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ANALYSIS METHODS FOR DETERMINING CONCRETE WATER

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Showing different ways to determine water resistance of concrete. Describe their main characteristics identified positive and negative points. The necessity of a new method of determining the water resistance of concrete.

Modern construction is unthinkable without concrete. 2 billion m3 per year – that is today the world volume of its application. This is one of the most popular building materials, which largely determines the level of civilization. However, concrete – the most sophisticated artificial composite material which can have quite unique properties. It is used in various operating conditions, in harmony with the environment, has an unlimited resource base and relatively low cost. To this should be added to high architectural construction expressiveness, the relative simplicity and availability of technology, the possibility of widespread use of local raw materials and disposal of anthropogenic waste during manufacturing, low energy consumption, environmental, safety and reliability. That is why concrete, without a doubt, will remain the main structural material in the foreseeable future.

All this is possible not only to create and master the production of new types of concrete, but also significantly expand the range of materials used in construction: concrete construction, special, heat-insulating, chemically resistant, strain, radiation protection, roads, waterworks, etc. [1].

Concrete mix for making watertight structures have to be prepared from aggregates of dense rock. The best result is achieved in this case by using gravel. It requires less water and is well within the concrete mix. For high-strength concrete structures should be used rubble. Properly selected particle size distribution of aggregates provides water resistance of concrete. Sand and gravel (gravel) alone should have particle size distribution according to GOST 2780-50 and GOST 2781-51 [2, 3].

Professor B.G. Skorotaev the selection of watertight concrete structures proposed increase in sand content, thereby increasing the density of concrete. In this case, increased connectivity of concrete mix, there are small water separation and good workability. According to his research, we recommend that the mixture of aggregates with a high content of sand (45 – 55%). The greatest strength of the concrete is achieved when the content of the sand in an amount of 35% in the aggregate mixture [4].

Need to know that the sand should be of medium size. Fine sand has a large overall surface area, thus increasing amount of water required for mixing concrete. Close same sand will create a large-sized pores in the concrete structure, which is also a negative impact on its waterproof.

Also factor in the density of the concrete structure and, consequently, the water leakage is a water-cement ratio. With increasing the amount of cement concrete bundle decreases, the density increases, and hence the water resistance of the concrete. With the increase in water decreases the strength and water resistance of concrete, so gauging the concrete mix should take the least amount of water.

According to studies to determine the optimal water-cement ratio, conducted by Professor M.G. Davidson, for waterproofing concrete mixture should have a water-cement ratio of 0,40 – 0,45 [5].

Type of cement has a significant effect on the water resistance of concrete. Cements used finer grind. In this case, the cement paste will have a high water resistance, which is caused by low water separation (sedimentation), small and evenly distributed pores and a high degree of hydration [5].

For watertight concrete prof. S.D. Okorokov suggested the following sequence of application of various types of cement, in order to increase the waterproof effect: aluminous cement, Portland cement, pozzolana cement, slag cement [6].

The most effective are pozzolana cement and slag cement. Aluminous cement was also less widely used, since the water demand of cement, aluminous somewhat higher than portland cement, and is 25 – 28%, as it is

less durable, as compared with Portland cement, raw materials for its production is limited, and price is 5 – 6 times higher [7].

There are the following methods for determining the water resistance of concrete:

A method for determining the water resistance of concrete, "wet spots", according to which samples are attached, and a cylindrical shape is sealed in special cages, fed in steps of 0.2 MPa water pressure on one of the end surfaces of each sample by holding the pressure at each stage for a predetermined time until the emergence on opposite end surfaces of the filter characteristics of these samples in the form of droplets of water or wet spots, and for taking appropriate waterproofing pressure value of 0.2 MPa at a reduced [8].

This method has several disadvantages. The method has considerable complexity, since the tests should be subjected to at least six samples. Unreliability tightness samples lead to additional errors and repeated tests. Feed pressure 0.2 MPa stages are very rough and cause additional systematic errors reaching 10-30 %. Because the level of 0.2 MPa may be omitted as well as the values of the waterproof 0.1, 0.3, 0.5, etc. For example, instead of 0.3 MPa waterproofness by this method must be adopted either 0.2 or 0.4 MPa instead of 0.5 MPa – either 0.4 or 0.6 MPa. Tests by this method are very durable - at every stage of retention time is 16 hours, but in general, such as waterproof 0.8-1 MPa test duration is 7-8 days. In this test it should be conducted around the clock and using expensive compression settings, as well as requires the involvement of operators for a long time. The disadvantage of this method is the use of sample and only a cylindrical shape and only one diameter (150 mm).

