in response to an external request. In HTTP this includes any response payload and the structure of posted content. In a messaging environment, this includes events that service emits and commands it receives. Endpoints are the place another service would go to connect to the service. In HTTP this is the URL, in messaging the source that service listening to commands on or publishing events to and its routing information. There are many different implementation techniques to provide backward compatibility, but it is impossible completely avoid breaking changes. API First method can help to pay due attention to contract design and reduce their quantity.

API First is one of engineering and architecture principles. Concisely, API First requires to define APIs outside the code first using a standard specification language and to get early review feedback from peers and client developers. Service APIs should evolve incrementally. Of course, API specification will and should evolve itera-

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tively in different cycles; however, each starting with draft status and early team and peer review feedback. API may change and profit from implementation concerns and automated testing feedback. API evolution during development life cycle may include breaking changes for not yet productive features. API First does not mean that developer must have full domain and requirement understanding and can never produce code before have defined the complete API and get it confirmed by peer review. On the other hand, API First obviously is in conflict with the bad practice of publishing API definition and asking for peer review after the service integration or even the service productive operation has started. It is crucial to request and get early feedback — as early as possible, but not before the API changes are comprehensive with focus to the next evolution step and have a certain quality, already confirmed via team internal reviews.

There are different techniques and technologies for API definition. The most popular are OpenAPI Specification with Swagger implementation and Contract Testing with Pact implementation.

Swagger is an open source software framework backed by a large ecosystem of tools that helps developers design, build, document, and consume RESTful Web services. While most users identify Swagger by the Swagger UI tool, the Swagger toolset includes support for automated documentation, code generation, and test case generation. It is extremely powerful framework, even cumbersome, but it is not suitable outside RESTful API [4].

Contract Testing is writing tests to ensure that the explicit and implicit contract of a service works as advertised. This methodology applicable for any kind of API: synchronous HTTP-based, asynchronous message-based, binary protocols. The Pact is a family of frameworks provide support for Consumer Driven Contracts testing. Consumer Driven Contracts is a pattern that drives the development of the Provider from its Consumer's point of view. It is Test Driven Development for services [5].

It is extremely important and relatively easy to implement contract testing as a part of the continuous delivery build pipeline. Continuous integration (CI) system should make cross validation for all contracts of the service against its consumers from production environment to check backward compatibility and validate version increment made by developer before real deployment. In addition, CI system should generate service manifest describing all external service contracts and supported versions. The manifest may be used by orchestration system on update and rollback operations to control cross compatibility of all services within a single environment. Except the manifest generation, CI system should assign unique identifier to the each built service to allow its simple identification in build history. For such simple cases, semantic versioning is overabundant, and recommended way is to use simple sequential counter or time-based generator.

There are different service versioning techniques, and each is with their own pros and cons. In our company, we use adapted semantic versioning approach for each separate service public API, and simple time-based unique versioning for a whole service. In addition, we use mandatory automated contract-based API testing to eliminate human error in version assignment. That allows us to use declarative description of microservice cluster structure, isolated testing of each service and automated control of cross-service consistency at the runtime environment, with the preservation of independent development and continuous deployment of each separate service.

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UDC 621.39

**COMPARISON OF METRIC FUNCTIONS AND CORRELATION
WHEN FINDING A MEASURE OF SIMILARITY BY THE COEFFICIENTS OF POLYNOMIAL**

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The main functions of the metric and correlation are disclosed in the article. The analysis of Hausdorff metric function is made, as well as the metric based on the root-mean-square error, and also the normalized averaged correlation function is depicted. The results of the experiment are compared. The conclusions are drawn.

Image processing using digital transformations is increasingly used to solve a variety of applied problems in communication, radar, measurement technology, medicine and other fields of science and technology. Various algorithms for finding similar images are widely used in the media, search engines, security systems. By searching for similar images, image classification tasks are effectively handled [1].

An effective approach to comparison of reference images is the use of image representation in the form of unordered sets of some pre-selected elements.

In order to find similarity of identification images similarity of measures are used. Measures of similarity are subdivided into four types: correlation coefficients; measures of distance; associative coefficients and probability of coefficients similarity. Although all four types of similarity measures were widely used at previous time, only correlation and distance coefficients were widely used [2].

1. The correlation coefficient - a measure of mutual influence nature of two random variable changes. Defined by the expression (1):

$$R^{COR} = \frac{\sum_{i=0}^{N-1} \sum_{j=0}^{N-1} (a_{ij} - \bar{a})(b_{ij} - \bar{b})}{\sqrt{\sum_{i=0}^{N-1} \sum_{j=0}^{N-1} (a_{ij} - \bar{a})^2} \cdot \sqrt{\sum_{i=0}^{N-1} \sum_{j=0}^{N-1} (b_{ij} - \bar{b})^2}} \quad (1)$$

where \bar{a} и \bar{b} - average images a and b

The value of the correlation coefficient varies from -1 to +1, with zero indicating that there is no connection between the objects.

The main drawback of the correlation coefficient as the similarity measure is that it is sensitive to the form by reducing sensitivity to the magnitude of differences between variables. Furthermore, the correlation calculated in this manner has no statistical sense [3].

2. Measure of distance (metric) is widely popular. Two objects are identical when description of their variables takes 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. One of the most well-known distances is a function based on the Hausdorff metric, defined as (2):

$$R^H = 1 - \frac{1}{L} \max_{ij} |a_{ij} - b_{ij}^*|, \quad (2)$$

where $i \in 0 \dots N-1, j \in 0 \dots N-1$

The Hausdorff metric is a natural metric defined on the set of all non-empty compact subsets of a metric space. Thus, the Hausdorff metric transforms the set of all non-empty compact subsets of a metric space into a metric space. Used as a measure of similarity, it is very sensitive to noise. Consequently, metricity in itself does not guarantee the strictness of the evaluation of similarity itself, but at the same time this measure satisfies the aggregate of other requirements, but not a metric, can in most cases give a better estimate of similarity than another measure that is a metric [4].

In this experiment, the metric determined the measure of similarity from the data of polynomials. Since the metric can only work with data.

Function based on root-mean-square error, defined as (3):

$$R^E = 1 - \frac{1}{LN^2} \sqrt{\sum_{i=0}^{N-1} \sum_{j=0}^{N-1} (a_{ij} - b_{ij}^*)^2} \quad (3)$$

The root-mean-square deviation characterizes the measure of data dispersion, but now (unlike dispersion), it can be compared with the original data, since the units of measurement are the same, but this indicator in its pure form is not very informative, since it contains too many intermediate calculations [5].

As the measure of uncertainty, it also participates in many statistical calculations. With its help, the degree of accuracy of various estimates and forecasts is established. If the variation is very large, then the standard deviation will also turn out to be large, hence, the forecast will be inaccurate, which will be expressed, for example, in very wide confidence intervals.

The disadvantage of these distance measures is that the evaluation of similarity strongly depends on the differences in the data shifts. Moreover, the metric distances change under the influence of scale measurement transformations of variables [6].

3. Computational experiment data.

In the course of the experiment, graphs were found for investigating and comparing with the reference polynomial the results of modeling and searching for each of the functions. The results of modeling of the Hausdorff function are presented in the graph 1.

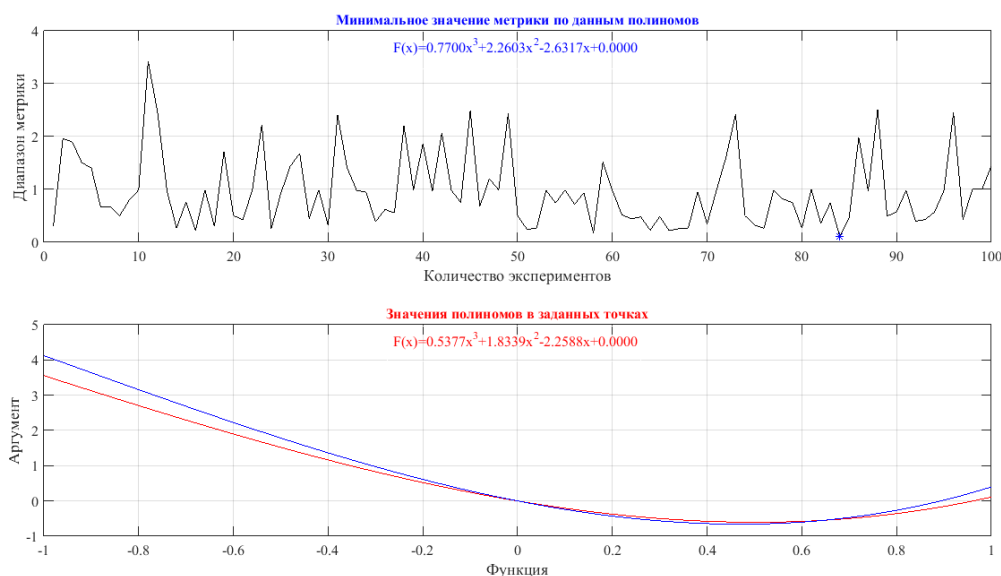


Fig.1. The graph of the Hausdorff function simulation

The result of the experiment on the coefficients of polynomials:

Reference polynomial:

$$F(x) = 0.5377x^3 + 1.8339x^2 - 2.2588x + 0.000$$

The polynomial found by the Hausdorff function:

$$F(x) = 0.7700x^3 + 2.2603x^2 - 2.6317x + 0.000$$

The results of modeling the root-mean-square error function are presented in the graph 2.

The result of the experiment on the coefficients of polynomials:

Reference polynomial:

$$F(x) = 0.5377x^3 + 1.8339x^2 - 2.2588x + 0.000$$

The polynomial found by the function of the root-mean-square error:

$$F(x) = 0.2346x^3 + 1.8569x^2 - 2.2076x + 0.000$$

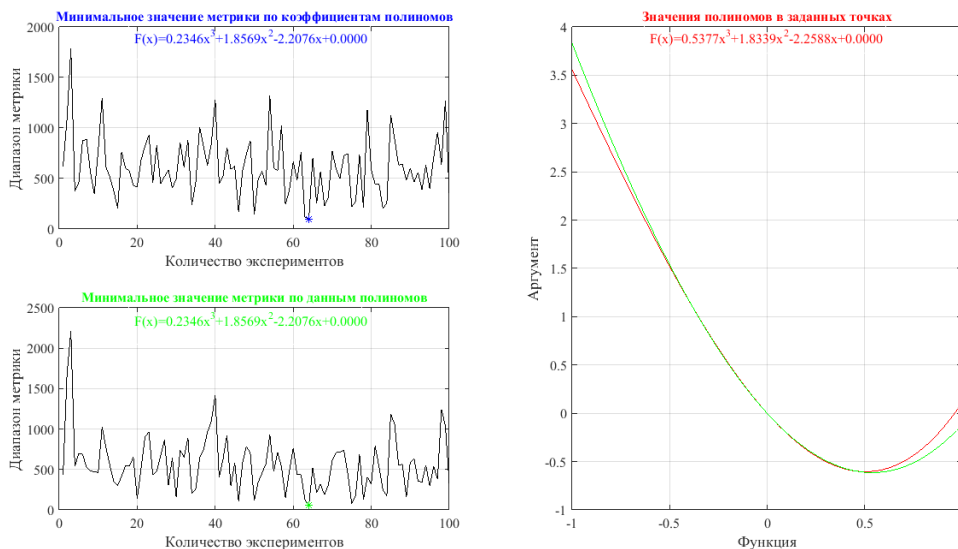


Fig.2. The graph of the function simulation based on the root-mean-square error

The results of modeling the normalized averaged correlation function are presented in graph 3.

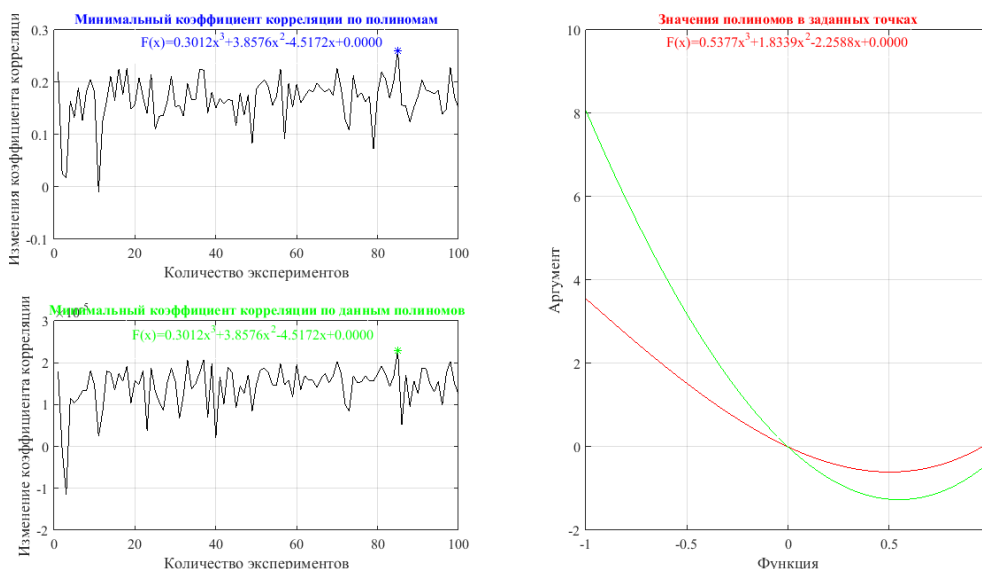


Fig.3. The graph of the simulation of the normalized averaged correlation function

The result of the experiment on the coefficients of polynomials:

Reference polynomial:

$$F(x) = 0.5377x^3 + 1.8339x^2 - 2.2588x + 0.000$$

The polynomial found by the normalized averaged correlation function:

$$F(x) = 0.3012x^3 + 3.8576x^2 - 4.5172x + 0.000$$

CONCLUSION. In this scientific article, some metrics and the correlation coefficient were examined in detail, in the context of their comparison in the search for a measure of similarity with respect to the coefficients of the polynomial. The computational experiment and the analysis of the obtained graphs both show that the best indicators for finding the measure of similarity by the coefficients of polynomials, showed metrics based on the root-mean-square error and the metric based on the Hausdorff function. The correlation function in the experiment for investigating a measure of similarity by coefficients proved to be less suitable, in view of the large

error in determining the similarity. It is established that the most promising method is determination of a measure of similarity with respect to the coefficients of a polynomial, since, in comparison with the data, it has an order of magnitude higher accuracy.

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SYNTHETIC APERTURE RADARS DATA FORMATTING BASED ON SPACE PACKET PROTOCOL

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For Earth remote sensing systems based on synthetic aperture radars it is important to ensure the reliability of information transfer from the platform carrier to the receiving point on Earth. In this paper an effective packetization algorithm according to Space Packet Protocol and Committee for Space Data Systems recommendations is presented. This algorithm implemented in MatLab software and all formed packets contribute to SPP requirements.

Currently, Earth remote sensing systems (RSS) based on synthetic aperture radars (SAR) are increasingly used. Such systems allow obtaining detailed area radar images with quality close to optical systems. The main advantage of remote sensing based on SAR is robustness to weather conditions and time of day. For these systems, it is important to ensure the reliability of information transfer from the SAR carrier to the receiving point on Earth.

To ensure the reliability of spacecraft SAR data reflected signal transmission and the necessary metadata to the receiver of such information, packet transmission is used. Based on the recommendations of the Consultative Committee for Space Data Systems (CCSDS [2]), the spacecraft SAR data package is based on SPP (Space Packet Protocol [1]). The packet generated according to the SPP, has to combine the data samples block where there are written radar image data and metadata. This packet is transmitted from a source to one or more terrestrial users. The content of the package data field entirely depends on application process and the specific characteristics of the spacecraft. The data sequence can be of variable or fixed length.

The source packet header must contain the application process identifier required to address the packet to the appropriate recipient and information about the packet length, packet sequence, and other characteristics. An optional secondary header should be provided for standardizing the transmission of time stamps and supporting data. The source package must consist of a 48-bit base header and a variable-length package data field. The minimum packet length is 7 bytes and the maximum length is 65,549 bytes.

In accordance with the requirements of SPP and CCSDS, an algorithm has been developed to form the spacecraft SAR package, which includes:

- packet primary header contains such fields as packet version number, packet type, secondary header flag, application process identifier, packet category, sequence flag, packet sequence count, and packet length. This fields are located in the first 6 octets.

- packet secondary header takes up 55 octets from 6 to 61 and includes the following fields: coarse and fine time, sync marker, data take ID, ECC number, test mode, Rx channel ID, instrument configuration ID, sub-commutated ancillary data word index, sub-commutated ancillary data word, space packet count, PRI count, error flag, BAQ mode, BAQ block length, range decimation, Rx gain, Tx ramp rate, Tx pulse start frequency, Tx pulse length, rank, pulse repetition interval (PRI), sampling window start time (SWST), sampling window length (SWL), SAS SSB message, polarisation, temp comp, elevation and azimuth beam addresses.

- data field includes calibration mode, Tx pulse number, signal type, swap, swath number and number of quads. This field is located in 62–67 octets. SAR data are written from 68 to 65549 octets.

A more detailed package structure description is presented in Table 1.

Raw data of RSA ERS-1[3] were used as initial data. In forming a packet process, the in-phase and quadrature samples of the reflected signal are ordered according to the SPP Protocol as follows: the in-phase part of a right sample, the in-phase part of a left sample, the quadrature part of a right sample, the quadrature part of a left sample.

The combining of the data of the reflected signal counts and metadata is performed in a cycle, the repetitions number is determined by the number of radiogram rows. The algorithm stage was modeled for one set of measurements, so the cycle was repeated 65 times. In order to unify and process more than one set of measurements, the software provides the necessary conditions for changing the coordinates of the position and speed of the platform.

Table 1. – SPP structure

Octet №	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	
0	Packet version number			Packet type	Secondary header flag	Application process identifier ☐			
1	Application process identifier				Packet category				
2,3	Sequence flag			Packet sequence count					
4,5	Packet length								
6-9	Coarse time								
10-11	Fine time								
12-15	Sync marker								
16-19	Data take ID								
20	ECC number								
21	n/a	Test mode			Rx channel ID				
22-25	Instrument configuration ID								
26	Sub-commutated ancillary data word index								
27-28	Sub-commutated ancillary data word								
29-32	Space packet count								
33-26	PRI count								
37	Error flag	n/a			BAQ mode				
38	BAQ block length								
39	n/a								
40	Range decimation								
41	RX gain								
42-43	TX ramp rate								
44-45	Tx start frequency								
46-48	Tx pulse length								
49	n/a			Rank					
50-52	PRI								
53-55	SWST								
56-58	SWL								
If SSBFLAG = 0, then:									
59	SSBFLAG=0	Polarisation			Temp comp		n/a		
60	Elevation beam address				n/a		< -----		
61	-----Azimuth beam address ----- >								
If SSBFLAG = 0, then									
59	SSBFLAG=1	Polarisation			Temp comp		n/a		
60	SAS test	Cal type			n/a		< -----		
61	-----Calibration beam address ----- >								
62	Cal mode			n/a		Tx pulse number			
63	Signal type				n/a			Swap	
64	Swath number								
65-66	Number of quads								
67	n/a								
68-65549	SAR data								

Further, the coordinate and velocity values are represented as a 32-bit array, followed by division into 2 arrays, each of which will further be an element of the metadata matrix. The formation of headers and metadata according to the structure of the package is showed in Listing 1.

Thus, data packaging modeling occurs in a cycle, the number of repetitions corresponds to the radar image rows number. The output product is implemented in MatLab is 65 packages of combined metadata and SAR RSS data.

Listing 1 – headers and metadata formation in accordance with the SPP structure

```

packetvers =[0 0 0];           %packet version number
typ=[0];                       %packet type
sehead=[1];                   %secondary header flag
identapl=de2bi(65,7)         %application process ID
categ= de2bi(12,4, 'left-msb') %Packet category
sequencfl= [1 1];
countseqflag= de2bi(count,14);
lengthpack= de2bi(5616*8+(62*8),16);%packet length
time= Data_time;             %fine time
sync=[0 0 1 1 0 1 0 1 0 0 1 0 1 1 1 0 1 1 1 1 0 0 0 0 1 0 1 0 0 1 1];Sync marker 352EF853 in HEX
datatakeID= de2bi(11527,32); %Data take iD
eccnumbr= de2bi(1,8);        %ECC number
testmode=[0 0 0];           %Test mode
rxchannelID=de2bi(RXCHIDcode,4); %Rx channel ID
instrumconfID= de2bi(3,32); %Instrument configuration ID
subcommutwrind= de2bi(count,8); % Sub-commutated ancillary data word index
subcommutwr= ADWIDX(j,:); %Sub-commutated ancillary data word
countpack= de2bi(t,32);      %Space packet count
pricount= de2bi(tre,32);     %PRI count
errorflag=[0];              %Error flag
baqmod= de2bi(12,5);         %BAQ mode
baqblock= de2bi(128,8);      %BAQ block length

```

Using the *histogram* function, which displays the values in the vector or matrix as horizontal bars, a graph is constructed (Fig. 1) implemented in MatLab models for the formation of packages showing the value of the dimension field of the secondary and primary headlines.

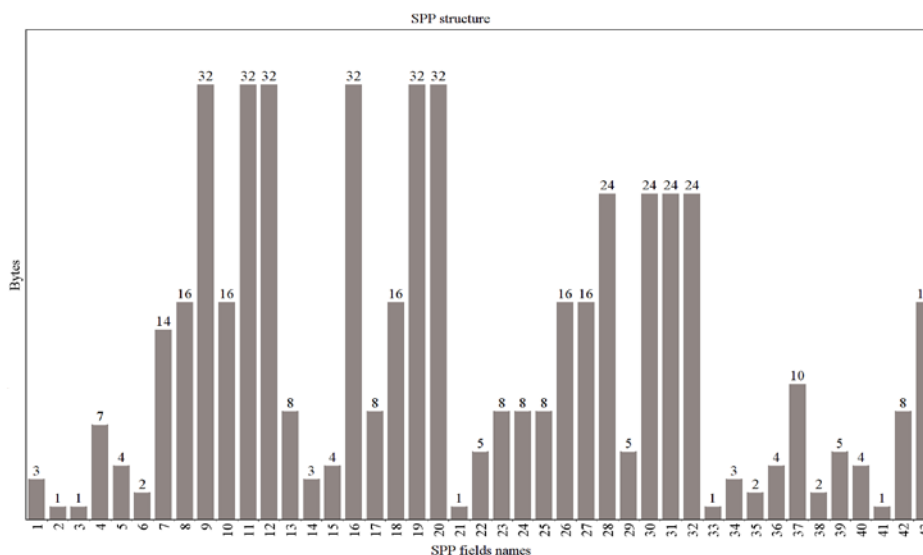


Fig.1. Metadata ordination according to SPP: 1 – Packet version number; 2 – Packet type; 3 – Secondary header flag; 4 – Application process identifier; 5 – Packet category; 6 – Sequence flag; 7 – Packet sequence count; 8 – Packet length; 9 – Coarse time; 10 – Fine time; 11 – Sync marker; 12 – Data take ID; 13 – ECC number; 14 – Test mode; 15 – Rx channel ID; 16 – Instrument configuration ID; 17 – Sub-commutated ancillary data word index; 18 – Sub-commutated ancillary data word; 19 – Space packet count; 20 – PRI count; 21 – Error flag; 22 – BAQ mode; 23 – BAQ block length; 24 – Range decimation; 25 – Rx gain; 26 – Tx ramp rate; 27 – Tx pulse start frequency; 28 – Tx pulse length; 29 – Rank; 30 – PRI; 31 – SWST; 32 – SWL; 33 – SAS SSB message; 34 – Polarisation; 35 – Temp comp; 36 – Elevation beam address; 37 – Azimuth beam addresses; 38 – Calibration mode; 39 – Tx pulse number, 40 – Signal type; 41 – Swap; 42 – Swath number; 43 – Number of quards

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As can be seen from Fig.1, the names fields, and the duration of the reading values of the secondary and primary heads correspond to the SPP. It confirms that the packets were formed correctly according to SPP requirements.

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UDC 004.93'12

OBJECT DETECTION USING FASTER R-CNN, YOLO AND SSD

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The paper describes and compares one of the most popular and effective lightweight object detection algorithms: faster R-CNN, R-FCN, YOLO and SSD. The article presents the intuitive approach and salient features of each method. The article gives an understanding of how deep learning is applied to object detection, and how these object detection models both inspire and diverge from one another.

Faster R-CNN is now a canonical model for deep learning-based object detection. It helped inspire many detection and segmentation models that came after it, including the two others we are going to examine in the article. Unfortunately, it is not possible to begin to understand Faster R-CNN without examining its predecessors, R-CNN and Fast R-CNN [1].

R-CNN, or Region-based Convolutional Neural Network, consisted of 3 simple steps (Fig. 1):

1. Scanning the input image for possible objects using an algorithm called Selective Search, generating ~2000 region proposals
2. Running a convolutional neural net (CNN) on top of each of these region proposals
3. Taking the output of each CNN and feed it into a) an SVM to classify the region and b) a linear regressor to tighten the bounding box of the object, if such an object exists.

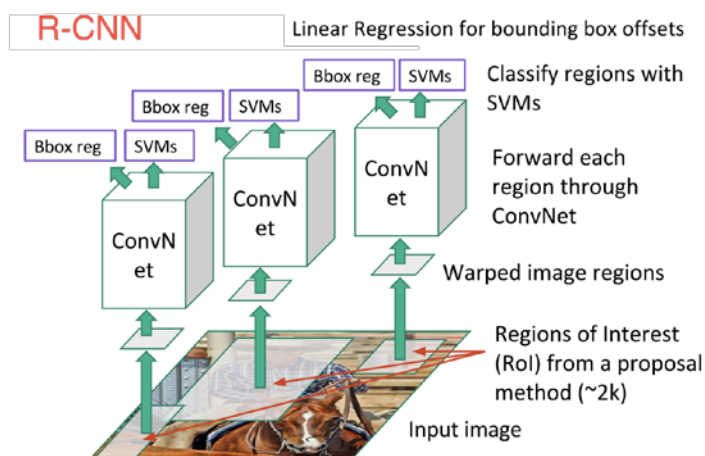


Fig. 1. Region-Based Convolutional Neural Network

In other words, we first propose regions, then extract their features, and then classify the regions based on their features. In essence, we have turned object detection into an image classification problem. R-CNN was very intuitive, but very slow.

R-CNN's immediate descendant was **Fast-R-CNN**. Fast R-CNN resembled the original in many ways, but improved on its detection speed through two main augmentations (Fig. 2):

1. Performing feature extraction over the image before proposing regions, thus only running one CNN over the entire image instead of 2000 CNN's over 2000 overlapping regions.
2. Replacing the SVM with a softmax layer, thus extending the neural network for predictions instead of creating a new model.

As we can see from the image, we are now generating region proposals based on the last feature map of the network, not from the original image itself. As a result, we can train just one CNN for the entire image.

In addition, instead of training many different SVM's to classify each object class, there is a single softmax layer that outputs the class probabilities directly. Now we only have one neural net to train, as opposed to one neural net and many SVM's.

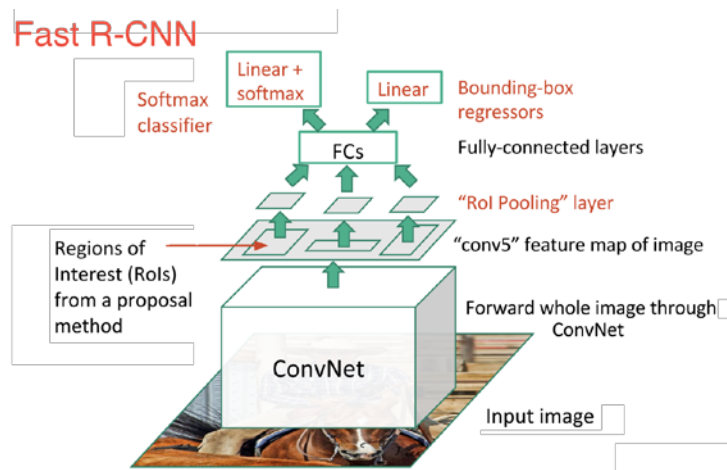


Fig. 2. Fast Region-Based Convolutional Neural Network

Fast R-CNN performed much better in terms of speed. There was just one big bottleneck remaining: the selective search algorithm for generating region proposals [1].

At this point, we are back to our original target: **Faster R-CNN**. The main insight of Faster R-CNN was to replace the slow selective search algorithm with a fast neural net. Specifically, it introduced the region proposal network (RPN) (Fig. 3).

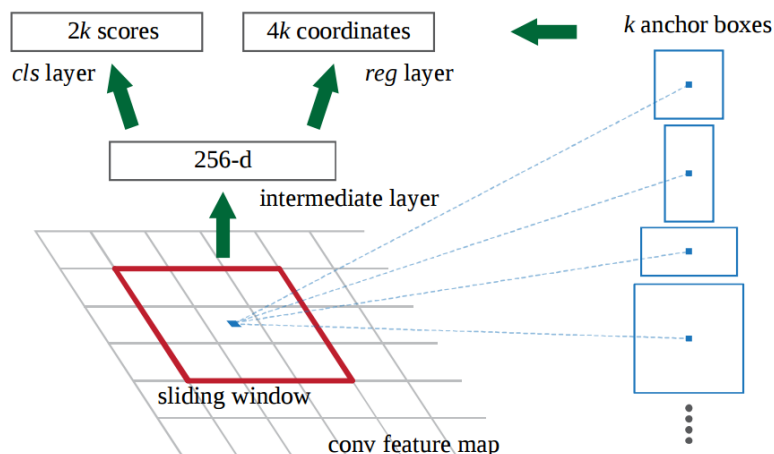


Fig. 3. Faster Region-Based Convolutional Neural Network

At the last layer of an initial CNN, a 3x3 sliding window moves across the feature map and maps it to a lower dimension (e.g. 256-d).

For each sliding-window location, it generates multiple possible regions based on k fixed-ratio anchor boxes (default bounding boxes).

Each region proposal consists of

1. An "objectness" score for that region.
2. Four coordinates representing the bounding box of the region.

In other words, we look at each location in our last feature map and consider k different boxes centered around it: a tall box, a wide box, a large box, etc. For each of these boxes, we output whether or not we think it contains an object, and what the coordinates for this box are. This is what it looks like at one sliding window location:

The 2k scores represent the softmax probability of each of the k bounding boxes being on 'object'. It should be taken into account that although the RPN outputs bounding box coordinates, it does not try to classify

any potential objects: its sole task is still proposing object regions. If an anchor box has an 'objectness' score above a certain threshold, the box's coordinates get passed forward as a region proposal.

Once we have our region proposals, we feed them straight into what is essentially a Fast R-CNN. We add a pooling layer, some fully-connected layers, and finally a softmax classification layer and bounding box regressor. In a sense, Faster R-CNN = RPN + Fast R-CNN (Fig. 4).

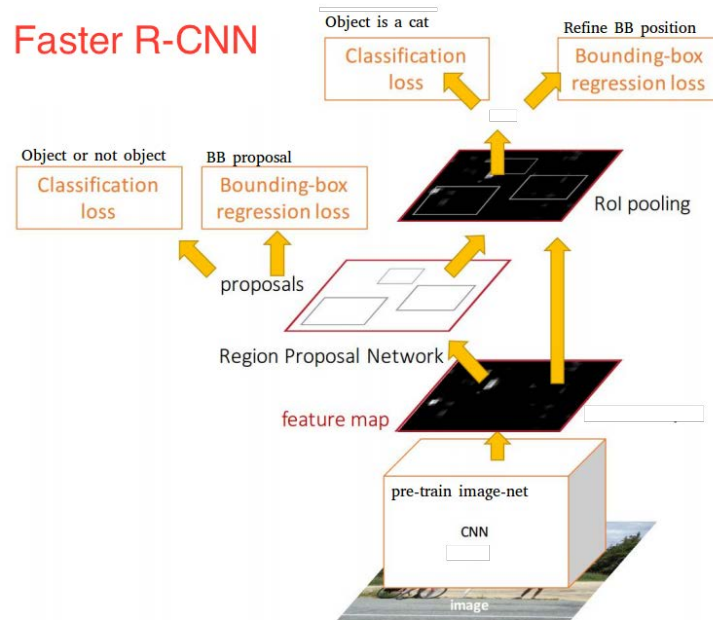


Fig. 4. Faster Region-Based Convolutional Neural Network as the Combination of RPN + Fast R-CNN

Altogether, Faster R-CNN has much better speeds and a state-of-the-art accuracy. It is worth noting that although future models did a lot to increase detection speeds, few models managed to outperform Faster R-CNN by a significant margin. In other words, Faster R-CNN may not be the simplest or fastest method for object detection, but it is still one of the best performing. A case in point, Tensorflow's Faster R-CNN with Inception ResNet is their slowest but most accurate model.

At the end of the day, Faster R-CNN may look complicated, but its core design is the same as the original R-CNN: to hypothesize object regions and then classify them. This is now the predominant pipeline for many object detection models, including our next one [1].

R-FCN, or Region-Based Fully Convolutional Net, shares 100% of the computations across every single output. Being fully convolutional, it ran into a unique problem in model design.

On the one hand, when performing classification of an object, we want to learn location invariance in a model: regardless of where a cat appears in the image, we want to classify it as a cat. On the other hand, when performing detection of the object, we want to learn location variance: if the cat is in the top left-hand corner, we want to draw a box in the top left-hand corner.

R-FCN's solution is position-sensitive score maps.

Each position-sensitive score map represents one relative position of one object class. For example, one score map might activate wherever it detects the top-right of a cat. Another score map might activate where it sees the bottom-left of a car. You get the point. Essentially, these score maps are convolutional feature maps that have been trained to recognize certain parts of each object [2]:

1. Run a CNN (in this case, ResNet) over the input image;
2. Add a fully convolutional layer to generate a score bank of the aforementioned 'position-sensitive score maps'. There should be $k^2(C+1)$ score maps, with k^2 representing the number of relative positions to divide an object (e.g. 3^2 for a 3 by 3 grid) and $C+1$ representing the number of classes plus the background;
3. Run a fully convolutional region proposal network (RPN) to generate regions of interest (RoI's);
4. For each RoI, divide it into the same k^2 "bins" or subregions as the score maps;

5. For each bin, check the score bank to see if that bin matches the corresponding position of some object. For example, if I am on the 'upper-left' bin, I will grab the score maps that correspond to the 'upper-left' corner of an object and average those values in the RoI region. This process is repeated for each class;

6. Once each of the k^2 bins has an "object match" value for each class, average the bins to get a single score per class;

7. Classify the RoI with a softmax over the remaining $C+1$ dimensional vector.

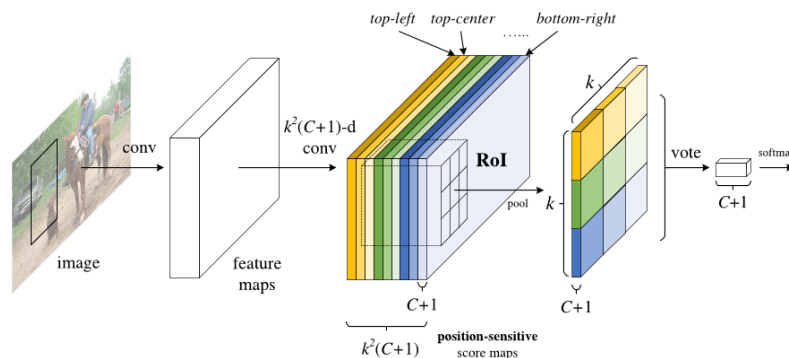


Fig. 5. Region-Based Fully Convolutional Net

Simply put, R-FCN considers each region proposal, divides it up into sub-regions, and iterates over the sub-regions asking: 'Does this look like the top-left of a baby?', 'Does this look like the top-center of a baby?', 'Does this look like the top-right of a baby?', etc. It repeats this for all possible classes. If enough of the sub-regions say 'yes, I match up with that part of a baby!', the RoI gets classified as a baby after a softmax over all the classes.

With this setup, R-FCN is able to simultaneously address location variance by proposing different object regions, and location invariance by having each region proposal refer back to the same bank of score maps. These score maps should learn to classify a cat as a cat, regardless of where the cat appears. Best of all, it is fully convolutional, meaning all of the computation is shared throughout the network [2].

As a result, R-FCN is several times faster than Faster R-CNN and achieves comparable accuracy.

SSD, which stands for Single-Shot Detector. Like R-FCN, it provides enormous speed gains over Faster R-CNN, but it does so in a markedly different manner.

Our first two models performed region proposals and region classifications in two separate steps. First, they used a region proposal network to generate regions of interest; then, they used either fully-connected layers or position-sensitive convolutional layers to classify those regions. SSD does the two in a "single shot," simultaneously predicting the bounding box and the class as it processes the image [3].

Concretely, given an input image and a set of ground truth labels, SSD does the following:

It passes the image through a series of convolutional layers, yielding several sets of feature maps at different scales (e.g. 10x10, then 6x6, then 3x3, etc.).

1. For each location in each of these feature maps, a 3x3 convolutional filter to evaluate a small set of default bounding boxes is used. These default bounding boxes are essentially equivalent to Faster R-CNN's anchor boxes.

2. For each box, simultaneously predict a) the bounding box offset and b) the class probabilities.

During training, the ground truth box is matched with the predicted boxes based on IoU. The best predicted box will be labeled 'positive', along with all the other boxes that have an IoU with the ground truth >0.5.

SSD sounds straightforward, but training it has a new challenge. With the previous two models, the region proposal network ensured that everything we tried to classify had some minimum probability of being an "object." With SSD, however, we skip that filtering step. We classify and draw bounding boxes from every single position in the image, using multiple different shapes, at several different scales. As a result, we generate a much greater number of bounding boxes than the other models, and nearly all of the them are negative examples [3].

To fix this imbalance, SSD does two things. Firstly, it uses non-maximum suppression to group together highly-overlapping boxes into a single box. In other words, if four boxes of similar shapes, sizes, etc. contain the same dog, NMS would keep the one with the highest confidence and discard the rest. Secondly, the model uses a technique called hard negative mining to balance classes during training. In hard negative mining, only a subset

of the negative examples with the highest training loss (i.e. false positives) are used at each iteration of training. SSD keeps a 3:1 ratio of negatives to positives (Fig. 6).

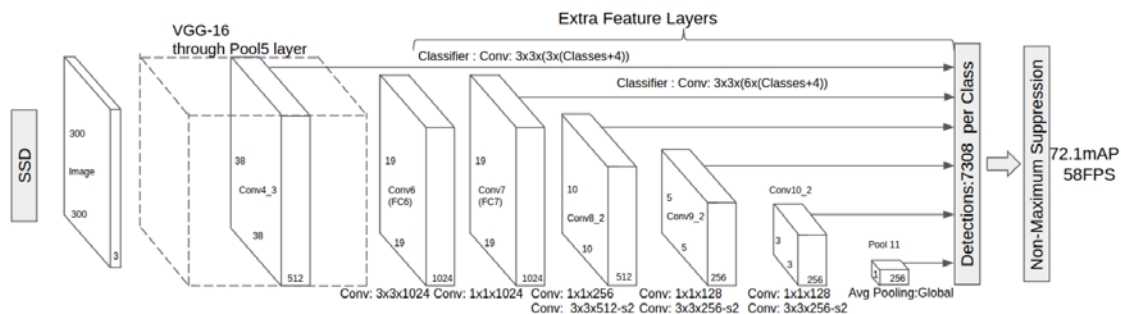


Fig. 6. Region-Based Fully Convolutional Net

As it was mentioned above there are ‘extra feature layers’ at the end that scale down in size. These vary-ing-size feature maps help capture objects of different sizes (Fig. 7).

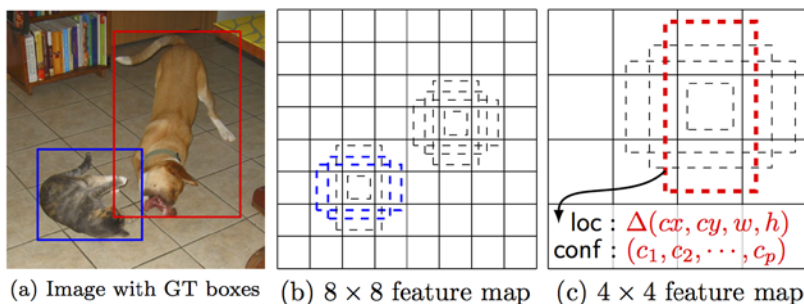


Fig. 7. SSD in Action

In smaller feature maps (e.g. 4x4), each cell covers a larger region of the image, enabling them to detect larger objects. Region proposal and classification are performed simultaneously: given p object classes, each bounding box is associated with a (4+p)-dimensional vector that outputs 4 box offset coordinates and p class probabilities. In the last step, softmax is again used to classify the object.

Ultimately, SSD is not so different from the first two models. It simply skips the ‘region proposal’ step, instead of considering every single bounding box in every location of the image simultaneously with its classification. Because SSD does everything in one shot, it is the fastest of the three models, and still performs quite comparably [3].

YOLO divides each image into a grid of S x S and each grid predicts N bounding boxes and confidence. The confidence reflects the accuracy of the bounding box and whether the bounding box actually contains an object (regardless of class). YOLO also predicts the classification score for each box for every class in training. It is possible to combine both the classes to calculate the probability of each class being present in a predicted box.

So, total SxSxN boxes are predicted. However, most of these boxes have low confidence scores and if we set a threshold say 30% confidence, we can remove most of them as shown in the example below (Fig. 8) [4].

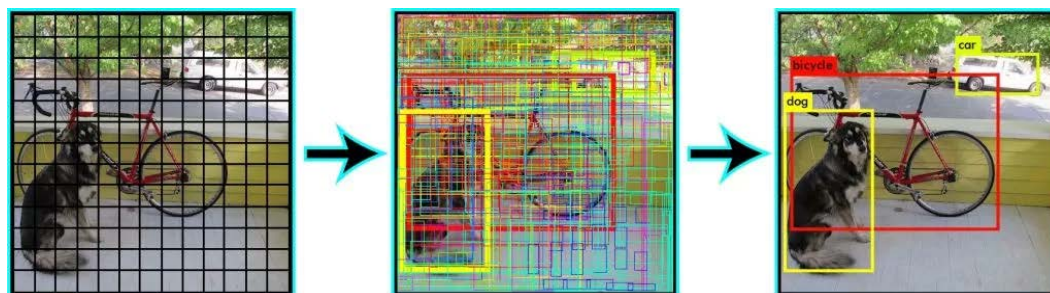


Fig. 8. YOLO in action

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Notice that at runtime, we have run our image on CNN only once. Hence, YOLO is super fast and can be run real time. Another key difference is that YOLO sees the complete image at once as opposed to looking only at a generated region proposals in the previous methods. So, this contextual information helps in avoiding false positives. However, one limitation for YOLO is that it only predicts 1 type of class in one grid hence, it struggles with very small objects.

The choice of the right object detection method is crucial and depends on the problem to solve and the set-up. Object Detection is the backbone of many practical applications of computer vision such as autonomous cars, security and surveillance, and many industrial applications.

Faster R-CNN, R-FCN, YOLO, and SSD are four of the best and most widely used object detection models out there right now. Other popular models tend to be fairly similar to these three ones, all relying on deep CNN's to do the initial heavy lifting and largely following the same proposal/classification pipeline.

Currently, Faster-RCNN is a good choice for accuracy numbers. However, if you are strapped for computation (probably running it on Nvidia Jetsons), SSD is a better recommendation. Finally, if accuracy is not too much of a concern but you want to go super fast, YOLO will be the way to go.

SSD seems to be a good choice as we are able to run it on a video and the accuracy trade-off is very little. However, it may not be that simple, as it is shown in the chart that compares the performance of SSD, YOLO, and Faster-RCNN on various sized objects. At large sizes, SSD seems to perform similarly to Faster-RCNN. However, you should look at the accuracy numbers, when the object size is small the gap widens.

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UDC 004

CHAT-BOT OF AUTOMATION OF WORK WITH CLIENTS OF SERVICE OF SUPPORT OF ONLINE SERVICE

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The problems of service support and a possible way to automate the work of online support is described.

Introduction. One of the main tasks of online services is to support customers. Customer support includes consulting before buying a product or service or after-sales support. The availability of high-quality customer support makes it possible to compete more effectively in the market. Customer support is provided in various ways: by phone, by correspondence in web chats, by e-mail, with the help of instant messengers.

To support customer online services, you must have a full staff, which includes specialists in working with clients, sales, technical specialists, service chiefs who will handle requests. The costs of maintaining support services are eventually pawned in the final price of the product, which increases costs and reduces competitiveness.

From the list of incoming requests from customers to the technical support, the largest number of requests are of the same type. On some online services, the number of similar requests is about 80% of the total number of hits. Automatic or automated processing of the most frequently encountered applications can significantly reduce the burden on online service support specialists.

The problem of automated processing is the "recognition" of the semantic load of queries. The current development of speech recognition systems allows us to accurately determine the meaning of what has been said, which allows us to develop a system capable of interacting with customers with the help of natural language [1].

Based on the current assessment of the market, chat bots, for messengers - a promising direction, which is currently experiencing rapid growth. The growth of the market is largely due to the fact that the number of messenger users has exceeded the number of users of social networks drawing. [2-4]

In 2016 there was a jump in commercial activity in the sphere of messengers (conversational commerce). This is understood as the use of chat rooms, instant messengers or other natural language interfaces (including voice) for communication with people, brands, services. Probably, right now we can talk about a new paradigm of user interaction with online services - messaging-as-an-interface [4].

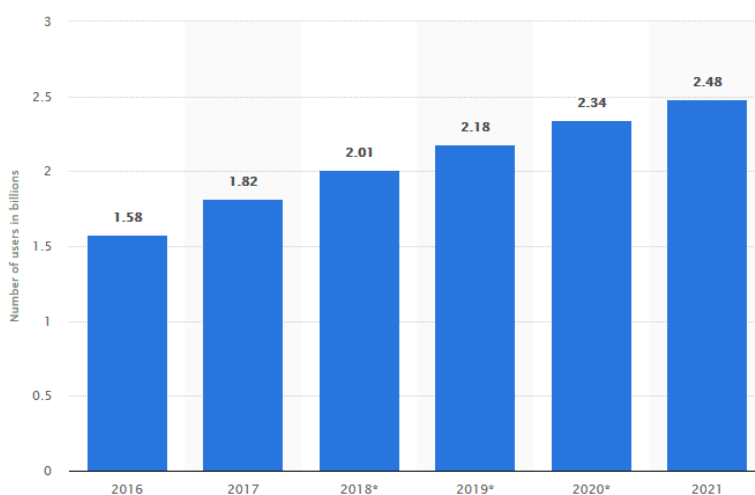


Fig. 1. Number of mobile phone messaging app users worldwide from 2016 to 2021

The natural language interface allows the user to interact with the software through the use of natural language.

