In picture 4 the oscillogram of frequency the modulated signal at the following data: $f_0$=40 MHz, F=4MHц is resulted.

In picture 5 the spectrum specified above a signal is resulted.

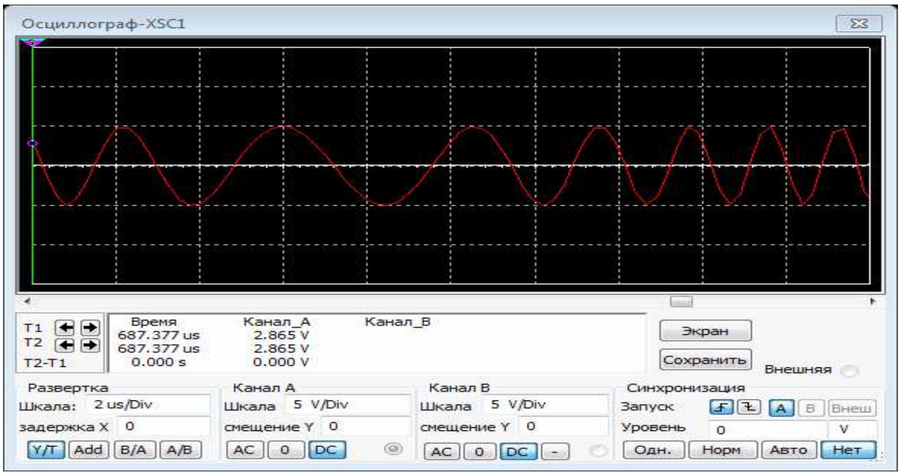


Fig. 4. The oscillogram of FM of a signal

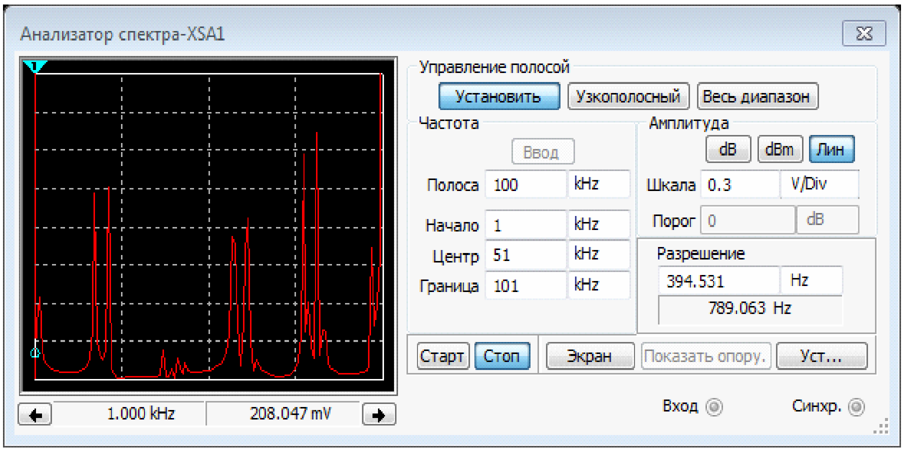


Fig. 5. Spectrum video signal

To sum up we shoul underline that the research of the frequency modulation allows to improve the noise refines security of the channel of transmission of video signals. Comprehensible level of non-linearity distortions of signals is thus provided. Analysed method can be used for transmission of video signals to a cable television.

REFERENCES

1. Янушкевич, В.Ф. Устройства оптической обработки сигналов : метод. пособие для студентов спец. 39.01.01 / В.Ф. Янушкевич. – Новополоцк : ПГУ, 2008.
2. Устройства оптической обработки сигналов / Ю.М. Щербак [и др.]. – Минск : БГУИР, 1997.