Method of rapid determination of water resistance of concrete in his breathability, whereby the surface of the lower (by hypothesis forming) the ends of the samples – cylinders or cubes flange mounted camera vacuumizing device coated with a sealing ring harness mastic. With said device creating under pressure in the chamber is not less than 0,064 MPa, determined by a drop in vacuum pressure chamber penetration value of air resistance of concrete and concrete water is determined by a predetermined calibration relationship between water resistance and resistance to air penetration concrete [9].

This method has the following disadvantages:

Used to test samples may have different humidity, that is a different degree of filling pores with water, which leads to a different strength of concrete penetration of air. Because this deviation of the measured values of the waterproof resulting from calibration curve reaches 15-20%. The very same calibration dependence has an error of 10 – 15%, as the air is not like water on the appearance of its properties such as surface tension, viscosity, and thermal expansion.

Establishment of the calibration dependence is a long and time consuming process, as it requires engaging the base method [8]. This situation is compounded by the fact that the relationship should not be one. They want to install as much as controlled concrete compositions, as the method is supposed to apply calibration dependence established only for a specific relation between aggregates and cement in concrete. Thus the discussion method is not precise enough, and its use requires a preliminary, labor-intensive and time-consuming tests to establish the calibration dependences. As a result, the total error determination waterproofness by this method is not less than 30%.

A method for determining water resistance of concrete, including water saturation water samples, drying them to constant weight to determine their water absorption and water resistance to finding tabulated statistical dependence between water resistance and water absorption [10].

The disadvantages of this method are the high accuracy, which reaches 40% and a substantial length thereof, up to 7 days.

High error method is primarily caused by the fact that the water resistance is proportional to the capillary, and not the total porosity of the material, which corresponds to the absorption of water. The total porosity is generally 1.3 – 1.5 times the capillary. Additionally, if the same capillary volume may be characterized by a porosity different pore size distribution and, therefore, various water filtration resistance under pressure, which is waterproof. This method also does not account for this.

Considerable duration of the process is due to the need for a complete saturation with water samples and their subsequent drying to constant weight (requirement determining water absorption according to GOST 12730.3). Duration of implementation of each of these operations is approximately 4 days.

A method for determining water resistance of cementitious materials, which comprises drying the samples to constant weight, waterproofing their side surfaces, water saturation, determination of water absorption and water resistance calculation in terms of saturation of the mortar and the rate of water absorption of the [11].

The disadvantage of this method is the large error, reaching 30%, and increased the duration of its implementation, reaching 5 days.

The large error in the method is due to the fact that water resistance is proportional to the capillary, and not the total porosity of the material, which corresponds to both water saturation and water absorption (see above

analysis of the previous method). Furthermore, an additional source of error is the saturation of the sample through an end surface of the sample state and a porosity which is not quite adequate and porosity of the material in the sample. Increased duration of carrying out this method due to the same factors that are listed in the foregoing assay method.

In Polotsk State University the work on the development of a method for determining water resistance of concrete with high marks for waterproof W18 – W20, trademarks frost resistance F200 – F400 is carried out.

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CHOICE OF METHOD OF INCREASING THE WATER RESISTANCE OF CONCRETE

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The article shows various ways to improve the water resistance of concrete. Their main features are described, positive and negative sides are identified. Ways to improve the water resistance of concrete can be divided into two groups. The first includes activities involving the use of different materials for waterproofing. Without changing the degree of water resistance of concrete, it protects against the penetration and impact of groundwater and process water. The second group of special device eliminates the waterproofing layer and provides for increased water resistance of concrete.

The last decades of the twentieth century were marked by significant advances in concrete technology. In those years there were widespread and new modifiers for concrete binders, active mineral additives and fillers, reinforcing fibers, new technological methods and methods for building composites. At the turn of the century greatly enriched understanding of the structure and properties of concrete, the processes of structure formation, the opportunity to predict the properties and characteristics of the active material management, successfully developing computer-aided design of concrete and automated process control.

Today a lot of different types of concrete are used in the construction, and the creation of new concrete intensively continues. Concrete is widely used in residential, industrial, hydraulic, energy and other types of construction.