The software has a natural language interface that allows you to reduce the entry threshold for using this software. Lowering the threshold of entry is due to the fact that the user does not need additional skills. The user is able to interact with the software using conventional language constructs.

At the same time, the number of people using instant messengers to contact brands has also grown. According to analysts, in the coming years the interest of commercial companies in chat bots will continue to grow [6].

Now in the business sphere, bots are used for several purposes: consultations, content distribution, search by parameters, gathering information about customers, accepting orders and sales.

Often, users have questions about the operation of services or the problems that they solve with the help of online services, for which the services organize the hotel service for processing requests. The service aggregates customer requests from various sources: calls, chats, e-mail. Then the operators process them, which takes a certain amount of time. When the number of requests exceeds the online support staff, queues arise, which entails an increase in the service time [5-6].

Business growth entails the need for a large staff of employees to provide appropriate user support. The costs of maintaining the staff of online support staff ultimately fall on the end customer.

At the same time, most user requests are of the same type, which allows them to be transferred to processing by automated means. Automation of similar requests will reduce the burden on support.

According to a large Russian developer of bots, the company "Nanosemantika" (working with Beeline and Webmoney), the presence of chat-bot removes up to 40% of the load from the operator-consultants [7].

Task formulation

Functional requirements for the software:

- interaction with customers through natural language interfaces;
- the possibility of training the system for various areas of business;
- work in various messengers;
- providing API for interaction with web-applications;
- possibility to continue dialogue with the operator;
- informing support operators when it is impossible to process the request;
- distribution of requests for operators;
- collection of statistics on the processing of requests.

To implement a software tool that allows you to automate part of the processing of requests, you first need to solve the problem of recognizing the semantic load of queries. To do this, you can use the ready solution wit.ai it's the same Ducling [8]. Ducling allows you to identify entities from a message, for further processing. The selected entities are provided in JSON format, convenient for further processing. Duckling Distributed under the license of MIT, which allows it to be used in commercial projects.

After recognizing the semantic load, it is necessary to determine the response of the system to this query. To determine the necessary reaction, you can use the expert system Clips [9]. This expert system allows you to create a database of "facts" and rules, which will be the necessary reaction. Depending on the certain semantic load of the query, the search will be performed on the basis of facts, rules will be used to search for the necessary reaction to the request. Then make the request processing by the kernel of the system. For Clips, there are libraries that allow you to integrate the expert system into applications written with the help of most popular programming languages.

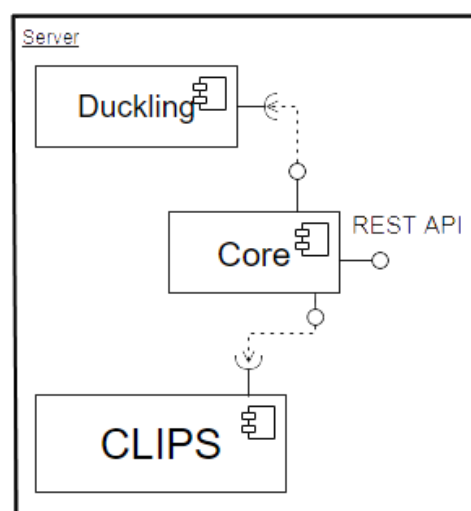


Fig. 2. Deployment diagram

To interact with other software, you need to implement the REST API, through which you will interact with chat rooms and other software. REST API will make the system independent of the implementation of chat bots, which will support the majority of popular chat rooms.

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MOBILE APPLICATION FOR LEARNING THE BASIS OF SAFETY**ROMAN KARTSEVICH, OKSANA GOLUBEVA**

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This article describes the problem of lack of knowledge of safety precautions among young people and the solution to this problem using a mobile application.

Description of the subject area

The role of a mobile phone in the life of modern man is quite difficult to overestimate. Thanks to this compact device, you can contact your friends, relatives, colleagues at any time to get the information you need. In addition to contacts, many people store memorable dates, ideas, thoughts and other various files on their mobile devices.

The mobile device today acts as a flash drive and a notebook. A variety of useful special programs, options, functions, which modern models of mobile phones are equipped with, make this small device multifunctional and practical.

Thanks to such a large number of advantages, mobile phones have become very popular with young people, especially thanks to the mobile applications of the game format. Teenagers can spend a lot of time following such applications in various places, such as:

- house;
- school;
- public transport;
- cafe;
- different waiting areas;

Taking into consideration this trend, it makes sense to develop a mobile application that would help address a number of issues of relevance among children related to safety and health hazards.

So one of the fundamental concepts of child safety is the danger. Its signs are: a threat to life or the possibility of damage to health. Children can encounter dangers in various places: at home, in the city, in the nature, when communicating with strangers.

Children's safety mainly depends on the training. One of the standard methods is regular explanatory work, which allows conveying information effectively to children. And the best way to carry it out is to make use of games. In our time, children are especially attracted to mobile gaming applications. A study by the Institute of Modern Media (MOMRI) found out that many professional psychologists consider mobile interactive games and applications useful for the child to acquire new competencies. A good result can be achieved by the right selection of content, playing time, the necessary and sufficient participation of an adult.

To create a mobile game, the training basics of safety engineering can identify the following requirements:

- several levels of complexity with modeling situations that contain hazards of different kinds;
- theoretical tips for implementing an option for an optimally safe exit;
- consequences when performing actions that deviate from safety procedures;
- keeping statistics of the passage of the game.

Implementation and design of the application

On the basis of the above characteristics, the functional structure of the mobile application for training the basics of emergency behavior was developed, which consists of the following subsystems:

- subsystem for working with menus, which is responsible for monitoring user actions in the application menu and processing relevant requests for its operation;
- game level selection subsystem, responsible for selecting the appropriate level of the game according to the user's request;
- subsystem for evaluating the passing of the level by the user. Responsible for assessing the levels at the end of their passage, depending on the selected actions of the player at the time of passing the level;
- a subsystem of choice of theoretical information. Responsible for providing the necessary theoretical information to the user in one of the menu sections;

– a subsystem responsible for verifying the correct behavior of the user. It is responsible for preventing errors from the user's side in order to ensure the correct operation of the application.

The functional structure of the program is shown in fig. 1.

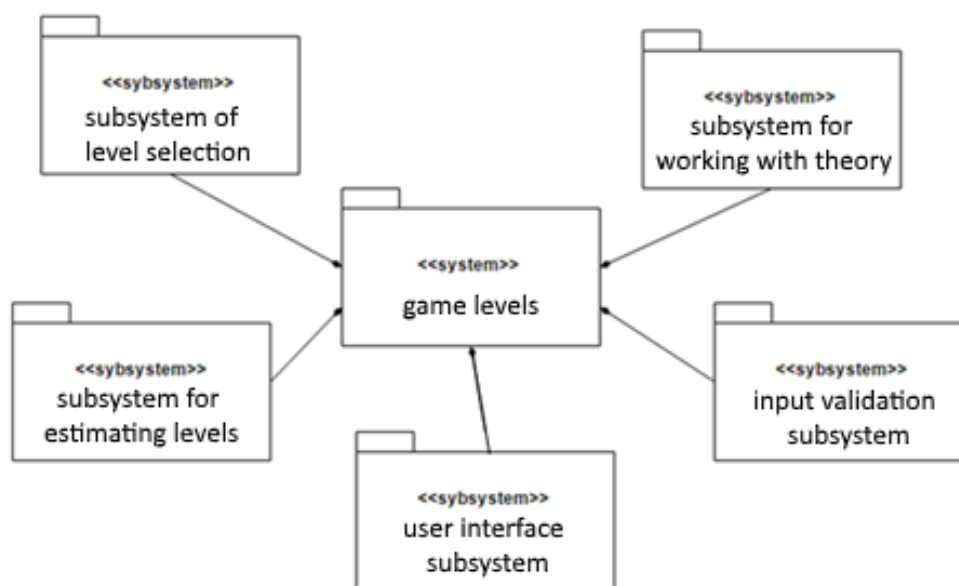


Fig. 1. Functional structure of the application

To develop the application, it was decided to use the cross-platform framework LibGDX, based on the Java programming language with some components written in C and C ++ to improve the performance of certain code. Currently supports Windows, Linux, Mac OS X, Android, iOS and HTML5 as target platforms.

LibGDX allows you to deploy the application on multiple platforms without modification. You can use all the tools of the Java programming language to increase productivity as much as possible.

LibGDX allows you to go to a lower level, giving direct access to the file system, input devices, audio devices and OpenGL through a single OpenGL ES 2.0 and 3.0 interface.

During the design of the architecture, the main classes of the application were identified, which describe the following objects:

- main menu of the game
- game levels
- level selection menu
- menu with theoretical information

For example, we describe the implementation of the main menu of the game: when developing the main menu of the mobile application, the MainMenuScreen class was created. This class is responsible for the screen containing the start menu items that are provided to the user immediately after the application is launched. To create menu items, the ButtonTexture class contained in the libGDX framework inherited from the Actor class was used. After creating objects like ButtonTexture, you need to use them on the stage as actors, as a result of which you can observe their presence on the screen. Finally, we need to create an event handler that will track the user's actions on the main menu screen and handle events.

As a result, this mobile gaming application provides an opportunity to apply the acquired knowledge of safety techniques for the successful passage of dangerous situations.

The game format of the application allows children in an easy and accessible form to acquire the information received during the game, which can be useful to them in real life.

As a result, we get a very convenient and practical solution to the problem associated with safety technology among adolescents in the modern world.

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UDC 004

OPEN SOURCE APPROACH TO PROJECT MANAGEMENT SYSTEM

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Managing large projects and involving different groups of people and complex tasks can be challenging. The solution is to use Project management software, which allows more efficient management of projects.

The project management (PM) has got detached from standard management disciplines for some last decades and has evolved into an independent one. The need for PM emerged as the economic situation has become relatively stable. In a state of transition PM cannot be applied so successfully as unstable environment situation isn't being given good forecast, and as a consequence, risks may appear here. According to the DEX [Data Exchange Specification], the definition of a project is: to take a plant, to do something; an intention; the first drawing or first ideas about something that is to be made or to be put into execution. Although, current practice identifies the project itself with the work to be completed but according to business planning activity business requirements and project management are separated from the project itself. PM requires a degree of professionalism, which increases simultaneously with increasing project complexity. The increasing number of factors involved in running a project, high values and limited resources turn everything into a highly complex activity [1].

Project management software market encloses a lot of products. From all there, a free or open source (OS) is considered to be a special category, being perfect for small business. A reason is the fact that such business actually do not **need** to buy huge project management software, but to understand the value of a well-founded project management. This free software generally provides only basic functionality such as time lines rudimentary, PERT charts, or Gantt charts. In terms of costs accounting line their offer is weak, particularly for the risk management and customer support.

Some client-server software project management is more specialized in niche areas. They are more targeted to desktop software and offers rich features such as the Gantt and PERT charts, risk management, Critical Path Analysis, EVA, accounting and resource utilization.

Sophisticated online web-based enterprise-wide project management solutions allow project members to report task evolution and report the details of their progress online. This, in turn, allows the project manager to readily understand the status of the various participants and to focus on the issues that are most important. There are web-based solutions that can be operated from anywhere in the world. This means that everyone from top management to the frontline workforce can access project-related information anytime. Outside subcontractors as well as customers, can log onto their relevant separate part of the project and get to track it. All other modules there are usually useful considering the timesheet modules, project calendars and email notification, helping the manager to monitor and to be proactive about both costs and time deadlines.

As it was mentioned in the introduction to this paper, a PM must provide modern software tools for planning, organizing, managing and collaborating within and across teams in order to reach the project goals and objectives. Classical solutions, offline and standalone are not good enough for these tasks, as they do not offer modules collaboration and as the communication between project members is made difficult. Web-based PM software comes with collaborative tools that facilitate fast and efficient management of tasks and activities. It is more comfortable to work with Web-based applications, so the increasing number of Web-based alternatives is not a surprise. When a company chooses to use online PM software, maybe it is because it does not want an application hosted on a server hosting company being paid as a monthly subscription. Some companies want to install software on their own server, assuming all responsibility for IT matters arising from there. A few years ago installing and configuring a Web server database and associated scripting language (e.g., Apache, MySQL, PHP), that was able to support an online software was a relatively difficult task that required the presence of an IT specialist. But currently there are OS application packages like XAMPP, WAMPP that make these tasks simpler to reach, even for a person who has a minimum IT knowledge.

Why should we choose open source software project management solutions? There are different levels of complexity for PM software, priced between 30 and 20.000 dollars or more. However, not everyone has the budget necessary to start with a PM commercial solution, such as Microsoft Project or something similar. Microsoft Project is undoubtedly a powerful tool for PM, an incredibly capable application, but often too complex

and exclusively targeted to the project manager. Similar situation can be encountered with Office package, 80% users using only 20% of the many features of Microsoft Project [2].

When a project manager needs software to improve collaboration or planning of a small project, he may choose simpler solutions for PM. Foreexample, one can choose software collaboration features and simpler planning such as Microsoft Outlook, SharePoint and Visio to solve problems. When, however, managers are challenged with large projects, planning or collaboration work may exceed the possibilities of normal software. In this situation some PM system is required and free and OS software (OSS) can be probably a good choice. The ticketing system and the management tasks are comprehensive, even if it has many forms. This is probably due to the fact that these applications are written by Web developers who understand the importance of a comprehensive system management tasks. This, online PM applications, by contrasting to commercial OS, are noted through a detailed task management. Commercial applications, on the other hand, are distinguished by attention to detail in the user interface. From simple presentation sites or portals, to collaboration and information complex sharing, in dynamic pages, from public administration and education to advertising, business, commerce and other services, OSS has proved to be an alternative worthy to take into account [3] [4]. The above-mentioned reasons are among the main reasons that led us to choose this particular category of software, with its many distinctive features and to achieve the present article.

Sustaining the idea that a Free/OS PM software (OSMPS) is an almost essential commodity to keep business and/or working life running smoothly in our days and to face the challenges of new economy [5], we will expose in the subsequent part of this paper an overview of OSPMS solutions. There is a process of identifying the best PM software for an organization. This is a necessary part from adoption an OSS (Fig. 1), as shown in documentation of governments which found that open source software alternative and open source platforms offer significant potential benefits to their governmental agencies and to their wider community [6] [7]. A review or a deep comparison of OSPMS solutions performances and features is difficult to be highlighted enough in a single paperwork. Thus, it will be the subject of a future research paper. For the current paper we decided to present the OSPMS solutions grouped by the criterion "web-based" and "desktop", because we believe that it is a defining element for choosing the most appropriate solution. In addition to a brief presentation of applications, we have considered the identification of features such as Collaboration, Project Portfolio Management, Resource Management Planning, Project Scheduling, Risk and Issue Tracking System, Document Management, Help / Support and platforms (operating systems) on that they can run.

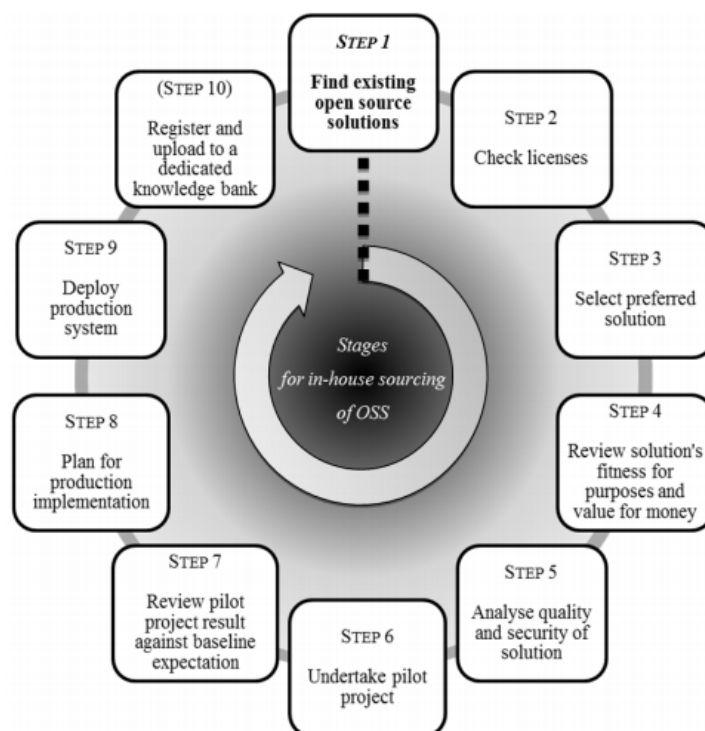


Fig. 1. A model workflow for in-house sourcing of OSS products [6, 7]

PM software market is rich in OS solutions that are able to provide similar functionality or even superior to commercial solutions. One of the main advantages of OSPMS is their availability on various platforms and operating systems, a fact that is very important in circumstances where there is a worldwide trend of increasing use of OS operating systems, usually for security and cost reasons. Most OS solutions are 100% compatible or supports import files in formats specific commercial software, so migration from commercial solutions to the OS is easy, while maintaining the consistency if necessary collaboration and file sharing firms using commercial solutions of PMS.

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**DESIGNING THE STEGOSYSTEM, BASED ON HIDING TEXT DATA IN AUDIO FILES BY MEANS
OF CHANGING THE DELAY TIME OF THE ECHO SIGNAL**

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The article presents a practical way of creating a reliable stegosystem with an unconventional way of hiding information. The purpose of this work is to build a system based on hiding text messages in audio files, as well as to study the attacks and to find out, whether such a system is suitable for practical usage. The task was being solved by splitting the main program into the library and sub-routines. The program is written in the Java programming language using JavaFX and the library for converting JAVE (Java Audio Video Encoder).

Introduction. The subject of the article deals with hiding data in audio files, using one of the steganography methods. Digital steganography is hiding one data in other data. Moreover, the concealment of this should be implemented in order not to lose the properties and value of hidden data and the inevitable modification of the digital storage medium wouldn't destroy the semantic functions and even wouldn't change them at the certain abstract level. Thereby the fact of one message transmission inside of another will not be revealed by the traditional approach.

The main audio signal settings are: amplitude, frequency and phase. All these setting are appropriate for steganographic modification, but before the integration it is necessary to estimate the limits of container modification settings as well as any distortions. The message rate, reliability, stability of the steganography system will largely depend on the degree of modification of the audio container [1].

The principle of a steganographic system designing and the description of the data hiding algorithm.

The standard steganographic scheme is maintained regardless of the technology used for its implementation. The task of embedding and separating messages from other data is performed by a stegosystem. Data, containing a hidden message, can be subjected to deliberate attacks or accidental interference. In the stegosystem two types of information are combined, so that they can be distinguished by two fundamentally different detectors. One of the detectors is the system of isolation of the CEH, another is a human [1]. To conceal the data, the method of embedding information was used by changing the delay time of the echo signal. This method allows to place data in the cover signal, changing the echo signal settings. The settings, carrying the embedded data are: initial amplitude, decay time and shift (delay time between the original signal and its echo). If the decline is reduced, two signals are mixed. At a certain point human ear ceases distinguishing two signals and the echo is perceived as additional resonance. The coder uses two time delays: one for coding zero, the other for coding unit. Both of them are less than the one a human ear is able to recognize. Besides the reduction of the delay time it is necessary to make the embedded information impossible for audio perception by a human listening system by means of setting the initial amplitude and the time of decline.

When encoding the information two values of echo signal delay were chosen: 0, 0012 & 0, 0008 seconds. These values reduce the efficiency of the extraction algorithm, reducing the probability of a correct extraction of the bit, but they are suitable for almost all types of containers. Amplitude value is 40%, because this value helps increase the probability that the fact of hidden data existence wouldn't be revealed.

Decoding of the embedded data means defining the time interval between signal and echo. For this it is necessary to consider the amplitude (at two points) of the autocorrelation function of the discrete cosine transformation of the logarithm of the power spectrum (cepstrum). The burst of the autocorrelation function will take place in δ_1 or δ_0 seconds after the original signal, shown in Figure 1. The decoding rule is based on defining the time interval between the original signal and autocorrelation burst.

According to the researches of V. Bender and N. Morimoto, such a scheme allows to imbed imperceptibly 16 bits in one second of audio, without losing its quality. The choice of the method of embedding data in sound files using echo conversion is determined by the fact that this method has resistance to amplitude and frequency attacks, which allows to bypass other methods that are unstable to these attacks. However, this method is unstable to temporary attacks that directly affect the length of the audio file and the number of samples in it. When it comes to implementing this method of steganographic protection of information through echo-signal conversion, it becomes clear that the main difficulty is the implementation of the most efficient algorithm for extracting embedded bits. Several researches in this field showed that it is possible to reach the highest efficien-

cy only by means of individual approach to each of the containers, changing the delay time of the overlaid echo signal.

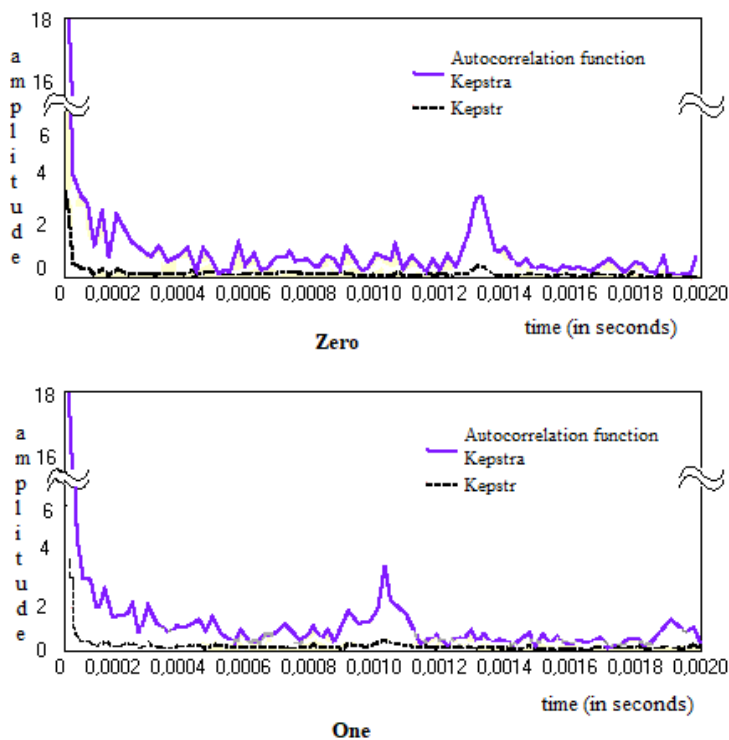


Fig. 1. Behavior of the autocorrelation function

Estimation of the implemented system stability.

There is a great variety of digitalized audio signals classifications according to their settings such as: sampling, the amount of channels (mono or stereo), recording quality (number of kbps), etc. At the same time, if the audio signals (containers) belong to the same data representation format (for example, WAVE), have the same sampling frequency, the same number of channels, the same sound quality and differ only in the music genre, it is difficult to assess the suitability of a container for steganography modification.

All audio files can be divided into three groups:

- audio files similar to speech, with a lot of pauses (poems, voice of the announcer, speech with low background music, etc.);
- audio files that do not have a wide frequency range, like ordinary musical compositions (pop songs, popular music, blues, etc.);
- audio files with a wide frequency range, passed additional computer processing (electronic music (trance, techno, etc.), synthesized sounds of nature, etc.).

The use of audio files from the first group was completely inappropriate for usage, regardless of the quality of the container used.

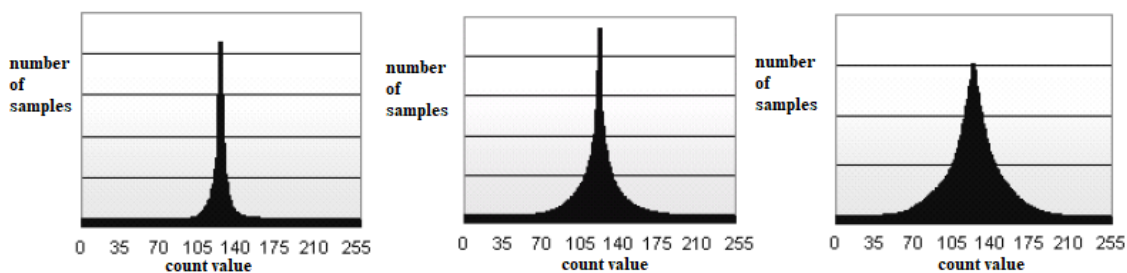


Fig. 2. Graphs of the distribution of samples for groups 1–3

When using audio files from the second group, the distortion is hardly discernible by a trained ear, and the probability of proper withdrawal is quite high. The use of audio files from group 3 showed that the probability of proper extraction is close to 100%, while distinguishing an empty container and a container with data by ear won't be possible.

From this we can make a conclusion, that the audio files that have been subjected to additional computer processing (electronic music) are the most suitable for the method of hiding data by means of echo-signal delay. The sampling rate and the number of channels should also be taken into account: the higher their values, the greater the probability of correct withdrawal is [2].

The main types of attacks on stegosystems are:

1. The attack on the basis of a known filled container. The task is to detect the presence of a hidden message. Listening to an audio signal in order to detect any interference. A container lasting 60 seconds, with the dynamic music was chosen, and a 20-character message was hidden. The result: after listening to the filled container using the speaker system extraneous sounds, wheezes and crackling were not detected.

2. An attack on the basis of a known empty container. If it is known, then by comparing it with an assumed container in which there is a hidden message, it is always possible to establish the presence of a stego channel. This can be a comparison of the length of the audio signal, the comparison in size, as well as listening. A container lasting 60 seconds, with dynamic music was chosen, and a 20-character message was hidden. The result: repeated listening to a filled container and original container using the speaker system without playing low frequencies (laptop) showed that there is no difference between the sound. However, when listening to an acoustic system with a device playing low frequencies, some differences in the depth of sound of the filled container and the original container became apparent.

3. Attacks against the built-in message, aimed at removing or corrupting the built-in data by manipulating the filled container, and also, aimed at hindering or inability to operate the detector correctly. In this case, the message in the audio file remains, but the ability to receive it is lost. Examples are: trimming (changing the length) of the audio signal, changing the format to another, changing the container's format settings, accelerating or slowing down, changing the key. Result: the method of data concealment using echo delay is unstable to temporary changes. If you change the length of the audio file for a few seconds, you can't extract any data. Changing any other settings of the audio file did not affect the receipt of hidden data [3].

The conclusion. Research in the field of steganography is a very promising direction of data protection, since in the modern world the task of transferring sensitive data is in step with hidden communication, i.e. hiding the fact of message transmission. Therefore, it is necessary to continue researches in this area to find new, effective, methods or improve the existing ones. In this article the method of embedding data in audio files was considered. The method of echo signals is the most promising, however, it needs to be improved in terms of throughput, and the probability of correct extraction of embedded bits of data. The software product is implemented and ready for usage with the possibility of modification.

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FEATURES OF WEB APPLICATIONS TESTING

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The article is devoted to the peculiarities of testing web applications. The principles of testing web applications, similarities and differences in testing with desktop and mobile applications are considered. Results of site testing are represented.

Nowadays the Internet has entered into all spheres of users' lives. Working online has several advantages. Web-based products take up very little space on the client machine, are accessible from any device connected to the Internet, and are updated regularly, allowing users to receive the latest data [1].

Based on the number of developed sites and users they use, it becomes clear why so many new web applications are being developed in the world. This process leads to the need to attract a large number of specialists.

Cloud technologies are becoming a new reality of the modern Internet: even the once familiar desktop Word and Excel today are represented as web alternatives from Microsoft.

The difference between testing desktop applications and the web is that they do not need access to the Internet [4]. When testing web applications, the same classical methods and techniques for designing tests are applied.

Web-testing involves a number of issues that usually do not arise with traditional desktop application testing. Examples of specialized web-based testing are things like: testing browser compatibility, testing web accessibility, checking for "broken" links, and also tracking messages between the client and the server. Many resources and web development tools are different from those used for other technologies.

Web-applications are a dynamically developing sphere [3]. Not all approaches and methods used to test classic applications can be applicable to testing Web applications. Since the web application is a client, a server application in which the browser acts as the client, and the web server as the server, which is already essentially two different sex programs that need to be tested both separately and in a bundle.

Almost all modern programs are oriented to work with the network. The data storage of web applications is carried out, mainly, on the server, information exchange takes place over the network.

When a user sees an error in the network environment, it is often difficult to accurately indicate exactly where it occurred, and therefore the mode of operation, or the error message that it receives, may be the result of errors that occurred in different parts of the network system.

To organize the testing of the website, a specially developed methodology is provided, according to which the verification is carried out [5].

Having much in common with testing classical applications, testing web-oriented applications has its own peculiarities, primarily related to the environment of functioning. Having component, structural and technological features, web applications are characterized by features of operating modes, speed, start, stop and delete, and the formation of an interface.

Working always with a network and with a large number of users, web applications imply different permissions for different users.

One of the advantages of testing web applications is the fact that clients do not depend on the specific operating system of the user, so web applications are cross-platform services.

Such software products, as a rule, have three levels, you can interact with them using a web browser. Testing websites and applications is complex, testers should consider all the features of the system, check all levels. Levels of web applications are web browser, server, database server. Specialists who perform manual and automated testing know that such products are usually written in programming languages: Java, JavaScript, PHP, Perl, ASP, JSP, VBScript, Cold Fusion.

Users see only the user interface that is displayed in the web browser. All operations are performed on the server, and data is stored on the database server.

Distinctive features of testing of web applications and desktop applications
1 Technology [3].

A classic application works using one or a family of related technologies.

The web application works with fundamentally different technologies.

2 Structure.

Classic application "monolithic". Consists of one or a small number of modules.

ITC, Electronics, Programming

Web application – "multi-component". It consists of a large number of modules.

3 Operating modes.

The classic application works in real time, i.e. It is known about the user's actions as soon as it is completed.

The web application operates in the "request-response" mode, i.e. It is known about some set of actions only after a request to the server

4 Forming the interface.

The classic application uses relatively well-established and standardized technologies to form the user interface.

The web application uses rapidly developing technologies to form a user interface, many of which compete with each other.

5 Working with the network.

The classical application practically does not use network data channels.

The web application actively uses network data channels.

6 Start and stop [3].

The classic application runs and stops rarely.

The web application is launched and stopped upon receipt of each request, that is very often.

7 Number of users.

Classic application: the number of users using the application at the same time is subject to control, is limited and easily predictable.

Web application: the number of users using the application at the same time is difficult to forecast and can change in a wide range over a wide range.

8 Failures.

Classic application: the failure of certain components immediately becomes obvious.

Web application: the failure of some components has an unpredictable impact on the performance of the application as a whole.

9 Installation.

A classic application - the installation process is standardized and maximally targeted at a wide audience of users. Does not require specific knowledge. Adding application components is done in a standard way using the same installer.

Web application - the installation process is often not available to the end user. Installation requires specific knowledge. The process of changing the components of the application is not foreseen or requires the qualification of users. the installer is missing.

10 Uninstallation.

Classic application: the uninstall process is standardized and executed automatically or semi-automatically.

Web application: the uninstallation process requires specific knowledge for the administrator's intervention and is often associated with changing the application environment code of the application, the database, the settings of the system OS.

11 The environment of functioning.

Classic application: the environment of functioning is standardized and does not greatly affect the functioning of the application.

Web application: the operating environment is very diverse and can have a serious impact on the performance of both the server and client part [3].

To ensure high quality of the web application, you should carefully perform:

1 Functional testing.

2 Testing the user interface.

3 Testing for application compatibility in different browsers.

4 Load testing, performance testing and stress testing.

5 Security testing [2].

You need to make sure that the system correctly processes and stores data in different network conditions. User data must be protected from attacks and safely stored.

Usability testing is nothing more than testing the friendliness of the application for the user. When testing usability, it is checked whether it is easy for a new user to understand the application. In general, when testing user-friendliness, system navigation is tested.

The purpose of this test is the usability test, which is verified in the simplicity and efficiency of using the product when using standard usability testing practices.

Functional testing is testing the functionality and operational behavior of a product to ensure that they meet specifications. Testing that ignores the internal mechanisms of the system or component. It concentrates exclusively on the output data obtained in response to user input and scenario execution conditions.

The purpose of the test is to make sure that your product meets the required functional specification mentioned in your development documentation.

Compatibility testing is used to make sure that your application is compatible with other elements of the system in which it is running - for example, browsers, operating systems or hardware.

The purpose of compatibility testing is to evaluate how well the software works in a particular browser, under a specific OS, with other software or hardware.

When testing databases, the backend entries entered through the web or desktop application are checked. The data that is displayed in the application must match the data stored in the database.

Security testing is aimed at finding shortcomings and gaps in terms of application security.

Performance testing is conducted to assess the compliance of a system or component with specific performance requirements.

Common test scenarios:

- 1 Determine the performance, stability and scalability of the application under different load.
- 2 Determine whether the current architecture can support the application at peak loads.
- 3 Determine which configuration leads to the best performance.
- 4 Determine whether the response time has changed for the new version of the application.
- 5 Evaluation of the product and / or hardware to ensure that they meet the projected load volumes.

In general, it is impossible to perform performance testing manually, because it requires a large amount of resources, it is also impossible to perform a number of actions simultaneously, there is no suitable way to track system behavior, falsely perform repetitive tasks.

Complex testing of web applications allows:

- 1 Ensure correct functioning.
- 2 Improve usability.
- 3 Increase productivity.
- 4 Check the safety.
- 5 Ensure compatibility.
- 6 Improve reliability.

Differences between Web testing and mobile applications

1 Mobile applications are designed for more users, more diverse devices than web applications. Although the differences between these two categories of devices are decreasing as more and more web applications become available in mobile formats. A mobile application can run on multiple devices, including a smartphone, tablet, pacemaker, a locking system or a fitness tracker.

2 Web browsers were created permanently. While mobile applications must constantly perform "on the go" computing functions, web applications tend to focus on stationary portable or desktop operations, with classic mouse, cursor, or Wi-Fi router functionality that are less involved in mobile applications.

3 RAM and storage limitations. Many mobile devices still come with 1 or 2 GB of RAM, and also with a relatively small 16 GB SSD. This creates serious limitations for the RAM and the storage capacity for testing.

4 Different interactions for different users. Interactions for computers and laptops have been stabilized for more than 30 years - the mouse and keyboard is the standard for everything from working in Facebook to a flash game. This makes up the characteristics of web application testing. The problem with mobile applications is a wide range of sensory actions - scrolling, pulling, jamming, voice capabilities.

Two sites were tested: <http://www.arngren.net>, <https://lpgenerator.ru/blog/2013/07/09/25-primerov-velikolepnogo-dizajna-internet-magazinov/#25>.



Fig. 1. Example site 1



Fig. 2. Example site 2

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Based on the results of testing the sites presented in Figures 1 and 2, it can be concluded that the site most convenient to use, reliable, attractive, understandable, and easy to manage is the site presented in Figure 2, since site 1 is overloaded with information and inconvenient in use.

Conclusion: Web testing raises a number of issues that usually do not arise with the traditional testing of desktop applications and mobile applications. Examples of specialized web-based testing are things like: testing browser compatibility, testing web accessibility, checking for "broken" links, and also tracking messages between the client and the server.

Testing any application, you need to understand the underlying technologies. You need to know the most appropriate tools and processes that can be used by the development team. There are no common methods for testing Web applications. For different products, their testing features apply.

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UDC 004.4

IMPLEMENTATION OF THE CLIENT PART OF THE MOBILE MMO-GAME IN SPACE STYLISTICS

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The article deals with the formulation of the task for the client part of the mobile MMO-game in the space setting and the concept of building the client application. It also describes an approach to the software implementation of this application for mobile devices running the Android system and the main structural components of the client application.

Introduction. According to statistics in 2017 about 575 million people around the world were playing online games, which is 3% more than in 2016, and according to forecasts by 2021 the number of gamers in the world will grow to 645 million [1]. According to statistics, there are several popular genres: MOBA (Multiplayer Online Battle Arena, "multiplayer online battle arena"), shooters, MMO and MMORPG, strategy, online gambling [1].

Multiuser online games and games in space stylistics have shown their relevance on the example of such popular games for personal computers as EVE Online, Elite: Dangerous, Star Wars: The Old Republic, Star Citizen. Therefore, for mobile device users, a space MMORPG with quest and arcade elements is capable of gaining popularity.

The world of the game is a galaxy that consists of many systems, which comprise a number of planets that revolve around the star. On the planets, the player can take quests, buy or sell goods, improve or repair equipment. The protagonist acts as the captain of the spacecraft on which he moves around the game world. The player will also have a virtual currency which he can use to improve or repair equipment, complete the team, conduct trade, etc. For the performance of tasks and participation in the battles, the player is credited with the experience that is used to improve the characteristics of the character. Fighting with other players will take place in a step-by-step mode. In the game there will be 3 races: green, red, blue. When the game starts, the user can join one of the above races. Depending on the choice, the player will be given starting characteristics.

Game screens. Based on the content of the game in the mobile client, we can pick up the following game screens:

The "Start screen" is the start point for the application. When it starts, all game resources are loaded and initialized. Data can be obtained from both the server and the local cache. After the completion of the preparatory work, the player moves to the "Main Menu" screen.

The "Main Menu" screen allows you to navigate to the "Registration and Authorization", "Settings", "About the application" screens, and also allows you to exit the application.

The screen "Registration and authorization". Log in is possible under Facebook, Google+, Twitter. If the player already exists, the user appears on the planet (the "Planet" screen), which he visited the last time. Otherwise, it goes to the "Create Character" screen.

The Settings screen provides the ability to configure notifications, vibration, music volume and sound effects.

The "About application" screen contains a summary of the current version of the game.

The "Character Creation" screen allows the user to select the name, sex, race and icon of the character. After choosing the characteristics player appears on a random planet in the galaxy.

Screen "Planet". Allows you to switch to the "Store", "Workshop", "Bulletin board", "Bar", "System", "Ship" screens.

The "Shop" screen allows you to buy components for the ship using virtual currency.

Screen "Workshop" allows you to repair and modify the components for the ship.

The "Bulletin board" screen contains a list of the quests available to the player for execution.

The "Bar" screen allows you to hire a team for virtual currency.

The "System" screen represents a number of planets that rotate around the star. The ship is controlled using a virtual joystick in the lower left corner. The speed and maneuverability of the ship depends on its technical characteristics. At any point in the game, you can go to the screens "Galaxy", "Ship", "Radar". When you click on someone else's ship, you can open the screens "Trade", "Fight", "Chat".

The screen "Galaxy" is a mini map of the galaxy and allows you to fly to any system that is available to the user. The range of flight depends on the technical characteristics of the ship and the skills of the team.

Screen "Ship" allows you to view the ship's components, the characteristics of the character and the team, a list of active quests.

The Radar screen is a mini map of the current system.

The screen "Fight". Fighting with other players will take place in a step-by-step mode, the essence of which is reduced to the sequential performance of certain actions, for example, the use of weapons, repair droid, etc.

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The "Trade" screen allows you to exchange goods between two real players.

The "Chat" screen presents a text chat between two real players.

As for the basic functionality, which is not tied to a specific form, we can point out:

- loading and displaying textures, sprites, fonts and particles, building a user interface;
- loading sound resources, playing background music and sound effects;
- Network communication with the server will be carried out using the protocols UDP, TCP and HTTP.

The first is for real-time data transmission, where the maximum speed is important and packet loss is acceptable. It's used interacting with players in the system during the flight. The TCP protocol is used for reliable data transmission, where packet loss is unacceptable. It's used in turn-based combat, performing quests, exchanging goods with other players, text chat, etc. HTTP protocol is used to interact with the server outside the game logic: in-game payments, authorization, registration.

- data storage;
- processing of client-side delays: client-side interpolation, client-side prediction, client move prediction and replay.
- receiving and processing notifications from the server, which inform the user about various events occurring in the game;
- text chat for communication of users during the game;
- purchase of virtual currency for real money;
- integration of bonus advertising (getting any virtual rewards for viewing ads).

Components of the mobile client. To implement the functionality of the mobile client, the MVP pattern (Model-View-Presenter) is selected. It allows you to separate business logic from display, which will facilitate automatic unit testing, editing and code support.

The work with graphics and sound will be implemented using LibGDX, which is a Java framework that provides a cross platform API for developing 2D games and real-time applications [2]. This framework has good documentation, provides a cross-platform API for in-game payments, makes it possible to use both low-level (OpenGL) tools for working with graphics, and high-level, completely free and has open source code.

To work with the network, the Netty framework will be used. This framework is compatible with LibGDX, allows you to work with UDP, TCP and HTTP, has good documentation and is completely free [3]. And Protocol Buffer will act as the protocol of serialization.

Data storage is implemented by the Realm library. The library is a free embedded NoSql database for mobile devices, which has a high speed of operation [4].

Work with notifications, advertisements and social networks is performed through the Firebase SDK, which provides the following tools:

Firebase Cloud Messaging is a cross-platform solution for working with notifications for Android, iOS and web applications, which is completely free.

Firebase Auth is a service that allows you to authenticate via Facebook, GitHub, Twitter, Google or an email address.

Adwords is a service for integrating advertising into mobile applications.

The figure shows a component diagram that represents the partitioning of the mobile client into structural elements.

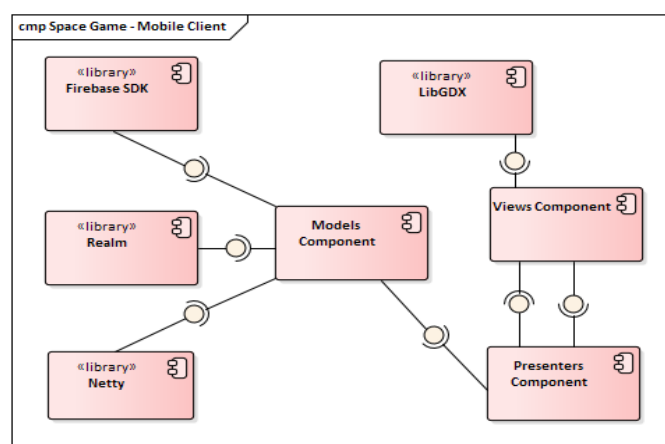


Fig. Mobile client components chart

The conclusion. The task for the client part of the mobile MMO game in the space setting is formulated. An approach to the software implementation of this application for mobile devices running the Android system is proposed. The architectural pattern is MVP. LibGDX was suggested as a tool for working with graphics and sound. Network interaction with the server is carried out with the help of the Netty framework. The storage of local data is realized by the Realm library. Integration with Google services is provided through the Firebase SDK.

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PROTECTION OF INFORMATION TRANSMITTED VIA THE SOAP PROTOCOL.
WEB SERVICE SECURITY (WS SECURITY)

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The article examines the peculiarities of the SOAP protocol, the problems you can face while using this protocol and the methods of their solution. The authors of the article analyse the main modern ways of providing security of the communication process with Web services via the Internet and their realization in the WS Security Standard. The article dwells on necessary measures for providing complete security while using web services.

At all times the process of automatization of different activities is the necessary condition of the development of the society. Nowadays developing the cutting-edge information technologies opens new opportunities for creating new automated systems in all spheres of national economy. Certainly there appear the problems connected with the necessity of increasing the level of security of such systems. Moreover, the choice of methods and means of processing information is defined not only by the importance of the processed information, but also by the composition of automated systems, their structure, the ways of processing information and also by the quantitative and qualitative composition of users and service personnel. Let's consider the system, where the main tasks are the remote compilation and the execution of program code on different web services. The most popular architecture among the modern application developers is the service architecture, because such applications are much easier to maintain and it's easier to solve the problem of zooming, but the problem of security appears, because transmission of data takes place via the net. In this article we are going to regard a variant of a system build, based on the SOAP protocol of transmitting data, and the WS Security Standard.

First of all, let's discuss SOAP. The SOAP (Simple Object Access Protocol) is used for exchanging random structured messages in XML format (Extensible Markup Language) via the cloud computing environment. It can be used with any protocol of an applied level, however more often SOAP is used above the HTTP (Hyper Text Transfer Protocol). Its message in XML format is presented in figure 1 and represents the envelope which contains a header and a body, the body in its turn can contain a fault. Microsoft allows you to use the SOAP Protocol with the help of the WCF (Windows Communication Foundation) [1].



Fig. 1. The Structure of XML Message Transmitted via the SOAP Protocol

Further we will examine three standards of security applied to the XML: authentication, data integrity and data confidentiality. The more detailed diagram is presented in figure 2.

Basic Standart	WS Security		
Basic Mechanisms	Security Token ↓ Authentication	Encryption ↓ Confidentiality	Signatures ↓ Integrity
Constituent Elements	The token profile for the user name.	XML Encryption	XML Signatures
	Profile of the token for certificate X.509	Symmetric Encryption	XML standardization
	Token profile for SAML	Asymmetric encryption	Digest algorithm

Fig. 2. The Structure of Basic WS Security mechanisms

The authentication guarantees that a sender and a receiver are the people who they claim to be, and it proves the authenticity of the sides. It can be realized in different ways. A simple variant is to provide the user's ID and password. A more complicated variant is using the certificate, which contains all the necessary accounting data and is associated with a pair of public and private keys.

To provide the integrity of information, which is exchanged by the sides, and to guarantee that the contents of the message won't be changed or damaged in the process of transmitting data, the data are signed with digital signature (DS) with using the certificate X.509 private key of the sender. Also you can sign SOAP headers of requests to guarantee the integrity of additionally transmitted information.

The third requirement for providing system security is confidentiality. Encryption technology is used to make an exchange of information in requests and web service responses unreadable for strangers. The aim is to guarantee that any attempt to request data while transmitting, in memory or after being saved will require relevant algorithms and security keys for their decryption.

At the moment all these security measures are easily realized and the ways of their realization can depend on the means of transmitting messages or be specific for SOAP protocol. Each of them separately can provide a sufficient level of security but in such cases a system is always at risk. Everyone will have an access to the service without authentication. There exists the possibility of substituting or damaging data without a digital signature. If all the listed above requirements are applied every system can be considered to be secured, whereas the ways of security realization are not so important. Surely there are systems in which you can ignore these rules, for example, if you don't need to restrict an access to a service, you can omit authentication. If the size of a system is limited by sending a request between a user and one point (service), then it is enough to use the HTTPS (Hyper Text Transfer Protocol Secure) and the necessity of encrypting is not needed. The same refers to the digital signature of data, it is not needed if transmitted messages are not valuable or can't damage a system.