**UDC 621.5;621.65**

## RECENT TRENDS OF INDUSTRIAL USE OF THE HEAT PUMP TECHNOLOGIES

***IHAR PISKUN***
**OJSC "Naftan", Novopolotsk**

*Describes technical and energy conditions for the generic use of the heat pump technologies in Housing and Public Utilities, heat-recycling systems and at industrial plants, which are utilizing water-retaining cooling systems for process equipment. An example of the low potential heat flows' evaluation at the refinery, as well as* *an example of the steam-air heat pump's use in housing and communal service and at the refinery's catalytic reforming unit are made.*

In economically developed countries the production's power-efficiency reaches 70…80 %. This figure is obtained by means of production's technology upward transition, which allows for maximum feed, materials, energy conversion to the end product. Nevertheless, every large-scale production has a high inertia, restraining pace of development of the innovation techniques. This problem is especially urgent in post-soviet countries, where the large-tonnage production was based on cheap energy resources.

Currently the situation is changed and it is highly prioritized for the countries lacking energy resources and electric energy. Specifically in Belarus consumed quantity of the energy resources is 8-10 times bigger than its own energy potential [1]. In current situation special attention shall be paid to all technical solutions directed at the deep recuperation of waste heat, dispersed to the atmosphere.

At industrial plant the heat flows can be conditionally divided into two groups: high-grade and low-grade. To *high-grade* heat flows belong the feed flows and final product flows with temperature from 200°C and higher, transporting the heat energy and directly participating in technological process. To *low-grade* heat flows can be added the heat energy, which is out of the process and dispersed to the atmosphere via air cooling vessels or water-retaining cooling system by means of water stacks (open construction).

It is obvious that power efficiency of the production will be determined by effective use of all listed heat flows, but the most important factor for production's power efficiency increase will be reduction in low potential flows and implementation of the low potential energy recuperation technology.

Let us take the refinery as an example and evaluate the potential and scale of the waste heat from low potential heat in water-retaining system. To cool down different flows by means of heat exchanging equipment there is used recirculated water as a cooling medium. Circulating through the exchangers water, warmed up to 30…40 °C, is supplied to water stacks, where due to the contact with air it is cooled down by 5…10 °C and returns to production process to cool down the heat flows. In spite of the fact that the water temperature change is usually around 10 °C, due to the big quantity of circulating water there is dispersed a considerable amount of heat to atmosphere:

$$Q = Gc(T_1 - T_2), \tag{1}$$

where $Q$ – quantity of heat waste to atmosphere ( joule/s); $G$ –heat carrier flow (kg/s); c – specific heat capacity of the heat carrier (joule /(kg·K)); $T_1$ ,$T_2$ – heat carrier temperature (K).

According to calculation (beginning of 2000) made at OJSC "Naftan-Plymir" it is found that loss of the low potential heat in water stacks can be rather compared with heat consumption in the form of steam [2; 3]. For example during summer there is supplied to water stacks around 30 000 m³/day of the circulating water in total, where the water is cooled down from 37…40 to 22…25 °C (depends on the ambient temperature). At the same time there is transported to the atmosphere around 26 000 kJ /s. Evaluating this heat flow with consideration of the oil combustion specific heat we will derive around 55 tons of oil per day in equivalent. Given figures are not indicative of the water circulation system's inefficiency and they do not call to replace the water stacks with other technologies, it is just an indication of the huge potential in low potential heat wastes' use.

Apart of the refineries, heating systems of the Housing and Public Utilities have a significant source of the low potential heat. Generally, heat for housing stock is supplied via heat supply system from the heat station or boiler house. In view of inefficient performance of many heating systems the return water flows back to heat station at the temperature higher than set by temperature charts. As a result, the heat loss by transportation reaches 30% when the standard is 5…10 % [4; 5]. Heat recovery of the return water before sending to heat station could increase the efficiency of the entire power system by 10…15 %.