Concrete, being the most striking representative of a wider class of materials – construction composites hydration hardening projected on the basis of a single material, gives a new impulse to create layered, thin-walled, and other specialized types of building structures of the new generation [1].

Concrete has high mechanical properties: durability, fire resistance, easy adaptability to almost any form. But it also has disadvantages, which primarily relates it watertight. Under the pressure of groundwater there is usually underground part of industrial, civil and public facilities. Seepage of water into structures (hydraulic facilities, tanks, pools, tunnels, basements, dams, etc.) can cause serious consequences. Therefore, improving the water resistance of concrete is an urgent task.

Ways to improve the water resistance of concrete can be divided into two groups. The first includes activities involving the use of different materials for waterproofing. Without changing the degree of water resistance of concrete, it protects against the penetration and impact of groundwater and process water. The second group of special device eliminates the waterproofing layer and provides for increased water resistance of concrete [2].

There are the following main types of waterproofing: the painting (from the roll and film materials), plaster, asphalt and team (made of metal and plastic sheets and profiles). Found application isolation cast (insulating material is poured into the insulated surface and fills the gap), impregnation (saturation of the upper layer materials) Loose-fill (from hydrophobic powders) and injection (injection into the cracks and crevices of waterproofing material) [3].

In the last 5 – 10 years for waterproofing civil and industrial buildings penetrating materials are often used. It has become common practice, both in the construction and the rebuilding of their health. Waterproofing materials are on the market for over 15 years one of the leading groups of companies takes "Kalmatron" producing a whole family of penetrating waterproofing materials and hydrophobisator NGL-11P.

Protective waterproofing penetrating material "Kalmatron" consists of Portland cement, dried, purified and fractionated quartz sand and complex reactive mineral supplements.

For "alerting" material "Kalmatron" requires only mixing the dry mixture with water in a certain ratio.

The principle of operation is based on the interaction of water in the presence of the chemically active part of the cement (as contained in the "Kalmatron", and the concrete structure to be protected), and when formation of this kind of electrolytic solution was saturated, which is due to osmotic choke structure penetrates the available concrete therein capillaries and pores (even towards the water pressure). And already in the concrete of this solution sparingly grow crystals that and compacted concrete structure, but not tightly sealing surface (the film), and sharing existing voids and pores on numerous smaller capillaries.

In any quality concrete have more or fewer non hydrated cement (i.e. not entered into the chemical reactions that result in a crystalline lattice of concrete). And these unreacted cement grains are "weak links" of the lattice, reducing its strength properties. Kalmatron involves them in a stronger reaction to form crystals, thereby increasing the surface layer of concrete.

Kalmatron may be used not only as a protective coating, but also as an additive in concrete and mortar (cement) mixture to streamline the entire array of concrete structures (due to complete passage of hydration of cement). Kalmatron concrete strength increases up to 20% increases water resistance for 2 – 3 steps and also increases the cold resistance of 50 cycles.

In addition, all materials family Kalmatron do not contain in their composition components harmful to human health, which allows their use in contact with drinking water.

Hydrophobisator NGL-11P (30% solution of sodium methylsiliconate, NGL analog-11H) is designed to protect from moisture absorbent porous building materials and structures. Composition "NGL-11E" gives water repellency treated materials.

Used for:

- processing materials in the masonry (brick silicate, ceramic brick, concrete, natural stone, etc.) to protect against water saturation;
- conservation decorative properties of construction materials for many years color retention and technical characteristics of the material reduces water absorption by 25 times;
- preventing the occurrence of leaks and efflorescence on the surface of ceramic bricks.

The treated surface retains its properties for 15 years.

On a constructive solution waterproofing can be single or multi-reinforced and unreinforced, with a protective layer and without ventilated when space under cover communicates with the outside air.

View received waterproofing depends on the required quality, strength, existing groundwater backwater. Take into account when selecting the required waterproofing indoor dryness, fracture designs. Select those materials that best meet the requirements for waterproofing, by comparing their performance with the operating conditions [3].

Unlike waterproofing associated with high labor and the cost of not providing the required quality and durability of construction, waterproof concrete has serious advantages, causing its wide application in construction.

To improve the water resistance of concrete there are the following groups of additives:

- sealing additives;
- hydrophobizing additives;
- plasticizing agents;
- complex additives.