Providing integrity, confidentiality and authentication of a message and its sender while maintaining transparency for extension are the main tasks of WS security [2]. It doesn't define any new technologies and is based on existing standards, for example the XML Encryption, the XML Signature, the X.509 certificates and different cryptographic algorithms. Due to the fact that their basic conception is based on message mechanisms, it becomes possible to provide End-to-End Security, for example, by using the Secure Socket Layer protocol instead of the protection aimed at transport. The main standard elements are the following basic mechanisms: security tokens, encrypting, digital signature and timestamps.

Security tokens are applied during authentication and their task is to perform credentials without which authentication is impossible. A user ID and a corresponding password most often perform the role of credentials.

We can give a lot of information on the topic of encrypting but principally we distinguish between two mechanisms of encrypting: symmetric and asymmetric. In the first case a generic key, always available for both sides, is used for encrypting and decrypting; this way is faster. In the second case different keys for encrypting and decrypting are used: a private key remains at with an owner and a public key is freely distributed; this way is

more reliable. Both approaches are often united in the following way: a client who generates a symmetric key, encrypts data of any size by using it, after that the key itself is encrypted with the help of an asymmetric algorithm and is enclosed in a message. Digital signatures are used to confirm the integrity of messages. Due to them you can recognize illegal modifications such as attachment, modification and deletion of data.

In Ws Security this approach is based on the XML Digital Signature standard. The principle of the Digital Signature is based on the creation of checksums with the help of special algorithms, (digests) after that the results are attached to the message and are partly transmitted in an encrypted way.

It's also important to regard the technology of timestamps. The thing is that in terms of the SOA (Simple Object Access) services should perform a definite action in such a way as to maintain an interaction stateless. This peculiarity allows attackers to perform replays, when an attacker sends a whole message again or its separate parts. To be protected from such attacks, it is necessary for a message to have its own unique identifier (Message ID) which a service keeps and takes into account in the following messages.

As a result we can make a conclusion that the SOAP protocol is quite flexible and suitable to use, it allows you to abstract a message with different web services via using their generic interface. Due to the WS Security standard you can provide a sufficient level of system protection against dangers. There has been made a decision to organize a direct communication of a client with web services by using the SSL protocol with a high enough level of security for transmitting data on the Internet directly from the client to the service.

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UDC 007

METHODS OF AUTOMATIC GENERATION OF THE UNIVERSITY TIMETABLE

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The problem of scheduling classes is a usual task at schools, and is fairly trivial, until you want to automate the process of generation. For this task, classical algorithms, genetic algorithms, and neural networks are used.

The class timetabling problem is a scheduling algorithm of great interest, which is connected with the fields of operational research and artificial intelligence. The problem was first studied by Gotlieb, who formulated a class-teacher timetabling problem taking into account that at every lecture there was a group of students and one teacher, so that the combination of teacher and students can be chosen easily. Because of the size of the problem, almost all effective solutions are heuristic in nature, and do not guarantee optimality. Among well-known results there are those that deal with various cases of problem settings. While setting a timetable, importance is given to effective utilization of resources such as classrooms, teachers, etc. This becomes a very tedious task which needs to be performed at least once a year by every academic institution. Most institutions deal with this problem manually, i.e. a trial and error method is used to set a timetable.

Due to the combinatorially explosive nature of the problem, enumeration and other deterministic methods fail and heuristics is preferable. Since the Timetabling problem is a common problem faced in different walks of life, its correlation with other operational research problems cannot be overlooked. For e.g., in scheduling sports timetables, consideration is not only given to scheduling a sport event, but also to reducing the cost factor, distance traveled by teams, etc. The Traveling tournament, where the total distance traveled by the team is minimized, further increased the academic interest in sports scheduling [3].

Timetabling is known to be a nondeterministic polynomial time complete problem i.e. there is no known efficient way to find a solution. Also, the most striking characteristic of NP-complete problems is that no best solution is known. Hence, in order to find a solution to a timetabling problem, a heuristic approach is chosen. This heuristic approach, therein, leads to a set of good solutions (but not necessarily the best solution). In a general educational timetabling problem, a set of events (e.g. courses and exams, etc.) are assigned into a certain number of timeslots (time periods) subject to a set of constraints, which often makes the problem very difficult to solve in real-world circumstances. In fact, large-scale timetables such as university timetables may need many hours of work spent by qualified people or team in order to produce high quality timetables with optimal constraint satisfaction and optimization of timetable's objectives at the same time. These constraints are of two types Hard and Soft constraints. Hard constraints include those constraints that cannot be violated while a timetable is being computed. For example, for a teacher to be scheduled for a timeslot, the teacher must be available for that time slot. A solution is acceptable only when no hard constraint is violated. On the other hand soft constraints can be changed while arriving at a solution. For example, though importance is given to a teacher's scheduling, focus is also made on setting a valid timetable and this can lead to free periods for teachers. Thus, while addressing the timetabling problem, hard constraints have to be adhered, at the same time effort is made to satisfy as many soft constraints as possible. Due to complexity of the problem, most of the work is concentrated on heuristic algorithms which help to find good approximate solutions.

Let's note the requirements on the preparation of the schedule.

When creating a timetable, the problem of optimal resource management arises: the teaching staff and the classroom fund. In the process of solving the problem, it is necessary to take into account mandatory restrictions, as well as additional requirements that may be violated in some cases [1].

Mandatory restrictions include such restrictions as:

- classroom capacity must be sufficient for the groups who are engaged in it, with the possible option when a few groups of students study in the same classroom simultaneously;
- the requirements on the equipment in the classrooms, which is necessary for this or that class;
- teachers from different universities can hold classes only on certain days and hours.

Additional requirements include such requirements as:

- lectures should be delivered at the beginning of the day, practical training is usually at the end of it;

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- study load of each group should be uniform, in order to avoid overwork of students, that is, on those days when there is a lecture on a subject that is considered hard, the remaining classes should be relatively simple;

- students should not have free periods in their timetable, at the same time there may be a free period for the teacher;

- if possible, teachers at the university should be provided with days free of classes;

- on Friday, the number of classes should be less than on other days of the week;

- the first lesson on Monday should be relatively simple, otherwise the student's progress may be significantly reduced.

It is important to note that the presented requirements are not common for all educational institutions. This list can be changed or supplemented.

Heuristic optimization methods are explicitly aimed at good feasible solutions that may not be optimal in cases where complexity of problem or limited time available does not allow exact solution. Generally, two questions arise: how fast the solution is computed and how close the solution is to the optimal one? Tradeoff is often required between time and quality which is reached by running simpler algorithms more than once, comparing results obtained from more complicated ones and effectiveness of comparing different heuristics. The empirical evaluation of heuristic method is based on analytical difficulty involved in the problem's worst case result. In its simplest form the scheduling task consists of class mapping, teacher and room combinations (which have already been pre-allocated) onto time slots. [3]

The problem of scheduling in educational institution can be divided into three main blocks: data preparation, scheduling, schedule approval. Input of the first block "data preparation" includes: disciplines in the curriculum, groups, classrooms, information on teachers and types of activities. Also at this step, the wishes of the teachers should be taken into account. The "data preparation" block supposes processing and structuring of the entered data. After that the data are transferred to the block "scheduling".

The scheduling unit can be implemented in various ways.

Consider the classic algorithm for scheduling on the basis of the data entered. The following steps should be performed:

- making the list of classes;

- finding free time slot for the lesson in the timetable;

- sorting the list of classes to increase the ease of their placement in the timetable;

- search for the most suitable time and place for the lesson;

- assessment of the quality of the timetable.

When estimating the ease of the lesson placement in the schedule:

- the number of classrooms suitable for the lesson, based on the equipment required and the number of workplaces;

- the number of lessons, conducted by a teacher per week;

- the number of lessons per week for a given group of students.

While sorting, first of all, the lessons with the least ease of placement are included in the schedule. When you add classes to the schedule, you search for the most suitable classroom and time for it. To do this, you need a full range of options, including space (classrooms) and time (time of the class, day of the week). In the process of possible variants estimation, hard constraints are checked first. If mandatory requirements are met, additional criteria are taken into account. Each of the criteria for assessing the quality of the lesson placement in the timetable should be considered as a separate specialized function with a weighting factor that reflects how important this criterion is. Flexibility and adaptability of the algorithm is achieved due to the ability to supplement the list of quality criteria without significant changes in the code. After evaluating the quality of all possible variants of the lesson placement in the schedule, the option with the maximum value is selected.

To improve the quality of the obtained schedule, the main algorithm for scheduling can be improved. In view of the availability of a set of tuning coefficients of the algorithm presented in the form of weights, it is possible to use a genetic algorithm. Thus, the tuning coefficients of the scheduling algorithm should be used as genes. As a result of the mutations, new sets of tuning coefficients will be obtained and as a consequence, the results of the algorithm will be different. The goal of the algorithm will be to achieve the maximum value of the quality of the schedule quality, which can be determined as summarized quality of each individual position.

The presented algorithms are not the only solution to this problem. At the moment there are many fundamentally different algorithms for scheduling classes, both classical and genetic. Also, the self-organizing feature map is used for scheduling, which is a method of projecting a multidimensional space into a space with a

lower dimension (most often, two-dimensional), it is also used to solve modeling problems, forecasting, identifying sets of independent features, searching for regularities in large data sets.

Despite the possible reduction of human efforts spent on scheduling, these algorithms are rather cumbersome, and do not always provide sufficiently effective results. Thus, it is most advantageous to use algorithms to approximate the distribution of classes at the beginning of the work, and then to edit the obtained schedule manually to achieve the desired result and to take into account any additional criteria, or to use algorithms to complete the schedule partially compiled by hand.

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SOFTWARE FOR SCAN BANK CARDS IN IOS MOBILE DEVICES

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In this article we propose the preprocessing algorithm for identifying information fields on the bank cards images. Bank cards details recognition software for iOS mobile devices, iPhone SDK frameworks, OpenCV and Tesseract libraries is implemented based on this algorithm. Results of the time cost for bank cards details recognition on the iPhone7 for video with different sizes of the input frame are presented.

Nowadays many M-banking apps require manual entry of bank card details (all information fields data applied on the card) into the system for payment transactions and it is not an easy task for a user. This process is time-consuming, requires attentiveness and diligence. Therefore, development of the algorithmic provision and software for recognition of bank card details for iOS mobile devices is relevant.

Offered recognition algorithm of bank card details for iOS mobile devices requires the following steps: card region detection; segmentation of the bank card image; converting colored segments to grayscale; contrast enhancement; emphasizing the boundaries of symbols using operations of mathematical morphology; adjusting the boundaries of the grouped blocks of symbols; recognition of symbol blocks by the Tesseract library. General scheme of the developed algorithm is shown in fig. 1.

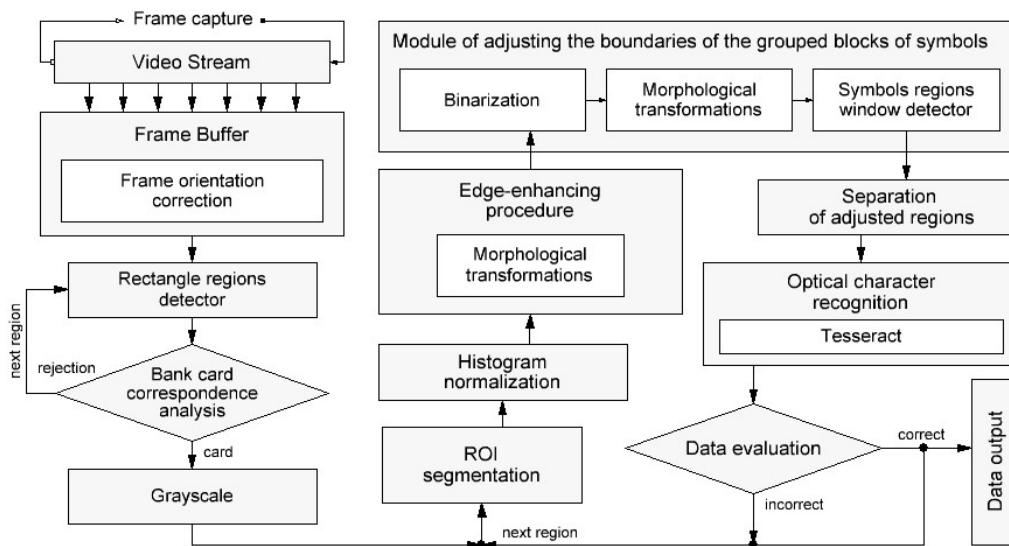


Fig.1. General scheme of the developed algorithm

The input data of the algorithm is video stream received from the mobile device's camera. The stream is divided into frames by time and represents images in the RGB color space. Considering characteristics of the iPhone 6 (2014), the camera has an 8-megapixel CCD, dual-LED flash and autofocus. The frame sizes can vary depending on the particular device model, and can reach 3840 × 2160 pixels. All devices younger than the above have better characteristics. The operating system (greater than iOS 2) is capable of automatically holding the focus on the subject, automatically adjusting the brightness and white balance in the photo. The above indicates that the image coming directly from the camera system will have the optimal input parameters: depth of field, brightness, sufficient frame size for accurate perception the details of the bank card.

Separation of the bank card image from the background is carried out by processing it with iOS algorithms, which are based on the Viola-Jones high-speed object detection method [1] and deep learning using the OverFeat method [2].

The main criterion for selecting a contour of the bank card from the set of detected rectangles R , where the number of rectangular areas found- N , is the ratio of its sides. Since dimensions of the card sides ($m_o \times n_o$) are defined by ISO / IEC 7811-1: 2017, the ratio of its sides is a constant value $\frac{n_o}{m_o}$. At first we represent the object of the found rectangle r_i as $R_i(m_i, n_i)$, where $i=0, 1, \dots, N-1$. Then the rectangles r for which this condition (1) is satisfied belong to regions of interest. The exact match is the rectangle with the longest side n_{max} among all selected.

$$\frac{n_i}{m_i} = \frac{n_o}{m_o} \quad (1)$$

Dimensions of the rectangular region $r_o(m_{max}, n_{max})$ and its location relative to the whole image $p_o(x_o, y_o)$ are used to extract the card region from original frame.

Regions of algorithm interest, containing information about the bank card number, the expiration date, the cardholder's name, are being separated from the card image I with sizes $m_{max} \times n_{max}$ (further as $m_i \times n_i$). The size and location of these regions are defined by ISO / IEC 7811-1: 2017 and can be written in the following presentation:

- region $C(x_C, y_C, n_C, m_C)$ - the bank card number;
- region $D(x_D, y_D, n_D, m_D)$ - the expiration date;
- region $E(x_E, y_E, n_E, m_E)$ - cardholder's name.

Since the sizes $m_i \times n_i$ of the obtained image of the card I can vary, it is necessary to convert C , D and E to the form that will be applicable for their correct separation from the image I . To this end, it is necessary to define two scaling factors: by width (2) and by height (3).

$$C_{scale.width} = \frac{n_I}{n_o}, \quad (2)$$

$$C_{scale.height} = \frac{m_I}{m_o}, \quad (3)$$

Multiplying each of regions parameters indicated above by corresponding scaling factor, we obtain the sizes of these regions relative to the size of the obtained image of the card I .

$$\begin{aligned} C_I(x_C \cdot C_{scale.width}, y_C \cdot C_{scale.height}, n_C \cdot C_{scale.width}, m_C \cdot C_{scale.height}) \\ D_I(x_D \cdot C_{scale.width}, y_D \cdot C_{scale.height}, n_D \cdot C_{scale.width}, m_D \cdot C_{scale.height}) \\ E_I(x_E \cdot C_{scale.width}, y_E \cdot C_{scale.height}, n_E \cdot C_{scale.width}, m_E \cdot C_{scale.height}) \end{aligned}$$

Separating fragments of regions C_I , D_I , E_I from the image of the bank card I , we obtain images: I_C , I_D , I_E , respectively, the card number, the expiration date and the cardholder's name.

According to ISO / IEC 7810 - 2006, the bank card number contains 16 digits distributed into 4 equal groups of 4 digits each. Based on this fact, the image I_C selected in the previous step with the card number region C_I is being divided into 4 equal regions C_{I1} , C_{I2} , C_{I3} , C_{I4} (4).

$$C_{Ij}(x_{CI} + (\frac{n_{CI}}{4} \times (j - 1)), y_{CI}, \frac{n_{CI}}{4}, m_{CI}) \quad j = 1, 2, 3, 4 \quad (4)$$

Separating the calculated regions C_{I1} , C_{I2} , C_{I3} , C_{I4} from the image I_C , we obtain respectively the images I_{C1} , I_{C2} , I_{C3} , I_{C4} - groups of the card number.

The next step is to convert the image to grayscale. After that, to increase the brightness difference between the symbol contours and the background of the images, a procedure of contrast increasing is used. The most effective for this task is method of histogram normalization, since it does not stretch the entire intensity range, but only it's most informative section. This allows us not to consider the true extremal values of the

brightness and to designate conditions for their determination with a given accuracy, which enhances the contrast effect due to the loss of noise regions with rarely encountered intensities [3].

To determine the tone of the background and the tone of the symbols we calculate the average brightness of the image $Y_{aver.}$: If $Y_{aver.} > 127.5$, then we take the background color of the received image as light, and the color of the symbols as dark, otherwise - vice versa. Using operations of mathematical morphology, the boundaries of symbols are emphasized. If the color of the characters is light, the WhiteTopHat morphological transformation function [4] is used. For dark symbols, the BlackTopHat function is used.

The structuring element for the kernels of both filters has a rectangular shape and a size of $n_b \times m_b$, calculated by the formula (5), where n_i , the width of the image received for the morphological transformation.

$$\begin{aligned} n_b &= n_i \cdot 0.06 \\ m_b &= \frac{n_b}{3} \end{aligned} \quad (5)$$

The next step is the binarization of images with an adaptive threshold based on the analysis of the local region [5, 6]. The method converts the image in grayscale I to a monochrome image according to (6).

$$bin_{x,y} = \begin{cases} g_{max}, & \text{if } Y_{x,y} > T(Y_{x,y}, block_size, c) \\ 0, & \text{else} \end{cases} \quad (6)$$

where $Y_{x,y}$ is the brightness value of the pixel with the (x, y) coordinates of the image I ; $g_{max}=255$ is the maximum brightness value, $T(Y_{x,y}, block_size, c)$ is the adaptive binarization threshold, calculated individually for each pixel; where the function T - is the weighted sum [5] (cross-correlation with the Gaussian window, Gaussian (7) [6]) of a block of pixels with size $block_size \times block_size$ adjacent to the processed pixel (with coordinates x, y) minus the coefficient c [5].

$$G_i = \alpha \cdot e^{-\frac{\left(i - \frac{(block_size - 1)}{2}\right)^2}{2 \cdot sigma^2}}$$

where $i=0 \dots block_size-1$,

$$\alpha - \text{is chosen in such a way that } \sum_i G_i = 1 \quad (7)$$

To reduce noise, to remove unnecessary non-informative details from the binarized image, and roughly approximate the symbols to isolated painted blocks different from the background of the image, successive morphological operations of closing and erosion are applied to it.

Structuring element b of the kernels of both filters has an ellipse shape, which is better suited for processing characters which font, OCR-B, according to ISO / IEC 7811-1: 2017, has smoothed edges. The size of the kernels $n_b \times m_b$, where n_b - should not exceed the size of a third of the thickness of the symbol $\frac{w_{symb}}{3}$

otherwise there is a probability of losing the symbol outline during processing.

The thickness of the symbol w_{symb} does not depend on the type of the processed fragment of the card image, and is strictly defined for OCR-B. The projection of the font width value (mm) to the size in pixels relative to the size of the full bank card region is calculated based on its full width (8), and is a constant within the processing of the current card region.

$$w_{symb} = n_0 \cdot 0.004884 \quad (8)$$

To adjust the edges of the symbol region on the processed image, the vertical sliding window method is used. The height of the window varies from the font size of the characters. For the bank card, these are values determined by ISO/IEC 7811-1: 2017, H_{cn} - card number font height (4,0mm), H_{exd} - expire date font height (2,85mm), H_{hn} - cardholder's name font height (2,65mm). Then their projections onto a height in pixels relative to

the size of the region of the full card are: h_{cn} , h_{exd} , h_{nn} . The general form of the calculation is represented by formula:

$$h = \frac{H \cdot m_0}{54.0} \tag{9}$$

where 54.0 mm is the height of the card according to ISO 7810 ID-1, and m_0 is the height of the detected region of the card (px).

Images are sequentially transmitted to the input of the Tesseract system for recognition, with parameters: the adjusted symbol area obtained in the previous step; language.

The proposed algorithm is implemented in the Objective-C programming language, using the OpenCV 2.4.13 library (this version is the most relevant for iOS), with the help of the iPhone SDK frameworks, such as: CoreMedia and AVFoundation - media data management; UIKit (UI) - work with application interfaces; CoreGraphics (CG) - low-level, lightweight processing of 2D images based on the Quartz engine.

The mobile app interface (fig. 2) is equipped with an image viewing area, captured by a mobile device's camera in real-time, a data output area, a mark of successful fixation on the recognition object. The capture area has a proportion of 4:3, which is the standard for a vertically oriented iPhone/iPad. The data output area contains three vertically arranged text fields into which the information recognized by the algorithm (the bank card number, expire date, cardholder's name) is sequentially displayed. The card detection mark is made in the form of a bright green rectangle with fixed thickness of borders and is displayed on the screen by repeating its boundaries when the card position is successfully determined. The capture of the video stream from the main camera of the device is implemented in separate thread using the AVFoundation framework and the AVCaptureDeviceInput object, which is initialized by the AVCaptureDevice object in the video capture mode. A new session of AVCaptureSession is being created, with the frame size parameters (for iPhone 7, the maximum size is 3840 × 2160). Using the addInput method, a previously defined input object is added to it and via the call startRunning - the session starts. The frame data is retrieved using the didOutputSampleBuffer: from Connection method, which shows the frames in the current context of the view controller using AVCaptureVideoDateOutput. The results of the time consuming estimation of the algorithm were run on the iPhone 7 for video with different sizes of the input frame (fig. 3).



Fig. 2 - Appearance of the mobile app:
 1 – the image viewing area; 2 – the mark of successful fixation of bank card;
 3 – the data output area

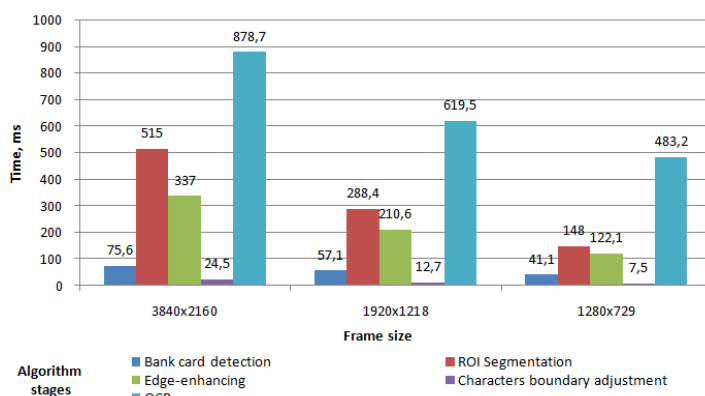


Fig. 3 - Time consuming bar graph

Conclusion

In this article, the task of recognizing information fields of bank cards is solved. The developed algorithm represents the processing of the sequence of frames received from the mobile device's camera and includes: bank card detection using the Viola-Jones high-speed object detection algorithm and the OverFeat method; ROI segmentation; improving the quality of symbols using the method of histogram normalization and morphological

transformations TopHat; adjusting the boundaries of symbols using the binarization with the adaptive threshold, performing morphological transformations on the results and searching for the most suitable region using the vertically sliding window. Recognition of adjusted regions is implemented by the Tesseract library.

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THE DEVELOPMENT OF GRAPHICAL USER INTERFACE OF AUTOMATED DISPATCH CONTROL SYSTEM

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Process control and equipment management requires operator to have a high reaction speed, rapid response capacity and ability to analyze a lot of information in a short time to make the appropriate decision. Automatic dispatch control system (ADCS) allows to simplify management process and make operator's work more efficient. ADCS provides an interface to the operator, which allows the operator to interact with process plant in more intuitive way. In most cases the interface is a graphical user interface. In this paper, an example of graphical user interface design of ADCS of electric power distribution system is presented as well as the underlying principles of graphical user interface design.

Automatic dispatch control system – is a control system that uses computers, networked data communications for high-level process supervisory management and other peripheral devices such as programmable logic controllers and discrete PID controllers to interface to the process plant or machinery. ADCS allows to interact with process plant through high-level interface, which is usually graphical user interface (GUI).

The reason why software giants have spent a lot of resources developing the best user interface (UI) and user experience (UX) is because they've done the research and recognize the real benefits of implementing good design [1]. Success and speed of operator's work largely depends on UX. Ill-conceived UX could lead to frequent delays and mistakes of operator. Because GUI in most cases is the main user interface of ADCS, it largely determines UX. In most cases the reason of UX ineffectiveness is the ill-considered GUI. Ultimately, providing reasonable GUI with ADCS software that makes the operators' job easier, allowing them to catch errors and resolve them immediately, minimize timewasting traps, save millions in machine damage and lost productivity cascading down the manufacturing process.

There are primarily six principles which can be used as the guidelines for user interface design [2]

1. **User familiarity:** the purpose of screen elements should be clear and understandable without prior training; permissible manipulations with these elements should also be intuitively understood. The user interface should not contain too much detail;

2. **Consistency:** A user with experience with some software can quickly adapt to any similar software. It also refers to different operations in the context of one program: the skills learned from one operation can be easily applied to other operations;

3. **Minimal surprise:** means that the comparable operations should incur the comparable results. If this does not happen, the users will become confused and frustrated, and even raise the doubt on the software design quality;

4. **Recoverability:** The system should not be sensitive to operator errors. The operator must be able to cancel any of his actions. For this purpose multiple confirmations, cancellations, backtracking, setting of control points, etc. are used;

5. **User guidance:** A well-designed help system is highly necessary. It should be incorporated and become a built-in component of the overall system. Also, comprehensive search and index tools should be provided to make the user query more convenient.

6. **User diversity:** A novice user should have a simpler interface with more tips. For an experienced user, the number of prompts should be reduced, as they interfere with work.

To implement the principles, the following components are used [3]:

• **Color and contrast:** Color and contrast often communicate before all other visual factors like text are taken into account. Color is used to convey instant meaning to objects, to draw attention to specific places that may need focus, and to distinguish items from each other. To create an interface that corresponds to the principles indicated above, you must select a color palette and assign each individual color with your own meaning. For example, red color means that an alarm has been triggered, or a power line is emergency shutdown. Operators must memorize the designations for each color, and therefore having a standardized set of colors will decrease confusion and speed up data interpretation.

Color contrast between lighter and darker tones can be used to make one object stand out compared to its surroundings. The greater the contrast between two colors is the more noticeable and legible it becomes.

• **Layout:** Layout gives operator a frame of reference for how they should interact with an environment. Layout refers to how buttons, diagrams, and other elements are laid out on screen in an organized fashion.

• **Navigation:** every ADCS software needs well-designed navigation to give users access to critical information quickly and intuitively. Basic rules include:

- o A hierarchy should be consistent
- o The navigation bar should be in the same place on all screens
- o A process overview should provide quick access to any part of the system

Ideally, with a well thought-out, consistent navigation system, someone without training but familiar with the plant should be able to navigate to any part of the ADCS without heading down dead ends.

• **Typography:** Typography refers to the use of fonts, font sizes, and font styling to convey meaning. Use of typography can be used to emphasize and de-emphasize content – such as by increasing contrast and boldness for important alerts, displaying hints with plain text, and using certain heights and colors for headings and subheadings.

• **Iconography and imagery:** Right image or icon could convey more information than a thousand words. However, large images are not recommended in industrial systems because screen real estate is precious and loading times can reduce speed. Instead, intuitive icons and shapes are preferred. A good icon should be simple, easy to read at different sizes, and clear in meaning.

• **Feedback:** To reach effective communication between operator and ADCS interface, it's important that the operator knows if the program understood him. Operator usually cannot see the plant and therefore needs to receive feedback that what he did had an effect.

On Fig 1. below graphical user interface of the system being developed is shown.

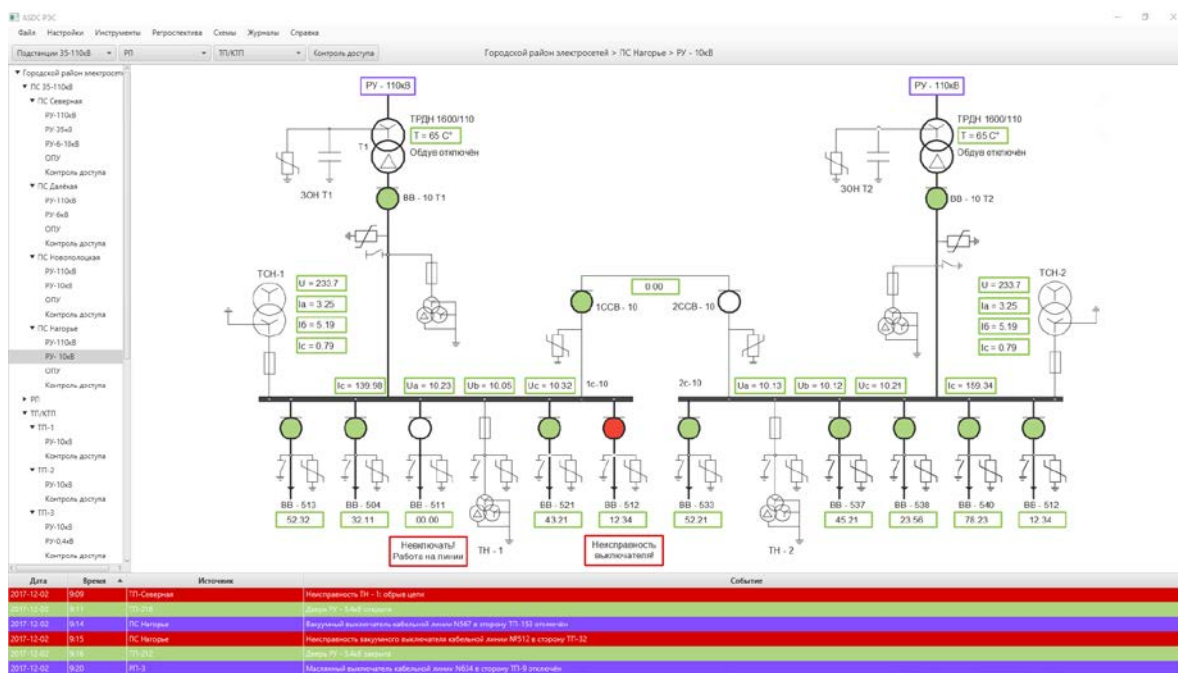


Fig. 1. Graphical user interface of the system being developed

GUI of ADCS consist of several parts: mnemonic diagram, units list, events box. Mnemonic diagram in the center of the screen is the main part of any ADCS or SCADA software. It displays information about the monitored process in real time and allows the operator to maintain normal system state. It was created in such a way to be much similar to power engineering drawing so that every engineer could understand it without prior training. Mnemonic diagram's color palette consist of four main colors. Light green color indicates that circuit breaker is on. Also it indicates an acceptable value of the controlled parameter. Boxes with light green border indicate that value of the controlled parameter inside the box in the normal range. If actual value deviates from the specified critical value, box borders become red. Red color indicates failures. Blue color is used to highlight jump points to other parts of mnemonic diagram. All power lines, busbars and other equipment are shown in black.

Primary equipment lines have a greater contrast than lines of secondary equipment. That allows operator to focused on most important parts of power system.

On the left of the screen there is a unit tree list. It is used for navigation purposes. Every power station, substation and switchgears are presented here hierarchically to allow operator to be aware of which point of the power supply system is shown in the center of the screen now so that he could jump to any other as quickly as possible.

At the bottom of the screen, the events box is displayed. It displays messages about controlled object state. There are three types of messages: notification message, normal state change messages and alert messages. Notification message notify operator about normal usual events in the power system, such as closing substation door or receiving acceptable value of the controlled parameter. Normal state change messages indicate normal changes in power system and provide feedback to operator when he changes power system state. Alert messages signal an accident for example equipment failure. Each message type has its own color: light green for notification message, blue for normal state change messages and red for alert messages. This color palette allows operator to distinguish messages by priority instantly and focus on the most important.

Adherence to the principles stated above allow us to create GUI for industrial software that is easy and even fun to use. Easiness and fun are important because they tangibly affect the operator's ability to control the process and respond quickly when things go awry. And over time, the engagement and performance of well-designed systems provide positive returns in decision-making speed and accuracy, plant productivity, and reduced training time.

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SIGNAL PROTOCOL FOR END-TO-END ENCRYPTION

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Many people merrily go about their life without worrying at all about encryption. Posting photos on Facebook and Instagram, Snapchat, and sharing private information over a multitude of messaging apps seems so natural to most millennials! Why should we even care that most of these apps do not implement end-to-end encryption? What is end-to-end encryption, and how does it work?

Implementing end-to-end encryption in a messaging service means that the contents of any given message are only available to you (the sender) and your friend (the intended recipient). Without E2EE, your message may be encrypted while it's being transmitted to the server, but the server might be able to read it. For example, some service providers might do this to generate ads that are more specific to a user.

With E2EE, your message is encrypted at all times as it makes its way through any possible intermediaries. No one except the intended recipient has the key to decrypt it. With a good E2EE protocol, neither intermediaries (messaging app server, database), nor anyone with malicious intents would be able to read the messages you send. With the amount of sensitive information, we might be sharing via text/instant messages, this is becoming an important issue. Signal - target for analyzing, a messaging app by Open Whisper Systems

The first step in establishing an end-to-end encrypted connection between two users using Open Whisper System's Signal Protocol is generating a set of long-term identity key pair, medium-term signed prekey pair, and several ephemeral prekey pairs. These keys are generated on the client side and stored locally somewhere secure. The second step involves packaging all of the public keys and registration ID into an object (known as the "key bundle") and registering it with a Key Distribution Center. In order for USER1 to send messages to USER2, USER1 must know and have access to USER2's registration ID and public keys to start a session. Thus, USER1 must first generate her own keys and register herself with the key distribution center and request USER2's key bundle.

Once a session is established, USER1 can start sending messages to USER2. This process relies heavily on the X3DH key agreement and is what gives Signal Protocol the ability to provide forward secrecy and cryptographic deniability. This also has an additional benefit of asynchronicity and thus the ability of sending messages while being offline. While the session is active, USER1 encrypts and sends messages to USER2 using the master shared secret and USER2's ephemeral keys. This step creates a root key, a corresponding chain key, and a message chain. These are critical for maintaining forward secrecy and privacy. Thus, each message that is sent leads to the creation of a new set of one-time session (ephemeral) keys that are then used to encrypt/decrypt any future messages.

On a higher level, the Signal Protocol is a security library on steroids. Despite its novelty and growing importance, there has been few formal analyses of this protocol, whilst it has been a driving force in the world of cybersecurity.

The Signal Protocol amalgamates the Extended Triple Diffie-Hellman (X3DH) key agreement protocol, Double Ratchet algorithm, pre-keys, and uses Curve25519, AES-256, and HMAC-SHA256 as cryptographic primitives. These are all well-established, low-level cryptographic algorithms that are frequently used to build computer security systems.

X3DH kicks things off, by generating all the necessary keys between two parties to communicate. It establishes the crucial shared secret key between the two parties who mutually authenticate each other based on their public key pairs. X3DH also allows for key exchange to occur where one party is "offline", and will instead exchange it through a third-party server [1].

This is used as part of a cryptographic protocol to provide E2EE based on a shared secret key derived from X3DH. Once both parties agree on a shared secret key via X3DH, parties can then use the Double Ratchet Algorithm to send and receive encrypted messages.

Double Ratchet Algorithm is used as part of a cryptographic protocol to provide E2EE based on a shared secret key derived from X3DH. Once both parties agree on a shared secret key via X3DH, parties can then use the Double Ratchet Algorithm to send and receive encrypted messages [2].

The key exchange from X3DH outputs a master secret, which in turn is used to derive two symmetric keys: "root key" and "sending chain key". As messages are being sent and received, these keys that are attached

to the messages continuously change via KDF. When USER encrypts her message for USER2, he advances him sending chain by one step, deriving a replacement sending chain key, along with a message encryption key. When he receives a message from USER2, he advances him receiving chain to generate a decryption key. The root chain is advanced when the session is initialised, which generates an ephemeral key (“ratchet key”). Then attaches this to his messages, so that each message carries a continuously changing ephemeral key, therefore making it impossible for third party snoopers to decrypt previous and future messages [3].

Given USER2’s 32-byte private key, Curve25519 generates his 32-byte public key. Given USER2’s 32-byte private key and USER1’s 32-byte public key, Curve25519 generates the master secret key shared by the two parties. The secret is subsequently used to authenticate and start encrypting messages between them. This algorithm was carefully designed to allow all 32-byte strings as Diffie-Hellman public keys. The Signal protocol leverages Curve25519 for all asymmetric cryptographic operations [4].

AES-256 is a symmetric block cipher to protect and encrypt sensitive data. This cipher encrypts and decrypts data in blocks of 256-bits. Symmetric ciphers use the same key for encrypting and decrypting data, therefore USER1 and USER2 must both know, and use, the same secret key. There are a total of 14 rounds of 256-bit keys — one round consisting of several processing steps that include substitution, transposition, and randomly mixing the plaintext (before encryption) to output a ciphertext (encrypted text) [5].

HMAC-SHA256 is a specific type of message authentication code involving a cryptographic hash function and a secret cryptographic key. It also verifies the data integrity, as well as the authentication of a message. This type of keyed hash algorithm is constructed from the SHA-256 hash function. This algorithm mixes a master secret key with the message data, hashes the result with the hash function then mixes that hash value with the secret key again, and finally invokes the hash function again. The output hash is 256 bits in length.

Thus, it is offered to consider independent retests as casual process with discrete time. The method of the moments established an asymptotic of process 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 is defined. It is shown that the last cannot be applied, for calculation of probabilities of numbers of progress far from the most probable values.

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DETECTION OF PHISHING AND TRACKING SYSTEMS IN EMAILS USING NEURAL NETWORKS

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This paper describes techniques and mechanisms built on the basis of neural networks that will help in the identification of phishing and tracked emails.

Currently, almost every Internet user uses an e-mail to register on various services, exchange corporate information and for other needs. An e-mail is a cheap and convenient way of communication between people. However, it can be used to access personal user data, as well as fraudulent activities such as phishing [1].

The principle of work of most tracking services is based on the injection of some picture in the email body that is located on an external server. When the recipient opens the email, a request is sent to the tracking service. In the response the text that is loaded by the browser or the client application of the user comes, at this moment images, styles and other elements of the HTML page from external servers are downloaded, one of which can be a tracking service [2].

Phishing is one of the problems of a modern network, it is a fake Web-site by which cybercriminals steal confidential information about a user without their knowledge (for example, the name, the password, the bank or card information, etc.). The purpose of attackers when creating a phishing URL is to deceive users, resulting in a fake resource that will receive the personal and financial data of the victim [3].

Most of the existing systems for detecting phishing resources use the following approaches to be safe from this type of threat:

- "Black list" approach. Determine if the requested URL is in the list of malicious resources. The drawback of this approach is that a black list cannot normally cover all phishing and tracking sites. Since the creation of a fraudulent website, it may take a long time before it is added to the list. And this time gap between starting and adding a suspicious website to the list can be enough for tracking systems.

- Heuristic approach meets several related website metrics to classify it as a phishing or this website. Unlike the "black list" method, using a real-time heuristic approach, you can recognize newly created fake Web sites.

Based on bellow, an heuristic approach was used to develop software to identify phishing sites or e-mail tracking systems. All references to objects that contains URLs to third-party resources (images, buttons, styles and other objects) are transferred to a system that as a result of its work determines whether the site is real and does not contain any information that will help track the message, or the investigated resource is phishing. To implement this algorithm, neural networks were used in addition to such systems as Google PageRank and Alexa rating.

In this paper, we used 14 different metrics, which will be used to create lexical and statistical analysis of URLs (Fig. 1):

- Presence of a domain in Alexa Rank, Google Page Rank.
- Domain length, subdomain length, path length. Phishing resources try to use a domain similar to the current resource.
- Entropy of URL address. The higher this value, the more complex the URL. Because the URLs of phishing resources have random text, you can try to find them by their entropy.
- The ratio of the length between parts of the address.
- Some service defined symbols (about 5 metrics) - like '@' or '!'.
 - Number of suspicious words, Euclidean distance, Kolmogorov-Smirnov statistics, Kulbak-Leibler divergence.

When choosing neural networks, we select recurrent neural networks (RNN) – this is a type of network capable of simulating consecutive patterns [4]. A distinctive feature of RNN is the concept of time for the model, which, in turn, allows you to process sequential data on one element at a time and study their successive dependencies [5]. The limitation of RNN is the inability to recognize the correlation between elements of more than 5 or 10 steps from each other. The model that overcomes this problem is LSTM [6]. Therefore, LSTM blocks

were used to build a model that receives the URL as an input parameter and predicts whether the URL corresponds to a phishing event or a monitored service (Fig. 2).

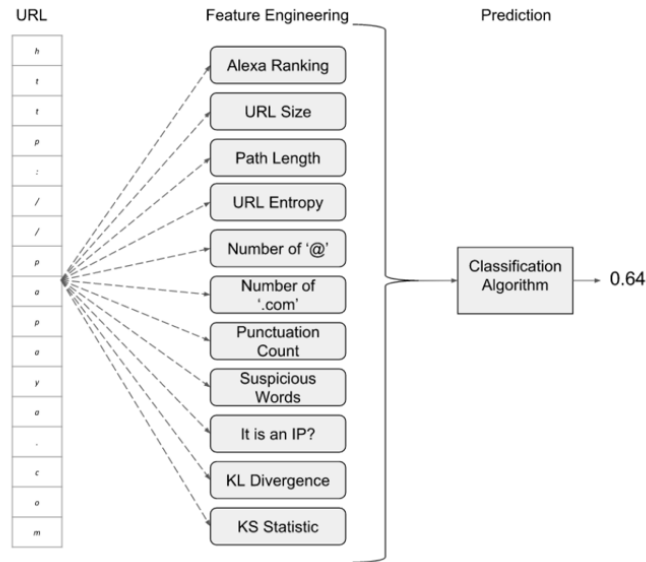


Fig. 1. The approach used to classify phishing URLs

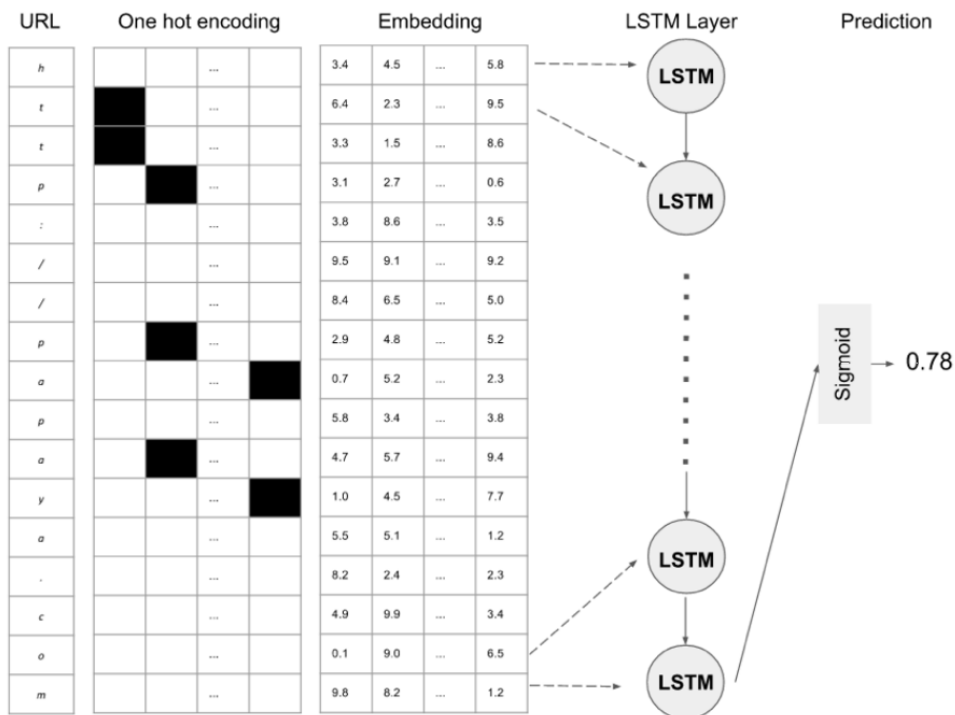


Fig. 2. Neural network for classification of URLs of phishing based on LSTM blocks

After training the neural network using two million different URLs that contained 5% of phishing sites, the implemented software passed the test, which resulted in the indicators shown in Table 1.

Table 1. – Results of the operation of the system based on LSTM

Fold	AUC	Accuracy	Recall	Precision	F1-score
0	0.999044	0.9871	0.991114	0.983203	0.987143
1	0.999106	0.987921	0.989549	0.986359	0.987952
2	0.999141	0.987844	0.98716	0.988506	0.987833
Average	0.999097	0.987622	0.987622	0.986023	0.987642
Std dev	4e-05	0.00037	0.00037	0.002178	0.000357

After analysing the results, we can conclude that parsing the URL by their samples is a good way to detect phishing sites and email tracking systems. Creating a system to secure against phishing and tracking systems based on URLs recognition is much faster and more efficient than full-text analysis. LSTM can evaluate URLs with the speed of 942 addresses per second. The LSTM model uses only 581 KB of memory to process the test data set. It is a crucial moment while installing the software into the systems with a limited access and the amount of resources.

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SOFTWARE FOR PROTECTING CORPORATE NETWORK FILES USING STEGANOGRAPHIC PRINTS

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Digital prints in confidential files of the company allow determining the membership to the company and the owner of the signed files without having to check the contents. A software tool that enables the introduction of digital prints when employees access confidential campaign files allows to increase the degree of protection of intellectual property contained in digital files, and the development of this software is topical.

Introduction. One of the threats to information security of an enterprise comes from insiders [1, 2]. Insiders are employees who are within the corporate network, and have some access to corporate servers and workstations [1]. Insiders include the members who misuse their privileges and perform the role of a privileged user [1]. The definition of an insider also includes incompetent employees who unintentionally violate established information security rules.