Analysis of the low-grade heat loss (Housing and Public Utilities and industry) reveals a huge potential and perspective of use of low-grade heat recovery technologies. Currently the most common solution for recuperation of the low potential heat is the heat pump [6]. This is the only equipment that performs the process of heat transport from the low temperature level up to the higher temperature level, pulling the unused natural and anthropogenic heat into useful circulation.

The Republic of Belarus has an experience of use of the geothermal heat pumps. In 2011, on the territory of the hothouse complex "Berestye" (Brest region), there was put in an experimental operation a geothermal station with the capacity of 1 MW. By means of two imported heat pumps, the constructed heat pump geothermal station increases temperature of the ground water from 24 °C to 60 °C. Consequently, the station heats a part of the greenhouses and provides a hot water supply for its own production needs [7].

Moreover, Belarus is developing the design and production of the domestic low power heat pumps up to 100 kW. Similar vapor compression heat pumps are designed on the basis of piston, spiral and screw compressors in the A.V. Luikov Heat and Mass Transfer Institute of the National Academy of Sciences of Belarus [8].

However, the common constraint for the wide use of the heat pumps at industrial plants is the fact that as a working medium in heat pump units are used hazardous substances such as ammonia, freon, hydrocarbon mixtures. Forthcoming withdrawal from circulation of the freon heat pump units is a problem for many Russian and leading western manufacturers of the heat pumps. This is related to ratification of the Kyoto protocol.

Search for the alternative heat pumps' working medium is a complicated and open problem yet. To fulfill the processes in thermal transformers the working medium must possess the required thermodynamic and physicochemical properties: low vaporization temperature; low condensing pressure; high heat of vaporization and high enough value of the polytropic index ($K$ = 1,3…1,4):

$$K = C_p / C_v, \tag{2}$$

where $C_p$ – specific heat at pressure $P$; $C_v$ – specific heat at volume $V$.

The steam-air mixture with water vapor content up to 50 % vol. can be considered as an alternative for the working medium. At certain conditions the intensive water vaporization can be obtained (temperature 25…40 °C and vacuum 20…30 kPa abs.). Moreover, it is known, that water has one of the biggest value of vaporization heat and at certain ratio the polytropic index of the steam-air mixture can be 1,5…1,7.

Under the supervision of professor Abaev there were undertaken the lab studies at PSU (Polotsk State University), at "Polymir" plant and at JSC «Technolit» (Polotsk). The purpose of those studies was construction and testing of the liquid-vapor heat pump. Consequently there was designed a pilot unit with the capacity of 25 kW and efficiency not less than 3. The main parts of this unit were rotary-plate vacuum-compressor and jet device. The unit was capable of recuperation of the low potential heat with temperature 25…40 °C by means of "hot water" production ($T$ = 80…90°C) (fig. 1).

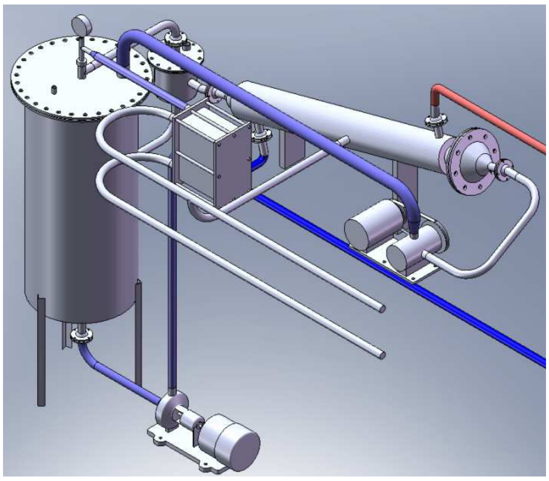

Fig. 1. Model of the steam-air compressive heat pump

Implementation of the given type of the heat pump in different branches of national economy, for instance, in the water rotation system of the petrochemical enterprise OJSC "Naftan" and in the heating system of Housing and Public Utilities.