Packers supplements increase water resistance of concrete through the use of water-soluble inorganic or organic substances. As used mill ground and mineral supplements from fine raw materials granulated blast furnace slag, fly ash and slag FCS. The effect of these additives is mainly to reduce mudding capillaries in concrete, and other leaks section greater than 1 mm, through which the moisture migrates. Such additives when soaking swell and clog the pores of the cement stone. Mineral supplements are considered waste and therefore cost-effective, but they increase the water resistance of concrete is negligible.

Water-soluble additives, concrete sealing materials include the following materials: iron chloride, sodium and potassium silicates, calcium nitrate, sodium aluminate, etc. [5].

Most cheap, simple and effective supplement is calcium nitrate (NC). At a dosage of 0.5 – 1% by weight of cement concrete water provides the best intensifies the strength development and increases the ultimate strength of 20 – 30% [6].

Hydrophobic additives – substances imparting hydrophobic properties of concrete and reduce water absorption of concrete [7].

They are adsorbed onto the cement grains in the form of a thin (monomolecular) layer to form on the surface a water-repellent film. However, they affect the curing process, contributing to the formation of cement with more homogeneous and fine-grained structure.

For water-repellent additives include abietates, sodium oleate, silicone water repellents (NGL), bitumen emulsion, etc.

Complex additives – chemicals that are multi-functional activity and containing in its composition two or more single-component additive [7].

The most used and effective complex supplements include a comprehensive waterproofing additive "Mabel" crystal- additive for water-resistant concrete Betocrete C-17 (C-17 Betokret (BFAU)).

Work on the technology of water-resistant concrete cost is many times cheaper than the device difficult, time consuming and costly waterproofing. This technology greatly affects the quality improvement structures extend their service life, and positively affect other properties of the concrete.

In Polotsk State University carried out the work on a method to improve the water resistance of concrete under the brand waterproof W18 – W20.

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STRENGTH OF MASONRY WITH RETICULAR REINFORCEMENT

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The results of the research of the strength of masonry with transverse reinforcement are given. The coefficient of the effectiveness of reinforcement and the coefficient of the utilization of armature are defined. New dependence by determination of the durability of the squeezed elements is offered.

Masonry is a monolithic anisotropic building material. A difficult tension arises in it under the influence of loading. It is caused by different strength and deformation characteristics of brick and solution. Masonry is widely used in the constructions working for compression. At the same time the increase of durability of separate parts of buildings (columns, walls, etc.) is often required. Mesh reinforcing can be used for it.

The norms [1, 2] are developed in accordance with the dependences received in the 30-60th of the past century. They are published since then practically without adjustments [3]. At the same time the production technology of brick and the idea of masonry tension were changed, other types of solutions and reinforcement appeared. All these facts demand of the specification of existing techniques of design and calculation.

In Polotsk State University the researches of stressedly-deformed condition of masonry with transverse reinforcement are conducted. The examples in the form of prisms were made from brickwork. The part of the examples were made as not reinforced, the other part was reinforced by grids of two types. The grids of "Type A" are in the form of a flat spiral; the grids of "Type B" are from being crossed cores.

The characteristic of the examples are represented in tab. 1.

Table 1 – Characteristics of the samples

Series	SI	SII	SIII	SIV	SV	SVI
Designations	К1, К2	К3, К4, К5	К6, К7, К8	К9, К10	К11, К12, К13	К14, К15, К16
Brick Solution	M150 M75	M150 M75	M150 M75	M200 M75	M200 M75	M200 M75
Type	–	Type B	Type A	–	Type B	Type A
The percentage of reinforcement μ, %	0	0,407	0,407	0	0,19	0,19

Tests were conducted in accordance with our program and taking into account [4]. Longitudinal and transverse deformation was measured. Stresses in the rods of reinforcing mesh were determined.

The character of the destruction of reinforced masonry is identified [5]. Failure occurs in the shearing of the outer layer and crushing rows of masonry. Only area A_{eff} was worked in the latter stages, see fig. 1. Stresses in the armature class S500 reached 350MPa. Such a way, the utilization rate: 350/500 = 0.7 (in the normative documents – 0.6).