The leakage of confidential information in the form of documents for internal use, training materials, other intellectual property objects to open access or to competitors through insiders causes significant material and non-material damage to the company. The leakage of digital files is carried out through various channels and to ensure a channel protection is not always possible due to the complexity and high cost of building a security system.

One of the effective means of protecting vulnerable company files is digital marking of the files that can be accessed by insiders. Digital prints in files provide the possibility to identify them without checking the contents that can be used to detect the leak of confidential information as well as the leak channel and to protect files from unlicensed use [2].

The main disadvantages of the existing implementations [3–9] of steganographic signing tools are a limited set of supported container formats and confidential information about the algorithms used to create a digital print, which does not allow to conclude that it is protected and stable. The advantages include the unique service for searching for the signed files in the open access and the comprehensibility of the programming interface. The need to develop a software tool for protecting corporate network files using steganographic prints is caused by the closure for changes in the existing commercial implementations and the need to integrate the software with the hardware and software environment of the corporate network and the security management system.

Corporate network. In general, a corporate network built on hardware and software consists of the following functional elements [1]:

- workplaces (subscribers);
- information servers intended for storage and processing of information arrays (databases) of various functional purposes;
- means of telecommunication that provide interaction between workstations and their interaction with information servers;
- security management system of a corporate network.

One of the methods for automating the processes of analyzing and controlling the security of the distributed computer systems is the use of the intelligent software agent technology, which is built on the console-manager-agent architecture [1]. A software agent is installed on every of the monitored subsystems, which performs tasks to control the security of the automated system. Agent management is performed through the network by the program manager. The console is used by security personnel to monitor and configure the system.

One of the elements of an integrated information security system is the data leak prevention or data loss protection (DLP) systems. The system performs control over the movement of the information at the level of communication with the external network and at the level of the end devices of users. When using DLP systems the basic approaches are grounded in the search for keywords and on the implementation of fingerprints in files [2].

DLP systems are introduced at the request of the units that manage the business of companies and are responsible for its security [2]. DLP systems are used to manage risks, reduce damage from leaks and reduce leaks of confidential information.

A software tool for protecting corporate network files using steganographic prints is built on the basis of the intelligent software agent technology for the ability to be deployed in corporate information security systems. The software belongs to the class of DLP systems and it is used in risk management.

Steganographic printing. Technologies of digital watermarks (DW) and identification numbers (IN) are used to protect copyright for intellectual property from copying and to carry out authentication. DW are built into the protected object and can be either visible or invisible. The DW and IN contain the authenticated code, the owner information and the control information. The introduction of IN is called fingerprint technology. The DW and IN technologies are used to protect electronic media against copying and prevent unauthorized use of information in electronic commerce, voice mailing, video surveillance systems and office work.

Hidden annotation of documents and optimization of data banks (information) is carried out using the technology of DW and IN. For example, the information in electronic medical records is available only to the treating physician. Hidden annotation of documents is used in medicine, cartography, multimedia data banks, as well as for searching for the necessary information in them.

Depending on the stability, the following types of prints are distinguished [10]: robust – have high resistance to external influences; fragile – destroyed with a minor modification of the filled container; semi-fragile – resistant to one impact and not resistant to others.

Fragile prints are destroyed with a minor modification of signals and are used for signal authentication. Semi-fragile prints are purposefully designed to be unstable for certain types of operations, for example, cutting or inserting fragments, but to be resistant to compression.

In this paper, it is assumed that the protected files can undergo numerous changes in the container, therefore, algorithms for creating fragile prints are not applicable. Protection is subject to intellectual property which is represented by the contents of the protected files therefore the algorithm for creating a print must have the properties of resistance to the container modifications possessed by robust and semi-fragile prints for use in this work.

There are many algorithms for introducing the print into the images [11, 13, 14]. Algorithms applicable to the images are used [15] for the introduction of the prints into the video stream. Subject to changes are several target sequence frames which are selected for the printing. Existing methods of introducing the print into the text are unstable to changes in the container that is reflected in works [1, 12, 14]. The introduction of prints into the images contained in the documents is used to protect text documents. Documents will not be subject for the introduction of the prints if they do not contain images suitable for modification.

Specific methods for creating robust and semi-fragile prints are selected on the basis of the format features for implementation, the computational complexity, the availability of existing implementations, the requirements of normative acts and other criteria.

Functional requirements. Software is designed to protect corporate confidential files by introducing prints using the steganographic method. Digital files subject to protection are educational materials in text and media formats and internal documents. The software is operated as a software agent on the information server. The agent is managed through the corporate network security management system.

The software can be used to detect leakage of confidential information, to determine the leakage path and to protect files from unlicensed use. The type of files for protection is determined at the stage of risk identification and analysis. There is the need to scan and search for digital prints of the campaign in files that are in open access for security implementation.

The software shall provide the following functions:

- creation and implementation of a sustainable print without violating the integrity of the contents of container;

- detection, retrieval and verification of the print from files;

- management of the software agent through the corporate network security management system.

Functioning. The structural diagram of the software is shown in the figure.

The software has three main components:

- the console on the corporate network security management server;

- the software agent on controlled information servers;

- the service for checking signed files.

The console is used to monitor and manage running software agents. Software agents are embedded in the software environment of the information servers and ensure that the confidential files that are given for reading are signed. Further distribution of files after copying from information servers is considered unknown. Signed Files Search Service performs the search and verification of the signed files in the open access and it is

represented by a separate software tool in the campaign environment or by a third-party service that provides the functions of scanning Internet resources.

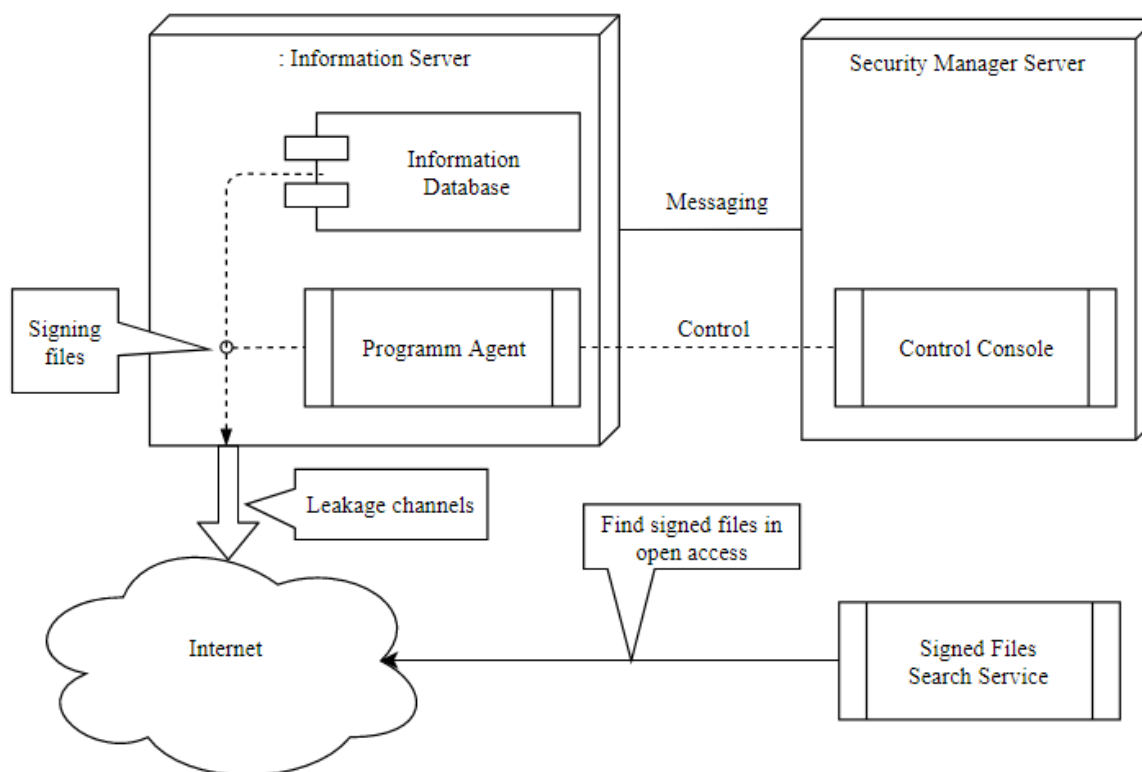


Fig. Structural diagram of the software

Conclusions. The threat of information security of confidential company files coming from insiders is considered in this paper. The description of the corporate network and the construction of information security systems are presented. DLP security systems and their use in risk management are presented. The tasks and algorithms for the introduction of steganographic prints for file protection are considered. The functional requirements for development are defined. The technology of construction of the system is grounded.

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**DEVELOPMENT OF THE ADMINISTRATIVE APPLICATION
FOR MANAGEMENT OF THE MAP OF POLOTSK STATE UNIVERSITY**

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The object of development is an administrative application for managing the information content of the map of Polotsk State University. The aim of the work is the creation of an information system of Polotsk State University with an emphasis on displaying information on the map. The issues of designing and developing an administrative application for working with a database are considered.

The goal of developing an administrative application for the map of Polotsk State University is to create a user-friendly application with a compact interface, through which you can easily work with the database, handle possible errors or completely avoid them.

To write the application, the .NET Framework version 4.5 was chosen. This choice is due to the fact that this platform is the main one for the operating systems of the Windows family, the most common OS family in the world. In addition, most people are visually accustomed to Windows, and it will be easier for them to perceive the application written for this OS.

For the immediate development of the application, the integrated development environment of Microsoft Visual Studio 2013 was chosen. It allows of creating various kinds of applications, as well as applying various modern technologies of this platform. The environment has a convenient code editor and a visual environment for developing a graphical interface.

Among all programming languages, the C # programming language was chosen. The choice was made on the basis of its advantages, namely:

- true object orientation;
- safe (in comparison with languages and C ++) code;
- support of event-oriented programming;
- "native" language for the application on the .NET platform;
- combining the best ideas of modern languages [1].

To develop the application interface, a graphical subsystem was used in the .NET Framework - Windows Presentation Foundation technology - a system for building Windows client applications with visually appealing user interaction capabilities using the XAML language. At the heart of WPF is a vector visualization system that does not depend on the resolution of the output device and is created taking into account modern graphics equipment [2].

WPF has the following advantages:

- independence from the screen resolution;
- good interaction with WinForms;
- Hardware graphics acceleration;
- the ability to declaratively define a graphical interface using XAML [3].

For the application to interact with the database, a special driver is used for the .NET platform for working with SQLite, which comes with the database itself from its developers.

To work with the database, classes were implemented that reflect the entities stored in the database. They contain the necessary fields and methods, thanks to which the "communication" with the database is carried out.

The creation of graphical forms of the application begins with determining their size and component content of the form, then creating event handlers that can occur when the administrator interacts with various components of the form.

The following components are available in the application being developed: TabControl – a linked set of tab pages; Button – command button; ComboBox is a combination of the edit field and the list, which allows you to enter data by typing on the keyboard or selecting from the list; StackPanel is a container for other components; Label – designed to display text information; TextBox – designed to enter data from the keyboard; Grid – container for other components, as well as other components.

During development, emphasis was placed on convenience and simplicity for the future user. The elements are arranged so that the user can immediately understand why they are there and how to work with

them. For example, elements of the Label type are placed next to the corresponding components, such as Text-Box and ComboBox, and the user immediately becomes aware that these elements are related and how to work with them.

The application consists of a main window and a set of child windows. The main window contains tabs for working with the most frequently used entities stored in the database: personnel, faculties, departments, public organizations, general departments and services. The appearance of the main window can be seen in Figure 1.

Fig. 1. Main window of the administrative application

Windows for working with other entities can be called up by selecting them in the upper menu. There are: cities, housings, hostels, historical and cultural places, places of leisure and administration. This approach simplifies the work with the application, making the more important and frequently used entities more accessible. For example, the appearance of the window for working with housings is shown in Figure 2.

Fig. 2 Work with the housings of the university

Thus, the administrative part for the map of Polotsk State University was designed and implemented. For the administrative application, an easy-to-use interface was developed that does not require additional training

and is intuitive, and a system of informing about errors or non-standard situations that help the administrator in work is implemented.

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INTEGRATION OF G SUITE FOR EDUCATION CLOUD PLATFORM WITH LOCAL EDUCATIONAL SERVICES

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This paper presents ideas for implementing a web application for testing knowledge and integrating this application with the G Suite for Education cloud platform.

Cloud technologies used in education allow you to manage information tools of learning, as well as automate regularly performed tasks of the educational process. G Suite for Education [2] is one such platform. It includes Gmail (including Inbox by Gmail), Calendar, Sync Chrome, Class, Contacts, Drive, Documents, Forms, Groups, Tables, Sites, Presentations, Talk/Hangouts, Safe and a number of additional services.

The most important service used in training is the Google Classroom [3]. With its help teachers can organize courses, invite students and other teachers, plan the training process, give out assignments, send out announcements and start discussions, and students can exchange materials, add comments to the course tape and communicate by email. The information about the jobs given is constantly updated, which allows the instructors to quickly check the tasks and put the grades. In the Classroom, you can work with Google Docs, Calendar, Gmail, Drive and Forms.

This cloud solution from Google is a universal base components. However, the requirements for software in various educational institutions may become tougher. Basic services are not enough, or their functionality has certain shortcomings. Therefore, educational institutions are forced to use third-party software, or develop their own, which will be devoid of certain shortcomings. In the second case, it is natural to develop specialized services for specific needs, implementing components of G Suite for Education, as the basis of the software platform. In addition, it is important to switch from several software products that are used separately to a single system consisting of multiple services.

After studying the products of G Suite for Education, a number of shortcomings were found in the field of testing students' knowledge. Although Google offers a Form service for this, it is not flexible enough to function, as, for example, the third-party solution is Airen [1]. Airen is free software with open source. It allows you to create tests and conduct tests on the local network, over the Internet or on single computers.

With the help of the Airen, teachers can create, save and edit tests, configure the test mode using a test profile, register the test lists in the program database and assign tests to run. During the testing, the teacher is provided with detailed information on the progress of the work, including data on the current progress of each student, up to answers to individual questions. Students can log in, view assigned tests, select tests from the assigned tests and start executing it, after execution you can view the test results.

Airen is able to work with all the most common types of questions: choosing one or several correct answers from among the suggested ones, with entering a response from the keyboard, establishing conformity, ordering and classifying. Also a question of any type can be accompanied by a script - a Pascal program, which will be performed before the question is shown to the test person. Thus, it is possible to create variational tasks, the individual content elements of which vary from the tested to the tested. Setting the test mode allows you to very flexibly manage the test parameters, the output of the result and the scale of assessments. All these parameters can be saved in the test profile, which is aligned with each test.

Studies G Suite for Education and Airen lead to the next decision. You should develop your own web application for testing knowledge, which includes all the functionality of Airen and is a service compatible with G Suite for Education. Thus, the basic components from Google are supplemented with a new multifunctional component of testing knowledge. Such a component can be especially useful when dealing with distance and distance learning students.

To develop a Web application, it is proposed to use the Java Enterprise platform [4] with the Spring Framework [5] architecture and the Apache Tomcat [6] application server.

PostgreSQL [7] will be used as the data store. This is a free cross-platform object-relational database management system. The strengths of PostgreSQL are high-performance and reliable transaction and replication mechanisms; an extensible system of built-in programming languages; inheritance; easy extensibility.

The server part is implemented using Java Servlet Technology [8]. The use of the Spring Framework greatly simplifies development with this technology. The central part of Spring is the Inversion of Control container, which provides tools for configuring and managing Java objects using reflection. The container is responsible for managing the object lifecycle: creating objects, calling initialization methods, and configuring objects by binding

them together [5]. Spring has its own MVC platform for web applications. It provides the developer with the following features:

- clear and transparent separation between layers in MVC and queries;
- interface strategy - each interface does only its part of the work;
- the interface can always be replaced by an alternative implementation;
- interfaces are closely related to the Servlet API;
- high level of abstraction for web applications.

Since passing a test is an ordered set of actions, each of which determines a certain state and, possibly, affects the further behavior of the subsystem responsible for the process of passing the test, it is reasonable to use Spring Web Flow [9]. Spring Web Flow is based on Spring MVC and allows you to implement "flows" of web applications. The flow is a sequence of steps that need to be taken to perform the business task. It consists of a set of HTTP requests that have states that operate on transaction data, reused, which can be either short-term or long-lived.

Spring Security [10] will be used to secure the Web application. This framework provides mechanisms for building authentication, authorization and access control systems. It is the de-facto standard for security in Spring-based applications.

The problem of integrating Google services can be solved with the help of the Spring Social framework [11]. Each service of the G Suite for Education platform provides a REST API (an application program interface that uses the REST architecture – the transmission of the view state). Spring Social interacts Spring applications with REST API providers, for example, Google Classroom. It's worth mentioning that Spring Social does not yet contain the implementation of the Google Classroom API and it needs to be developed independently, but Spring Social is an extensible framework that simplifies the process of connecting local user accounts to the service records. It has an input controller that allows authorization in a web application through the service entry and connection controller, which processes the authorization process between the web application, the service and users. Spring Social includes the implementation of the OAuth 2.0 protocol for Google services. OAuth 2.0 is an authorization protocol that allows one service (application) to grant access to user resources on another service. The protocol eliminates the need to trust the application login and password, and also allows you to issue a limited set of rights, not all at once [2].

The client part is implemented by standard HTML, CSS, JavaScript (jQuery) and executed by a web browser. It also uses JSP (JavaServer Pages), a technology that allows web developers to create content that has both static and dynamic components [12]. The JSP page contains two types of text: static source data, which can be formatted in one of the text formats HTML, SVG, WML, or XML, and JSP elements that construct dynamic content. In addition, JSP-tag libraries, as well as EL (Expression Language), can be used to introduce Java code into the static content of JSP pages.

Implementing such a web application in practice, you can have a high-performance knowledge testing system with the services included in the cloud platform G Suite for Education. The performance of the system is not limited due to the support for the clustering of PostgreSQL storage and the Apache Tomcat application server. However, one should keep in mind that the following performance limitations are documented in the Google Classroom API [13]:

- no more than 4,000,000 requests per day per client;
- no more than 50 requests per second for each client;
- no more than 5 requests per second for each user.

These restrictions do not interfere with the normal operation of a web application with a fairly large number of online users, they are rather aimed at combating various flood-attacks.

Further development of the project can go in the direction of developing client applications for mobile platforms. In Spring MVC, it is possible to create REST-controllers that send data at the request of the client, for example, in JSON-format. Due to this, mobile development does not need to re-implement business logic, but focuses on HTTP-interaction with the web application and visualization of data [5].

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WEB APPLICATION FOR MANAGING VARIOUS TYPES OF VACATIONS IN THE COMPANY

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This article explains why it is important to keep a schedule of holidays in companies and describes the main features of the developed web application and the technologies that will be used.

Introduction. Control of employee leave is an integral part of management in the enterprise. This is most clearly expressed when a company works with several projects, over which a separate group of employees is working. To achieve maximum performance, you need to monitor clearly the status of the group, since the absence of team members can adversely affect the entire workflow. From the point of view of the company's management, the leave chart should ensure that there are no problems during the entire calendar year, including the period of the greatest use of vacations by employees. The task of the director is to compile and optimize the employee leave chart in such a way as not to reduce the performance of the enterprise.

From the point of view of the company's employees, a correctly drawn up vacation chart enables the employee to plan his holiday in advance at the desired time and provides certain guarantees that the vacation will take place within the agreed timeframe and will not be postponed to another time.

In general, vacation management involves the following tasks:

- planning of important events for the year. It is necessary to determine the intervals in which the absence of workers is undesirable or impossible before the planning of vacations;
- replanning unapproved vacations;
- accounting the facts of care and return from vacation. By results of this stage it is possible to estimate, how the plan of holidays was executed.

It is difficult to keep in mind the factors affecting the schedule of holidays when a large number of people work in the company. Therefore, automation systems are increasingly being used for planning.

There are various systems that allow management of employee leave in companies. There are "1C: Personnel management", Web application "Chancellor", Web application "Vacations" from Webasyst, component of the Bitrix24 system - "Absence schedule".

However, these software tools have disadvantages: some of them are provided as part of a complete system, so it costs a lot, others have an uncomfortable user interface and small functionality.

Task formulation. Thereby, it was decided to develop a web application for management of vacation schedules, which will help the director to compose the vacation schedule, and workers to create requests for leave quickly and receive a response.

The following requirements will be applied to the web application:

- extensibility - in future it is planned to expand the web application with accounting management, human resources and document management modules;

- security - the application must have several levels of users to ensure correct access to the data;
- reliability - the application must respond to unexpected errors and maintain its efficiency.

The main functions of a web application will include:

- user authorization;
- the ability to create, view, modify and delete various types of leaves;
- the ability to view the schedule of leaves by months and years;
- filtering vacation schedules according to different criteria;
- the possibility of changing the period of dates of the holiday schedule;
- availability of notification service;
- the ability to create, view, change and delete holidays and workday shifts;
- the ability to view employee personal information;
- the ability to approve or deny applications for leave;
- the creation of orders for various types of leaves;
- display the imposition of leave from employees who are on the same project on the schedule of holidays;

Technologies. C # programming language is planned to be used to implement the server part of the application.

C# is a simple, modern, general-purpose, object-oriented programming language developed by Microsoft. Nowadays, it is used in various applications: from small desktop programs to large web portals and web services that serve millions of users every day. It is encompassing strong typing, imperative, declarative, functional, generic, object-oriented (class-based), and component-oriented programming disciplines [1]. Object-oriented approach allows to develop large, but at the same time flexible, scalable and extensible applications. C # continues to develop actively, and with each new version there is more and more useful functionality.

MS SQL Server will be used to store the necessary information.

Microsoft SQL Server is a relational database management system that supports a wide variety of transaction processing, business intelligence and analytics applications in corporate IT environments. Microsoft SQL Server is built on top of SQL (Structured Query Language), a standardized programming language that database administrators and other IT professionals use to manage databases and query the data they contain. SQL Server is tied to Transact-SQL (T-SQL), an implementation of SQL from Microsoft that adds a set of proprietary programming extensions to the standard language [2].

Angular will be used for the user interface implementation.

Angular is a platform that makes it easy to build applications with the web. Angular combines declarative templates, dependency injection, end to end tooling, and integrated best practices to solve development challenges. Angular empowers developers to build applications that live on the web, mobile, or the desktop [3].

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MTPROTO PROTOCOL FOR ENCRYPTING MOBILE CLOUD CHAT APPLICATIONS

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The protocol is designed for access to a server API from applications running on mobile devices. This symmetric encryption scheme is based on 256-bit symmetric AES encryption, 2048-bit RSA encryption and Diffie–Hellman key exchange.

The protocol is subdivided into three virtually independent components:

1. *High-level component* (API query language): defines the method whereby API queries and responses are converted to binary *messages*.
2. *Cryptographic* (authorization) layer: defines the method by which messages are encrypted prior to being transmitted through the transport protocol.
3. *Transport component*: defines the method for the client and the server to transmit messages over some other existing network protocol (such as HTTP, HTTPS, TCP, UDP) [1].

High-Level Component (RPC Query Language/API)

From the standpoint of the high-level component, the client and the server exchange *messages* inside a *session*. The session is attached to the client device (the application, to be more exact) rather than a specific http/https/tcp connection. In addition, each session is attached to a *user key ID* by which authorization is actually accomplished.

Several connections to a server may be open; messages may be sent in either direction through any of the connections (a response to a query is not necessarily returned through the same connection that carried the original query, although most often, that is the case; however, in no case can a message be returned through a connection belonging to a different session). When the UDP protocol is used, a response might be returned by a different IP address than the one to which the query had been sent.

There are several types of messages:

1. RPC calls (client to server): calls to API methods.
2. RPC responses (server to client): results of RPC calls.
3. Message received acknowledgment (or rather, notification of status of a set of messages).
4. Message status query.
5. Multipart message or container (a container that holds several messages; needed to send several RPC calls at once over an HTTP connection, for example; also, a container may support gzip).

From the standpoint of lower level protocols, a message is a binary data stream aligned along a 4 or 16-byte boundary. The first several fields in the message are fixed and are used by the cryptographic/authorization system.

Each message, either individual or inside a container, consists of a *message identifier* (64 bits), a *message sequence number within a session* (32 bits), the *length* (of the message body in bytes; 32 bits), and a *body* (any size which is a multiple of 4 bytes). In addition, when a container or a single message is sent, an *internal header* is added at the top, then the entire message is encrypted, and an *external header* is placed at the top of the message (a 64-bit *key identifier* and a 128-bit *message key*).

Authorization and Encryption

Prior to a message (or a multipart message) being transmitted over a network using a transport protocol, it is encrypted in a certain way, and an *external header* is added at the top of the message which is: a 64-bit *key identifier* (that uniquely identifies an *authorization key* for the server as well as the *user*) and a 128-bit *message key*. A user key together with the message key defines an actual 256-bit key which is what encrypts the message using AES-256 encryption [2]. Note that the initial part of the message to be encrypted contains variable data (session, message ID, sequence number, server salt) that obviously influences the message key (and thus the AES key and iv). The message key is defined as the 128 middle bits of the SHA256 of the message body (including session, message ID, etc.), including the padding bytes, prepended by 32 bytes taken from the authorization key. Multipart messages are encrypted as a single message.

The protocol's principal drawback is that an intruder passively intercepting messages and then somehow appropriating the authorization key (for example, by stealing a device) will be able to decrypt all the intercepted messages *post factum*. This probably is not too much of a problem (by stealing a device, one could also gain ac-

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cess to all the information cached on the device without decrypting anything); however, the following steps could be taken to overcome this weakness:

1. Session keys generated using the Diffie-Hellman protocol and used together with the authorization and the message keys to select AES parameters. To create these, the first thing a client must do after creating a new session is to send a special RPC query to the server (generate session key) to which the server will respond, whereupon all subsequent messages within the session are encrypted using the session key as well [3].

2. Protecting the key stored on the client device with a (text) password; this password is never stored in memory and is entered by a user when starting the application or more frequently (depending on application settings).

3. Data stored (cached) on the user device can also be protected by encryption using an authorization key which, in turn, is to be password-protected. Then, a password will be required to gain an access even to those data.

HTTP Transport

Implemented over HTTP/1.1 (with keepalive) running over the traditional TCP Port 80. HTTPS can also be used in addition to the encryption method described above.

An HTTP connection is attached to a session (or rather, to session + key identifier) specified in the most recent user query received; normally, the session is the same in all queries, but crafty HTTP proxies may corrupt that. A server may not return a message into an HTTP connection unless it belongs to the same session, and unless it is the server's turn (an HTTP request had been received from the client to whom a response has not been sent yet) [4].

The overall arrangement is as follows. The client opens one or more keepalive HTTP or HTTPS connections to the server. If one or more messages need to be sent, they are made into a *payload* which is followed by a POST request to the URL/api to which the payload is transmitted as data. In addition, *Content-Length*, *Keepalive*, and *Host* are valid HTTP headers.

Having received the query, the server may either wait a little while (if the query requires a response following a short timeout) or immediately return a dummy response (only acknowledging the receipt of the container). In any case, the response may contain any number of messages. The server may at the same time send out any other messages it might be holding for the session.

In addition, there exists a special long poll RPC query (valid for HTTP connections only) which transmits maximum timeout T . If the server has messages for the session, they are returned immediately; otherwise, a wait state is entered until such time as the server has a message for the client or T seconds have elapsed. If no events occur in the span of T seconds, a dummy response is returned (special message).

If a server needs to send a message to a client, it checks for an HTTP connection that belongs to the required session and is in the "answering an HTTP request" state (including long poll) whereupon the message is added to the response container for the connection and sent to the user. In a typical case, there is some additional wait time (50 milliseconds) against the eventuality that the server will soon have more messages for the session.

If no suitable HTTP connection is available, the messages are placed in the current session's send queue. However, they find their way there anyway until receipt is explicitly confirmed by the client. For all protocols, the client must return an explicit acknowledgment within a reasonable time (it can be added to a container for the following request).

If the sent queue overflows or if messages stay in the queue for over 10 minutes, the server forgets them. This may happen even faster, if the server is running out of buffer space (for example, because of serious network issues resulting in a large number of connections becoming severed).

TCP Transport

This is very similar to the HTTP transport. It may also be implemented over Port 80 (to penetrate all firewalls) and even use the same server IP addresses. In this situation, the server understands whether HTTP or TCP protocol must be used for the connection, based on the first four incoming bytes (for HTTP, it is POST).

When a TCP connection is created, it is assigned to the session (and the authorization key) transmitted in the first user's message, and subsequently used exclusively for this session (multiplexing arrangements are not allowed).

If a payload (packet) needs to be transmitted from the server to a client or from a client to the the server, it is encapsulated as follows: 4 length bytes are added at the front (to include the length, the sequence number, and CRC32; always divisible by 4) and 4 bytes with the packet sequence number within this TCP connection (the first packet sent is numbered 0, the next one 1, etc.), and 4 CRC32 bytes at the end (length, sequence number, and payload together).

There is an *abridged* version of the same protocol: if the client sends *0xef* as the first byte (only prior to the very first data packet), then packet length is encoded by a single byte (*0x01..0x7e* = data length divided by 4; or *0x7f* followed by 3 length bytes (little endian) divided by 4) followed by the data themselves (sequence number and CRC32 not added). In this case, the server responses look the same (the server does not send *0xef* as the first byte).

In case 4-byte data alignment is needed, an *intermediate* version of the original protocol may be used: if the client sends *0xe* as the first int (four bytes), then packet length is encoded always by four bytes as in the original version, but the sequence number and CRC32 are omitted, thus decreasing total packet size by 8 bytes.

The full, the intermediate and the abridged versions of the protocol have support for quick acknowledgment. In this case, the client sets the highest-order length bit in the query packet, and the server responds with a special 4 bytes as a separate packet. They are the 32 higher-order bits of SHA256 of the encrypted portion of the packet prepended by 32 bytes from the authorization key (the same hash as computed for verifying the message key), with the most significant bit set to make clear that this is not the length of a regular server response packet; if the abridged version is used, bswap is applied to these four bytes.

There are no implicit acknowledgments for the TCP transport: all messages must be acknowledged explicitly. Most frequently, acknowledgments are placed in a container with the next query or response if it is transmitted in short order. For example, this is almost always the case for a client's messages containing RPC queries: the acknowledgment normally arrives with the RPC response.

In the case of an error, the server may send a packet with a payload of 4 bytes, containing the error code. For example, Error Code 403 corresponds to situations where the corresponding HTTP error would have been returned by the HTTP protocol [5].

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BASIC ASPECTS OF SAFETY IN MEDICAL INFORMATION SYSTEMS

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The article presents the main aspects of architectural features in the provision of security and the protection of confidential data in medical information systems. The algorithm of the technology of distribution of access rights in medical information is considered.

Introduction. With the increase in the volume of concentrated information in the medical field, there is a need for the formation of standardized and uniform storage systems for this information. This question helps to solve the development of specialized medical information systems.

The medical information system is different from other software products, especially in that it stores and processes personal and confidential information. In this regard, they are subject to increased requirements for reliability and limitations of access to information, legal responsibility, technical measures to protect data. Any user who accesses the medical information system bears full (moral, administrative and criminal) responsibility for the confidentiality of information that he makes, uses or transfers to other users.

Methods of information protection in medical information systems. At the moment there is a question of information security in medical information systems from two points of view:

1. Protection of the rights of the individual from the dissemination of confidential information;
2. Protection of interests of the state and departments. Possibility of information leak, abuse, violation of ethics.

Based on these requirements, the following tools should be used to ensure the protection of information and programs of medical information systems: [1]:

1. Legal;
2. Organizational and administrative;
3. Technical (hardware-software).

Legal means prevent unauthorized use of information and are a deterrent to potential violators.

These include the rights and obligations for obtaining, processing and restricting the dissemination of information, which are prescribed in the legislative framework of the state, which is subject to actions to work with the medical information system.

To ensure the safety information, this legislative base should be subject to both medical information systems and all participants taking part in the work with it.

Organizational and administrative means regulate the functioning of medical information systems, the use of its resources, personnel activities, as well as the interaction of users with the system and users with system administrators.

Based on this, the health information systems should have a hierarchy of roles, each of which is related to different positions of medical workers, their areas of activity, and the role of the patient. Each of these roles must have a number of unique rights to interact with the system. This distinction serves to admit to that part of the information that corresponds to the competence of the user. This feature is implemented through technical means of protection, and is regulated by legal means.

Technical means perform the following protection functions: creating obstacles to possible ways of penetration and access of potential infringers to the medical information system, identification and authorization of users, delineation of access rights to resources, registration of events, cryptographic protection of information [2].

The software and hardware measures of the health information security system should provide means for allocating access rights, ensuring that the user can only access the information and programs that are necessary to perform the functional duties. These funds traditionally use the following concepts:

1. User Authorization (a technology that confirms that the real user and the person whose name is being accessed is the same person)
2. Access groups (logical grouping of users into one group for which the system grants the same rights)
3. Access rights (differences in the ability to work with a medical information system, for example - reading information, reading and changing data, deleting documents or even modifying code)
4. Access control list (a table that groups access groups and their associated rights levels for a particular system object).

Algorithm for the distribution of access rights. The algorithm of the operation of the technology of the distribution of access rights in the medical information system is as follows:

- During the start of the system, user authorization is performed. For authorization, a login-password link is often used, where the login identifies the user, and the password is a means of verifying the identity. In this case, the password must be presented in an encrypted form, when stored in the system. The most commonly used algorithms are AES, DES, Blowfish and others. In addition, when working on the network, it is necessary to provide password transfer via secure protocols, such as SSL - an information transfer protocol that uses asymmetric cryptography to authenticate exchange keys, symmetric encryption to preserve confidentiality, message authentication codes for message integrity. [3]

- At the moment of the first access to the server after the authorization, a session with the server is created. During the initialization of the session, the system determines which groups the user belongs to and uniquely associates the user with these groups. All further actions in the system, including opening the database, displaying its design elements or other program elements, are carried out only based on the current list of access groups.

- If the client requests the system objects sequentially on the server side, it checks for the presence or absence of the necessary access rights to the object. If none of the user groups is included in the object, the server does not provide the client with information about the presence and properties of the object. Given the highest priority of the security system, unauthorized access to such an object (server, database, presentation, program, document or single field) becomes theoretically and practically impossible.

- At the same time, the system at the kernel level includes the functions of logging of unauthorized access and software processing of exceptions in the system code that simultaneously allow the administrator to see all suspicious requests from the security point of view and, on the other hand, provide the required level of stability and performance of applications of the system.

In addition to the distribution of access rights, the software and hardware security measures of medical information systems should provide for encryption of various textual information as well as multimedia. Various multimedia data must be stored in binary form in the database, taking into account the encryption algorithms, and presented to the user as decrypted data in the interface. Figure 1 shows a variant of the encrypted image stored in the database as a type of binary type Blob, suitable for encryption.



Fig. 1. An example of an interface with an image of the Blob type encrypted by the AES algorithm.

Conclusion. The described technical, regulatory and other means of ensuring security to date allow medical information systems to provide the entire necessary set of measures to protect information and programs, which is a prerequisite for the suitability of such systems for their operation.

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BASIC ASPECTS OF NECESSITY TO CREATE THE ATHLETE ORGANIZER

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At present, the sports sector is actively developing in the Republic of Belarus. The life of an athlete is full of many activities, fees, competitions, which are difficult to keep in mind. Athletes' schedule should be updated regularly. It should contain up-to-date information about an event, place and time.

A clear schedule helps athletes achieve results. The educational process is a pedagogically organized interaction of its participants. However, sports education is different from ordinary activities. The most optimal is to create an application for specific goals and objectives of the sporting direction. The application can be used in all sports schools and colleges of the republic.

There is a lot of scattered information about teachers, pupils, events in paper journals and diaries. To find some information is difficult for everyone. Therefore, it is important to organize a single information storage space for such information. And also to adjust interaction of coaches and sportsmen with the help of the organizer application.

It is necessary to conduct a research and study of analogues and prototypes of the developed system for a detailed analysis of the need to create an application. The feasibility of creating a product is analyzed taking into account the results obtained. The results of the research are many systems for creating plans and schedules. Let's consider several applications.

The first analogue is the system of planning personal files «Todoist». This application is designed to create a list of tasks that should be done. Tasks can be divided into different categories. To create a task, the task name and the execution date are filled in, which can be edited, deleted, added to tags, and searched for tasks. However, in this software tool, you cannot assign tasks to other users or a group of users. The application is not designed to analyze the overlapping of one task with another.

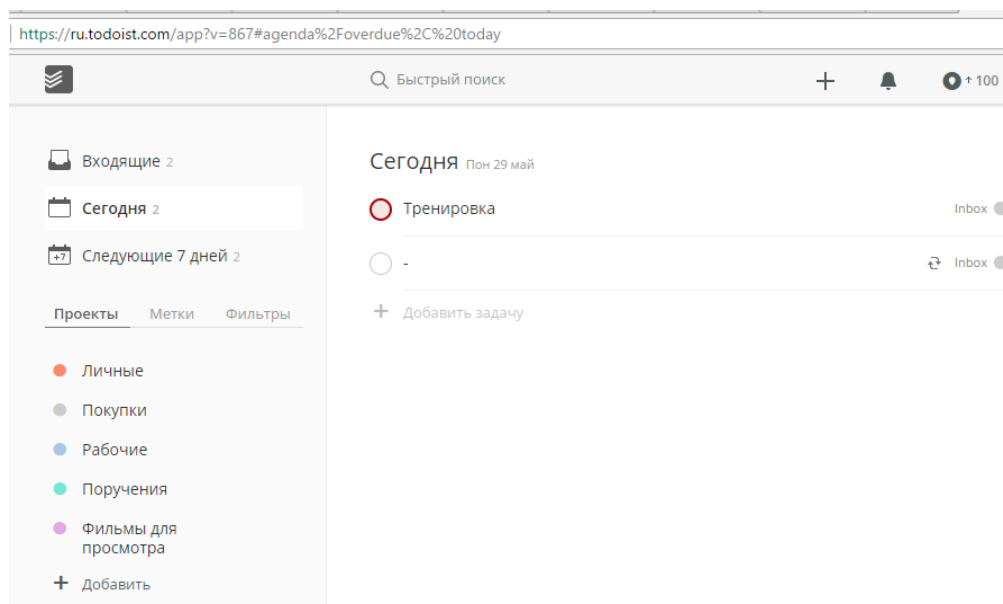


Fig. 1. «Todoist» system

The second analogue is the "Outlook calendar" application. This application is intended for corporate use. Users can see the schedule of other users if they have permission. It is possible to assign events to other users or a group of users. However, it is necessary that all athletes register in the system and allow access to their schedule. But this program also has several drawbacks. The person should know the email of the necessary users for assigned events. This application is not specialized for the institution. It cannot store special data about athletes

without signaling the approximation of the insurance contract and other specific topics for the given area of things. It does not signal the approach the end of the insurance contract and other specific things for the sport area. In Outlook, the coach will not be able to view the centralized list of information about his athletes.

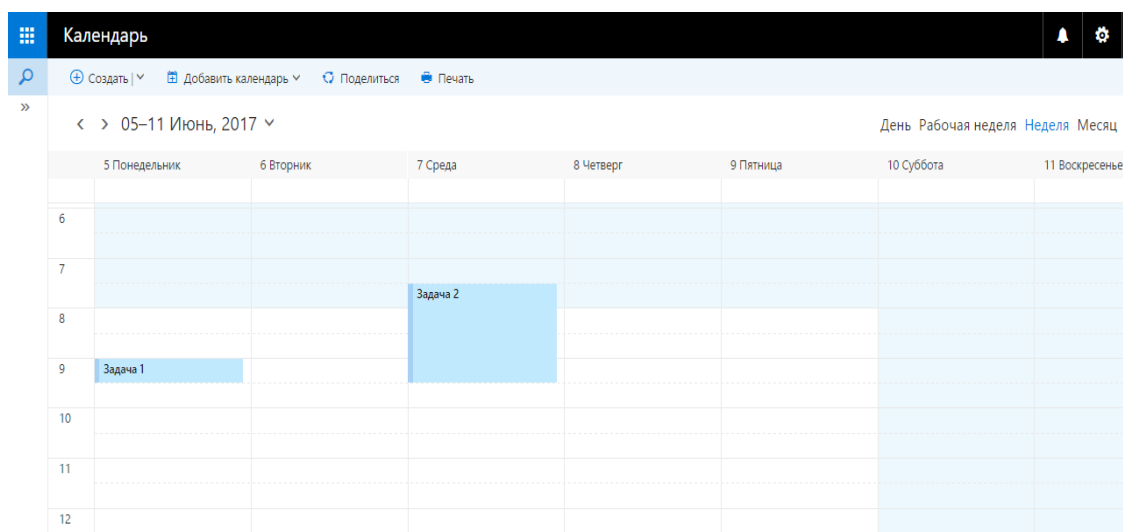


Fig. 2. "Outlook calendar" application

There are also applications called training diaries. They are suitable for the personal conduct of their plans after the athlete. "Simple Workout Log" is the example of such an organizer diary. The application allows you to track your workouts and plans. A clear disadvantage is the impossibility for the coach to participate in the management of this diary and review the training plan.

The athlete organizer has a similar goal and logics with analogues and prototypes. However, it should be noted that some of the analyzed programs do not take into account the peculiarity of the subject area. The advantage of the software being developed is that the system will be developed for specific, highly specialized purposes. The application will have a user-friendly interface. The functional purpose will correspond to the needs of educational institutions of a sports type.

The athlete organizer is relevant, as it has unique necessary functions. Timely receipt of information in a convenient form affects the effectiveness of training and the achievement of planned goals.

The application will be used in educational institutions such as the Children's and Youth Olympic Reserve School, the Olympic Reserve School and other sports schools.

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**THE PRINCIPLE OF NONLINEARITY IN THE NOISE CONDITION
UNDER THE INFLUENCE OF THE SUPERHIGH FREQUENCY BROADBAND AND HARMONIC SIGNALS**

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A method for increasing the sensitivity of a nonlinear radar to nonlinear elements possessing small overall properties is considered; a method for determining the optimum frequency for the detection and investigation of NEs in the region of its optimum frequencies. An algorithm for using the UWB signal for NLR was developed. A structural diagram of the NLR has been developed, which applies this algorithm.

Of all the variety of possible methods of searching for objects, nonlinear radar occupies one of the most important places and has been actively developing since the 70s of the last century. Nonlinear radar (NLR) allows detecting nonlinear elements (NEs), not only in the active mode (during signal transmission), but also in the passive mode (accumulation mode) and also in the off state.

A significant difference between the NLR and the classical one with the active response is the direct conversion of the probing signal incident on the object to the energy of the higher harmonics. In this connection, the model of radar detection in conditions of nonlinear location can be classified as an observation with a semi-active response, which is connected with the lack of energy consumption by the object from a special power source. Its peculiarities are the very small value of the coefficient of nonlinear transformation ($\xi N \ll 1$) and the dependence on the frequency and power of the sounding signal of the locator [1].

At present, the sensitivity of NLR plays a huge role. The leads (NEs), as well as the conductors of the embedded device's printed circuit board, function as an antenna for broadcasting the re-emitted signal. Due to the reduction of the overall dimensions of the NE, the operating frequency of the antenna is increased. The rapid development of micro- and nanoelectronics poses the task of improving the sensitivity of NLR to embedded devices with small dimensions.

It is possible to improve the sensitivity of traditional radar in several ways:

- increase the frequency of sounding;
- apply a complex signal as a probing signal;
- reduce the duration of the pulses of the probing signal;
- increase the power of the sounding signal.

In traditional radar, the use of complex signals allows us to resolve the contradiction between the energy potential and sensitivity [2]. In nonlinear radar, the application of complex signals has a slightly different character [3]: the use of complex signals leads to a deterioration in the sensitivity and accuracy of the range measurement. Therefore, a method using ultra-wideband signals and optimizing the frequency of the sounding signal is of interest.

As shown in the source [4], different NEs have different optimum frequencies for detection. An example is shown in Table 1. The power of the re-emitted signal depends on the frequency of the probing signal and, of course, on the NE itself, its dimensions or the dimensions that make up its p-n elements. In this case, the power of the generated higher harmonics in the re-emitted signal becomes larger when the wavelength of the sounding signal corresponds to the linear dimensions of the NE [4].

Table 1. – Results of practical measurement of the level of the second harmonic of nonlinear objects at the level of the probing signal +10 dBm

Object\F	960 MHz	3600 MHz	7200 MHz	10400 MHz
KT315	-114 dBm	-81 dBm	-83 dBm	-108 dBm
SIM card (two different)	-90/-88 dBm	-68/74 dBm	-78/-88 dBm	-105 / noise -118 dBm (NE defined)
Led	-105 dBm	-88 dBm	-88 dBm	-103 dBm
КД522	-82 dBm	-69 dBm	-65 dBm	-96 dBm
Processor MSP430F149	-108 dBm	-85 dBm	-90 dBm	-97 dBm
2A606 diode	-65 dBm	-60 dBm	-53 dBm	-55 dBm

To determine the optimal frequency of NE detection, it is proposed to use ultra-wideband (UWB) signal as a sounding. Using it determines the optimum frequency for NEs and conducts further analysis of the nonlinearity at the optimum frequency. For this purpose, the following algorithm for detecting NEs has been developed.

First, the NLR evaluates the noise level in the received frequency range and determines the trigger threshold to prevent false positives. At the next step, the NE is irradiated by the UWB signal with the band $f_{min} - f_{max}$. The re-emitted signal is received by an NRL receiver with a bandwidth of $2f_{min} - 2f_{max}$. The spectrum of the received signal is analyzed. As a result of the analysis, it is determined whether harmonic components are present in a given band with an amplitude level above the established threshold, which is determined in the previous step. In the positive case, the search for harmonic components with the maximum value of the amplitude is conducted. In the negative case, it is concluded that there is no negative effect. If the NE is present and the harmonic component of $2F_{max}$ with the maximum amplitude in the re-emitted signal is determined, then the UWB signal radiation ceases, and the harmonic superhigh frequency signal transmitter is turned on instead. The frequency of the generated superhigh frequency signal is F_{max} . Finally, a standard method is used to determine the type of semiconductor (false or real) - analysis of the levels of the second and third harmonics of the re-emitted signal [1]. A flowchart of the algorithm is shown in Figure 1.