One of the sources of the low-grade heat in OJSC "Naftan", as it has been mentioned before, can be the heat of the circulating water of the cooling system of processing facilities and product stream.

Analysis of the heat losses in the system of the water rotating system of the pump-and-compressor equipment of Catalytic Reforming Unit has revealed around 1.5 MW/h of the low-grade energy. Accordingly, the usage of the heat pump in the cooling system of the pump-and-compressor equipment is suggested in order to lower the temperature of the circulating water and hot water generation (Fig. 2).

The proposed type of the heat pump will allow recovering only a tiny part of the heat energy of the circulating water of the system, nevertheless its possible implementation will let obtain field experience of the industrial application of the heat pumps.

Application of the heat pump in Housing and Public Utilities is possible for the heat recovery of the circulating district heating water coming from the residence buildings back to the Heat and Power Station (Fig. 3). The recovered heat is supposed to use in the residence building heating, lowering the consumption of the hot water coming from the Heat and Power Station. Outside the cold season, the district heating water can be used for heating the potable "hot" water in the household boiler. Estimating the quantity of the heat pumps for the Housing and Public Utilities is was determined that for the typical two entrance halls of the nine-storied residence house of 72 flats one heat pump with the capacity of 25 kW is enough.

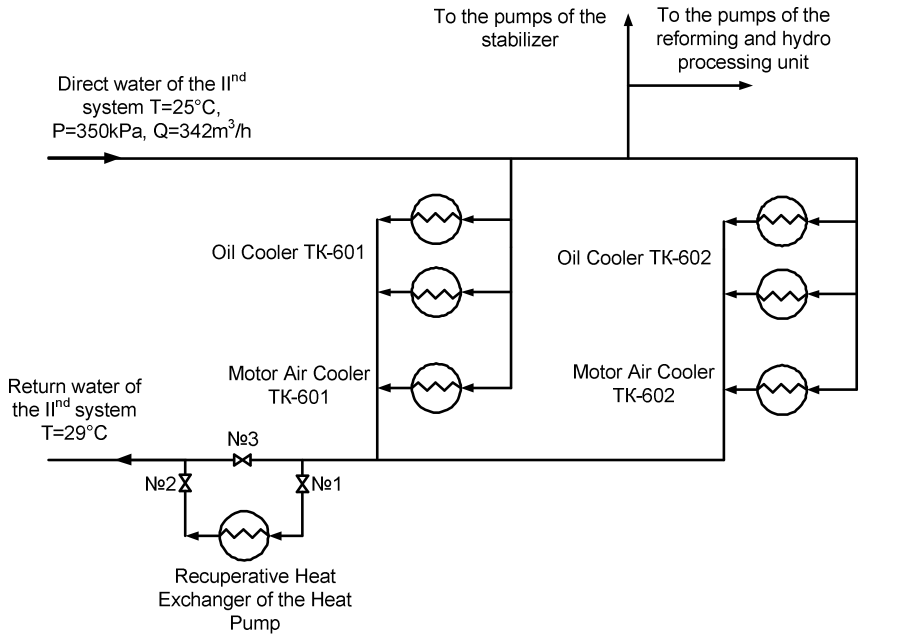


Fig. 2. Heat Pump application diagram for the processing unit of OJSC "Naftan"