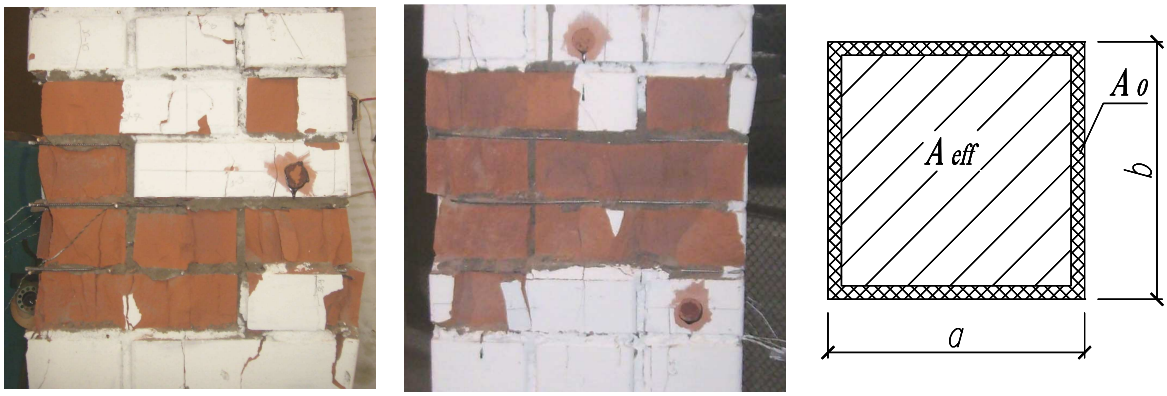


Fig. 1. Character of destruction reinforced samples, division section on A_{eff} and A_0

A single value of the coefficient of the effectiveness of reinforcement of masonry "*K*" for all types of brick *K* = 2 established in [1, 2]. "*K*" is 3.8 ... 5.4, calculated by [6] – 10, based on [18], an average of 8 according to the results of experiment. The quantity of "*K*" was a 3 ... 4 and decreased to 2.2 at 0.8. 1.6% in experiments of V.A. Kamejko [17]. see fig. 2.

In the calculations of reinforced concrete structures:

– the coefficient "*K*" depends on the present of reinforcement, concrete strength and armature [8 – 10, 11];

– in the norms [12 – 16] "*K*" is assumed to be a single number;

– the percent of reinforcement is defined only for area of section A_{eff}.

A new dependence for determining the breaking load than [1, 2] was proposed:

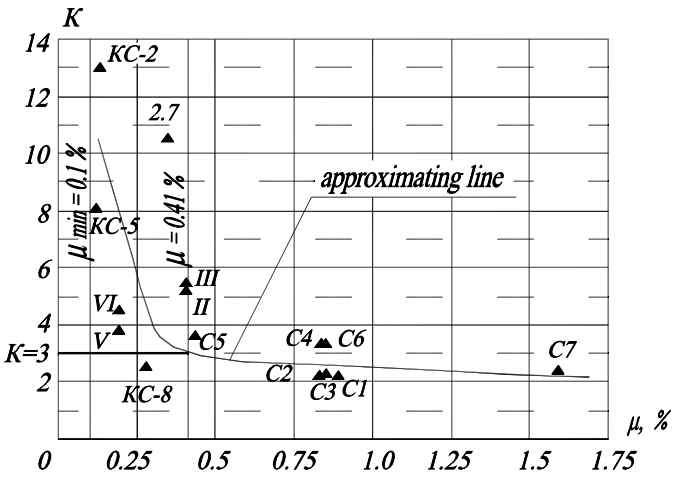
$$N_u = m_g \varphi (R_u A + \frac{KR_{sn}\mu}{100} A_{eff}) \quad (1)$$

where m_g – the coefficient taking into account the effect of long-acting loads;

φ – the coefficient of buckling;

R_u, R_{sn} – the tensile strength of masonry and normative resistance of armature, respectively;

K – the coefficient of the effectiveness of reinforcement.



II, III, V, VI – Series SII, SIII, SV, SVI
C1-C7 – [17]
KC-2, KC-5, KC-8 – [18]
2.7 – [6]

Fig. 2. Dependence of "K" on μ

Comparison of values N_u obtained in an experiment with N_u by [1, 2] and (1) is satisfied in tab. 2

Table 2 – Results of calculation

Series	*	R_u, MPa	R_{sn}, MPa	K	N_u, кN	$\frac{(N_u - N'_u)}{N_u}100\%$
II, III	A	5	300	2	887	14,1 (18,6)
	B	4,95	350	3,8…4,9	1033(1090)	–
	C	5	350	3	1023	1,0 (6,1)
V, VI	A	4	300	2	930	40,8 (42,5)
	B	4,43	350	5…5,4	1572 (1617)	–
	C	4	350	3	1181	24,9 (27,0)

* *A* – по [1, 2]; *B* – the experiment results; *C* – of (1)

Suggested dependence (1) corresponds to the mechanism of destruction of masonry with mesh reinforcement. Calculations according to (1) give good agreement with experimental results.