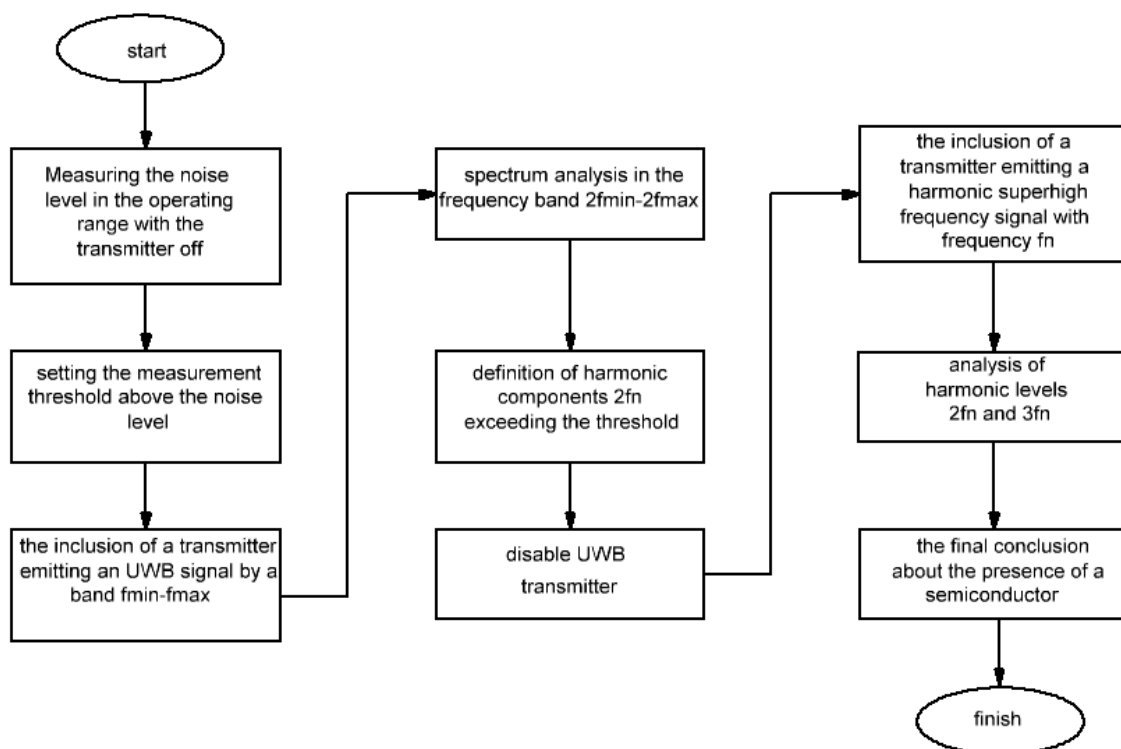


Fig. 1. Block diagram of the algorithm for detecting NEs

According to the above-described NE detection algorithm, the structural scheme of NLR was synthesized with the determination of the optimal frequency for detecting NEs (Figure 1).

In the structural scheme, the antenna switch commutes the UWB antenna to the UWB transmitter or to the programmable superhigh frequency transmitter. The UWB signal is generated by the UWB transmitter unit. The programmable superhigh frequency transmitter generates a harmonic superhigh frequency signal at a predetermined frequency upon the command of the microcontroller. The re-emitted signal is received by the UWB receiver, sent through the matching device to the unit performing the fast Fourier transform (FFT) and, accordingly, in the harmonic detection device with the maximum amplitude where the frequency component with the maximum amplitude is determined. The results of the analysis are transferred to the microcontroller, which sets the operating mode and sends the results of the operation of the NRL to the input / output device that a PC can serve.

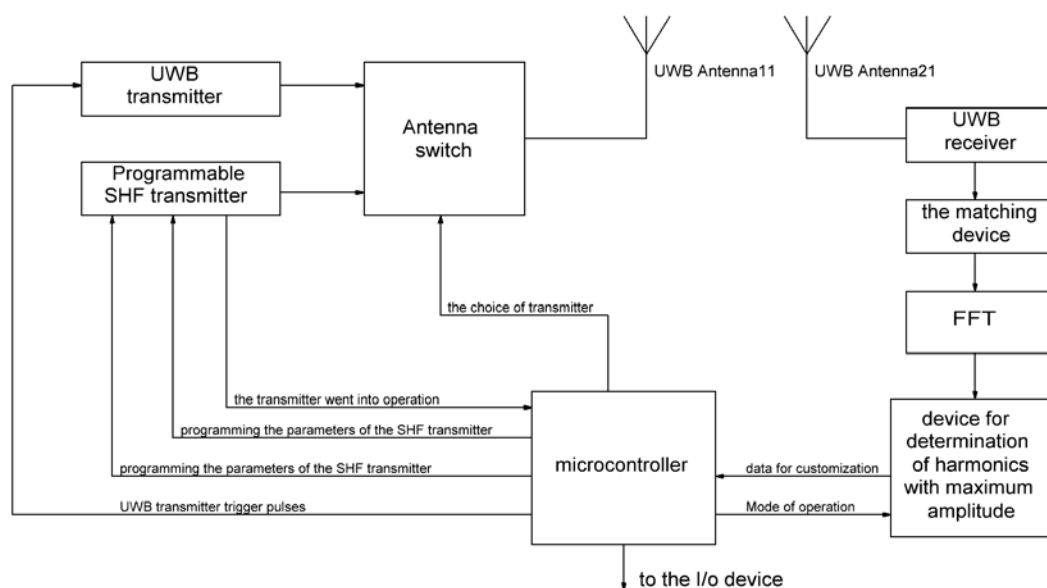


Fig. 2. Block diagram of the NLR

Thus, the use of UWB signals leads to:

- the possibility of investigating NEs in the region of its optimal frequencies;
- increasing the sensitivity of NLR to NE with small dimensions;
- decrease in sounding power.

The combination of detection methods leads to an increase in the accuracy of identification of semiconductor compounds and the detection of false semiconductors.

The presented algorithm for detecting NEs and the structural diagram of NRL are the foundation for further research and practical tests.

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UDC 004.4

IMPLEMENTATION OF MANAGEMENT SYSTEM OF MULTI-USER ONLINE GAME

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An approach for implementation of a multi-user online game management system as a distributed web application is the interaction of components, which is based on the principles of the architectural style of REST. We consider the architectural style of REST, the component approach for implementing the client part of the web application, and the structure of the REST API for the management system. The concept of a web application has been described.

Introduction. Despite the popularity of games aimed at computers, mobile multiplayer online games have been gaining increasing popularity in recent years. The growth of hardware characteristics of mobile devices over the past five years has expanded the capabilities of game developers, allowing the creation of much larger and more ambitious projects [1]. As a rule, online games require the availability of special functionality, which is placed in separate applications that allow you to manage the game process.

Control systems are designed not only to monitor the game process, but also to obtain statistical information necessary for data analysis, as well as to study the interests of players.

The application administrator has the opportunity to independently determine the rights of users, and also to edit, create or change the structure of the displayed information, provide technical support to users and send news. The user gets the opportunity to edit his personal information, monitor his game statistics and statistics of other players, ask for help from the game's administrators and so on. These features facilitate the support and further development of the game in general, and also necessitate the availability of a management system, since the additional functionality for management is not directly related to the game process and its presence is not always convenient within the game application, especially for mobile application.

The game world is a galaxy, which consists of many sectors that contain a certain number of planets. On the planets, the player can take quests, buy / sell goods, improve equipment and repair the spaceship with the help of which they move around the game world. Each player can choose a character with the following characteristics: pilot accuracy, pilot maneuverability, technical knowledge, trade skill, leadership, pilot fascination. After completing tasks, or participating in battles, the player is credited with an experience that can be used to improve the characteristics of his character. The galaxy is inhabited by three races: green, red and blue. The character of each race has different characteristics. The player can also choose a race.

Management system of multi-user online game. The functionality provided by the management system is determined by the description of the game. The registration and authorization page is the entry point to the application, allows the user to register, or to log in through popular social networks: Facebook, Google+ Twitter. After successfully passing the authorization / registration procedure, the user will be assigned special access rights that can limit or provide access to various management system resources, for example, such as adminpanel, the user profile page will also be available to the user.

The user profile page displays a section of game statistics, a personal information section, a game control section and a menu that allows you to navigate through the pages of the management system that are available to the user.

The section of personal information is intended for displaying information about the user: name, email, age, gender.

The game statistics section is intended for displaying information about the user's game progress: pilot accuracy, pilot maneuverability, technical knowledge, trade skill, leadership, pilot fascination. In addition, game statistics includes the display of information about the spaceship. The data displayed in the personal information and game statistics sections are received from the server application when the page is loaded and dynamically updated.

The game control section provides the ability to manage functionality that provides interaction with the game process, so the user is provided with the following options:

- the ability to modify the components of the spaceship, such as: body, engine, fuel tank, radar, scanner, repair droid, generator of the protective field, weapons;
- the ability to change the race for which he plays, among the available: green, red and blue;

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– the ability to view information about planets that are available to the user, and also to select a certain planet as a base.

The menu section allows you to go to the pages: adminpanel (if you have user access rights), a galaxy, players, technical support.

Adminpanel page allows you to: manage user accounts, answer user questions from the technical support section, manage the game server.

Page galaxy displays a list of available star systems, the user can open any of them. After selecting the star system, a list of planets will be displayed, the user can open detailed information about the planet, in addition, a list of players who are in this system or on the planet at the moment will be displayed.

The players page displays a list of players depending on the selected filter: registered, now in the game. Choosing a player from the list you can see his game statistics.

The technical support page allows users to interact with administrators.

The web-client must provide the following features:

– dynamic update of data that will change when players interact with each other within the game process: statistics, current player level, damage during the battle, number of wins and losses, information about users interacting with each other;

– to manage the game server and the game process;

– exchange of data with the game server using WebSocket, to update the information which displayed on the pages;

– interaction with the application server using HTTP requests.

Structural components of the management system. The presence of a web browser on all modern computers and mobile devices causes the development of a web client, through which the user and administrator interact with the server and the gaming environment.

To implement the client part of the web application, a component-oriented architectural style has been chosen that allows to decompose the application into smaller logical components that can be oriented to work with a certain part of the REST API. Due to this, any component can be replaced with minimal changes in other parts of the system, since the interconnection between the components of the application is minimal, which speeds up the development and further maintenance of the application.

Dynamic data updating is based on WebSocket technology, which allows you to connect to the game server and accordingly receive the necessary data.

The presence of overlapping opportunities between a web client and a mobile gaming application, such as registration, authorization, user profile management, and so on, allows us to implement server application that will be a REST API application and a centralized database. The REST architecture requires the use of most HTTP protocol capabilities [2]. The REST application has several advantages over JSON-RPC, the client application is independent of the names and arguments of the procedures, has standard status codes, has caching support, also allows you to send a request from the client application by adding additional information to the URL, or the header of HTTP request [3].

To limit the access of third-party applications, the application server allows authentication during the execution of the request using RBAC. For controlling the access of the client application to the REST API, Cross-origin resource sharing (CORS), a technology of modern browsers, is responsible for allowing the Web page to access resources of another domain [4].

Based on the concept of the management system, the application server should allow to interact with the database through special requests to specific nodes. Each node must correspond to an object of the domain, for example: user, settings, messages, spaceship, galaxy, ship component, statistics. The request sent from the client will be processed by the controller, which also corresponds to the object of the domain, this controller is located in the component REST Controller Component, which interacts with the Model Component. Each controller must provide functionality for reading, editing, deleting and adding new entries.

The server application includes the following structural components:

– Database Component - implements interaction with a database;

– Active Record Component - provides an interface for converting the passed parameters to SQL, interacts with the database component;

– Model Component - is a model of a real-world object that implements the Active Record interface;

– CORS Component is a component that is responsible for providing access to REST API resources;

– Service Component - provides an interface for processing data that belongs to different models;

– RBAC Component - provides an interface that allows authorization for the execution of the request and determines the access rights;

- REST Controller Component - provides an interface for interaction with the REST API.
- A web-client consists of the following structural components:
- Firebase SDK (library) - provides an API for working with Google services, and an API for registering and authorizing;
 - Controller Component - interacts with the View and Http component, provides data for display on the user interface;
 - View Component - forms the user interface;
 - HTTP Component - interacts with REST API, is responsible for authorization and registration of users;
- The figure displays a component diagram that shows how the software system is divided into structural components.

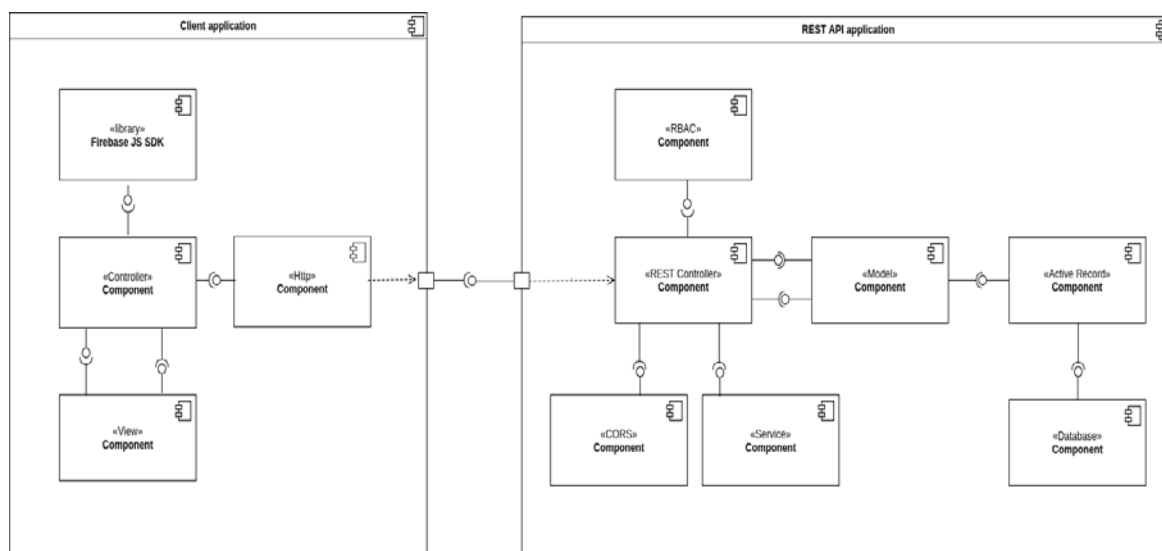


Fig. Web application component diagram

Conclusion. An approach to the implementation of a multi-user online game management system using the architectural style of REST is proposed. The functional capabilities of the control system and its structural components are defined.

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**APPLYING OF REACT NATIVE FRAMEWORK ON THE EXAMPLE OF DEVELOPING
A CROSS-PLATFORM APPLICATION FOR LEARNING ENGLISH WORDS**

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This article discusses technologies for implementing a cross-platform application for learning English words.

Free communication is currently one of the main factors in the success of modern man. And the main language is certainly English. English for communication between people and various countries for whom this language is not native. Thus, English has become a necessary attribute of a business person. And my application will help to replenish your vocabulary at any convenient time: in the metro, in a break between work or household chores. And in order to make a decision for more people, I use the cross-platform framework React Native.

React Native is a framework for developing cross-platform iOS and Android applications. It is designed to build a user interface from components, both standard and custom. This framework has the following factors: cross-platform, good performance and an approach to building a UI, which makes it easy to split the interface into independent components.

React Native uses the Flux architecture. Flux is a new architectural approach that complements React and the principle of unidirectional data flow. To implement this approach used the most famous Redux tool.

Features of Redux:

1. Redux uses only one store for the entire application state.
2. Store has read-only access. The only way to change the state is to pass "action" – an object that describes what happened.
3. Changes are made by "clean" functions.

Listing 1.

```
<?  
export default (state, action) => {  
  switch (action.type) {  
    case types.LOAD_VOCABULARY_SUCCESS:  
      return action.vocabulary;  
    ...  
    default:  
      return state;  
  }  
}
```

Main parts of Redux:

1. Actions – it are a signals that the store will change. These are clear functions. Action must have a type field. This is the field by which the future will be indexed exactly what happened in our system. They created Action-Created functions.
2. Dispatcher – receives actions on the input and sends these actions (and associated data) to the registered handlers.
3. Stores – containers for the state of applications and business logic in handlers registered in Dispatcher.
4. Controller Views – React-components that collect the state of the repositories and pass it to the child components via props.

Redux offers to keep the entire state of applications in one place, called the "store". Components "Dispatch" the state change to the repository, not directly to the other components. The components that must be aware of these changes are signed to the repository.

Event loop for Redux is shown in figure 1:

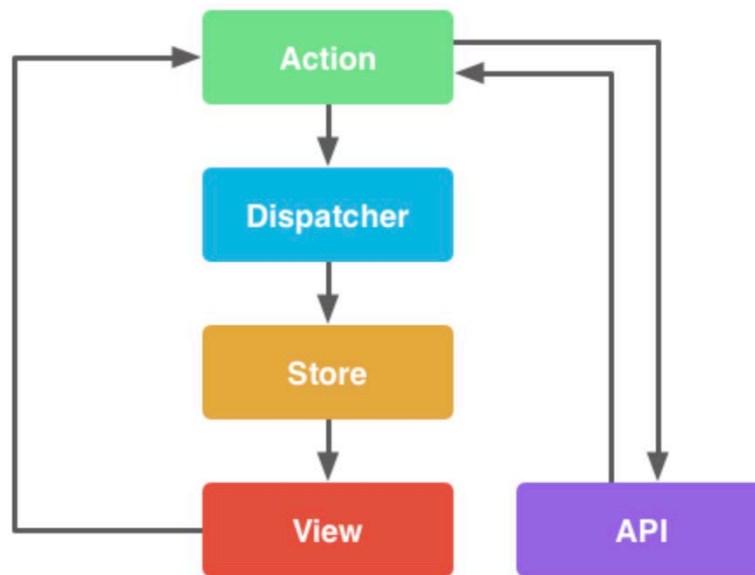


Fig. 1. Functional structure of the application

Developing applications will helpfully understand and implement the React Native technology.

React native updates the tree using Virtual DOM unlike other cross-platform frameworks. It updates only that part of the tree house that requires it. And because of this, the speed of the application increases several times compared to other cross-platform applications.

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INSTRUMENTAL IDENTIFICATION OF STOCHASTIC PROCESS CHARACTERISTICS

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An overview of the most practical and rational methods of instrumental identification of each characteristic of stochastic process is presented. Mathematical descriptions for each method are given and the functional diagrams of the devices are shown.

Introduction. The measurements of the probabilistic characteristics of stochastic processes have spread in various fields of science and technology, and the range of specialists interested in such measurements has expanded considerably. A lot of new measuring techniques and measuring devices have been designed; a lot of journal articles stating the methods and diagrams of devices and the solutions to the theory of measuring problems have appeared.

Today it is quite problematic to cover the whole set of measuring methods and instrumentation, as well as academic papers. Therefore, the choice of methods for each parameter should show the *instrumental identification of stochastic process data* and demonstrate the whole idea of the stochastic process itself clearly.

For further work in this direction, there is also a selection of proposed methods, for example, microcontrollers or microprocessors. In its turn it will significantly reduce outlay costs for the identification, dimensions of the entire complex of necessary devices and the speed of the operations to be performed.

The goal: to select and describe the methods of instrumental identification of the.

Objectives: describe the essence of the methods of stochastic process characteristics briefly.

Mean value measurements

Measurements of the mean value are performed by discrete methods according to the algorithm [1]

$$m_x^* = \frac{1}{N} \sum_{i=1}^N x(iT_0), \quad (1)$$

where, T_0 — is the range of samples of discrete values of the realization $x(T)$; N — is the total number of samples.

An operation description of a variant of a digital device which measures the mean value of a stationary ergodic stochastic process: the implementation voltage $x(t)$ of the stochastic process $X(t)$ under investigation enters an analog-to-digital converter. At the time of the sampling specified by the polling pulse, the implementation voltage is converted into a proportional number of pulses $q_i = cx(iT_0)$ (proportionality factor $c=10^a$).

These pulses are fed to the input of the time selector and can pass through it to the counter only when the "enabling" voltage is applied from the trigger to the input of the selector, which occurs if the trigger is in position 1. For N samples (polls), the counter accumulates a number.

$$B = \sum_{i=1}^N q_i = c \sum_{i=1}^N x(iT_0) = cNm_x^* \quad (2)$$

The number of samples (measurement duration) is specified by a circuit consisting of a time selector, a frequency divider, a trigger and a pushbutton switch.

According to the expression (2), measured mean value estimation

$$m_x^* = \frac{B}{cN} \quad (3)$$

Since the proportionality coefficient of the analog-to-digital conversion is 10^a , and the number of samples $N = 10^b$, then

$$m_x^* = B \cdot 10^{-(a+b)} \quad (4)$$

Consequently, the meter reading gives an immediate estimate of the average value, with the number $a+b$ determining the position of the comma.

Measurement of average power, dispersion, and root-mean-square deviation

The method of quadrature. The average power (the mean square value) of a stationary ergodic stochastic process is given by

$$p_x = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x^2(t) dt, \quad (5)$$

if the limit exists.

To measure the average power, it is necessary to obtain the voltage $y(t)=cx^2(t)$, using a device with a quadratic characteristic, and then to perform averaging. In reality the measurement is carried out for a finite time interval T .

The average power of the stochastic process can be measured with the help of various wattmeters.

The root-mean-square value of the implementation voltage, which is often of interest in practice, is measured according to the formula

$$U_* = \sqrt{x^2(t)} = \sqrt{\frac{1}{T} \int_0^T x^2(t) dt}, \quad (6)$$

It is known [2] that the root-mean-square (effective) value of the voltage of the complicated shape is measured by an electronic voltmeter with a quadratic detector.

The operation of extracting the square root is embedded in the graduation scale.

Measuring the variance of a stationary ergodic stochastic process defined by expression

$$D_x = \overline{x^2(t)} - [\overline{x(t)}]^2, \quad (7)$$

results in measuring the average power of the centered process $X(t)$, i.e., the average power of the variable component.

Measurements of correlation functions

To measure the correlation functions, special instruments, called correlometers or correlographs, are used.

In accordance with the principle of action, there are correlometers based on the methods of multiplication, summation (subtraction) and squaring, the approximation of the correlation function by the sum of the terms of its expansion in terms of orthogonal functions, sign correlation, mapping of the scattering diagram, and the like.

One must select a correlometer that works by the multiplication method, performing the actions necessary to obtain estimates of the correlation and mutual correlation function of stationary ergodic stochastic processes in accordance with the expressions

$$K_x^*(\tau) = \frac{1}{T} \int_0^T x(t) x(t+\tau) dt, \quad (8)$$

$$K_{xy}^*(\tau) = \frac{1}{T} \int_0^T x(t) y(t+\tau) dt, \quad (9)$$

i.e., it carries out a relative shift (delay) for a time τ and multiplies two voltages $\overset{\circ}{x}(t)$ and $\overset{\circ}{x}(t+\tau)$ or $\overset{\circ}{y}(t)$ and $\overset{\circ}{x}(t+\tau)$ averages this product for a sufficiently long interval T .

Digital Correlometers. The devices of this type presuppose the sampling of time and quantization (at many levels).

Such devices, which allow obtaining the highest accuracy, are specialized electronic computing systems, in which many blocks and nodes, similar to those used in universal digital computers are applied. It should also

be noted that the digital correlometers have been chosen with the expectation of improving the performance of this complicated device for determining the characteristics of stochastic processes.

Spectrum analysis

The spectral power density $G_x(f)$ allows us to judge the frequency properties of the stochastic process $X(t)$. It characterizes its intensity at different frequencies or, in other words, the average power per unit frequency band.

The apparatus spectrum is determined using an instrument called the spectrum analyzer. His work can be based on various methods of analysis.

The most known method is called the filtration method, which consists in isolating narrow sections of the spectrum of the process under investigation using a device with a selective amplitude-frequency response. The main element of the analyzer, which makes it possible to implement this method, is a bandpass filter with a narrow bandwidth in comparison with the width of the spectrum.

The power density can be determined by measuring the average power in the known narrow band. In other words, to measure the power spectral density, it is necessary to "cut out" a narrow band of the spectrum of the process under investigation at first, and then perform the same operations done while measuring the average power (the mean square value) of the stationary stochastic process.

The analysis of probability distribution

The method of analysis under consideration and the principles of constructing the apparatus extend mainly to stationary stochastic processes possessing an ergodic property.

The general functional diagrams of the instrument for such measurements are shown in Figure 1.

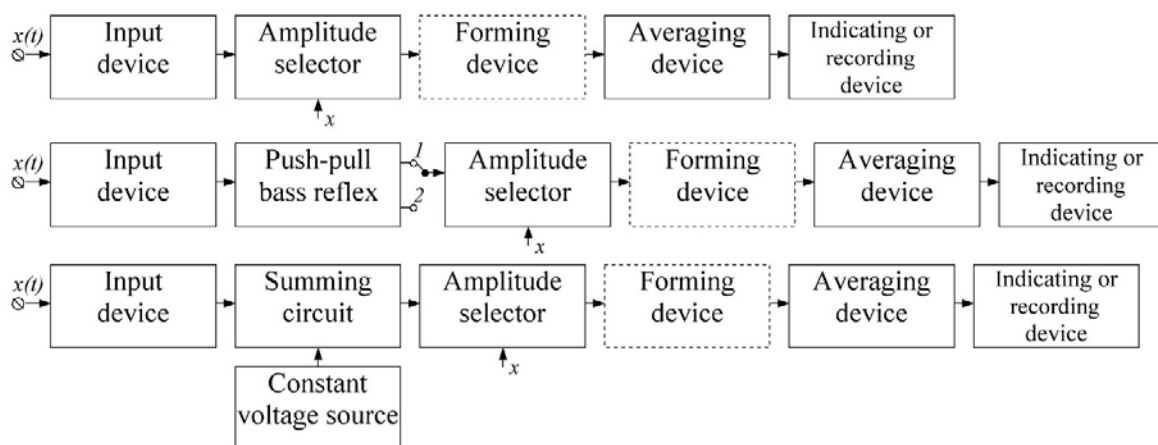


Fig. 1. Functional diagram of probability distribution analyzers

The input device usually has a calibrated attenuator, a cathode (emitter) repeater and, if necessary, an amplifier.

The amplitude selector is a device that emits signals with an amplitude above or below a certain level - the threshold of selection.

The forming device generates single pulses of duration τ_i or Δt_i from the signals received at the output of the amplitude selector. The amplitude selectors, with the combined functions of selection and formation are often used.

The average device is usually an integrator or a low-pass filter.

Magnetolectric devices, recorders, oscilloscopes with a long afterglow of the screen, digital meters of time intervals are used as indicating and recording devices.

The measurements of conditional probability characteristics

One of the main objectives of the instrumental analysis of stochastic processes is to establish the presence of stochastic relationships between processes and to study the nature and tightness of these interrelationships.

A whole series of objects and processes that have to be dealt with in practice are characterized by non-linear connections. In such situations, the use of correlation analysis is ineffective and can lead to erroneous conclusions. The regression analysis is more general than the correlation one and is based on measurements of

conditional probability characteristics. Such characteristics are the conditional mathematical expectation $M[Y(t)|X] = m_{Y|X}$ of one random process relative to the values of the second stochastic process, the function (curve) of regression, the conditional (residual) variance, the variance function of the stochastic process, the mutual dispersion function of two stochastic processes, the correlation ratio of two stochastic processes, the conditional function and the density probability distribution.

Since the listed emission parameters are stochastic variables, theoretical and experimental studies rely on the probabilistic characteristics of these parameters, which are abbreviated as emission characteristics.

The measurement of the probabilistic characteristics of emissions

An analog-to-digital probability distribution analyzer of parameter V can be constructed on the basis of a device with a digital discriminator. The addition of this device with a peak detector, a frequency-pulse modulator, a time selector and a delay circuit for rectangular pulses allows us to obtain a universal analyzer for the emission of stochastic processes [3]. Its functional diagram is shown in Figure 2.

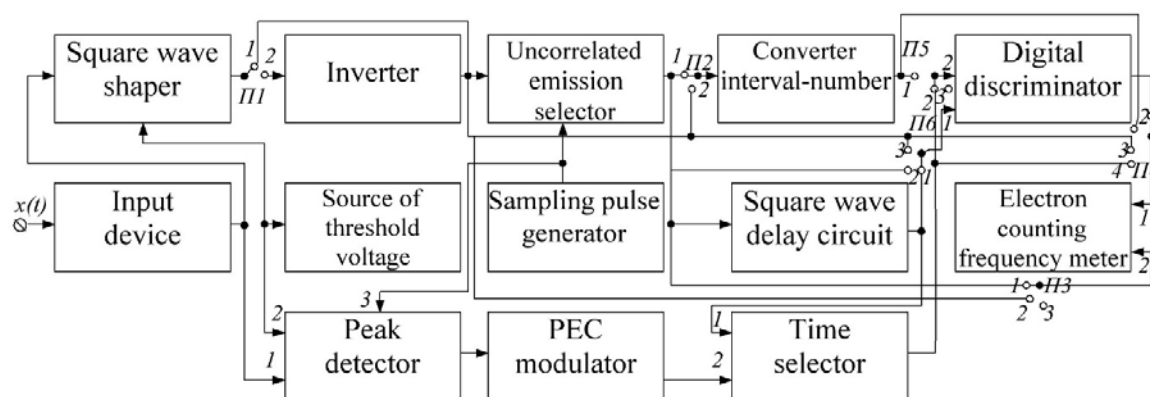


Fig. 2. Universal Emission Analyzer

Conclusion. To summarize it all, we can conclude that while organizing a set of devices for identifying the characteristics of stochastic processes, the selected methods will significantly improve the speed of execution of the necessary calculations, reduce the overall dimensions of the entire complex, thus reducing economic costs. Moreover, it will enable us to perform all the necessary operations using microcontrollers, or microprocessors, while doing further research. This can keep the costs down and result in reducing the size of devices and increasing computational speed.

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REVIEW AND COMPARISON OF TIME MANAGEMENT SYSTEMS

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Time management is a combination of knowledge, skills and abilities, so that people can prioritize, accurately impose their time, thereby increasing their personal productivity in organizing their working time.

Time management systems are designed to help the user improve their productivity by properly distributing tasks and evaluating the time they use. Also, these systems help the user to keep track of the daily routine, sleep and rest regime, which positively affects health.

Intelligent time management systems can not only perform the role of a simple to-do list, but also offer adjustments to the user's schedule. These systems are often used in sports, they help to use sleep, rest and food.

Until the 20th century, planning of working time was carried out with the help of primitive methods: memos for memory, to-do lists, etc. At the beginning of the last century, along with business development, new tools facilitated the work on planning time.

The time management system should solve the following tasks:

- Folders. Group related lists into easily accessible folders;
- Comments. Keep all discussions in one place and accessible to everyone;
- Public to-do lists. Share your lists with colleagues, friends and family;
- Cross-platform. Android, smart-watch and web-site;
- Reminders. Add reminders so you will not forget anything;
- Execution dates. Set a deadline to not disrupt the deadline;
- Notes. Add notes and do not miss any of the ideas;
- Notifications. Receive notifications of changes via email or push notifications;
- Mail. Convert your task to letters and simply forwarding them;
- Marks. Use marks to add more information for your tasks.

There are many good ready solutions for this task: Trello, Any.Do, ToDoist, Wunderlist, Toodledo, Springpad, MLO, Doit.im, Producteev, Asana, Remember the milk, Things, Google Tasks, OmniFocus, TickTick.

Each of these solutions deserves attention, the article will detail the two most popular solutions to date, which are used by millions of people around the world. These two services outperformed all other options.

ToDoist. The project, which appeared in 2007 and has been developing ever since. By 2013, the number of ToDoist users has reached the coveted figure of 1000 000users, and to date, according to some data, there are already more than 4000000 users.

ToDoist features an easy and simple interface and at the same time good functionality. There are under all modern platforms.

Service Features:

- Add tasks and projects;
- The ability to give access to the project to anyone - colleagues, friends, family members - to work together on common plans and goals;
- The breakdown of tasks into subtasks. By breaking serious tasks into smaller subproblems, it becomes easier for us to perform them;
- Subprojects. Inside the main task list, you can create additional lists;
- Dates in words. You can set the due date using the usual language, for example "Monday at 2 pm";
- Notifications. Get notified by email or push notifications as significant changes occur;
- A powerful tool for repeating dates. Quickly set the due date using a common language, for example "every day at 2 pm";
- Synchronization of information in real time. Data is automatically synchronized on all platforms and devices;
- Visualize your performance. With the help of Todoist-karma, you can monitor your performance and eventually analyze its performance;
- Priorities for tasks;

- Reminders (only in the premium version). Receive reminders via email, push notifications or SMS messages. Also receive on-the-go location-based alerts;
 - Comments (only in the premium version). Using notes to tasks, add as many details as you want. Or attach pdf-files, tables and photos;
 - Tags and filters (only in the premium version). To define the context of tasks using tags is a great way to become even more organized. Create custom filters that suit your workflow;
 - Synchronize your calendar (only in the premium version);
 - Project templates (only in the premium version);
 - Add notes and files to tasks (only in the premium version);
 - Adding a task using e-mail (only in the premium version);
 - Location alerts (only in the premium version). Get notifications about tasks on iOS or Android when you arrive or leave from a specific place;
 - Search by tasks (only in the premium version);
 - There is a function to backup your tasks (only in the premium version);
- There is an API (for accessing the service from other applications and scripts);
- A system of hot keys for convenient work with the application through the keyboard;
 - The maximum number of projects - 80 (in the free version) and 200 (in the premium).

As you can see, ToDoist is a very functional solution, which rightly is one of the three best solutions for managing tasks to date.

The first negative, as you probably already understood, is that most ToDoist functions are only available in the premium version.

The second disadvantage is that sometimes in ToDoist there are incomprehensible errors that spoil the whole impression.

Wundelist. At the moment, the audience of Wundelist has 13 million users around the world, and the head of the company, Christian Reber, has set a goal to reach 100 million in the near future. To this end, the company launched this month special APIs that allow you to integrate Wunderlist into other services.

Wunderlist is very similar to ToDoist. Almost the same functionality, easy and intuitive interface, instant synchronization, the possibility of teamwork, but almost all functions in Wunderlist are completely free of charge.

Main features of Wunderlist:

- The ability to group task lists into folders;
- Adding tasks and projects (lists);
- Shared lists. Wunderlist allows you to create joint lists. Very convenient for delegating tasks;
- Setting the deadline for completing the task;
- You can attach a voice message to any task (by pressing a special button inside the task, the recording starts from the microphone);
- Subtasks. Achieve more by breaking serious tasks into smaller sub-tasks (multi-level);
- Synchronization of information in real time. Now you do not need to do the synchronization manually, everything happens automatically on all platforms and devices;
- Notifications. Get notified by email or push notifications as significant changes occur;
- Notes to any task. Using notes to tasks, add as many details as you want. Or attach files, spreadsheets and photos;
- Comments on any task. If the task is delegated to another person, then you can communicate within the task through the commenting system;
- Ability to print any task list;
- Search by task;
- Adding a task using email;
- Sync with calendar;
- The ability to make the task list public (can be used for motivation);
- Tags. Identify the context of tasks using tags - a great way to become even more organized;
- Selection of active tasks (the selected task is automatically moved to the top of the list);
- You can change the background image of the main program window;
- Ability to create a full backup of data and save it on your computer;
- System of hot keys for convenient work with the application through the keyboard;

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- Smart list system;
- Ability to interact with the service via the API;

Wunderlist has only one drawback - it's the lack of gaming, which I liked so much in ToDoist. Geomification is an excellent tool for motivation, so in my opinion - it is necessary to use it in task managers.

In this article, an overview of the most popular and predominated time management systems was made, and the main functions that should be implemented in such a system were identified.

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UDC 004.852

EDUCATIONAL DATA MINING

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This article describes the effectiveness of using machine learning tools for educational data mining.

Making decisions in the field of education is a complex, multifaceted process that usually involves a lot of people. A big and effective part in this process plays the analysis of information coming from participants of the educational process at its various stages. Huge quantities of educational data about various aspects of the educational process are accumulated: about students and their academic performance, teachers and their scientific and educational work, distance learning courses, educational forums, testing and questioning systems for students, and much more. So, a lot of data has been acquired in the recent years and is continuing to accumulate.

The interest in new methods and approaches in the automated detection of new, sometimes hidden, relationships in data and their interpretation has arisen in connection with the growing use of information technologies in education. There are many fields where the methods of statistics, machine learning and knowledge extraction are useful for all participants of the educational process: students, teachers, developers of training courses, methodologists, administrative personnel. However, the theoretical basis for the application of these methods in practical activities is not sufficiently developed at the moment.

Educational data mining (EDM) is a set of methods for detecting previously unknown but useful information about the educational process and its participants in order to support decision making. The aim of EDM is to process and analyze data obtained within the framework of the educational process for finding hidden patterns. Methods, algorithms, tools for intellectualizing the solution of applied problems in education are being developed within the framework of EDM. Sources of educational data are information systems such as computer educational programs, university information systems, social networks, logs, test results, work programs of disciplines, etc. For a large audience of courses, the application of algorithms of EDM becomes particularly important. In connection with the active growth of information flows and the intensive accumulation of information, the task of processing and analyzing information and making rational decisions becomes important. Applying modern machine learning technologies is the solution for this task.

Machine learning is a field of computer science, the main point of which is to grant computers the ability to learn without being explicitly programmed for any particular task. This was coined by Arthur Samuel, an American pioneer in the field of computer gaming and artificial intelligence, back in 1959. And since then it has evolved from the study of pattern recognition and computational learning theory into artificial intelligence research. Machine learning is closely related to computational statistics, which also focuses on prediction-making through the use of computers and explores algorithms that can learn from and make predictions on data, of which we have a lot in the case of educational data. Machine learning algorithms overcome strictly static program instructions by making data-driven predictions or decisions, through building a model from sample inputs. All this makes machine learning an absolute leader for solving tasks of EDM.

Machine learning perfectly conflates with data mining, where the latter subfield focuses more on exploratory data analysis and is known as unsupervised learning. Within the field of educational data analytics, machine learning can be used as a method to devise complex models and algorithms that lend themselves to predictions of very complex things like a student's performance. These analytical models could allow us to produce reliable, repeatable decisions and results and uncover hidden insights in all entropy of educational data through learning from historical relationships and trends in the data from the past years.

Machine learning tasks are typically classified into two broad categories, depending on whether there is a learning signal or feedback available to a learning system:

3. Supervised learning: The computer is presented with example inputs and their desired outputs, given by a "teacher", and the goal is to learn a general rule that maps inputs to outputs. In special cases, the input signal can be only partially available, or restricted to special feedback.

4. Semi-supervised learning: the computer is given only an incomplete training signal: a training set with some (often many) of the target outputs missing.

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5.Active learning: the computer can only obtain training labels for a limited set of instances (based on a budget), and also has to optimize its choice of objects to acquire labels for. When used interactively, these can be presented to the user for labeling.

6.Reinforcement learning: training data (in the form of rewards and punishments) is given only as feedback to the program's actions in a dynamic environment, such as driving a vehicle or playing a game against an opponent.

7.Unsupervised learning: No labels are given to the learning algorithm, leaving it on its own to find structure in its input. Unsupervised learning can be a goal in itself (discovering hidden patterns in the data) or a means towards an end (feature learning).

If we look at this from the perspective of EDM, we can say that it's possible to create a model and train it using supervised learning where we feed data from the past years and the results we got from this data (student papers and some final mark of their research). Also, if we deal with flexible input data and we cannot even find a direct result for a given set, we can use unsupervised learning, allowing the model to determine some statement for the data given that can be used further.

As a scientific endeavor, machine learning grew out of the quest for artificial intelligence. Already in the early days of AI as an academic discipline, some researchers were interested in having machines learn from data. They attempted to approach the problem with various symbolic methods, as well as what was then termed "neural networks"; these were mostly perceptrons and other models that were later found to be reinventions of the generalized linear models of statistics.

Artificial neural networks are computing systems inspired by biological brains and their natural neural networks. Such systems progressively improve performances on tasks by considering examples without task-specific programming as it is described in machine learning definition. An artificial neural network is based on a collection of connected units or nodes called artificial neurons. Each connection between artificial neurons can transmit a signal from one to another. The artificial neuron that receives the signal can process it and then signal artificial neurons connected to it. In the real implementation of artificial neural network, the signal at a connection between artificial neurons is a real number, and the output of each artificial neuron is calculated by a non-linear function of the sum of its inputs. Artificial neurons and connections typically adjust weights as learning proceeds. The weight increases or decreases the strength of the signal in the connection. Typically, artificial neurons are organized in layers. Different layers may perform different kinds of transformations on their inputs. Signals travel from the first layer, that is considered to be an input layer, to the last layer, which represents the desirable format of output, possibly after traversing the layers multiple times. The original goal of the artificial neural network approach is to solve problems in the same way that a human brain would, like finding connections in data.

Machine learning and data mining often employ the same methods and overlap significantly, but machine learning focuses on prediction, based on the known properties learned from the training data.

Data mining focuses on the discovery of unknown properties in the data. Educational data mining can use many machine learning methods, but with different goals.

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EDUCATIONAL DATA MINING – PHASES AND TECHNICAL METHODS

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The article deals with Educational data mining aims and objectives. The main phases in EDM are defined and described. Popular data mining methods are considered. The article concludes with an analysis of the current state of affairs in this research area.

INTRODUCTION. Data mining, also known as Knowledge Discovery in Databases (KDD), is used to find out valid, novel, and potentially useful information from large amount of data. Data mining has been applied in a great number of fields, including retail sales, bioinformatics, and counter-terrorism. In recent years, there has been an increasing interest in data mining application to investigate scientific questions within educational research. This research field has been termed educational data mining. Educational data mining (also referred to as "EDM") is defined as a discipline concerned with developing methods for exploring the unique and increasingly large-scale data that come from educational settings (e.g. universities and intelligent tutoring systems), and using those methods to better understand students, and the settings which they learn in.

EDM refers to techniques and tools designed for automatically extracting meaning from large repositories of data generated by people's learning activities in educational settings. At a high level, the field seeks to develop and improve methods for exploring this data, which often has multiple levels of meaningful hierarchy, in order to discover new insights about how people learn in the context of such settings. The main objective of applying Data Mining to educational data is to analyze educational Data contents, models, to summarize/analyze the learner's discussions, etc. Education Data Mining concentrates on the computing process models which focus on Education context (e.g. assessments, attendance and progress). In educational system, a student's performance is determined by the term work, attendance and end semester examination. The term work is carried out by the teacher based upon a student's performance in educational activities such as class tests, assignments, attendance [1].

Phases in Educational Data Mining

Educational data mining is an emerging *growing* research community. A lot of mining techniques has been accomplished in a variety of educational contexts. The major objective is to translate raw data into meaningful information about the learning process, to make better decisions about the design and trajectory of a learning environment.

EDM generally consists of four phases [2]:

1. Discover relationships
2. Validate relationships
3. Make Predictions
4. Decision Making

1) Discover Relationships

The first phase in the EDM process (not including preprocessing) is to discover relationships between data. It is accomplished by searching in a repository of data in an educational environment with the objective of finding consistent relationships between data variables. Various algorithms are used for finding such relationships: classification, regression, clustering, factor analysis, social network analysis, association rule mining, and sequential pattern mining.

2) Validating Relationships

Discovered relationships must be validated in order to avoid over fitting.

3) Make Predictions

Valid relationships are used to make predictions about further events in the learning environment.

4) Decision Making

Predictions made in the previous phase are used to support decision-making processes and in making policy decisions. In phases 3 and 4, data is often visualized and distillated to enable a human to quickly identify or classify features of the data. Visualising Data is one of the best practices in research.

Technical Methods

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EDM methods fall into the following general categories: prediction, clustering, relationship mining, discovery with models, and distillation of data for human judgment (Table 1) [3].

Table 1. – Basic types of educational data mining methods

Types of Methods	Goals
Prediction	Develop a model which can infer a single aspect of the data (predicted variable) from some combination of other aspects of the data (predictor variables)
Clustering	Find data points that naturally group together, splitting the full data set into a set of categories
Relationship Mining	Discover relationships between variables
Discovery with Models	A model of a phenomenon developed with prediction, clustering, or knowledge engineering is used as a component in further prediction or relationship mining
Distillation of Data for Human Judgment	Data is distilled to enable a human to quickly identify or classify features of the data

The first three types are largely acknowledged to be universal across types of data mining (albeit in some cases with different names). The fourth and fifth types achieve particular prominence within educational data mining.

Educational data mining researchers view the following as the goals for their research [2]:

1. Predicting students' future learning behavior by creating student models that incorporate such detailed information as students' knowledge, motivation, metacognition, and attitudes;
2. Discovering or improving domain models that characterize the content to be learned and optimal instructional sequences;
3. Studying the effects of different kinds of pedagogical support that can be provided by learning software;
4. Advancing scientific knowledge about learning and learners through building computational models that incorporate models of the student, the domain, and the software pedagogy.

CONCLUSION. Educational Data Mining is an emerging discipline concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings which they learn in. Educational Data Mining focuses on developing new tools and algorithms for discovering data patterns. EDM develops methods and applies techniques from statistics, machine learning, and data mining to analyze data collected during teaching and learning. EDM tests learning theories and informs educational practice.

The application of data mining methods in the educational sector is an interesting phenomenon. Techniques in educational organizations help us to learn a student's performance and behavior, designing courses, curriculum and to motivate students on various parameters.

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UDC 621.371:550.837.6

ELECTRONIC SYSTEM FOR IDENTIFICATION OF HYDROCARBON DEPOSITS

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The analysis of the structural design of radio engineering systems for the identification of hydrocarbon deposits on the basis of two-frequency, pulse and modulated signals is carried out. The characteristic of methods of exploration based on the use of these systems is done.

The relevance to the present work task is to improve the existing electromagnetic methods of exploration and development of new methods of searching, identification of oil and gas (hydrocarbons) [1 – 6].