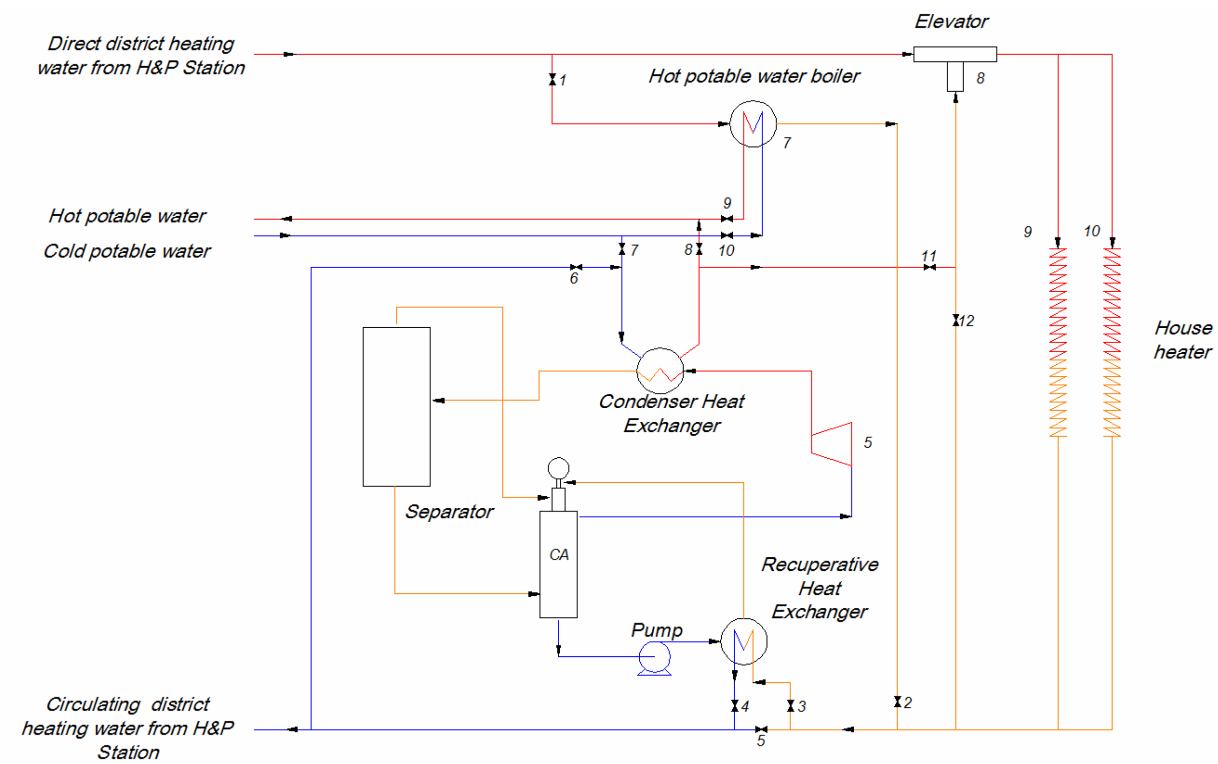


Fig. 3. Heat recovery of the circulating district heating water in the Housing and Public Utilities system with application of heat pump

Analysis of modern trends of heat pump equipment application in industry shows dynamic development of technologies and designs for low-grade heat recovery. Analysis of low-grade heat loss amount, as in housing and utilities sector, and in industrial plants shows huge potential and perspective of low-grade heat recovery technologies application. However, modern technologies and equipment, which is based on usage of high-priced and hazardous working mediums, have significant limitations, which restrains its wide industrial application.

Consequently, designing of effective heat pump with moderate and safe working medium is a contemporary direction for the development of modern science and technologies in Belarus.