It is possible to use new methods of calculation with the development of computer technology. For example, using the finite element method, we plan to create finite element models and their comparison stress state with experimental data. Also we consider the development of methodology for calculating cross sections of arbitrary shape and reinforcement using both equilibrium equations external and internal forces, deformation diagrams, deformation conditions section.

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UDC 711.04

THE FOUR TEMPERAMENTS IN INTERIOR DESIGN

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Designers and architects pay special attention to the psychological type, especially, temperament. There are four human temperaments in psychology. They have great influence on creating the interior for each person.

Modern interior design – is an amazing art, which describes architectural and artistic building space. It talks about organization and combination of lines, shapes, textures, furniture, lighting and color in a room. As a result, there is a particular environment of a man, characterized by functional convenience, safety, climate, comfort and artistic appeal.

Since people spend most of their time in rooms, well-designed interior plays an important role in ensuring their psychological comfort. Interior design effects on productivity, helps save money, provides health and safety of people.

For each person concept convenience and comfort are different. That's why all the interiors are fundamentally different from each other. They have their own distinctive features or characteristics.

The first and the most important step in creating interior spaces is the study of the character of the owner, his preferences, tastes, interests, work, etc.

Definition of temperament is a major factor in shaping the future of the interior from the psychological point of view.

Temperament – a complex of individual personality features of the host.

Only after determining the dominant temperament of the owner an architect can move to the next step: the development of conceptual design.

There are four temperaments in psychology. They are phlegmatic, choleric, melancholic, and sanguine. Each temperament has its own positive and negative characteristics.

Among the positive qualities we can consider:
melancholic – a tendency to deep feelings and emotions;
phlegmatic – no hasty decisions;
sanguine – responsiveness for any job;
choleric – activity to work.
Of negative qualities we can consider:
melancholic – isolation and shyness;
phlegmatic – excessive tardiness;
sanguine – superficiality, dispersion, inconstancy;
choleric – hasty decisions, irritability, aggressiveness.

Temperament – is the outward manifestation of the type of higher nervous activity. As a result of education, self-education the outward manifestation may be distorted, modified, there is a "disguise" the true temperament. There is no so-called "real temperament." There is a combination of two or even three temperaments in a man.

The rhythm of activity, speed of movement, relaxation methods depends on a person's temperament. Consequently, the creation and development of environment depends on a person's temperament too.

Each temperament has its specific manifestations in the interior.

Choleric

Choleric – one of the four types of temperament. Human choleric temperament can be described as rapid and abrupt, but at the same time, unbalanced. This temperament is characterized by strong, quickly appearing feelings clearly reflected in speech, gestures and facial expressions.

There is a mixture of several styles in the interior of choleric apartment. He calmly combines classic and hi-tech, minimalist and country styles in one room. Such people can go to the experiments and are ready to bring new parts into their home.

An interior that will smooth and trim choleric stormy temperament is the best. It must satisfy cravings for change. The best color is a deep blue color. The combination with green will relax and soothe the nerves.

The better way is to stick to minimalism. Furniture should be light and capable of transforming (fig. 1).

Choleric prefers all technical achievements. There are curtains and a chandelier on the remote control, sensor lights and etc.

Choleric likes experiments, including in the design of rooms. They can easily paint one wall in a bright color, so materials are always changed in a room.

Fig. 1. Interior for a choleric

Phlegmatic

We can describe phlegmatic person as slow, imperturbable man with stable aspirations.

Phlegmatic person is one of the four main types of temperament. It is characterized by a low level of mental activity, slowness, and expressionless facial expressions.

Stability and peace are two values of the phlegmatic temperament. They are fully reflected in the character of the interiors. Such person likes things, which are not subject of fashion trends. There is furniture from parents or even grandparents in the house of phlegmatic.

The phlegmatic prefers a classic style. The furniture is durable. All elements of furniture are made of ecological elements. The interior is solid and respectable, almost without a change for decade. It is cozy, because of warm colors and natural materials (ceramics, wood, natural stone).

There are many paintings, books and sculptures in a phlegmatic's house. Each item has its own history and artistic value (fig. 2).