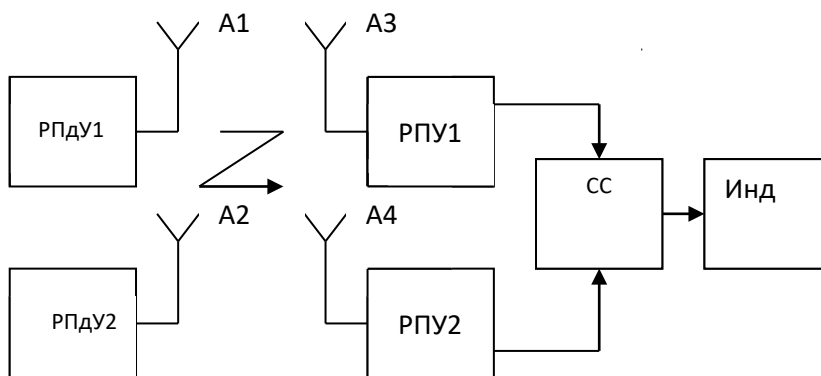


Fig. 1. Two channel RTS with the spacing in frequency

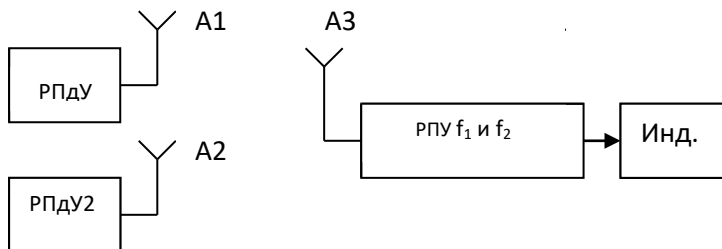


Fig. 2. RES using the illumination source

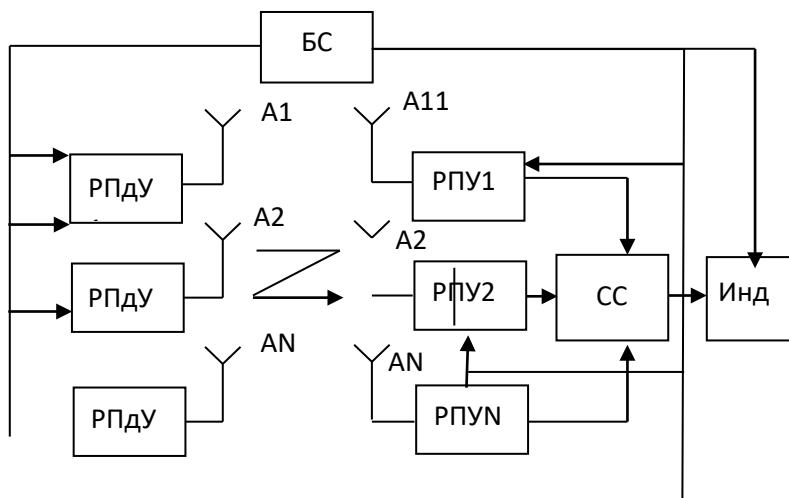


Fig. 3. Multi-channel RES

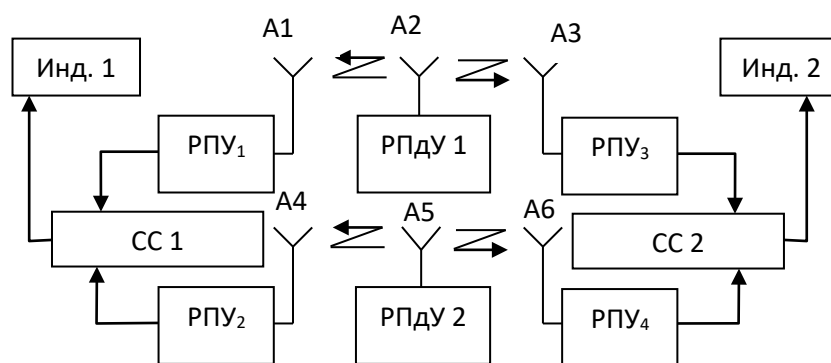


Fig. 4. Two-frequency RES for the implementation of equidistant receivers

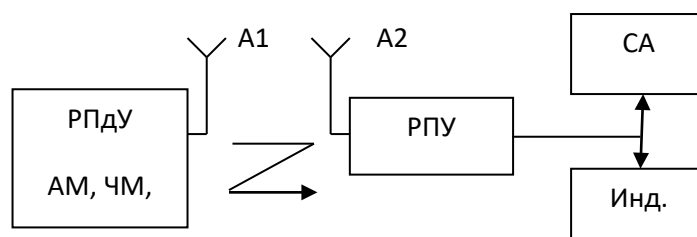


Fig. 5. RES on the basis of the modulated signals

The scheme presented in Fig.1 consists of two transmitters and РПДУ1 РПДУ2 operating at frequencies f1 and f2, two receivers РПУ1 and РПУ2 configured to frequency transmitters and four antennas A1 to A4. It is designed to transmit and receive electromagnetic effect frequencies f1 and f2.

Signals from the outputs of receivers are sent to the comparison circuit (SS) and then to the indicator (ind.). This scheme RTS provides an implementation of the methods of natural radiation UVZ and acoustic impact.

RTS realized according to the scheme given in Fig.2, allows the registration of UVZ boundaries and deep faults.

The scheme shown in Fig. 3, is a multi-channel device consisting of n Transceivers and N receivers. On the receiving side, spectral analysis of the received signals is possible. It provides a reliable definition of the boundaries of UVZ. Thus the avoidance of the superposition of the radiated fields electromagnetic effects in the structure of the RTS is provided by block synchronization of BS.

The scheme shown in Fig. 4 is built on the basis of equidistant receivers method. It differs from the scheme shown in Fig. 1 (two receivers tuned respectively to the frequencies f1 and f2). The technique consists in recording the electric field strength in two directions at the same distance from the stationary transmitters operating at frequencies f1 and f2.

The transmitter is installed at the point $l=0$. It produces a measurement of the ratio of the intensities of electric fields straight I_{st} and reverse I_{rev} , and $I_{st} = - I_{rev}$.

$$k_E = \frac{E_{np}(I_{np})}{E_{обр}(I_{обр})}$$

The scheme shown in Fig. 5, consists of a transmitter modulated signals (AM, FM, or AMM). The receiving side requires the use of RTS, comprising the spectrum analyzer.

In the implementation of RTS for exploration UVZ much attention was paid to the development of antennas.

Informative methods of searching and contouring hydrocarbon deposits can significantly improve the use of radio-complex methods. Group UH with known as radioprotector UVZ contributes to the improving efficiency of exploration, especially in complex interference conditions.

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WILDFIRE SMOKE DETECTION USING CONVOLUTIONAL NEURAL NETWORKS

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This article describes the algorithm for detecting smoke from a fire, implemented in the Java programming language. Examples of the work of the developed application are given and conclusions are drawn about the expediency of using convolutional neural networks to solve the task.

Introduction. In connection with the intensive development of computer technology, computer vision systems have become available to a wide class of users and can effectively solve many problems in human practical activities [1-2]. One of the actual applied problems, solved recently with the help of computer vision systems, is the detection of forest fires. To solve this problem, an algorithm for processing dynamic images with the use of deep learning, in particular, convolutional neural networks (CNN), was developed.

The developed algorithm includes the following three stages of program execution: color segmentation, detection of moving regions, and classification of the selected assumed smoky areas.

Localization of objects in the scene occurs in two main stages. First, in the video sequence, moving objects are searched, after which they are classified according to the color characteristics.

As a method of detecting motion, the method of subtraction of the background, based on a mixture of Gaussian distributions, was chosen. This method allows you to detect slow moving objects in the scene.

It was decided to carry out the classification of moving objects in the HSV color space, since the classification in this color space gives fewer false smoke detections than the YUV color space.

The classifier of localized regions is the trained convolutional neural network. As a neural network architecture, the AlexNet model [3] was chosen, which is simple, but does not require large computing resources and allows for training.

The general scheme of the developed algorithm is shown in Figure 1.

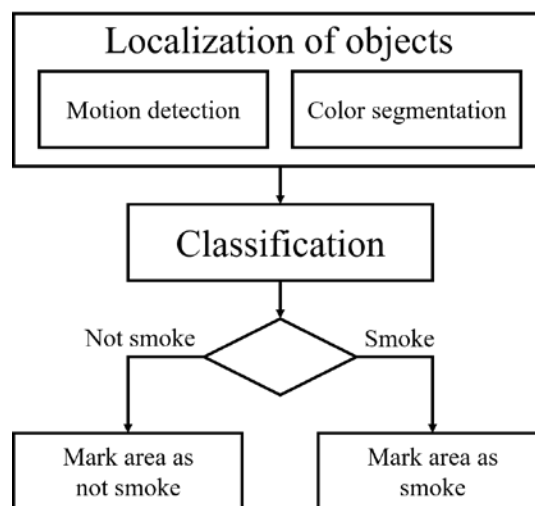


Fig. 1. Scheme of the developed algorithm

Implementation. To carry out the experiments and evaluate the results of the research, the algorithm developed was implemented in the Java language using the integrated software development environment IntelliJ IDEA, the computer vision library OpenCV 3.0 and the DL4J deep learning library. When designing the graphic interface, it was decided to use the platform to create JavaFX applications.

The development, testing and analysis of the algorithm's results were carried out using a Samsung 300E5Z laptop with the following main characteristics: CPU - Intel Core i3-2350M with a clock frequency of 2.3GHz, RAM - 4.0GB, graphics accelerator - Intel HD Graphics 3000.

To capture a video stream (from a video surveillance camera or from a permanent computer memory) and extract frames from the video sequence, an OpenCV library is used. OpenCV (Open Source Computer Vision Library) is a library of algorithms for computer vision, image processing with open source code [4]. OpenCV is designed to provide a common standard machine vision interface for applications in the field of dynamic image processing and to increase the use of computer vision systems in commercial products.

Construction, training and use of the CNN was carried out using DL4J library. DL4J (Deep Learning for Java) is a deep learning library written for Java and the Java virtual machine (JVM) and a computing environment with broad support for deep learning algorithms [5].

To demonstrate the capabilities of the algorithm, it was decided to implement an application designed for early detection of forest fires. The interface of the implemented application is shown in Figure 2. The application interface consists of a main window, a text information output window and a video output window.

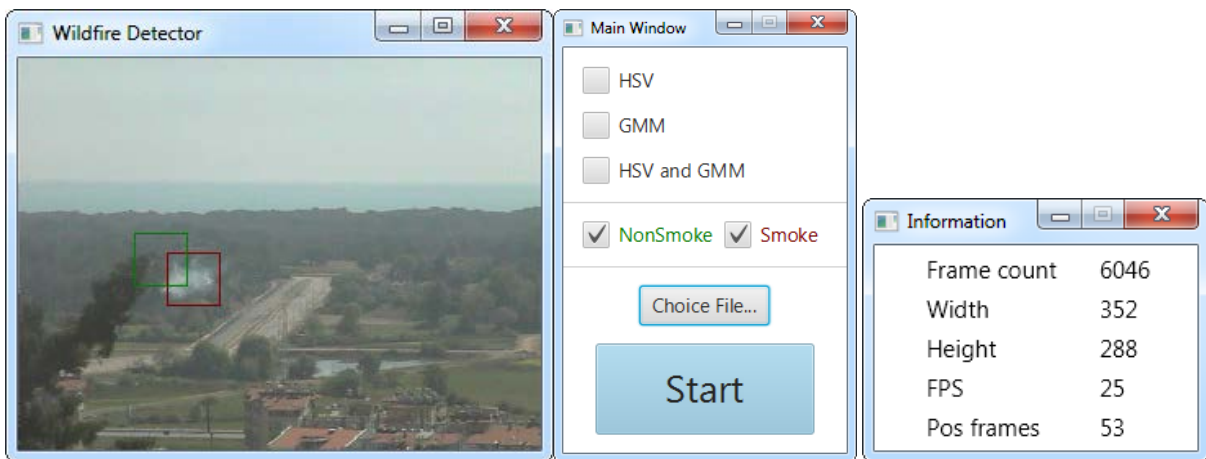


Fig. 2. The interface of the software product

For the analysis of the developed algorithm, video sequences obtained in real light conditions for shooting outdoors with a different angle of inclination, including an unstable background, were used. The work of the developed application is shown in Figure 3.

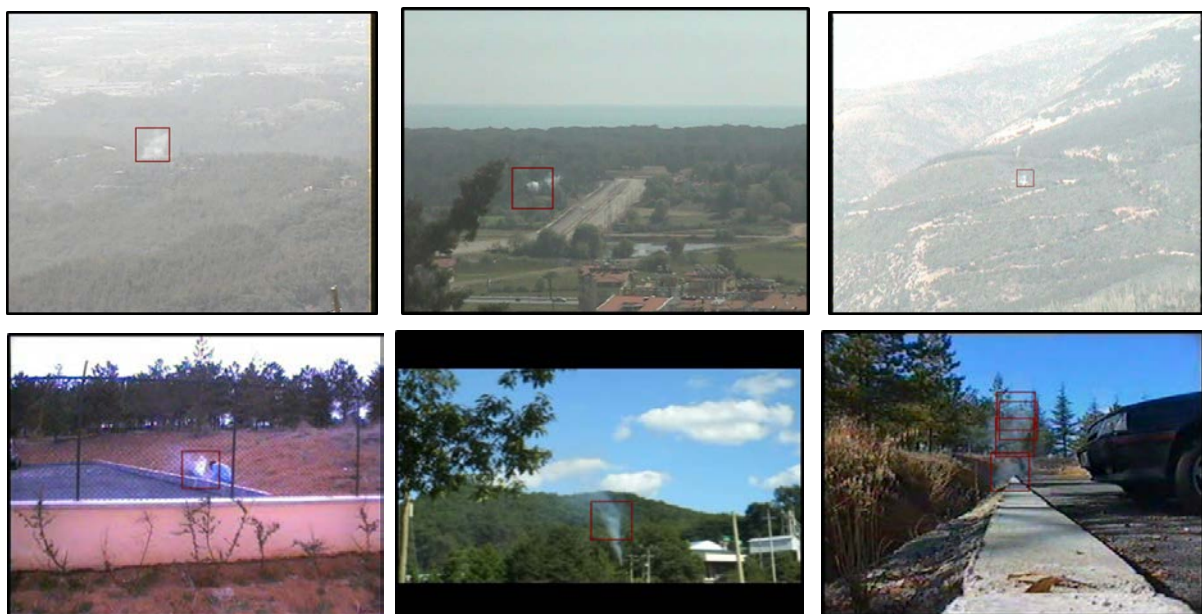


Fig. 3. Frames of used video sequences

Conclusion. The results of testing the developed algorithm have shown that convolutional neural networks can serve as a fire classifier. In view of the fact that a simple network model was chosen as a classifier, and a relatively small sample of samples was used in training, testing showed poor results. The coefficient of false positive classification of the developed algorithm was 7%, which is not permissible. However, it can be assumed that when using complex architectures of neural networks and a large training sample, the results of fire detection can be improved many times.

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UDC 37.02:519.85

**INSPECTION OF HYPOTHESES OF THE LAW DISTRIBUTIONS USING THE CHI-SQUARE TEST
OF EXPERIMENTAL RESEARCH RESULTS IN PEDAGOGY**

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The paper proposes one of the ways of testing the hypothesis of distribution law of a sample aggregate. It consists of the following: intuitively choosing the distribution law of a random variable (CB) and estimating its parameters for constructing the statistics of a chi-square test, dividing the definition set of the chosen law into intervals with the same probability of falling into the values of the selected CB. The boundaries of the intervals can be easily found using the distribution function of the selected CB. It is easy to determine the theoretical frequencies of hits in the intervals as they are equal and do not need to be adjusted (here the number of intervals, the sample size) and the statistics of the criterion

Usually, when constructing the distribution law of a random variable (CB) from a selective set, the following elements are present:

1) By the geometric characteristics of the sample and by the relationships between the numerical characteristics, the form of the distribution law is chosen. Sometimes the form of the distribution law is established from intuitive considerations;

2) the parameters of the chosen distribution law are estimated;

3) the consistency of the constructed distribution law with the sample data is checked.

The traditional method of implementation is as follows. We break up a set of selective values on k equal intervals, where $k \approx 1 + 3,22 \cdot \lg n$, n – sample size, m_i – number of sample values, of i interspace, $i = 1, 2, \dots, k$.

Further, we find the theoretical probabilities p_i' and theoretical frequencies $m_i' = n \cdot p_i'$. The lower limit of the first interval is assumed to be equal to the minimum value of the domain of definition of the chosen law, and the upper limit of the latter to the maximum. Theoretical frequencies must satisfy the condition $m_i' \geq 5$. If for some intervals this condition is not met, then they are combined with neighboring ones. After this, the statistics of the chi-square test are calculated (χ^2) and the result is compared with the critical value.

In this paper, in order to perform step three, it is proposed to split the set of values of the chosen distribution law into k intervals with the same probability $1/k$ hit in each interval. Boundary intervals x_i are determined using the distribution function $F(x)$ chosen law as a result of solving the equations $F(x_i) = i/k$ ($i = 1, 2, \dots, k-1$). For all practically important distributions, it is possible to specify the boundaries in advance when dividing into l intervals ($l = 3, 4, \dots, k$).

Example 1. Construct the law of distribution of SV for the sample:

Table 1.

i	1	2	3	4	5	6	7	8	9	10	11	12	13
X_i	0,07	0,09	0,16	0,23	0,53	0,75	0,9	1,24	1,41	1,68	2,1	2,2	2,21
i	14	15	16	17	18	19	20	21	22	23	24	25	
X_i	2,32	2,41	2,62	2,78	3,14	4,03	4,54	9,95	10,8	11,47	12,06	15,91	

Solution. 1st method. In this case $n = 25, 1 + 3,22 \cdot \lg 25 \approx 5,5, \Rightarrow k = 5$. As X_{\min} choose $X_0 = 0$, as X_{\max} choose 16. Then the length of each interval $\Delta = 16/5 = 3,2$ and it is easy to calculate the number of values (frequencies) at intervals. Such a frequency distribution is possible for an exponential distribution with a distribution function $F(x) = 1 - \exp(-\lambda \cdot x)$, $x > 0$, that is, a hypothesis is advanced H_0 : the sample is made from the general population with the exponential distribution law. Numerical characteristics of the sample

$\bar{X} = 3,824; D^* = 19,788; S^* = \sqrt{D^*} = 4,448$. We estimate the parameter $\lambda = \frac{1}{\bar{X}} = \frac{1}{3,824}$ and calculate the theoret-

ical probabilities p_i' and theoretical frequencies m_i' . As a result, we get the calculation table:

Table 2

Intervals	(0; 3,2)	(3,2; 6,4)	(6,4; 9,6)	(9,6; 12,8)	(12,8; 16)
m_i	18	2	0	4	1
p_i'	0,5669	0,2455	0,1063	0,0461	0,0352
m_i'	14,1725	6,1375	2,6575	1,1525	0,88

The condition is to satisfy $m_i' \geq 5$ 2, 3, 4 and 5 intervals should be combined, and for calculating the statistics of the criterion χ^2 we obtain only two intervals (the minimum number of intervals is 3), that is, the hypothesis H_0 deviates.

2nd method. Hypothesis H_0 has already been put forward and for the distribution function, the expression is $F(x) = 1 - \exp(-\frac{x}{\bar{X}})$, $x > 0$. We break the sample set into intervals with the same probability $p' = 1/5 = 0,2$ hit in them the values of the investigated CB. The boundaries of the intervals, as already noted, we find from the equation $F(x_i) = i/5 \Rightarrow 1 - \exp(-x_i/\bar{X}) = i/5$. Solving this equation for x_i , we get $x_i = -3,824 \cdot \ln(1 - i/5)$. It is finding x_i and counting the number of values found in the intervals, we obtain.

Table 3

Intervals	(0; 0,853)	(0,853; 1,953)	(1,953; 3,504)	(3,504; 6,154)	(6,154; ∞)
m_i	6	4	8	2	5

Since for each interval the theoretical frequency is $m_i' = 25 \cdot 0,2 = 5$, we can calculate the statistics of the criterion χ^2 (3 and 4 intervals are combined):

$$\chi_{emp}^2 = \sum_i \frac{(m_i - m_i')^2}{m_i'} = \frac{(6-5)^2}{5} + \frac{(4-5)^2}{5} + \frac{(10-10)^2}{10} + \frac{(5-5)^2}{5} = 0,4.$$

According to the table of quantiles of the chi-square the distribution is $\chi_{4-1-1; 0,95}^2 = 5,99$. As $\chi_{emp}^2 < \chi_{2; 0,95}^2$ ($0,4 < 5,99$), then the hypothesis H_0 is adopted.

Most often we have to test the hypothesis of a normal distribution, since many statistical criteria are based on this distribution. In this case, the need for the item disappears. We establish with an accuracy of 5 digits after the comma of the boundary for the partition of the normal distribution $N(0; 1)$ on 4, 5, 6 and 7 intervals with the same theoretical probability $1/k$ ($k = 4; 5; 6; 7$) hit in each interval.

$$\left. \begin{aligned} k = 4: & -\infty; -0,67448; 0; 0,67448; +\infty, \\ k = 5: & -\infty; -0,84162; -0,25334; 0,25334; 0,84162; +\infty, \\ k = 6: & -\infty; -0,96739; -0,43070; 0; 0,43070; -0,96739; +\infty, \\ k = 7: & -\infty; -1,06757; -0,56594; -0,18; 0,18; 0,56594; 1,06757; +\infty. \end{aligned} \right\} \quad (1)$$

Example 2. Table 4 contains a fragment of the results normality verification of a pedagogical experiment conducted at the Department of Higher Mathematics of Polotsk State University.

Explanations to Table 4. The essence of the experiment was to compare the values of the control group (CG) and experimental group (EG). At the initial stage (Stage 0), the homogeneity of the groups taken for the experiment was tested (group 10BB-KG, and group 10 TV-EG). To compare the indicators of the groups selected, the sum of the points obtained in the testing and in the certificate was chosen. In subsequent stages, the quality of the knowledge the students received by traditional presentation of the material (CG) and in the experimental (EG) was compared (stages 1 and 2 - the results of the 1st and 2nd semesters

were chosen as indicators for comparison - the sum of the scores obtained in control papers and in exams in the first and second semesters).

Table 4. – $UN_i = (XN_i - \overline{XN}) / SN_x, VN_i = (YN_i - \overline{YN}) / SN_y (N=0,1,2)$

№	Stage 0				Stage 1				Stage 2			
	10 BB		10 TB		10 BB		10 TB		10 BB		10 TB	
	X0	U0	Y0	V0	X1	U1	Y1	V1	X2	U2	Y2	V2
1	17	-1,5362	21	-1,4254	11	-1,8524	12	-2,4493	11	-1,7806	12	-2,5319
2	17	-1,5362	24	-1,2568	12	-1,6852	17	-1,4344	12	-1,6104	17	-1,6155
3	18	-1,4689	25	-1,2006	12	-1,6852	17	-1,4344	13	-1,4402	17	-1,6155
4	19	-1,4016	28	-1,0320	13	-1,518	18	-1,2314	14	-1,27	19	-1,2490
5	19	-1,4016	29	-0,9758	15	-1,1835	19	-1,0284	14	-1,27	22	-0,6991
6	21	-1,2671	29	-0,9758	15	-1,1835	19	-1,0284	14	-1,27	24	-0,3326
7	22	-1,1998	29	-0,9758	15	-1,1835	20	-0,8255	16	-0,9295	24	-0,3326
8	23	-1,1325	30	-0,9196	16	-1,0163	21	-0,6225	16	-0,9295	24	-0,3326
9	23	-1,1325	32	-0,8073	16	-1,0163	21	-0,6225	16	-0,9295	24	-0,3326
10	24	-1,0653	33	-0,7511	18	-0,6818	21	-0,6225	17	-0,7593	24	-0,3326
11	24	-1,0653	35	-0,6387	19	-0,5146	21	-0,6225	17	-0,7593	24	-0,3326
12	25	-0,9980	35	-0,6387	19	-0,5146	23	-0,2165	17	-0,7593	26	0,0339
13	25	-0,9980	37	-0,5263	20	-0,3473	24	-0,0135	18	-0,5891	26	0,0339
14	32	-0,5270	40	-0,3577	20	-0,3473	24	-0,0135	18	-0,5891	26	0,0339
15	33	-0,4597	42	-0,2454	20	-0,3473	24	-0,0135	18	-0,5891	26	0,0339
16	35	-0,3252	46	-0,0206	20	-0,3473	25	0,1894	19	-0,4189	26	0,0339
17	36	-0,2579	48	0,0918	21	-0,1801	25	0,1894	20	-0,2487	27	0,2172
18	37	-0,1906	49	0,1480	21	-0,1801	26	0,3924	20	-0,2487	27	0,2172
19	39	-0,0561	53	0,3727	21	-0,1801	26	0,3924	20	-0,2487	29	0,5838
20	39	-0,0561	54	0,4289	22	-0,0129	26	0,3924	21	-0,0785	29	0,5838
21	39	-0,0561	57	0,5975	22	-0,0129	27	0,5954	23	0,2618	29	0,5838
22	44	0,2803	59	0,7099	23	0,1544	27	0,5954	23	0,2618	29	0,5838
23	44	0,2803	61	0,8222	24	0,3216	27	0,5954	23	0,2618	31	0,9503
24	44	0,2803	62	0,8784	24	0,3216	29	1,0014	24	0,4320	32	1,1336
25	45	0,3476	64	0,9908	24	0,3216	30	1,2043	24	0,4320	32	1,1336
26	47	0,4822	64	0,9908	24	0,3216	30	1,2043	24	0,4320	33	1,3168
27	49	0,6167	65	1,0470	25	0,4888	30	1,2043	25	0,6022	38	2,2332
28	49	0,6167	75	1,6089	26	0,6561	30	1,2043	25	0,6022		
29	49	0,6167	78	1,7775	26	0,6561	31	1,4073	25	0,6022		
30	51	0,7513	87	2,2832	26	0,6561	32	1,6103	27	0,9426		
31	52	0,8186			28	0,9905			27	0,9426		
32	53	0,8858			28	0,9905			27	0,9426		
33	53	0,8858			29	1,1578			27	0,9426		
34	53	0,8858			30	1,325			28	1,1128		
35	54	0,9531			30	1,325			29	1,2830		
36	54	0,9531			31	1,4922			29	1,2830		
37	56	1,0877			31	1,4922			32	1,7937		
38	56	1,0877			32	1,6595			32	1,7937		
39	59	1,2895			32	1,6595			32	1,7937		
40	63	1,5586										
41	63	1,5586										
42	68	1,8950										

As a criterion for comparison, a two-sample t-criterion for comparing averages was selected [1, p. 128]. This criterion is based on the normal distribution and first of all it is necessary to check the normality of the re-

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ceived samples. This fact is verified in this paper with the help of the method of splitting the sample collection into intervals proposed above. First of all, for each sample that is marked $X_0, Y_0, X_1, Y_1, X_2, Y_2$, the mean values were found \bar{X}, \bar{Y} , Selective variances and mean square deviations Dx, Dy, Sx, Sy .

\bar{X}_0	39,833	\bar{Y}_0	46,367	\bar{X}_1	22,077	\bar{Y}_1	24,067	\bar{X}_2	21,46	\bar{Y}_2	25,815
D0x	220,92	D0y	316,72	D1x	35,757	D1y	24,271	D2x	34,52	D2y	29,772
S0x	14,864	S0y	17,797	S1x	5,980	S1y	4,9266	S2x	5,875	S2y	5,456

After that, the $\frac{X-\bar{X}}{Sx}, \frac{Y-\bar{Y}}{Sy}$, each of which has a distribution $N(0,1)$ provided that the corresponding sample has a normal distribution. Each sample of CG was divided into 6 intervals, and EG into 5 intervals. Using formulas (1) with $k=6$ and $k=5$ it is easy to get a partition of each sample into intervals with the same theoretical probability. For an example, we give a partition in case X_1 and calculate for this partition the statistics of the chi-square test: $X_1: m'_i = \frac{39}{6} = 6,5, m_1 = 9, m_2 = 3, m_3 = 9, m_4 = 5, m_5 = 4, m_6 = 9$ (combine the 1st and 2nd

intervals of the 5th and 6th): $\chi_{emp}^2 = \frac{(12-13)^2}{13} + \frac{(9-6,5)^2}{6,5} + \frac{(5-6,5)^2}{6,5} + \frac{(13-13)^2}{13} = 1,38 < 3,84 = \chi_{1,0,95}^2$.

It is also proved that all the samples satisfy the normality condition. In conclusion, we note that the proposed method allows to determine the minimum sample size for testing hypotheses by the chi-square test. It is easy to propose the following formula: $n \geq 5 \cdot (r + 2)$, where r – number of parameters of the law being checked.

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UDC 004.41

DEVELOPMENT OF ONLINE SERVICE FOR TEACHING PROGRAMMING ON JAVA

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The article deals with the step-by-step development of a web application with MVC architecture using the level of business logic (services), as well as POJO. This web application was implemented using a number of frameworks, including Spring Framework, Spring Security and MyBatis.

Introduction. Recently, online services have been gaining increasing popularity. They have a number of advantages, unlike traditional teaching methods. Online services can provide materials in the form convenient for perception: tables, graphics, animation, store a large amount of information of different kinds in one place and work with this information easily. They also provide an opportunity for transition to advanced teaching methods, when students study independently.

There is a small range of free online learning systems that are needed as a training apparatus at university. To such systems, including, belong systems for teaching programming languages. When analyzing the most popular languages and similar systems, the Java language was chosen, since it takes the second place in the ranking of the most popular programming languages after the query language SQL.

Main part. James Gosling, Mike Sheridan, and Patrick Naughton initiated the Java language project in June 1991. Java was originally designed for interactive television, but it was too advanced for the digital cable television industry of the time. The language was initially called Oak after an oak tree that stood outside Gosling's office. Later the project got the name Green and was finally renamed Java, from Java coffee. Gosling designed Java with a C/C++-style syntax that system and application programmers would find familiar.

PostgreSQL 9.6 was chosen as the database. This DBMS is a free software with an open source, and it is a very powerful system. There is a fairly large community where you can easily find answers to your questions. Despite the huge number of built-in functions, there are a lot of add-ons which allow you to manage the data [1].

List of the main frameworks used:

- Spring Framework. This is the central element of Spring is its inversion of control (IoC) container, which provides a consistent means of configuring and managing Java objects using reflection. The container is responsible for managing object lifecycles of specific objects: creating these objects, calling their initialization methods, and configuring these objects by wiring them together [2].

- Spring MVC. The Spring Framework features its own model-view-controller (MVC) web application framework, which wasn't originally planned. The Spring developers decided to write their own Web framework as a reaction to what they perceived as the poor design of the (then) popular Jakarta Struts Web framework, as well as deficiencies in other available frameworks. In particular, they felt there was insufficient separation between the presentation and request handling layers, and between the request handling layer and the model. Like Struts, Spring MVC is a request-based framework. The framework defines strategy interfaces for all of the responsibilities that must be handled by a modern request-based framework. The goal of each interface is to be simple and clear so that it's easy for Spring MVC users to write their own implementations, if they choose so. MVC paves the way for cleaner front-end code. All interfaces are tightly coupled to the Servlet API. This tight coupling to the Servlet API is seen by some as a failure on the part of the Spring developers to offer a high-level abstraction for Web-based applications [citation needed]. However, this coupling makes sure that the features of the Servlet API remain available to developers while offering a high abstraction framework to simplify work with the said API [2].

- Spring Security. This is a Java/Java EE framework that provides authentication, authorization and other security features for enterprise applications. The project was started in late 2003 as 'Acegi Security' by Ben Alex, with it being publicly released under the Apache License in March 2004. Subsequently, Acegi was incorporated into the Spring portfolio as Spring Security, an official Spring sub-project. The first public release under the new name was Spring Security 2.0.0 in April 2008, with commercial support and training available from SpringSource [2].

- Commons DBCP. This framework is responsible for creating a connection pool to a database in which each connection can consistently serve multiple clients.

- MyBatis. This is a Java persistence framework that couples objects with stored procedures or SQL statements using an XML descriptor or annotations [3].

To develop the client part, HTML was selected and the Bootstrap framework. It includes a set of tools for creating websites and web applications, HTML and CSS design templates for typography, web forms, buttons, labels, navigation blocks and other web interface components, including JavaScript extensions.

When designing a web-application, the architecture presented in Figure 1 was taken as the basis.

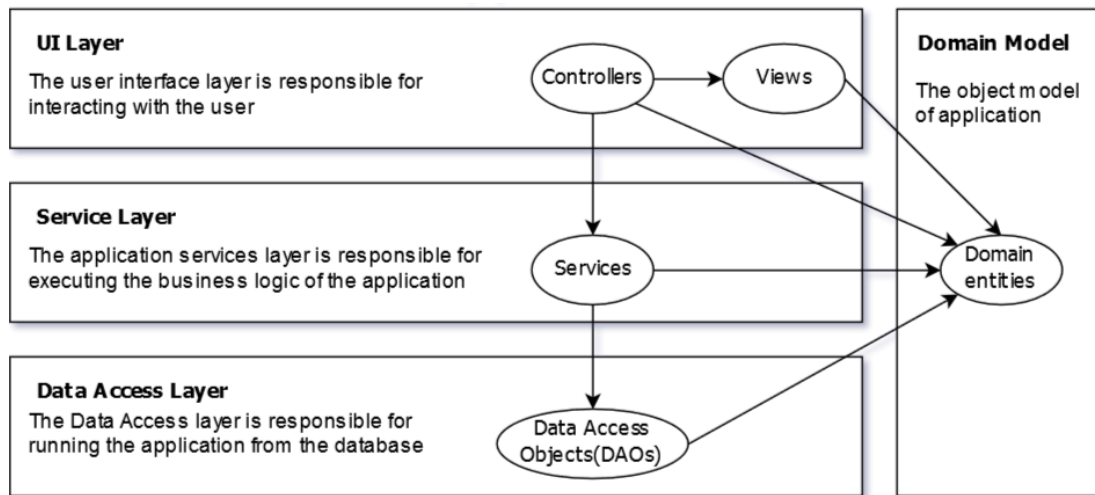


Fig. 1. The architecture of the developed web application

At the initial stage, the database schema was designed (Figure 2). From the figure it is possible to understand what functionality the developed service has.

After all the tables were defined, it was necessary to create the entity classes in the web application for convenient data manipulation. These classes are very similar to the tables in the database, but instead of storing the identifier for related data from another class, objects are stored. That is, if the product ID contains a record identifier from the product_types table, then the ProductType object is stored in the Product class object. In the case where many-to-many relationships are used, the entity list stores a list of objects.

The next step was the creation of DAO interfaces, as well as their implementation to retrieve and modify data stored in the database. Data Access Object is an object which provides an abstract interface to any type of database or storage mechanism. Certain features are provided regardless of what storage mechanism is used.

DAO was implemented with the help of MyBatis, for this purpose there were created classes that extend SqlSessionDaoSupport and implement their own DAO interface, as well as XML files where queries to the database were written. The implementation of methods consists mainly of getting the SQL session and calling the method described in the XML file.

When the DAO was ready and tested successfully, the implementation of the service layer (business logic) was started. As in DAO, first, a set of interfaces was created in which it was clearly defined what methods should be used. In the interface implementation classes, the fields are the DAO interfaces for which methods for inserting data (setters) were created. The methods used these fields to retrieve data from the database. As an example, you can consider the implementation of the process of saving a user in the system. Suppose we have a saveUser method in the service, it is necessary to save the user, and it does not matter if it exists at the moment, for this, the user's ID is checked in the implementation. If it is null, then it is necessary to call the create method from DAO, which will create a user, but in case the user already has an identifier, then the update method will be called, which will update the changed user data.

The next step was to create jsp pages, implement a set of custom tags, and also create controllers for the corresponding pages, as well as validators (on pages where data was stored in the database).

A custom tag is a tag that describes its implementation of something in HTML. For example, you can create an input tag, but where it will be specified additionally in which it will be wrapped (div with a certain set of classes), and will also have a label for this element (label). As parameters to such a custom tag, you can specify the text to the element's signature. These tags are very useful in case you are working with some UI framework, as usually simple designs are complicated by additional tags.

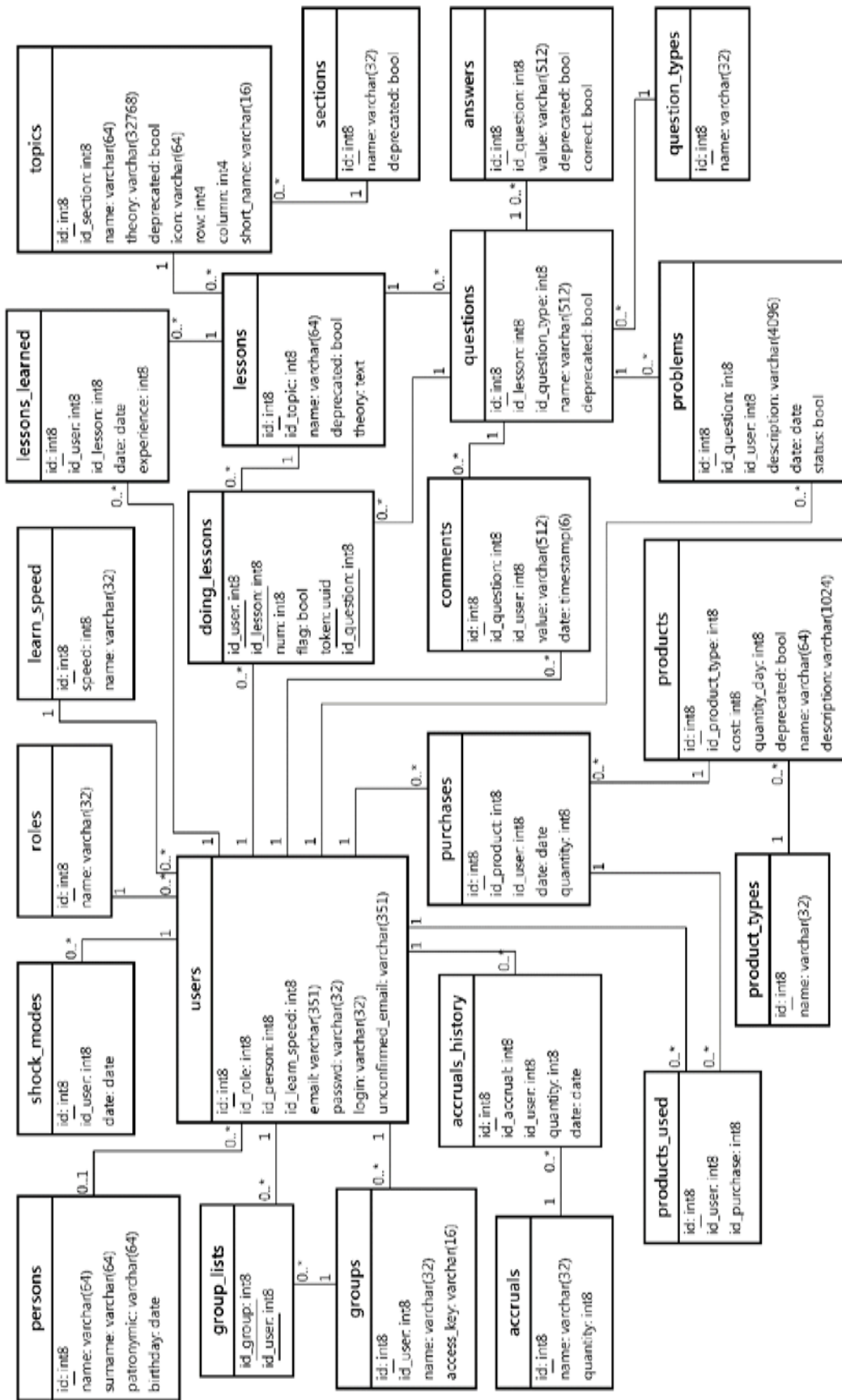


Fig. 2. Database schema of the developed web application

JSP (JavaServer Pages) is a technology that allows you to create content that has both static and dynamic components. The JSP page contains two types of text: static source data, which can be formatted in one of the text formats HTML, SVG, WML, or XML, and JSP elements that construct dynamic content. In addition, JSP-tag libraries, as well as EL (Expression Language), can be used to embed Java code in the static content of JSP pages.

Page controllers are implemented as follows. In the case when a stranger receives any data from the user, the validator is called, which checks the transmitted data. If all the data is correct, then the saving method is called, and if not, the user will receive an error of filling in the data. On pages that do not have the ability to update the data, depending on the situation, the data is transferred from the services to the JSP page.

Conclusion. Having considered the steps of creating this web application and architecture, it can be concluded that all were implemented in dependency order, as each layer of the web-application uses some other layer. It can also be noted that the author designed and implemented the service for interesting language learning of Java programming. Additional functionality is currently being developed.

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UDK 621.371: 550.837.6

METHOD OF TREATING INCOHERENT RADAR IMAGES IN REMOTE SENSING SYSTEM BASED ON FILTERING SPECKLE - NOISE

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The analysis of non-coherent processing of radar imaging methods is provided. The presence of speckle – noise leads to decryption complications of the radar image (RI), radiometric resolution and accuracy of the radar portrait component measurement of the object, 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 of RI. The main procedure for such filtering is incoherent accumulation or averaging of independent observations on the area of the selected window on the radar.

Introduction. A specific feature of radar signals reflected from different types of objects when irradiated with a narrow-band sounding microwave pulse is the presence of fluctuations (speckle noise), which are caused by interference of elementary reflectors forming the object. Principal in the formation of speckle noise is the ratio of the size of the object and the size of the image resolution element formed during coherent signal processing. For many artificial objects, such as aircraft, missiles, ships, the radar image is a set of bright marks from mirror points (dominant reflectors) with changes in the viewing angle. When broadband (or ultra-wideband) signals are used, the group object is divided into elements. Their mutual position during the synthesis can change under the influence of motion or shading. This leads to a violation of the coherence of the trajectory signal, a deterioration in the spatial resolution of the radar image, and an increase in the fluctuation.

The presence of speckle noise leads to a deterioration in the decipherability of the radar image, radiometric resolution and accuracy of measurement of the components of the radar portrait of the object, as well as to increasing the requirements for the data transmission channel and information display facilities. The main method of speckle noise reduction is the filtration of the resulting amplitude of the radar image or radar image by the energy corresponding to the squared amplitude.

Main part. Historically, the first generation of cosmic X-ray diffraction were permitted on the horizontal distance coarser than the resolution limit. They are used for the synthesis of RI optical signal by processing device selection synthetic aperture to have the same resolution in both coordinates. Available stocks of signal duration are used for non-coherent accumulation.

The method in which a single element resolution of synthetic diagram directivity antenna (DNA) of averaged radar images obtained at different Doppler frequencies (within element incoherent accumulation) is called «Multilook» 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 we can apply separation azimuth spectrum of Doppler frequencies subspectre followed by their further synthesis, detection and partial summation of radar images. The same incoherent accumulation operation can be performed and occur 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).

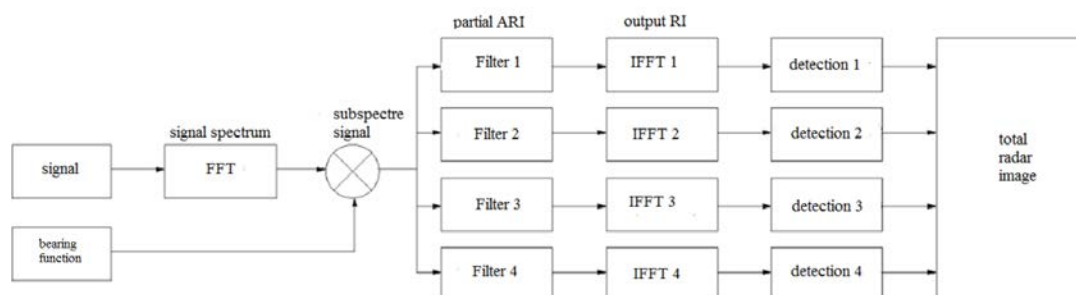


Fig. 1. Block diagram within Element incoherent accumulation

As the noise, we take the signal shown in Figure 2.

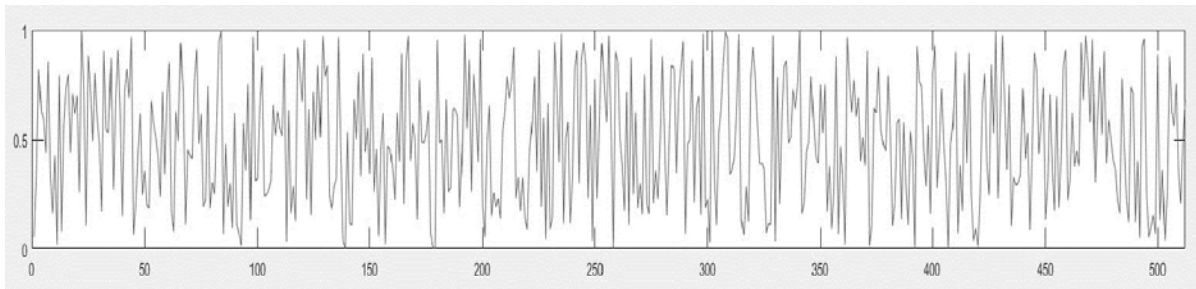


Fig. 2. Noise

As an input signal there will be a matrix of dimension 512x512. The result of matrix multiplication by noise is shown in Figure 3.

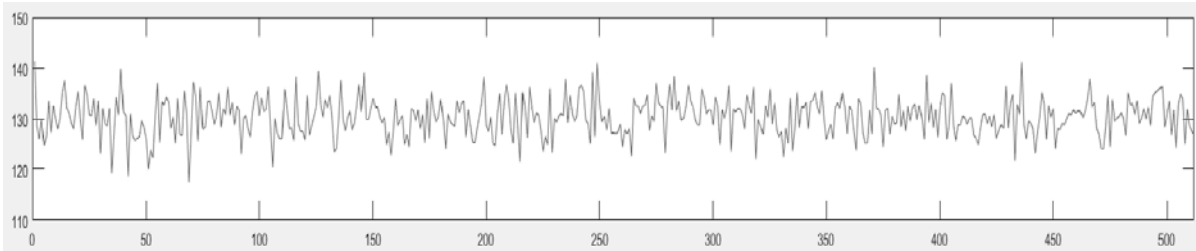


Fig. 3. Result of matrix multiplication with noise

The filter will use the Simple moving average Figure 4.

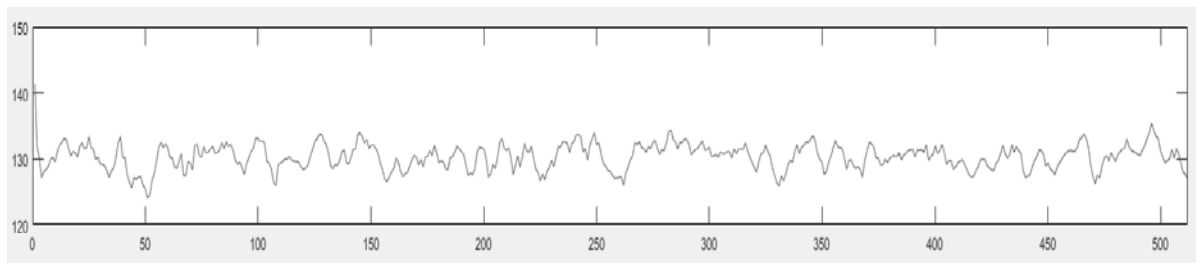


Fig. 4. Simple moving average

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. It can be seen from the figures that the moving average algorithm gives a small win in the speckle noise filtering.