REFERENCES

1. Энергоэффективность аграрного производства / В.Г. Гусаков [и др.] ; НАН Беларуси, Отд. аграр. наук, Ин-т экономики, Ин-т энергетики ; под общ. ред. акад. В.Г. Гусакова, Л.С. Герасимовича. – Минск : Беларус. навука, 2011. – 57 с.
2. Рекуперация низкопотенциального тепла системы оборотного охлаждения с использованием термокомпрессионных циклов / Г.Н. Абаев [и др.] // Материалы. Технологии. Инструменты. – 1998. – № 1. – С. 49–52.
3. Пилотная установка по рекуперации низкопотенциального тепла / Г.Н. Абаев [и др.] // РЭК нефтехим-1 : тр. междунар. науч.-техн. конф., Новополоцк, 17–19 нояб. 1998 г. ; Полоц. гос. ун-т ; редкол.: Г.Н. Абаев [и др.]. – Новополоцк, 1998. – С. 200–203.
4. Прокопчик, Г.А. Цена тепла / Г.А. Прокопчик // Журнал Директор. Белорус. ежемес. информ.-аналит. науч.-практ. журнал для руководит. – 2006. – № 10. – С. 8.
5. Бондарь, Е.С. Тепловой насос – энергетически эффективная составляющая систем кондиционирования воздуха / Е.С. Бондарь, П.В. Калугин // Тепловые насосы. – 2011. – № 2. – С. 25–30.
6. Энергосбережение: разработать пилотную установку по рекуперации низкопотенциального тепла систем оборотного охлаждения с использованием термокомпрессионных циклов : отчет о НИОКР / Полоц. гос. ун-т ; рук. темы Г.Н. Абаев. – Новополоцк, 1998. – С. 22 – 98. – № ГНТП 55.
7. Грибик, Я. Развитию геотермальной энергетики в Беларуси препятствуют межведомственные барьеры / Я. Грибик, В. Зуй, Н. Долбик // Дикая природа Беларуси [Электронный ресурс]. – 2013. – Режим доступа: http://www.wildlife.by/node/24255. – Дата доступа: 31.05.2015.
8. Государственное научное учреждение «Институт тепло- и массобмена имени А.В. Лыкова Национальной академии наук Беларуси» (Институт тепло- и массобмена им. А.В.Лыкова НАН Беларуси). – Минск, 2015. – Режим доступа: http://www.itmo.by/. – Дата доступа: 22.07.2015.

**UDC 551.528.2/2 (476)**

## GIS TECHNOLOGY APPLICATION FOR DETERMINATION OF POTENTIAL ZONES OF ACCIDENTS ON MAJOR PIPELINES

***ANASTASIYA BODRAYA, GALINA SHAROGLAZOVA***
**Polotsk State University, Belarus**

*The author has collected and systematized data, determining factors causing accidents on major pipelines. The analysis of these data has found practical application in the establishment of GIS project maps of zones of potential accidents on major pipelines. The purpose of these maps is to identify potentially dangerous areas of pipelines, which are exposed to geodynamic factors, and timely warning of possible catastrophic consequences.*

Predictive estimation of the risk of accidents on major pipelines is a necessary element of the design and building of engineering constructions. However, as a rule, the problem of accidents on major pipelines is analyzed from the engineering aspect only: at the design and construction stage hydraulic, thermal and mechanical calculations are performed [1]. Thus, seismic-tectonic factors are practically not taken into consideration. Moreover, there is no direct guidance on taking into account the interdependent influence of man-made and tectonic factors.

The paper tries to generalize the accumulated extensive geological, geophysical and seismological data related to the conditioning of accidents on linear constructions on the territory of Belarus. GIS project was created on the basis of collected and systematic geological, geophysical and geodetic data, determining factors of accidents on major pipelines of Belarus. It reflects possible occurrence of accidents (POA) on major pipelines.

The analysis of information on the accidents showed that the probability and density of accidents is primarily influenced by such factors as the activity of tectonic faults, the proximity to power lines, the type of salinity of subsurface water.

The selection of these factors is explained by the following:

– the fact of confinement of accidents on oil pipelines in Belarus to tectonic faults for more than 70% [1];

– electromagnetic fields generated by power lines and current leakage increase corrosion processes to a large extent;

– electrolyte properties of mineralized fracture water are enhanced under the influence of power lines, which leads to intense chemical corrosion [2].

The composed GIS project takes into account these three factors, and it is aimed at identifying the areas of possible occurrence of accidents (POA) on major pipelines.

The layout of GIS project has been created using technology ArcGIS9.3.1. The geodatabase consists of the attribute tables containing the necessary data, raster images and layers. Working with maps of different