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APPROACHES TO DESIGNING A GRAPHICAL WEB-BASED INTERFACE USING AN EXAMPLE OF A WEB APPLICATION
"THE WEB PORTAL OF THE AMATEUR HANDBALL OF THE REPUBLIC OF BELARUS"

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The article presents the analysis of the technologies used in the implementation of web application interfaces. The example of the implementation of the web interface of one of the web application pages is given.

Introduction. Nowadays various software products with access through a web interface are called web applications or sometimes web-based systems. A web application is a client-server application in which the client acts as a browser, and the server is a web server. The logic of the web application is distributed between the server and the client, the data is stored mainly on the server, information is exchanged over the network. One of the advantages of this approach is the fact that clients do not depend on the specific operating system of the user, so web applications are cross-platform services.

The significant advantage of building web applications to support standard browser functions is that the functions must be executed independently 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 an arbitrary chosen platform and is deployed on it.

The relevance of creating a web application is justified by the fact that with the development of portable computers and mobile devices, the client part of the web application can be used not only on stationary computers and laptops, but also on the mentioned mobile devices.

Means of solving the problem. The main approaches and means for implementing the interface of the developed web application covering the amateur handball of the Republic of Belarus are considered.

As an authentication system, the ASP.NET Identity system will be used, which allows to authorize through external services, manage roles to differentiate access to data, validate email and phone by SMS, and validate passwords [1].

To optimize the design of the site for various types of devices and to simplify the task of graphic design of the site, Twitter Bootstrap, jQuery, AJAX will be used.

jQuery is a javascript library, the use of which makes development of javascript code much faster and easier. In the recent past, this library allowed you to quickly develop scripts. The jQuery library helps you easily access any DOM element, access and manipulate the attributes and contents of DOM elements. Also, the jQuery library provides a convenient API for working with AJAX [2].

AJAX, or, Asynchronous Javascript And Xml, is a technology for interacting with the server without reloading the pages. Due to this, the response time is reduced and the web application interactivity more resembles the desktop. For example, you can leave comments on the page summarizing the results of the competition and immediately see the result of adding a comment without reloading the page. To exchange data with the server, a special XMLHttpRequest object is used, which can send a request and receive a response from the server. When updating data, the web page does not completely restart, and web applications become faster and more convenient [3].

Bootstrap is a framework that Twitter has developed. It is designed to facilitate the construction of a graphical interface. The library itself includes a huge number of elements such as buttons, web forms, navigation blocks, etc. If nothing is initially changed, the resulting form will be similar to that of many other developers using the same framework, but it should be taken into consideration that at the early stages of development an accurate interface can be obtained, and eventually it can be still customized. The source codes are also distributed by the MIT license, which allows free use and change of technology [4].

Interface design. The main site page contains news from the world of handball, at the bottom of the screen there is the information about the nearest birthdays of the players. At the top of each page of the site, using the master page, the navigation bar and registration, login, exit buttons from the personal cabinet can be seen (fig. 1).

When clicking on the "Registration" link, the user will be redirected to the registration page. On this page, the user must enter a name, a unique email, a password and a password confirmation. If the user fill in the forms correctly, they will be redirected to the login page.

In the personal account, the user can register new sports events if their email has been confirmed. To confirm the email, you must click the "Confirm email" link, after which an email with a further instruction will be sent to the user's email.

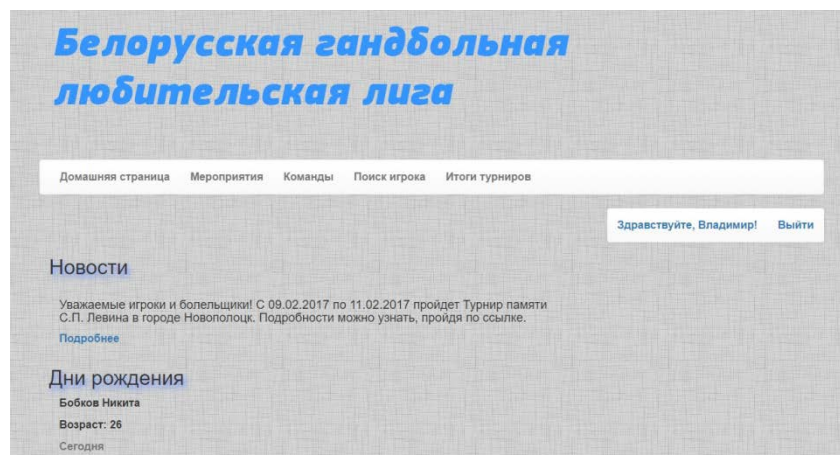


Fig. 1. Home page

On the right on the personal cabinet page, the user can change the avatar by downloading an image up to 4 MB in size. On the left on the personal cabinet page, the user can see a list of all the events that they have registered earlier.

If the user selects "Tournament totals" in the navigation bar, the user will be taken to the page with the list of the past sporting events. Selecting one of the tournaments from the list of events, the user will be able to view the results of the tournament with a photo and video report, and, if the user is authorized, to share comments at the bottom of the page. The dynamism of adding comments without reloading the page has been obtained using the AJAX web technology for the form of adding new comments. When editing a sports event, the administrator, in addition to editing the basic information about the tournament, can attach a photo and video to the selected event, and use the wysiwyg editor's built-in page [5] to fine-tune the text description of the event.

If the user selects "Search for a player" in the navigation bar, the user will go to the page containing a table with a list of all players participating in amateur tournaments. The user has the following functionality on this page:

- 1 select the number of players displayed on the page;
- 2 sorting players by any field;
- 3 page output of the list of players;
- 4 dynamic search of the player on any of the fields.

This functionality has been achieved by using the jQuery-plugin DataTables [6], which in addition to these functions provides a wide range of settings and customizations for tables.

If the user selects "Teams" in the navigation bar, the user will go to the page containing the list of teams. When you click on the name of one of the commands, you go to the page containing detailed information about the selected team.

The conclusion. In conclusion, when developing web interfaces, it is necessary to take into account not only the beautiful external component, but also such important factors as "usability", ease of use, understandability for the user, browser independence, cross-platform, adaptability for various sizes screens, dynamism. And all these requirements can be achieved by using an absolutely small set of frameworks and libraries like Twitter Bootstrap, AJAX, jQuery in mentioned above case.

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UDC 004.492.2

SYSTEM FOR PROTECTING EXECUTABLE FILES OF THE JAVA PROGRAMMING LANGUAGE

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The paper describes a way to protect Java applications from unauthorized access to bytecode using symmetric encryption algorithm RC5. Great attention is paid to the implementation of javaagent and maven-plugin.

Currently, most attacks occur at the application level. Therefore, software protection has the highest priority. Difficulties often arise with software developed to order, as information protection and vulnerabilities in the system are given minimal attention, as very often modern software products are developed in a short time and with limited budgets.

One of the most effective methods for protecting software is to encrypt files with executable code. Encryption of executable files allows you to secure the software product, prevent most problems, such as unauthorized access, the introduction of bookmarks, the activity of network worms and viruses, the use and modification of the software product.

The development of a software product that provides protection for executable files of the Java programming language to prevent unauthorized access to the software product is a very urgent task.

The Java source file is a text file with a .java extension that contains one or more class definitions. The Java compiler generates a bytecode from each .java file. The bytecode obtained during the compilation process, for each class is written in a separate executable file, whose name coincides with the class name and has the extension .class. When the program starts, the necessary .class files are loaded by the JVM (Java virtual machine) and bytecode instructions can be executed [1].

The main idea of the development is that the .class files will be stored in an encrypted form, and they will be decrypted when they are downloaded to the JVM. The files can be encrypted by any program after compilation, then it will be shown how to automate this process. And the decrypt files will be javaagent - a program that can intercept the bytecode of another program when it is loaded into the JVM [2].

One of the main tasks that need to be solved at the design stage is the choice of a reliable encryption algorithm. As such an algorithm RC5 (Ron's Code 5 or Rivest's Cipher 5) was chosen - a block cipher developed by Ron Rivest from RSA Security Inc. in the mid-90's, with a variable number of rounds, the length of the block and the length of the key [3].

There are several different variants of the algorithm, in which the transformations in the "half-rounds" of the classic RC5 are slightly modified. In the classical algorithm, three primitive operations and their inversions are used:

- Addition modulo 2^w ;
- XOR;
- the operation of cyclic shifting to a variable number of bits ($x \lll y$).

The main innovation is the use of a shift operation on a variable number of bits not used in earlier encryption algorithms. These operations are performed equally quickly on most processors, but at the same time significantly complicate the differential and linear cryptanalysis of the algorithm.

Encryption using the RC5 algorithm consists of two steps:

- procedure for expanding the key;
- encryption.

To decrypt, the key expansion procedure is performed first, and then follow the operations that are the reverse of the encryption procedure. All operations of addition and subtraction are performed modulo 2^w [3].

Now everything is ready to demonstrate the features of the implementation of javaagent as a decrypting program.

The decryption program is divided into two subsystems: decryption and downloading of bytecode. The decryption subsystem includes the RC5 class, which implements the decryption of the byte array. This class provides a decryption function, in which parameters the array of encrypted data bytes, the byte array of the key, and the original size of the .class file are transferred to the encryption. The decryption function returns an array of decoded data bytes of the original size, i.e. After decryption, the array is reduced to the size of an unencrypted .class file.

The byte-code download subsystem includes the ClassTransformer class. It implements the ClassFileTransformer interface, redefining the transform method, thereby allowing through the Java Instrument API to access the bytecode that is loaded by a third-party application of classes [4]. The transform method ensures that only those classes that have been encrypted are decrypted, the bytecode of the remaining classes remains unchanged. Also in class ClassTransformer functions are implemented to load the key from the file and load the display "class name - the initial size of the class file".

The entry point of the decrypting program is the premain function of the PreMain class. The premain function has access to the javaagent parameter passed to the function parameters, which must contain the name of the key file and the file name with the class names and their initial sizes, separated by the ";" symbol. Another parameter to the premain function is the Instrumentation class object passed to the JVM. This object will allow the JVM to pass the implementation of the ClassFileTransformer interface, i.e. class ClassTransformer. After this, the JVM loads the third-party program classes via the overridden transform method.

Earlier it was said about the automation of encryption of executable files. This problem can be solved with the help of Maven-plugin, which encodes .class-files after compilation. Apache Maven is a popular tool for building Java projects [5]. It has a variety of different plug-ins that can be used during various assembly phases. In addition, there is an opportunity to develop your own plug-in, which will be discussed later.

The encryption program (Maven-plugin) is divided into three subsystems: encryption, interaction with Apache Maven, key generation. The main functionality of the encryption subsystem and the key generation subsystem is implemented in three classes: RC5, Encryptor, EncryptionInfoSaver.

The RC5 class implements the same algorithm with a 64-bit encryption unit, key length 255 bytes and 150 rounds of encryption, which ensures that differential cryptanalysis can not be cracked. This class contains a key function called encrypt, which takes three parameters into the input: the incoming byte stream to be encrypted; the outgoing byte stream, in which, after exiting the function, the encrypted content of the incoming stream will be The key by which the incoming byte stream will be encrypted. This function returns the number of bytes read from the incoming stream. This number will need to be known during decryption, because the encrypted file can be more decrypted (or original). The difference in the sizes of the decrypted and encrypted file is explained by the fact that the RC5 encryption block has a length of 64 bits, which means that the size of the encrypted file must be a multiple of 64 bits. Therefore, when encrypting the size of the original array of bytes increases to a value that is a multiple of sixteen (bytes), and when decryption, the original size is restored.

The Encryptor class contains functions for encrypting the folder in which the compiled .class files are located. First, you determine the path to the folder you want to encrypt, the path to the folder to which to encrypt the files and the list of file filters. A file filter is a string template, to exclude those files that do not require encryption. The file filter pattern is built using the same rules as in the Windows command line and in the Unix console, for example, the "?" And "*" characters represent one or more characters respectively, and the "* Controller?. Java" filter will include such files, as "SystemControllerA.java", "FlurryController1.java", etc. After defining the paths to the folders and filters, a key for encryption is generated. The key is stored as an array of bytes. Then there is a recursive encryption of the folder. Encrypt only those files that have the extension .class and do not fall under the conditions of the user file filters, the rest of the files are copied to the destination folder. During the encryption process, the display shows "class name - the size of the original .class file". This mapping is used when decrypting.

The EncryptionInfoSaver class contains functions that store information about encryption, namely the key and the display "class name is the size of the original .class file". The information stored by this class is not encrypted. Therefore, when a key file is transmitted over an open channel, it must be previously encrypted with third-party software.

The subsystem of interaction with Apache Maven is implemented in the class CryptoMojo. This class extends the AbstractMojo class and overrides the execute method [6]. The CryptoMojo class uses the Maven Plugin API to make its functionality available to the Maven collector. Overriding the execute method is one of the requirements of the Maven Plugin API, when executing the plug-in by the Maven collector, this method is performed. The CryptoMojo class has three attributes: buildDir - the folder with the source compiled files .class; targetDir - the folder in which I will save the encrypted files; exclusions - a set of filters to exclude certain files that do not require encryption. All attributes are marked with an @Parameter annotation. Therefore, the values of these attributes are loaded from the. Pom-file of the project's Maven configuration. The excluding parameter is optional and can be omitted. The CryptoMojo class itself is marked with an @Mojo annotation with the encrypt parameter and therefore, when configuring the plugin, it is necessary to set the goal "encrypt". After loading all the attributes the execute method is called, in this method the encryption methods are called, the encryp-

tion information is saved, and if Maven is started in debug mode, output information about the actions of the plugin in the general log.

The results of this study can be used by software developers and users to prevent unauthorized impacts on the software product.

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DEVELOPMENT OF A SERVICE FOR ANALYZING THE POPULARITY OF TOURIST ATTRACTIONS IN GRODNO

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This article is about the service, which was developed as a map with visual representation of the popularity of tourist attractions in Grodno by location based on photos from Instagram for a given polygon.

Today, due to the intensive growth in the development of information technologies and services on the Internet, a number of all kinds of websites, portals and information resources are steadily growing.

Any user can easily find a website where he can pick up information about the city or country he is interested in. In the augmented reality mode user can go through virtual museums, see photos of his countries of interest.

However, all of the above cannot be compared with a true journey. And before going on a trip, users often think about what they will visit in the city, and about what attractions they will happily pay attention to.

The actuality of the work lies in the fact that Grodno is a territory of visa-free entry to the park "Augustow Canal"[1], and, consequently, the influx of tourists into the city should significantly increase.

The purpose of creating a cartographic service is to provide tourists and residents of Grodno with up-to-date interactive information about popular spots in the city. The service also identifies local attractions, plus historical and cultural heritage. This allows tourists to orientate themselves in an unfamiliar city and see it through the eyes of its inhabitants.

A web service is any piece of software that makes itself available over the internet and uses a standardized XML messaging system. XML is used to encode all communications to a web service. For example, a client invokes a web service by sending an XML message, then waits for a corresponding XML response. As all communication is in XML, web services are not tied to any one operating system or programming language--Java can talk with Perl; Windows applications can talk with Unix applications.

Web services are XML-based information exchange systems that use the Internet for direct application-to-application interaction. These systems can include programs, objects, messages, or documents. [2]

First of all, for the development of the service, a coordinate polygon was obtained from Grodno:

Coordinates of the northern part of the city: 53 ° 45'52.7 "N 23 ° 48'28.7" E

Western part: 53 ° 40'09.7 "N 23 ° 42'59.9" E

Southern part of the city: 53 ° 36'28.4 "N 23 ° 49'05.8" E

Eastern: 53 ° 39'23.5 "N 24 ° 00'00.8" E.

The work of cartographic service is implemented as follows, which are represented in the figure 1.

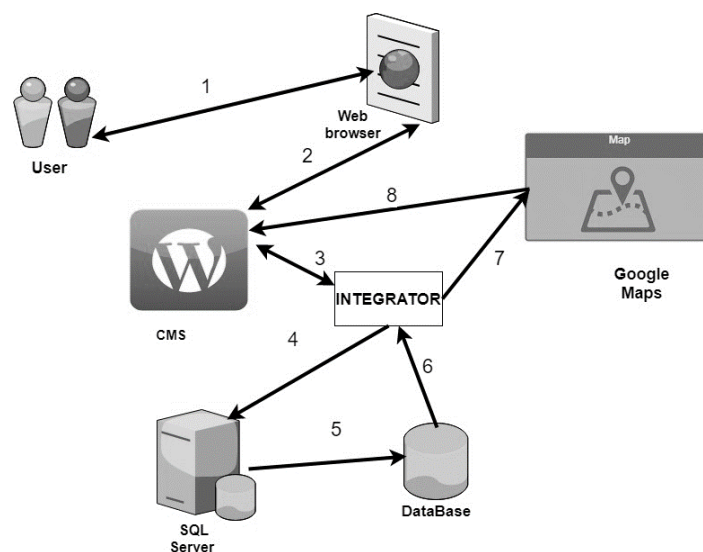


Fig. 1. The architecture of the developed service

The user enters the web browser at the specified address, the web browser in turn refers to the CMS (Content Management Software) WordPress. In order to display data to the user The CMS executes the request in the SQL server.

Requests are made through the PHP language and the MySQL Database. The server, in turn, accesses the database using SQL-queries and takes information at the user's request. In order for the user to return a map with content as a response, a query is received from the database to the integrator, which performs the function of integrating the request to the Google Maps API, where a map is formed for a given coordinate polygon with the required parameters from the user. Working with the Google Maps API is done using the JavaScript scripting language. In order to see the result, the card is transferred to the CMS platform. As a result, the user is shown a map where the total number of photos taken in this place is displayed.

Before executing all queries, the database must be filled with information. The architecture of this interaction is presented in Figure 2.

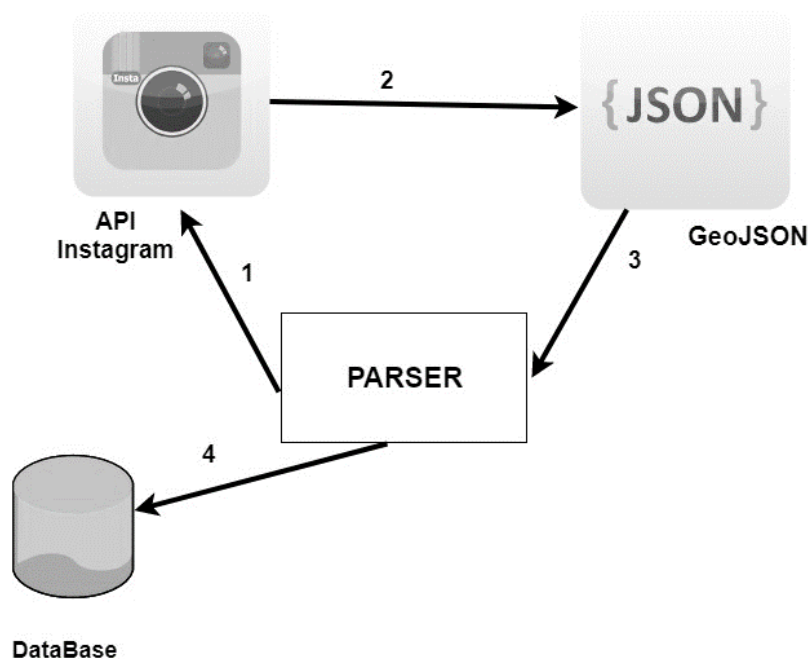


Fig. 2. Getting the geodatabase and filling the database

To access the Instagram API, first you need to register as an Instagram developer, and then register the application with Instagram Developer. After registration, you can use `client_id` and `client_secret` - this will allow you to take custom and photo data from the Instagram API. The parser, written using the Python programming language, accesses the Instagram API to retrieve the location of the photos to transfer this data to the Google map in the future. As a result, the analyzer returns a response in the JSON format. It processes this response and transfers the geographic coordinates to the database. Counting the total number of photos taken in one place is done through SQL queries.

User work with cartographic service in two modes: unauthorized user and authorized. To an unauthorized user, a city map is available that shows the total number of photos taken at different locations in the city, depending on the specified geolocation data of Instagram users; the same card is available to the authorized user and the ability to select certain criteria for map formation is added. So the user can select a certain period of time, at this point the query is sent to the database in the database for this period, then using the integrator and the PHP language, geolocation data from the database is mapped to Google Map coordinates and with the help of JS and GoogleMapsAPI the data is drawn on the map, presented in the CMS platform. Thus, based on a custom map, the user can see which places were popular for the period he selected. Also, the user has the ability to work only with the data of his account. If in your account in the Instagram the user has photos stored in Grodno with a marked geolocation, then a parser is started which fills the database for this user, where a map with visual analysis of the sights popularity of this particular user is presented.

As a result, a cartographic service was developed, which is a map with visualization of the analysis of the popularity of tourist attractions in Grodno by geographical coordinates of photos from the social network of Instagram for a given range.

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FUZZY LOGIC SYSTEMS

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This article gives a brief description of fuzzy logic systems, comparative analysis of Defuzzification methods used to build artificial intelligence. The description of the basic principles, rules and operations for working with fuzzy sets is introduced.

Fuzzy systems have been successfully applied as a paradigm, demonstrating the use of linguistic information in the design of systems. Industrial design is involved in the process of monitoring and improving products, for this purpose forecasting and time series analysis are used. In production control and planning fuzzy systems are the subject of research and implementation. For example, applications of fuzzy constraint removal in planning [1], fuzzy approach to dispatching rules in schedules [2].

The process of a fuzzy system design is described as a process of articulating commonsense knowledge by using terms, creating fuzzy rules and numerically defined membership functions for them, and applying a fuzzy inference method. The notion of a fuzzy set was introduced first by Lotfi Zadeh in 1965, who later developed many of the methods of fuzzy logic based on this simple notion. It took a couple of decades for the rationale of fuzzy sets to be understood and applied by other scientists [3].

The traditional way of representing elements u of a set A is through the characteristic function: $\mu_A(u) = 1$, if u is an element of the set A , and $\mu_A(u) = 0$, if u is not an element of the set A , that is, an object either belongs or does not belong to a given set. In fuzzy sets an object can belong to a set partially. The degree of membership is defined through a generalized characteristic function called membership function.

The values of the membership function are real numbers in the interval $[0, 1]$, where 0 means that the object is not a member of the set and 1 means that it belongs entirely. Each value of the function is called a membership degree. One way of defining a membership function is through an analog function.

Ordinary sets are a special case of fuzzy sets when two membership degrees only, 0 and 1, are used, and crisp borders between the sets are defined. All definitions, proofs, and theorems that apply to fuzzy sets must also be valid in the case when the fuzziness becomes zero, that is, when the fuzzy set turns into an ordinary one.

An analog-function representation of membership functions is used to represent some operations with fuzzy sets. The following operations over two fuzzy sets A and B defined over the same universe U are the most common in fuzzy theory: Union, $A \cup B$, Intersection, $A \cap B$, Equality, $A = B$.

One of the most important steps toward using fuzzy logic and fuzzy systems for problem-solving is representing the problem in fuzzy terms. This process is called conceptualization in fuzzy terms. We often use linguistic terms in the process of identification and specification of a problem, or in the process of articulating heuristic rules [4].

The term linguistic variable is a variable which takes fuzzy values and has a linguistic meaning. The process of representing a linguistic variable into a set of linguistic values is called fuzzy quantization. Choosing the number and the form of all the fuzzy labels that represent a fuzzy variable is a crucial point for a fuzzy system. If we have defined the fuzzy-quantizing labels, for example, "small," "medium," or "large," we can represent any particular data item as a set of membership degrees to the fuzzy labels. Fuzzy discretization does not lead to loss of information if the fuzzy labels are correctly chosen.

Fuzzy values defined by standard membership functions have some useful properties when used in fuzzy rules. Choosing a standard type of membership function, when not given or known a priori, resembles choosing the gaussian probability distribution for the conditional probability in the Bayes's theorem.

Fuzzy quantization is possible not only on numerical variables but also on qualitative variables like "truthfulness of events." Fuzzy qualifiers give a fuzzy evaluation of the truthfulness of an event. Typical fuzzy qualifiers are "very true," "more or less true," and "not true,".

The biggest restriction in classic propositional and predicate logic is the fact that the propositions can have their truth-values as either True or False. This restriction has its assets as well as its drawbacks. The main asset is that the decision obtained is exact and precise. The main drawback, however, is that it cannot reflect the enormous diversity of the real world, which is analog and not digital. The truth value of a proposition in classic logic cannot be unknown, for example.

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In order to overcome this limitation of classic logic, multivalued logic has been developed. The truth of a proposition is represented by a set T of n possible truth-values, when n -valued logic is considered. For the three-valued logic, $T = \{0, 0.5, 1\}$. There are a huge number of theories, formulated on the basis of the multivalued nature of truth. Fuzzy logic can be considered an extension of the multivalued logic.

Fuzzification is the process of finding the membership degrees $\mu_{A1}(x'1)$ and $\mu_{A2}(x'2)$ to which input data $x'1$ and $x'2$ belong to the fuzzy sets $A1$ and $A2$ in the antecedent part of a fuzzy rule. Through fuzzification the degrees to which input data match the condition elements in a rule are calculated. When fuzzy input data are used, such a degree can be represented by the similarity between the input membership function and the condition element.

Defuzzification is the process of converting information from the space of universal fuzzy data into the space of output operational values. In 1996, in scope of the Intelligent Control Term Project Papers, a study was conducted of the characteristics of various defuzzification methods conducted by Won-Kyung Song and Jong-Pil Lee [4]. Conversion of fuzzy sets to numerical values is impossible without losing part of the information contained in it. Many dephasing methods have been developed, but most of them have similar problems. And there is no single rule that helps to choose a method for solving a particular problem. The authors considered 14 methods of defuzzification:

Comparison of defuzzification methods for standard membership functions is presented in table 1.

Table 1. – Modern methods of defuzzification and its characteristics

	Continuity	Disambiguity	Plausibility	Comp. Complexity	Weight Counting	Confidence Level Loss	Discrete Version
Center of Gravity	Yes	Yes	No	Bad	No	Yes	Yes
Center of Sums	Yes	Yes	No	Bad	Yes	Yes	Yes
Mean of Maxima	No	Yes	No	Good	No	No	Yes
Center of Maxima	No	Yes	No	Good	No	No	Yes
First of Maxima	No	Yes	No	Good	No	No	Yes
Last of Maxima	No	Yes	No	Good	No	No	Yes
Center of Area	Yes	Yes	No	Bad	No	Yes	Yes
Center of Largest Area	No	No	Yes	Bad	No	Yes	Yes
Height	Yes	Yes	No	Good	Yes	Yes	Yes
Maximal Height	No	No	Yes	Good	No	No	Yes
BADD	Yes	Yes	No	Bad`	No	Yes	Yes
SLIDE	Yes	Yes	No	Bad	Yes	Yes	Yes
M-SLIDE	Yes	Yes	No	Bad	Yes	Yes	Yes
Saade's Method	Yes	Yes	Yes	Bad	Yes	Yes	No

Conclusion. In this article we have examined the basic principles of fuzzy logic, the main ways to build fuzzy systems. A brief description of the basic concepts and terms is given - fuzzy set, membership functions, classifiers, quantization. The stages of fuzzification and de-fuzzification were studied, and the methods of defuzzification and their characteristics were compared.

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WEB-RESOURCES PARSING IMPLEMENTATION FOR ACQUISITION OF MEDIA CONTENT

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There is great amount of media content in the world, which constantly grows after release of new films, serials, etc. In order to collect all this information together, it is necessary to customize web-resources parsing process, which is constantly able to update the single database of media content. The necessity of writing is based on the fact that there is no single parser which allows to obtain all necessary information from web-sources.

Site parsing can be divided into three phases: obtainment of the content in the original view, extraction and transformation of data, report generation.

In the first phase a web page is downloaded for its further analysis and extraction of necessary information. Different libraries are provided for almost every language which allow to get the information from the site.

In the second phase parser extracts necessary information from the code of web page thereby separating necessary information from the programming code of the page. For each resource its own data collection rule is created. Before these programmers analyze the page with data and work out a solution where the necessary information is displayed, where it is hidden, which way it is displayed in. All this process, in fact, means the customization of parser.

The last phase is report generation. Parser transforms obtained data in the type of information that was set. It might be text files, or data record directly in the database of the site, or another type of final information obtainment [1]. Data received during the parsing is necessary to enter into temporary storage. After preview and settings, they can be used in the main storage. Also it is necessary to enter the logging of the parser's work, in order to be able to respond on the errors which appeared in the work.

There are some approaches to data parsing: analysis of DOM tree, Xpath, Regex.

The first approach is based on analysis of DOM tree. Using this approach, data may be obtained by ID directly: name or other attribute of the tree element (such elements can serve as paragraph, table, block, etc.). Also if element is not specified by any ID, that you can get to it by some unique way such as getting down the DOMs tree.

You should use a DOM parser when:

- you need to know a lot about the structure of a document;
- you need to move parts of the document around (you might want to sort certain elements out, for example);
- you need to use the information in the document more than once.

When you parse an XML document with a DOM parser, you get back a tree structure that contains all of the elements of your document. The DOM provides a variety of functions you can use to examine the contents and structure of the document.

Advantages of this approach are the following:

- you can get data of all types and difficulty level;
- if you know the placement you can get its value by writing the path to it.

Disadvantages of this approach are the following:

- different HTML / JavaScript tools generate DOM tree in various ways, so it is necessary to bind to a specific tool;
- the path of the element can be changed, so, as a rule, such parsers are designed on short-term period of data collection;
- DOM-path can be difficult and now always definite [2].

The next evolutionary step of DOM tree analysis is the use of XPath — it means the paths, which is widely used for parsing XML data. The nature of this approach is to describe, with help of some simple syntax, the path to the element without necessity of gradual movement down along the DOM tree.

Xpath provides a simple way to get an enumeration of necessary elements of HTML page, for example, the list of new series, which will present a container, that stores text and graphic information.

HtmlAgilityPack tool is necessary for the adequate work of XPath. XPath can work only with valid XML. HTML page in most cases is not valid, because some browsers do not demand the valid XML – just one unopened tag and standard components for work with XPath and it simply cannot download the document for further processing [3].

Following are the key components of XPath are required:

- Structure Definitions - XPath defines the parts of an XML document such as elements, attributes, texts, namespace, processing-instructions, comments, and document nodes.

- Path Expressions XPath provides powerful path expressions and select nodes or list of nodes in XML documents.

- Standard Functions XPath provides a rich library of standard functions for manipulation of string values, numeric values, date and time comparison, node and QName manipulation, sequence manipulation, Boolean values etc.

- Major part of XSLT XPath is one of the major element in XSLT standard and it must have data in order to work with XSLT documents.

- W3C recommendation XPath is official recommendation of World Wide Web Consortium (W3C).

XPath uses a path expression to select node or list of nodes from an xml document. XPath parser is used to navigate XML Document only. It is better to use DOM parser for creating XML.

One of the approaches is based on the parsing with the use of regular expressions. Regular expression (regex) – is a mechanism, which allows to assign the sample for a string and to implement the data search, which is appropriate to this sample in assigned text. In addition, extra function for work with regex allow to get found data in the form of string array, produce replacement in the text according the sample, split the string according the sample, etc. However, the main function, which all others are based on, is exactly the function of data search in text appropriate to sample described in syntax of regular expressions. Regular expressions are necessary only for extraction of data, which has strict forms.

Regular Expressions, most often known as “RegEx” is one of the most popular and widely accepted technological means used for parsing the specific data contents from large texts. A regular expression is a specific pattern or a specific sequence of some special characters (known as “meta characters”) that gives you an ability to concisely and flexibly “match” or “capture” (specify and recognize) strings of text, such as sequence of particular characters, words, or patterns of characters.

The technique of extracting only the required data and neglecting all the other unnecessary content from the given large text with the help of Regular Expressions is nothing but “RegEx Parsing”.

There are many tools that are used for RegEx parsing. Some of them are RegxBuddy, RegexPal, RegexMagic, RegexPlanet and Rubular.

The main thing about regular expressions that makes it so simple and useful for all is its syntax. The regular expression syntax is declarative. The pattern “looks like” what you want to match. Another most important thing that makes regular expression to spread their magic very quickly is its vast and powerful set of meta characters. Regular expressions are blessed with very rich and powerful set of meta characters. Each of these meta characters has its unique meaning in itself and plays an important role independently or dependently in making the regular expression more powerful.

The most appropriate approach for obtainment media content is the approach based on the analysis DOM tree. It provides to get necessary information regardless the validity of html-page. During the analysis of DOM tree, you can get data of all types and difficulty levels. The example of parser which implements the obtainment of information about the serials is described on listing 1.

Listing 1. Example of parser implementation

```
// create a DOM from the URL
$html = file_get_html('http://www.lostfilm.tv/series/');
// path for saving pictures
$path = './images/serials/';
// select all the div tags with the class row on the page
// this block contains information about the show
foreach ($html->find('div[class=row]') as $element) {
// search for a link to image
    $imgUrl = $element->find('img[class=thumb]')->src;
// retrieve image by link
```

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```
$img = file_get_contents($imgUrl);  
// get the series name  
$nameSerials = $element->find('div[class=name-ru]')->text;  
// save information about the sereal in the database  
(new Serials)  
->setName($nameSerials)  
->setImagPath($path . $nameSerials)  
->save();  
// save the picture to the server in the specified location  
file_put_contents($path . $nameSerials, $img);  
}
```

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UDC 621.371: 550.837.6

FORMATION OF IMAGES IN A DIGITAL RADAR

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This article shows an algorithm for creating images in digital radars with synthesized aperture using the example of a radio hologram constructed with the help of the MATLAB environment. A linearly frequency-modulated pulse is used as the probing signal. The main parameters for the formation of a radio hologram are calculated.

Satellite radar is currently one of the most important and dynamically developing directions of remote sensing.

The basis of satellite radar is the development of methods and equipment that provide the formation of radar images of the earth's surface with high spatial resolution, which serve as information support for solving a wide range of scientific, economic and defense problems [1].

In modern conditions, radar facilities for remote sensing of the Earth, using radars with a synthetic aperture of aircraft and space based systems, have wide application in the world practice.

The method of synthesized antenna aperture is a special case of information processing methods used in holography. The peculiarity of holography is the registration of not the direct image of an object, like a photograph, but the Fourier transform that determines the structure of an image. The synthesized aperture is formed sequentially in time, at each given moment, the EMV is received by a real antenna, and the synthesized aperture is the result of a time-based reception of the EMV by a real aperture at its different position relative to the EMV source [2].

Remembering a series of signals sequentially received by the radar antenna at each point on the path section, coherently summing them, we obtain a narrow DN of the artificially generated antenna array. The lattice size is equal to the length of the trajectory section, on which the storage and coherent summation of the signals is made.

In the digital radar model, a pulsed radar method will be used: the radar transmitter emits energy briefly, with repetitive pulses, in pauses; the receiving pulses are received by the receiving unit of the same radar. The measurement of the range to the target is reduced to measuring the time interval between the moment of the pulse emission and the moment of reception, that is, the time of the pulse movement to the target and back.

To ensure a sufficiently high resolution in range, it is necessary to emit probing pulses of 0.1 μ s duration, however such short pulses have low energy. Therefore, the apparatus with a mode of operation of short pulses has a short range. Increasing the range is achieved using the technique of pulse compression. The transmitter emits a pulse of tens of microseconds, which provides a large pulse energy, and hence a longer range. High resolution is provided by compression - reducing the pulse width in the receiver due to the use of intrapulse modulation.

The frequency inside the radiated pulse increases linearly with time. Reflecting from the target, the chirp pulse comes after amplification in the receiver in the compression filter. The principle of the filter is. That the lower the frequency of the received signal. The more time he lingers in the filter. As a result, at the moment of the end of the pulse, all of its energy is concentrated at the output of the filter - the pulse is compressed. [3]

We form a probing chirp pulse duration 1 μ s and amplitude 1 according to the formula:

$$S_{LPM}(t) = S_0 \cos \left\{ \varphi_0 + 2\pi \left(f_0 t + \frac{b}{2} t^2 \right) \right\} \quad (1)$$

where S_0 - signal amplitude

φ_0 - initial phase

f_0 - central carrier frequency

b - signal duration

The plot of the sounding signal built in the matlab environment (fig. 1).

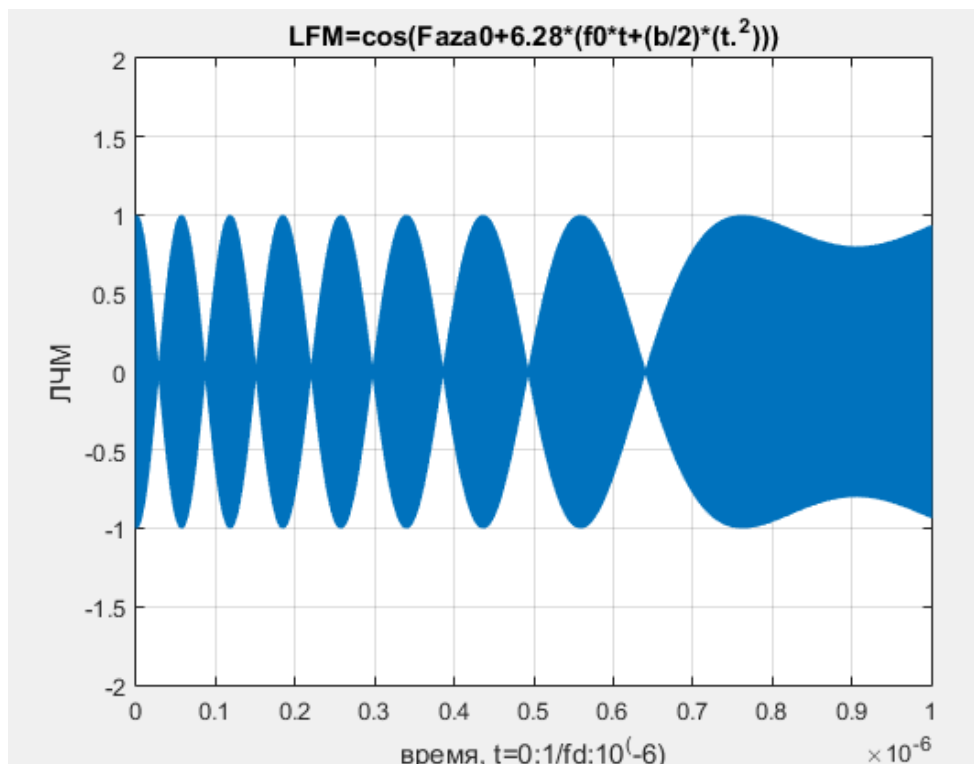


Fig. 1. Probing signal plot

The sounding signal reflected from the ground goes to the receiver. With the help of the filter, the carrier frequency of the reflected signal is removed and the signal is divided into a real and imaginary part. In order to model the unevenness of the relief, we set the signal shift by 100 samples.

Make convolution - take a copy of the signal without shifting from the array of the signal in the form of an entire line and multiply with the signal from the array in which the calculation of the signal shift during the flight is realized. And already from this array a radio hologram is being built.

The received radar information in digital form represents a complex radar image (each element (pixel) of which is characterized by a complex number - real and imaginary components or amplitude and phase, the numerical value of which determines the parameters of the signal received from the corresponding element on the earth's surface.

Using arrays of the reflected signal data without a shift and with a shift and azimuth resolution, we construct radio holograms. For an interval of time of observation the antenna moves in space on distance of resolving ability on an azimuth from an extreme to an extreme point which is called the length of the synthesized aperture

$$L_a = R_0 \cdot f / 2c \cdot DN \quad (2)$$

where DN – this is the resolving power in azimuth, i.e. DN

c – speed of light

f - frequency

R_0 – distance from the satellite to the target

Using the available data, we construct a radio hologram in the motlab medium (fig. 2).

Based on the radio hologram received, we can see the change in the terrain from the target point target that we took as an object of research.

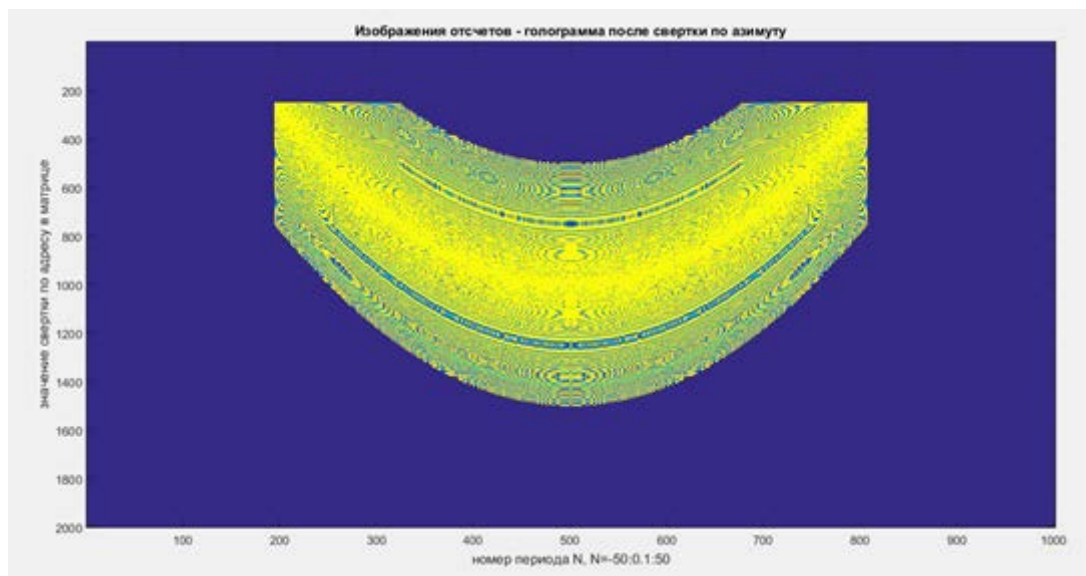


Fig. 2. Radiogollogramma routing mode

Thus, the carried-out analysis showed that application of different operation modes will allow to carry out surface shooting of sections of the Earth's 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 algorithm of formation of radio holograms on the basis of use of an impulse method of radiolocation in relation to X – the range with frequencies of bearing oscillations of 9, 5 - 9,8 GHz is considered. The results of the research can be applied in systems of remote sensing of the Earth.

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IMAGE FORMATION IN AUGMENTED REALITY DEVICES

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The article presents some kind of basic technologies of image formation in augmented reality devices. The paper also has the description of these technologies and some schemes of making optical system for transmitting the picture from a display into an eye.

Introduction. Augmented reality is the result of combining perceived reality with virtual reality, supplementing information about the environment in real time. The example of augmented reality can be the trajectory of the movement of the puck in the television tournament.

In modern laparoscopic operations, the image on the endoscope is complemented by the image obtained during intraoperative angiography. This allows the surgeon to know exactly where the tumor is located inside the organ, and to minimize the loss of healthy tissue.

Modern combat aircraft and helicopters often use an indication on the windshield or on the helmet of a pilot. It allows the pilot to receive general information directly against the background of surveillance, without being distracted from the main instrument panel. It is possible to save precious seconds during a maneuverable air battle. A lot of such systems cover goals by turning the head or the movement of the eyeballs.

The augmented reality devices should be compact and ideally do not overlap the eye view with their design, and also have good brightness, clarity and contrast of the complemented image.

All devices of augmented reality can be divided into:

- near to eyes application, when the image is up to 100 mm from the eyes;
- the application, remote from the eyes, the image is at a distance of more than 100mm.

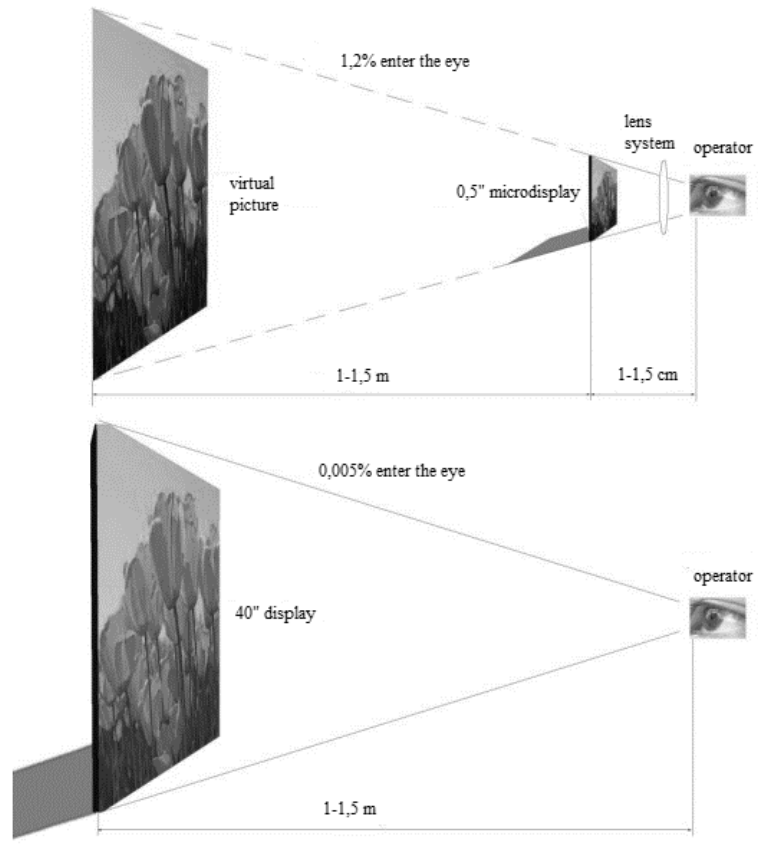


Fig. 1. Improving the efficiency of information display using micro-display technology

Examples of augmented reality of near to eye application are glasses, helmets, lenses. Examples of augmented reality that can be used for medical purposes.

From a physical point of view, the creation of near to eye is laborious, because depending on the use of microdisplays, the design becomes much more complicated and the characteristics of the supplemented image change.

For near to eyes display of the main parameter is the focal length. For a centered optical system consisting of spherical surfaces, the focal length describes the ability to collect beams into one point, provided that these rays go from infinity by a parallel beam parallel to the optical axis.

The angle of sight is also important. It determines the size, depending on the distance from the eyes. The microdisplay measuring 0.5 inches, located at a distance of 1-1.5 cm, will be perceived by the eye as a "virtual" image corresponding to the full-screen picture of a 40-inch television with an indentation of several meters - figure 1. Therefore, the closer a screen to an eye, the less the screen should be.

As can be seen in the figure, the gain in the information display efficiency is 300-500 times. [1]

Classification of indication systems. By transparency, microdisplays can be divided into:

- transparent;
- opaque.

Transparent microdisplays are not completely transparent, they have a transparency of 50%. This is determined by the number of current-carrying tracks to pixels.

The use of opaque microdisplays implies the creation of an optical system that transmits an image to the eye.

For projection systems and around-the-eye displays, various optical schemes are used. In Figure 2, 3 represent the optical circuits for the two main types of microdisplays applications. Requirements for the parameters of microdisplays intended for use in projection systems and near to eye display systems also differ (Table 1). When developing both the microdisplay and the optical circuit, various strategies should be used to optimize the output systems, in order to increase the light efficiency, economy, and price reduction.

Table 1. – Key parameters for two technologies for the use of microdisplays

Technologies	Projection	Near to eye
Key parameters	High resolution	Low consumption
	High brightness	Small weight
	High contrast	Small dimensions
	Wide colour palette	Low price

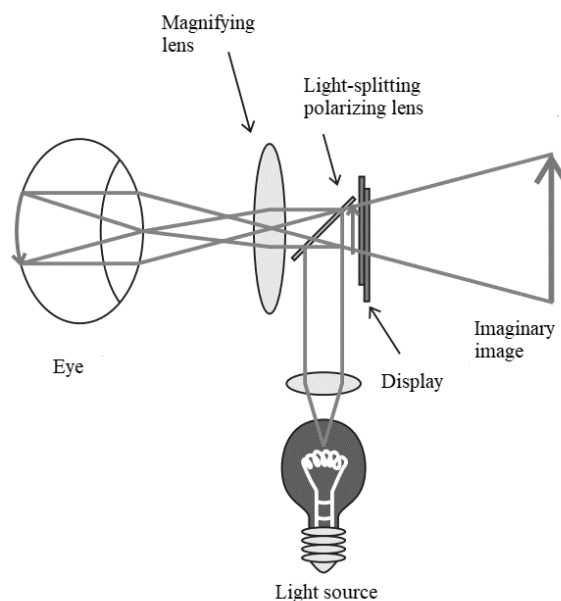


Fig. 2. Optical scheme for the use of microdisplays in near to eye displays [2]

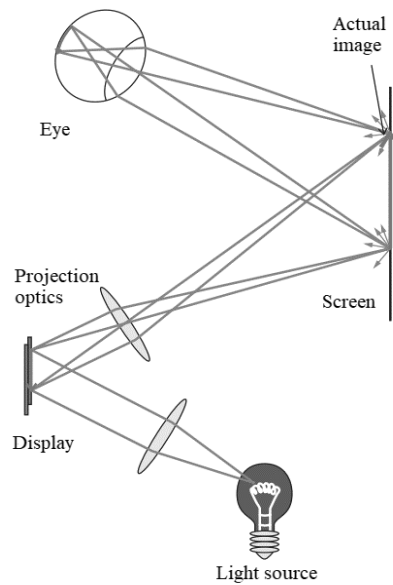


Fig. 3. Optical scheme for the use of microdisplays in projection systems [2]

Hinged display system with waveguide plate.

The helmet-based display system consists of several main blocks and two channels:

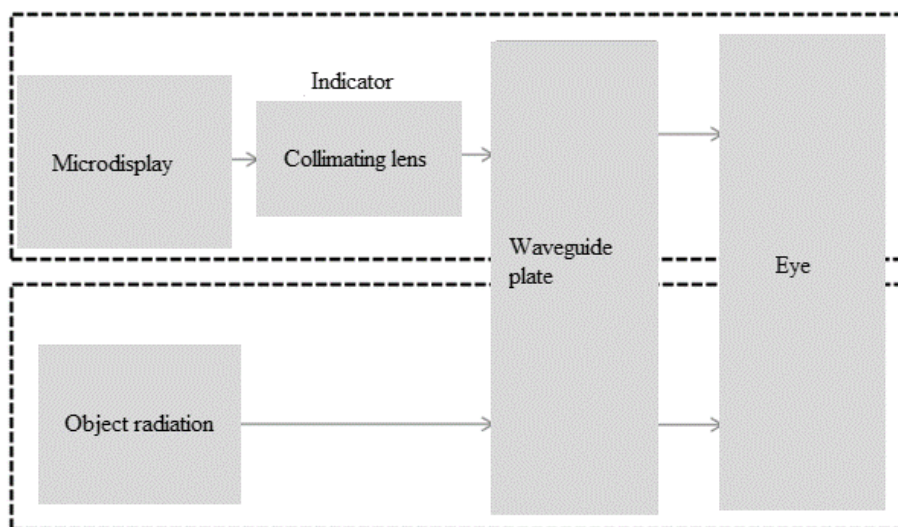


Fig. 4. Block diagram of a helmet-mounted display system with a waveguide plate

Thus, the image formed on the indicator collimates to infinity with the help of a collimating lens, then the image hits the waveguide plate, which in turn ensures the transfer of the image and its entry onto the observer's retina.

Conclusion. Technology is constantly evolving, which allows you to create more compact and functional devices. The development of technology in the future can create a favorable environment for creating augmented reality devices replacing mobile phones, televisions and computers.

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UDC 004.8

DATA PREPROCESSING FOR MACHINE LEARNING

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Pre-processing and cleaning data are important tasks that typically must be conducted before dataset can be used effectively for machine learning. Raw data is often noisy and unreliable, and may be missing values. Using such data for modeling can produce misleading results. These tasks are part of the Team Data Science Process and typically follow an initial exploration of a dataset used to discover and plan the pre-processing required.

Reason to Data Pre-Processing

Real world data is gathered from various sources and processes and it may contain irregularities or corrupt data compromising the quality of the dataset. The typical data quality issues that arise are:

- **Incomplete:** data lacks attributes or containing missing values.
- **Noisy:** Data contains erroneous records or outliers.
- **Inconsistent:** Data contains conflicting records or discrepancies.

Quality data is a prerequisite for quality predictive models. To avoid "garbage in, garbage out" and improve data quality and therefore model performance, it is imperative to conduct a data health screen to spot data issues early and decide on the corresponding data processing and cleaning steps.

Standard Monitoring Methods

We can check the general quality of data by checking:

- The number of records.
- The number of attributes (or features).
- The attribute data types (nominal, ordinal, or continuous).
- The number of missing values.
- Well-formedness of the data.

When you find issues with data, **processing steps** are necessary which often involves cleaning missing values, data normalization, discretization, text processing to remove and/or replace embedded characters which may affect data alignment, mixed data types in common fields, and others.

Major Tasks In Data Pre-Processing

1. **Data cleaning** – fill in or missing values, detect and remove noisy data and outliers.

To deal with missing values, it is best to first identify the reason for the missing values to better handle the problem. Typical missing value handling methods are:

- Deletion: remove records with missing values
- Dummy substitution: replace missing values with a dummy value: e.g, *unknown* for categorical or 0 for numerical values.
- Mean substitution: If the missing data is numerical, replace the missing values with the mean.
- Frequent substitution: If the missing data is categorical, replace the missing values with the most frequent item
- Regression substitution: use a regression method to replace missing values with regressed values.

2. **Data transformation** – normalize data to reduce dimensions and noise.

Data normalization re-scales numerical values to a specified range. Popular data normalization methods include:

- Min-Max Normalization: linearly transform the data to a range, say between 0 and 1, where the min value is scaled to 0 and max value to 1.
 - Z-score Normalization: scale data based on mean and standard deviation: divide the difference between the data and the mean by the standard deviation.
 - Decimal scaling: scale the data by moving the decimal point of the attribute value.
3. **Data reduction** – sample data records or attributes for easier data handling.

There are various methods to reduce data size for easier data handling. Depending on data size and the domain, the following methods can be applied:

- Record Sampling: sample the data records and only choose the representative subset from the data.

- Attribute Sampling: select only a subset of the most important attributes from the data.
- Aggregation: divide the data into groups and store the numbers for each group.

4. **Data discretization** — convert continuous attributes to categorical attributes for ease of use with certain machine learning methods.

Data can be discretized by converting continuous values to nominal attributes or intervals. Some ways of doing this are:

- Equal-Width Binning: divide the range of all possible values of an attribute into N groups of the same size, and assign the values that fall in a bin with the bin number.
- Equal-Height Binning: divide the range of all possible values of an attribute into N groups, each containing the same number of instances, then assign the values that fall in a bin with the bin number.

5. **Text cleaning** — remove embedded characters which may cause data misalignment, for e.g., embedded tabs in a tab-separated data file, embedded new lines which may break records, etc.

Text fields in tabular data may include characters which affect columns alignment and/or record boundaries. For e.g., embedded tabs in a tab-separated file cause column misalignment, and embedded new line characters break record lines. Improper text encoding handling while writing/reading text leads to information loss, inadvertent introduction of unreadable characters, e.g., nulls, and may also affect text parsing. Careful parsing and editing may be required in order to clean text fields for proper alignment and/or to extract structured data from unstructured or semi-structured text data.

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PUSHWOOSH NOTIFICATION SERVICE IN THE MOBILE APPLICATION "MUSICIANS OF RUSSIA" FOR THE ANDROID OPERATING SYSTEM

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This article describes the way how we can use the service PushWoosh in our applications. This service provides a push notification system, which we can use on all modern platforms. There are advantages of the PushWoosh service and examples of using this notification system on mobile application "Musician of Russia", which was written in Java for Android system.

Introduction. Push notifications are short pop-up alerts that appear on the screen of a mobile phone or computer and report you about important events and updates. With effective use, these brief informative messages are a powerful marketing tool. The main purpose of push notifications is to inform users about updates on websites or applications, added new content, or any other news [1].

According to statistics, provided by the world-famous company Localytics, which has a huge experience in analytics and application marketing, it is possible to note the following:

- 1) push notifications increase user engagement by 88%;
- 2) if the notifications is turned on, 65% of users return to the application within 30 days;
- 3) > 50% of users switch on push notifications and consider these messages useful;
- 4) push notifications increase the number of application starts by 27%;
- 5) correctly configured notification system increases interaction with customers 3 times [1].

The given statistical data make it clear that for the successful promotion of the application it is necessary to use the notification system. For this reason, push notifications have found wide application in the development of mobile applications.

PushWoosh is an excellent free solution for implementing a user notification system. This service is cross-platform, that allows it to use on more than 20 different platforms. Figure 1 shows the systems that support PushWoosh.

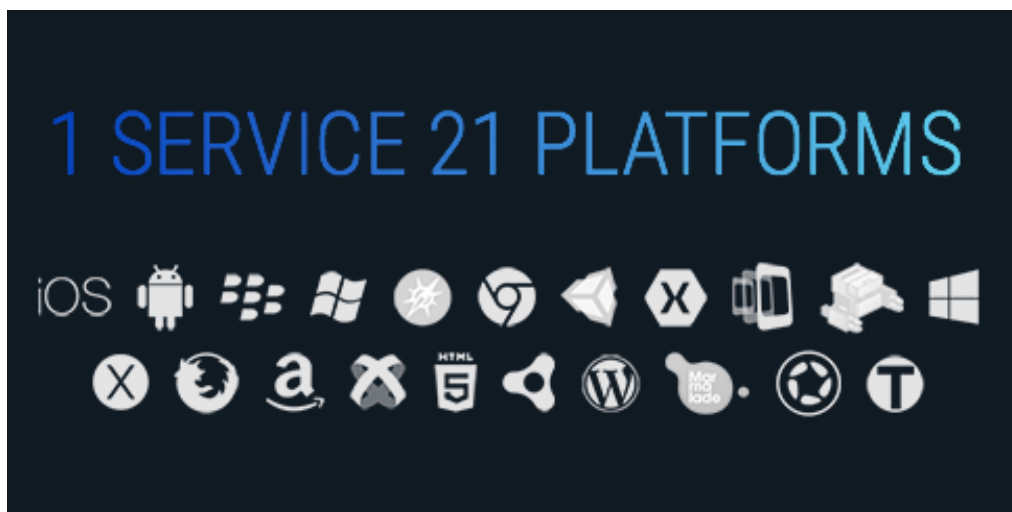


Fig. 1. Platforms for working with PushWoosh service

Main features of PushWoosh. PushWoosh has many features that make it solution more useable compared to its competitors. Among the most significant are the following:

- 1) Private Cloud. Each user is provided with a secure cloud storage. Service PushWoosh carefully save privacy of your personal data;
- 2) High Speed. The service works with incredibly fast speed. Every day PushWoosh sends over 250 million push-Referrals;

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3) Mult-language. PushWoosh always knows which language is installed on the device that is signed for updates. This allows you to create a unique set of alert messages, adapted for each language, which easily allows you to overcome the language barrier;

4) Geozones. This PushWoosh feature can be used on devices running IOS, Android or Windows Phone. It allows you to create areas on the map, with an accuracy of 50 meters, to send notifications to users in a specific location;

5) Timezone Sensitive. Service PushWoosh provides the ability to send notifications to the user in accordance with his time zone. This allows you to make your push messages timely for each specific user and, as a result, more attractive [2].

Example of using PushWoosh in the mobile application "Musicians of Russia". PushWoosh service has proved itself and it is the best solution for working with push notifications. For this reason, when we created a mobile application "Musicians of Russia" for the Android operating system, it was decided to use this particular service. Next, an example of using this service in a mobile application written in the Java programming language will be considered. The process of integration of this service is quite simple, on the official site you can find detailed instructions on how to use PushWoosh on any platform, so let's move on to describing the application logic.

The main idea of the mobile application "Musicians of Russia" is to provide users with detailed information about music partners around the country. By musical partners are understood: concert venues and rehearsal bases, music labels and online stores, training bases as well as concert agencies. Was developed loyalty program, which means providing customers with personal bonus cards with discounts on the services of music partners. Also, the user is always aware of all important musical events [3].

An important role in the application "Musicians of Russia" is played Push Notifications. After all, they allow you to know in time about discounts and promotions in music stores, about changes in the schedule of visiting rehearsal bases and music labels, about imminent important events in the world of music. The system of notifications is based on the PushWoosh service. Below is an example of how you can use this service in your application.

First of all, you need to inherit the MainActivity from the FragmentActivity class and implement the PushEventListener interface (Listing 1).

Listing 1 – Implementing the PushEventListener interface

```
public class MainActivity extends FragmentActivity implements PushEventListener
```

```
In the onCreate method, we call the PushFragment.init(this); method (Listing 2).
```

Listing 2 – Initialization of the PushFragment

```
@Override
```

```
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    // initialize PushWoosh Fragment
    PushFragment.init(this);
}
```

Next, create the onNewIntent method and call the PushFragment.onNewIntent(this, intent); (Listing 3).

Listing 3 – Creation of onNewIntent method

```
@Override
```

```
public void onNewIntent(Intent intent)
{
    super.onNewIntent(intent);
    // check if we have a new intent with push notification
    PushFragment.onNewIntent(this, intent);
}
```

After that, you need to implement the PushEventListener interface methods. The most important for us will be the doOnMessageReceive (String message) method, which is called when we receive a new notification from the PushWoosh service. This method implements the processing and output of a pop-up notification to the screen of the mobile device (Listing 4).

Listing 4 – Processing and displaying the notification on the user's screen

```
@Override
```

```
public void doOnMessageReceive(String message)
{
```



```

String show = parsePushNotification(message); // the message comes in JSON format, so it must be parsed
NotificationCompat.Builder builder = new NotificationCompat.Builder( getApplicationContext())
    // create a notification
    .setSmallIcon(R.drawable.info) // set a small icon for our message .setContentTitle("Музыканты
России") // set the title
    .setContentText(show) // place the text of the message
    .setVibrate(new long[]{10, 1000}) // add vibration to our alert
    .setColor(Color.rgb(255,45,192,233))
    .setAutoCancel(true); // the message automatically disappears from the notification menu
when the user touches it
Intent intent = new Intent(getApplicationContext(), MainActivity.class); // create a new instance of Intent
PendingIntent pendingIntent = PendingIntent.getActivity(getApplicationContext(), 0, intent, 0); // grant the
rights to the PushWoosh service to execute a code fragment
NotificationManager notificationManager = (NotificationManager) getApplicationCon-
text().getSystemService(Context.NOTIFICATION_SERVICE); // Notification Manager – Android system service that
manages all notifications
builder.setContentIntent(pendingIntent); // provide a response that will be received when you click on the noti-
fication
Notification notification = builder.build(); // we merge all the properties that were set for notification and re-
turn an instance of the Notification class
notificationManager.notify(1, notification); // the notification object is passed to the system by calling the noti-
ficationManager.notify()
}

```

Conclusion. As you can easily notice, the processing of push notifications in the mobile application "Musicians of Russia" for the Android operating system is quite simple and does not require any additional knowledge. All you need is to carefully read the instructions on the official website and take all the necessary steps step by step. This simple way to integrate push notifications with PushWoosh is one of the best modern solutions for implementing push notifications in your application.

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COMPARATIVE ANALYSIS OF LPWAN NETWORK

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The article presents a review and comparative analysis of technologies, LPWAN (Low-power Wide-area Network). The advantages and disadvantages of each of them. Comparative analysis helps to identify more effective and preferable network technology LPWAN.

LORA technology

LoRa Alliance developers believe that LoRa technology has significant advantages over WiFi and cellular networks, thanks to the possibility of deploying machine-to-machine (M2M) inter-machine connections for distances up to 20 km at speeds up to 50 Kbp/s, and also has minimum power consumption which provides several years of battery life on one AA battery. The scale of applications of this technology is great: from home automation and the Internet of things to industry and smart cities [1, 2]. LoRa is the next step in the development of the LPWAN solution, which was developed and patented by Semtech Corporation. The essence of the technology is reduced to the variation of linear frequency modulation (Chirp Spread Spectrum, CSS). The technology uses data encoding with broadband pulses with frequencies that decrease or increase over a certain time interval. This solution allows the receiver to be resistant to frequency deviations from the nominal value and simplifies the requirements for the clock generator, thereby allowing the use of inexpensive quartz resonators.

SigFox technology

SIGFOX is a private company that aims to create a worldwide network specially designed for devices IoT (Internet of Things). The technology allows data transfer over long distances with low power of the transmitter and low battery capacity [3]. The network is great for simple and stand-alone devices that send a small amount of data to this network. So the SIGFOX network is similar to the cellular infrastructure, but is more energy efficient and at the same time less expensive. SIGFOX uses an ultra-narrow band (Ultra Narrow Band, UNB) based on radio technology to connect devices to the global network. The use of UNB is a key factor in ensuring a very low power level of the transmitter that will be used during the state of maintaining a reliable data connection. The network operates in the existing unlicensed bands on a global scale and coexists in these frequencies with other radio technologies without the problem of overlapping the network or bandwidth problem. In Europe, the 868.8 MHz band is widely used, and in the US 915 MHz.

NB-IoT technology

NB-IoT (NarrowBand IoT - "narrowband Internet of things"), the same standard LTE-Cat. Has a number of advantages such as a wide coverage area, rapid modernization of the existing network, low power consumption, guaranteeing a 10-year lifespan batteries, low cost of the terminal, plug and play, increased reliability and a high carrier class security network [4]. The NB-IoT ideally meets the requirements of the LPWAN market, allowing operators to expand this new area. NB-IoT allows modern operators to work with traditional IoT directions, such as smart metering, tracking systems, thanks to ultra-low cost, and also opens up more industry opportunities, for example, "smart City", e-health systems. NB-IoT technology considers evolution from the cellular communication industry to the Internet of things. This is a wireless narrowband version of global networks with low power consumption, which is primarily designed for M2M (Machine-to-Machine) applications. The NB-IoT standard was specified by the 3GPP agreement in Release 13 (LTE Advanced Pro).

Weightless P Technology

Leader of the development of the standard Weightless was the industrial IoT company Ubiik [5]. Weightless – is an open standard for LPWAN networks of increased power, designed for network performance. In the special interest group Weightless (Special Interest Group, SIG), three different protocols are proposed - Weightless-H, Weightless-W, and Weightless-P, which support various forms and uses. Weightless-W is an open standard designed to work in the television frequency range (TV white space, TVWS). Weightless-W is ideal for use in the oil and gas industry. Weightless-N focuses on an extremely wide coverage area instead of high data rates. Although it is limited to one-way traffic. Weightless-N supports greater range and lower power consumption.

Comparison of long-range network technologies LPWAN

A comparison of long-range network technologies is presented in Table 1. As shown in the table, the technologies have a long range of communication, increased noise immunity, low data transfer rate, low power consumption and, as a result, a high degree of autonomy of terminal devices.

Table 1. – Comparison of long-range network technologies

Technical specifications	LoRa	SIGFOX	NB-IoT	Weightless P
Modulation method	CSS	-	OFDMA	FDMA/TDMA
Band	IMS	IMS	licensed	IMS
Speed	0.3-50 kb/s	100 bit/s	1-144 kb/s	0.2-100 kb/s
Autonomy time	> 10 years	-	< 10 years	3-5 year
Security	AES-64 / 128	AES	-	AES-128 / 256
Range	< 2.5 km	< 10 km	-	< 2 km
Support	LoRa Alliance, Semtech	SigFox, Samsung	Huawei, Intel	Ubii, Weightless SIG

Conclusion

The analysis revealed that each technology has a lot of advantages and features and none of the above options can be left out and takes place in the modern technology world. According to an independent assessment, the state and future development of global networks with low energy consumption for the Internet market Things for the next one or two years the most popular technology will be LoRaWAN and probably SIGFOX. In the future, it will be possible to expect the joint use of 3GPP-enabled technologies (for example, LTE-M) and the existing LPWAN technologies.

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SCALABLE VECTOR GRAPHICS

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Scalable Vector Graphics (SVG) is a language for describing two-dimensional graphics in XML. This graphics can consist of paths, images, and/or text that may be scaled and resized without losing image quality.

Inline SVG refers to the embedded code written within HTML to generate this graphics in a browser. There are many advantages of using SVG in this way, including having access to all graphics individual parts for interactivity purposes, generating searchable text, DOM access for direct edits and promoting user accessibility.

There are a number of ways to include SVG in your projects: inline, an ``, a background-image, an `<object>`, or as Data URI. I will specifically refer to the use of SVG inline which involves writing SVG code within the body of a properly structured HTML document.

SVG details reside within a `<svg>` element. This element contains several attributes which permit the customization of your graphics "canvas". Although these attributes are not completely necessary for image rendering, their absence may leave more complex graphics vulnerable when performing in browsers and make them susceptible to undesirable rendering. Inline graphics can be written "by hand", or embedded by accessing the XML code generated by vector graphic software. Anyway proper organization and structure are crucial to writing efficient SVG code, primarily because the order of these graphical elements determines their stacking order.

An SVG document fragment is made up of any number of SVG elements contained within the `<svg>` element. Organization within this document is crucial. Content in the document can be rapidly expanded and proper organization promotes accessibility and efficiency in everything that benefits both the author and users.

The `<svg>` element is classified as both a container and a structural element, and can be used to nest a standalone SVG fragment inside the document. This fragment establishes its own coordinate system. The attributes used in this element, such as width, height, save Aspect Ratio and viewBox, define the canvas for writing graphics.

The `<g>` element is a container element for grouping related graphics together. Using this element in combination with the description and title elements provides information about your graphics and aids in organization and accessibility by grouping related graphical components together. Also, by grouping related elements together I can manipulate the group as a whole versus the individual parts. This is especially convenient when animating these elements, for example, as the animation can be applied to the group. Any element that is not contained within a `<g>` is assumed to be its own group.

The `<use>` element allows you to reuse elements throughout a document. There are additional attributes that can be included in this element, such as x, y, width, and height, which define the mapping location details of the graphics within the coordinate system. Using the href attribute here enables you to call on the element to be reused. For example, if there was a `<g>` with an id of "square" containing the image of a square that needed to be reused this image can be referenced by `<use>: <use x="50" y="50" href="# square " />`. This element can be a significant time saver and helps to minimize the required code.

While `<use>` allows you to reuse already rendered graphics, graphics in the `<defs>` element is not displayed on the canvas, but can be specified and then displayed using href. Graphics is defined in `<defs>` and can then be used throughout the document by referencing the id of that graphics. The contents of the `<defs>` has no visual output until it is called on by referencing its unique id.

The `<symbol>` element is similar to `<g>` as it provides the way to group elements, however, elements within `<symbol>` have no visual output (like `<defs>`) until called on with the `<use>` element. Also unlike the `<g>` element, `<symbol>` establishes its own coordinate system separate from the viewport it's rendered in.

The stacking order of SVG cannot be manipulated by z-index in CSS as other elements in HTML. The order in which SVG elements are stacked depends entirely on their placement in the document fragment.

SVG contains the following set of basic shape elements: rectangles, circles, ellipses, straight lines, polylines, and polygons. Each element requires a set of attributes before it renders, like coordinates and size details.

The `<rect>` element defines a rectangle. The width and height attributes establish the size of the rectangle, while fill sets the interior color for the shape. The numerical values default to pixels and fill would default to black when left unspecified. Other attributes that can be included are x and y coordinates. These values will move the shape along the appropriate axis according to the dimensions set by the `<svg>` element. It is also pos-

sible to create rounded corners by specifying values in rx and ry attributes. For example, rx="5" ry="10" will produce horizontal sides of corners that have a 5px radius, and vertical sides of corners that have a 10px radius.

The <circle> element is mapped based on a center point and an outer radius. The cx and cy coordinates establish the location of the center of the circle in relation to the workplace dimensions set by the <svg>. The r attribute sets the size of the outer radius.

An <ellipse> element defines an ellipse that is mapped based on a center point and two radii. While the cx and cy values are establishing the center point based on pixel distance into the SVG coordinate space, the rx and ry values define the radius of the sides of the shape.

The <line> element defines a straight line with a start and end point. Together the x1 and y1 values establish the coordinates for the start of the line, while the x2 and y2 values establish the end of the line.

The <polyline> element defines a set of connected straight line segments, generally resulting in an open shape (start and end points that are not connected). The values in points establish the shapes location on the x and y axis throughout the shape and are grouped as x, y throughout the list of values. An odd number of points here is an error.

A <polygon> element defines a closed shape consisting of connected lines. The points of the polygon shape are defined through a series of grouped x, y values. This element can also produce different closed shapes depending on the number of defined points.

SVG <paths> represent the outline of a shape. This shape can be filled, stroked, used to navigate text, and/or used as a clipping path. Depending on the shape this path can get very complex, especially when there are many curves involved. Basic understanding of how they work and the syntax involved, however, will help to make these particular paths much more manageable.

The path data is contained in a d attribute in the <path> element, defining the outline for the shape: <path d="<path data specifics>". This data included in the d attribute spell out the moveto, line, curve, arc and closepath instructions for the path.

The moveto commands (M or m) establish a new point, as lifting a pen and start to draw in a new location on paper. The line of code comprising the path data must begin with a moveto command. Moveto commands that follow the initial one represent the start of a new subpath, creating a compound path. An uppercase M here indicates absolute coordinates will follow, while a lowercase m indicates relative coordinates.

The closepath (Z or z) ends the current subpath and results in a straight line being drawn from that point to the initial point of the path. If the closepath is followed immediately by a moveto, these moveto coordinates represent the start of the next subpath. If this same closepath is followed by anything other than moveto, the next subpath begins at the same point as the current subpath. Both the uppercase and the lowercase z have here identical outcomes.

The line to commands draws straight lines from the current point to a new point.

The L and l commands draw a line from the current point to the next provided point coordinates. This new point then becomes the current point, and so on. The uppercase L signals that absolute positioning will follow, while the lowercase l is relative.

The H and h commands draw a horizontal line from the current point. The uppercase H signals that absolute positioning will follow, while the lowercase h is relative.

The V and v commands draw a vertical line from the current point. The uppercase V signals that absolute positioning will follow, while the lowercase v is relative.

There are three groups of commands that draw curved paths: Cubic Bezier (C, c, S, s), Quadratic Bezier (Q, q, T, t), and Elliptical arc (A, a).

The C and c Cubic Bezier commands draw a curve from the current point using (x1,y1) parameters as a control point at the beginning of the curve and (x2,y2) as the control point at the end, defining the shape details of the curve. The S and s commands also draw the Cubic Bezier curve, but in this instance there is an assumption that the first control point is a reflection of the second control point. Manipulating the first and last sets of values for this curve will impact its start and end location, while manipulating the two center values will impact the shape and positioning of the curve itself at the beginning and end. The S and s commands also draw a Cubic Bézier curve, but in this instance there is an assumption that the first control point is a reflection of the last control point for the previous C command. This reflection is relative to the starting point of the S command. The uppercase C signals that absolute positioning will follow, while the lowercase c is relative. The same logics is applied to S and s.

Quadratic Bézier curves (Q, q, T, t) are similar to Cubic Bézier curves except that they only have one control point.

Manipulating the first and last sets of values impacts the positioning of the beginning and end points of the curve. The center set of values, Q defines the control point for the curve, establishing its shape. Q and q draw the curve from the initial point to the end point using (x1, y1) as the control. T and t draw the curve from the initial point to the end point by assuming that the control point is a reflection of the control on the previously listed command relative to the start point of the new T or t command. The uppercase Q signals that absolute positioning will follow, while the lowercase q is relative. The same logics is applied to T and t.

An Elliptical Arc (A, a) defines a segment of an ellipse. These segments are created through the A or a commands which create the arc by specifying the starting point, end point, x and y radii, rotation, and direction.

The viewport is the visible section of an SVG. While SVG can be as wide or as high as you wish, limiting the viewport means that only a certain section of the image can be visible in a certain period of time. The viewport is set through height and width attributes in the <svg>. If these values are not defined, the dimensions of the viewport are generally determined by other indicators in the SVG, like the width of the outermost SVG element. However, leaving them undefined it makes our artwork susceptible to be cut off.

The viewBox allows for the specification that a given set of graphics stretches to fit a particular container element. These values include four numbers separated by commas or spaces: min-x, min-y, width, and height that should generally be set to the bounds of the viewport. The min values represent at what point within the image the viewBox should start, while the width and height establish the size of the box. If we choose not to define a viewBox the image will not scale to match the bounds set by the viewport.

The min values within the viewBox define the origin of the viewBox within the parent element. In other words, the point in the viewBox in which you want it to be started is to match the viewport.

Thus, all of these elements are container structural elements in SVG that help to reuse elements easier while keeping the code cleaner and more readable. And each of the elements I considered in this article has its own use cases. Now as I know what each one does and how they differ, I can decide which one to use, depending on my needs.

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UDC 621.31

THE OPTIMIZATION OF THE OPERATING MODE OF A THREE-PHASE ASYNCHRONOUS MOTOR CONNECTED TO A SINGLE PHASE CIRCUIT

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In the typical scheme of switching on a three-phase asynchronous motor with a capacitor start it is suggested to use an automatic control scheme to change the capacitor's electrical capacitance depending on the moment of loading on the motor shaft. This will make the working section of the motor mechanical characteristics more rigid and increase the performance of the motor.

Introduction. Often there is a need to connect a three-phase asynchronous motor to a single-phase electrical circuit. There is a wide variety of schemes for connecting these motors to a single-phase electrical circuit, both with phase-shifting capacitors [1, 2] and with thyristors [3, 4].

One of the typical schemes of connecting a three-phase asynchronous motor to a single-phase circuit with a phase-shifting capacitor [1, 2] is shown in fig. 1.

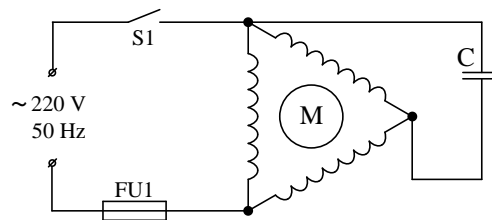


Fig. 1. Typical scheme of connecting a three-phase asynchronous motor to a single-phase electrical circuit

The capacitance of the capacitor is calculated by the formula [1]:

$$C = 4800 \cdot \frac{I}{U}, \quad (1)$$

Where C – capacitance of the working capacitor in μF ;

U – voltage in the electrical circuit, V;

I – the current consumed by the motor in A;

The current consumed by the electric motor in the formula (1) is calculated from the known power of the three-phase asynchronous motor according to the formula [1]:

$$I = \frac{P}{\sqrt{3} \cdot U \cdot \eta \cdot \cos(\varphi)}, \quad (2)$$

where P – motor power in W, specified in its passport;

η – is the coefficient of efficiency;

$\cos(\varphi)$ – is the power factor.

The main disadvantages of such a scheme for connecting a three-phase asynchronous motor to a single-phase electrical circuit are reduction in motor power by approximately 35–40% and a softer mechanical characteristic, that is a significant reduction in motor speed with increasing torque on the shaft, which reduces the productivity of the machine.

A simplified view of the working section of the mechanical characteristic of an asynchronous motor when it is connected to a single-phase electrical circuit is shown in Fig. 2 [1].



Fig. 2. An approximate view of the working section of the mechanical motor characteristics

Method of implementation. The stated goal can be achieved if the capacitor capacitance value is changed in the scheme with the asynchronous motor connection depending on the magnitude of the load torque on the motor shaft. Since the current consumed by the motor from electrical circuit increases with increasing load torque on the motor shaft, it is convenient to control the capacitance value depending on the strength of the indicated current.

Fig. 3 shows the functional diagram of connecting a three-phase asynchronous motor to a single-phase electrical circuit with an automatic switching capacitor capacitance value. This scheme improves the loaded operating mode of the motor.

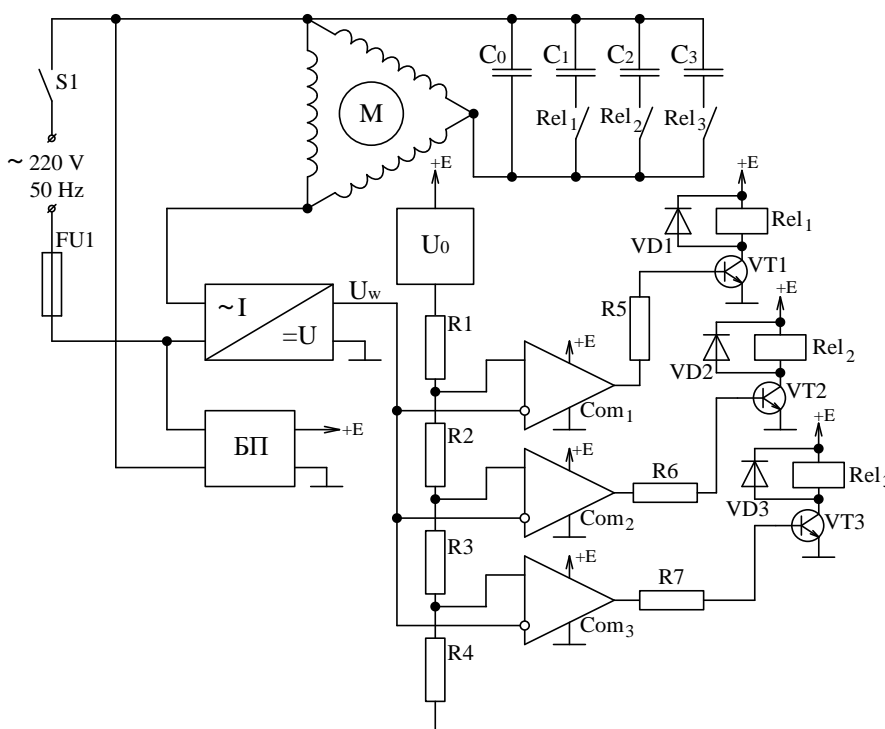


Fig. 3. Functional diagram of connecting a three-phase asynchronous motor to single-phase electrical circuit with the automatic control of the capacitance value depending on the load moment

In addition to the asynchronous motor M with a set of capacitors C_0 , C_1 , C_2 and C_3 , the scheme includes the power supply unit БП, the current-voltage converter $\sim I / = U$, the reference voltage source U_0 , the voltage divider for the resistors R_1 , R_2 , R_3 and R_4 , the voltage comparators Com_1 , Com_2 and Com_3 , the amplifiers on the transistors VT_1 , VT_2 and VT_3 for the relays Rel_1 , Rel_2 and Rel_3 .

The device for optimizing the loaded operating mode of the asynchronous motor operates as follows. After starting the motor, the S_1 switch is turned on, the motor uses a large current from the electrical circuit and the current-voltage converter $\sim I / = U$ respectively generates a large voltage U_w . As a result, all the three voltage comparators Com_1 , Com_2 and Com_3 are triggered, the transistors VT_1 , VT_2 and VT_3 are opened and the relays

Rel₁, Rel₂ and Rel₃ are switched on. Also, the capacitors C₁, C₂ and C₃ are connected in parallel to the main capacitor C₀. Consequently, the maximum capacity close to the starting capacity is connected to the motor and it accelerates.

As the motor accelerates, the current consumed from the circuit decreases. Accordingly, the output voltage of the current-voltage converter U_w decreases and the voltage comparators Com_i, for which U_w < U_{0i} are switched. VT_i disconnect the relay Rel_i via the transistors. As a result, the capacitors are turned off. The remaining equivalent capacity connected to the motor corresponds to the amount of current consumed from the electrical circuit and respectively to the magnitude of the load moment on the motor shaft.

With the increase in the load moment on the shaft of the asynchronous motor, the current consumed from the circuit increases. The output voltage of the current-voltage converter U_w also increases. And if for any Com_i comparator the condition U_w > U_{0i} is fulfilled, it will start working, and through the transistor VT_i the relay Rel_i is switched on, which turns on the corresponding capacitor C_i parallel to the main capacitor C₀. The total value of the capacitance connected to the motor increases, and it increases the torque.

As the load torque on the shaft of the asynchronous motor decreases, the reverse process takes place. The current consumption from the circuit decreases, the output voltage of the voltage converter U_w also decreases, and if for any comparator Com_i the condition U_w < U_{0i} is fulfilled, it will switch. Via the transistor VT_i the relay Rel_i is switched off, which disconnects the corresponding capacitor C_i from the main capacitor C₀. As a result, the total value of the capacitance connected to the motor will decrease, and this also increases the torque.

The working sector of the resulting mechanical characteristic of an asynchronous motor with such control over the value of the connected capacitance looks like this (Fig. 4).

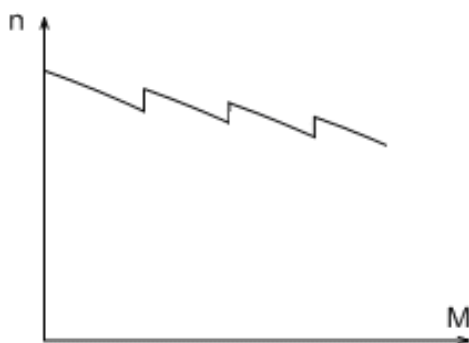


Fig. 4. An approximate view of the working section of the mechanical characteristic of a motor with the automatic control of capacitance depending on the load moment

Conclusions. The application of the scheme of automatic switching of capacitance when an asynchronous motor is connected to a single-phase circuit allows optimizing the loaded operating mode of the motor:

- prevents the decrease in the asynchronous motor speed with the increase in the load moment on the motor shaft, and consequently makes the mechanical characteristic of the engine stepped, but more rigid;
- increases the working section of the mechanical characteristic;
- increases the productivity of the mechanism driven by such a motor.

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PRINCIPLES OF DEVELOPING WEB APPLICATIONS USING THE "TWELVE-FACTOR APP" METHODOLOGY

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The article presents principles of developing software-as-a-service web applications using the "Twelve-Factor App" methodology. Solutions to problems that are often encountered in the development of modern applications are considered.

In the modern era, software is commonly delivered as a service: called web apps, or software-as-a-service (SaaS). Software as a service is a software licensing and delivery model in which software is licensed on a subscription basis and is centrally hosted. SaaS is typically accessed by users using a thin client via a web browser.

The twelve-factor app is a methodology for building software-as-a-service apps that [1]:

1. use declarative formats for setup automation to minimize time and cost for new developers joining the project;
2. have a clean contract with the underlying operating system offering maximum portability between execution environments;
3. are suitable for deployment on modern cloud platforms obviating the need for servers and systems administration;
4. minimize divergence between development and production enabling continuous deployment for maximum agility;
5. can scale up without significant changes to tooling, architecture, or development practices;
6. are written in any programming language, and use any combination of backing services (database, queue, memory cache, etc.).

These factors are written by software engineers that have been directly involved in the development and deployment of hundreds of apps. They represent general conceptual solutions to problems that are often encountered in the development of modern applications.

Codebase. There is only one codebase per app, but there will be many deploys of the app. A deploy is a running instance of the app. This is typically a production site, and one or more staging sites. Additionally, every developer has a copy of the app running in their local development environment, each of which also qualifies as a deploy. The codebase is the same across all deploys, although different versions may be active in each deploy. For example, a developer has some commits not yet deployed to staging; staging has some commits not yet deployed to production. But they all share the same codebase, thus making them identifiable as different deploys of the same app.

Dependencies. A twelve-factor app never relies on implicit existence of system-wide packages. It declares all dependencies, completely and exactly, via a dependency declaration manifest. Furthermore, it uses a dependency isolation tool during execution to ensure that no implicit dependencies "leak in" from the surrounding system. The full and explicit dependency specification is applied uniformly to both production and development.

Config. An app's config is everything that is likely to vary between deploys (staging, production, developer environments, etc). This includes:

1. Resource handles to the database, Memcached, and other backing services;
2. Credentials to external services such as Amazon S3 or Twitter;
3. Per-deploy values such as the canonical hostname for the deploy.

Apps sometimes store config as constants in the code. This is a violation of twelve-factor, which requires strict separation of config from code. Config varies substantially across deploys, code does not.

The twelve-factor app stores config in environment variables (often shortened to env vars or env). Env vars are easy to change between deploys without changing any code; unlike config files, there is little chance of them being checked into the code repo accidentally; and unlike custom config files, or other config mechanisms such as Java System Properties, they are a language- and OS-agnostic standard.

Backing services. A backing service is any service the app consumes over the network as part of its normal operation. Examples include datastores (such as MySQL or CouchDB), messaging/queueing systems (such as RabbitMQ or Beanstalkd), SMTP services for outbound email (such as Postfix), and caching systems (such as Memcached). The code for a twelve-factor app makes no distinction between local and third party services. To the app, both are attached resources, accessed via a URL or other locator/credentials stored in the config.

A deploy of the twelve-factor app should be able to swap out a local MySQL database with one managed by a third party (such as Amazon RDS) without any changes to the app's code. Likewise, a local SMTP server could be swapped with a third-party SMTP service (such as Postmark) without code changes. In both cases, only the resource handle in the config needs to change.

Build, release, run. The twelve-factor app uses strict separation between the build, release, and run stages. For example, it is impossible to make changes to the code at runtime, since there is no way to propagate those changes back to the build stage. A codebase is transformed into a (non-development) deploy through three stages:

1. The build stage is a transform which converts a code repo into an executable bundle known as a build. Using a version of the code at a commit specified by the deployment process, the build stage fetches vendors dependencies and compiles binaries and assets;

2. The release stage takes the build produced by the build stage and combines it with the deploy's current config. The resulting release contains both the build and the config and is ready for immediate execution in the execution environment;

3. The run stage (also known as "runtime") runs the app in the execution environment, by launching some set of the app's processes against a selected release.

Processes. The app is executed in the execution environment as one or more processes. Twelve-factor processes are stateless and share-nothing. Any data that needs to persist must be stored in a stateful backing service, typically a database. Some web systems rely on "sticky sessions" – that is, caching user session data in memory of the app's process and expecting future requests from the same visitor to be routed to the same process. Sticky sessions are a violation of twelve-factor and should never be used or relied upon. Session state data is a good candidate for a datastore that offers time-expiration, such as Memcached or Redis [2].

Port binding. Web apps are sometimes executed inside a webserver container. For example, PHP apps might run as a module inside Apache HTTPD, or Java apps might run inside Tomcat. The twelve-factor app is completely self-contained and does not rely on runtime injection of a webserver into the execution environment to create a web-facing service. The web app exports HTTP as a service by binding to a port, and listening to requests coming in on that port.

Concurrency. In the twelve-factor app, processes are a first class citizen. Processes in the twelve-factor app take strong cues from the unix process model for running service daemons. Using this model, the developer can architect their app to handle diverse workloads by assigning each type of work to a process type. For example, HTTP requests may be handled by a web process, and long-running background tasks handled by a worker process.

Disposability. The twelve-factor app's processes are disposable, meaning they can be started or stopped at a moment's notice. This facilitates fast elastic scaling, rapid deployment of code or config changes, and robustness of production deploys. Processes should strive to minimize startup time. Ideally, a process takes a few seconds from the time the launch command is executed until the process is up and ready to receive requests or jobs. Short startup time provides more agility for the release process and scaling up; and it aids robustness, because the process manager can more easily move processes to new physical machines when warranted.

Development/production parity. Historically, there have been substantial gaps between development (a developer making live edits to a local deploy of the app) and production (a running deploy of the app accessed by end users). These gaps manifest in three areas [3]:

1. The time gap: A developer may work on code that takes days, weeks, or even months to go into production;

2. The personnel gap: Developers write code, ops engineers deploy it;

3. The tools gap: Developers may be using a stack like Nginx, SQLite, and OS X, while the production deploy uses Apache, MySQL, and Linux.

The twelve-factor app is designed for continuous deployment by keeping the gap between development and production small. Looking at the three gaps described above:

1. Make the time gap small: a developer may write code and have it deployed hours or even just minutes later;

2. Make the personnel gap small: developers who wrote code are closely involved in deploying it and watching its behavior in production;

3. Make the tools gap small: keep development and production as similar as possible.

Logs. Logs are the stream of aggregated, time-ordered events collected from the output streams of all running processes and backing services. Logs in their raw form are typically a text format with one event per line (though backtraces from exceptions may span multiple lines). Logs have no fixed beginning or end, but flow con-

tinuously as long as the app is operating. A twelve-factor app never concerns itself with routing or storage of its output stream. It should not attempt to write to or manage logfiles. Instead, each running process writes its event stream, unbuffered, to stdout. During local development, the developer will view this stream in the foreground of their terminal to observe the app's behavior.

Admin processes. One-off admin processes should be run in an identical environment as the regular long-running processes of the app. They run against a release, using the same codebase and config as any process run against that release. Admin code must ship with application code to avoid synchronization issues.

Summarizing the factors described above, we can conclude that, despite some difficulties in the technical implementation of all methods, this methodology avoids many problems in the development of a web application. However, it should be noted that following some aspects of this approach does not always bring results at the initial stage of development. Often, some factors manifest themselves only when the application is scaled.

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