Fig. 2. Interior for a phlegmatic

Melancholic

Melancholic temperament is one of the four main types of temperament. Such person is easily vulnerable and weak.

The melancholic is characterized by low levels of mental activity, slowness of movement, speech and motor restraint. Melancholic feature are high emotional sensitivity, depth and stability of emotions in low external expression. Negative emotions are dominated.

The main thing for the melancholic is to avoid stress. He creates an atmosphere of comfort, warmth and tranquility. Melancholic addictions in interior are very diverse: from classic to modern, from the Scandinavian style to ethno.

Space and emptiness are not for a melancholic. He prefers cubbyholes, hidden from other eyes. Here he can relax and perhaps spend time in the company of close friends.

Typically, melancholic zones space with shelving, screens or translucent blinds. He prefers soft, diffused lighting. There are many carpet floors and soft covers (fig. 3).

The most using colors are shades of yellow, amber and terracotta. Romantic and sentimental melancholic has many deferent things with their own history. There are many photos, children's drawings, souvenirs, toys, dried flowers in his house. Therefore interior of a melancholic person consists of cupboards, alcoves and chests.

Fig. 3. Interior for a melancholic

Sanguine

Person with sanguine temperament is living, moving, cheerful and jovial. Sanguine is characterized by high psycho-analytical activity, vigor, efficiency, speed and liveliness movements, diversity and richness of facial expressions, the rapid pace of speech. Sanguine emotions are mostly positive. They occur rapidly and quickly replaced. Sanguine person quickly adapts to new conditions and rapidly converges with people.

Sanguine lives brightly, so he paints walls of his home in fresh and bright colors: yellow, orange, cream, red, amber, terracotta. The house of a sanguine is full of joy and energy. There are noisy children, animals and guests, the music plays. His apartment is full of air and light.

Sanguine does not like large furniture and excess things. But we cannot say about one stylistic preference. Maybe, one sanguine prefers the romantic style, and the other - an extreme. His house is full of air, light and color. The sanguine person has lot of glass and mirrors that visually expand the space.

In short, a sanguine tends to create bright and welcoming atmosphere in his house.

Fig. 4. Interior for a sanguine

Thus, knowledge about temperament is widely used in many fields of human activity, especially in the design. It is clear that unlike people need a completely different decor. Interior is a reflection of the individual owner. That is why psychologists and designers recommend paying special attention to the psychological type of the owner, especially his temperament.

Creating a specific interior in his apartment or house, an architect try to find the point of intersection of the two worlds: the world of interiors with their laws, canons, history, and the world of his own mental and taste preferences. Therefore, experts say that the search for "his style" interior is simple and complex at the same time: decor elements should be in harmony with the inner world of a man.

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STRENGTH AND DEFORMABILITY OF COMPRESSED CONCRETE ELEMENTS WITH MECHANICAL CONNECTIONS OF REINFORCING BARS

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In this research work experimental data of the mechanical properties of armature of mechanical connections are presented. They ate featured by device simplicity, minimal cost as well as the necessary strength.

Results of research obtained from testing connections in full-scale samples - reinforced columns.

Due to the increasing part of monolithic construction of buildings and structures, as well as the development of high-rise construction in Belarus questions of docking rebar very relevant and in time. Consideration of this issue suggests that the mechanical butt splice fittings for the last 10 years have found their place in the monolithic construction in our country and the CIS.Industry documents that establish requirements for splicing rebar developed for introduction of mechanical connections in the design and construction of buildings of nuclear power plants. Constructions were used on most built objects [1].

Currently, there are multiple options for the mechanical coupling connections rebar, built on different principles of force transmission between the docked bars. The main requirements for methods of joining fittings for their implementation:

- guaranteed reliability of mechanical connection;
- minimum cost of connecting element;
- minimum cost to operate the equipment when performing a connection;
- minimum time to perform a connection.

Evident that to achieve simultaneous full implementation of all conditions cannot be [2].

Field of application of mechanical connections expands and gets new horizons in the practice of monolithic construction.

The purpose of this research work is to determine the influence of mechanical butt- joint of armature of a new construction on strength and deformability of compressed concrete elements.

As prototypes were made 8 samples of reinforced concrete rectangular columns size 200x200x2000 mm (fig. 1(a)), manufactured of heavy concrete with strength of 33.5 MPa and 45.8 MPa.

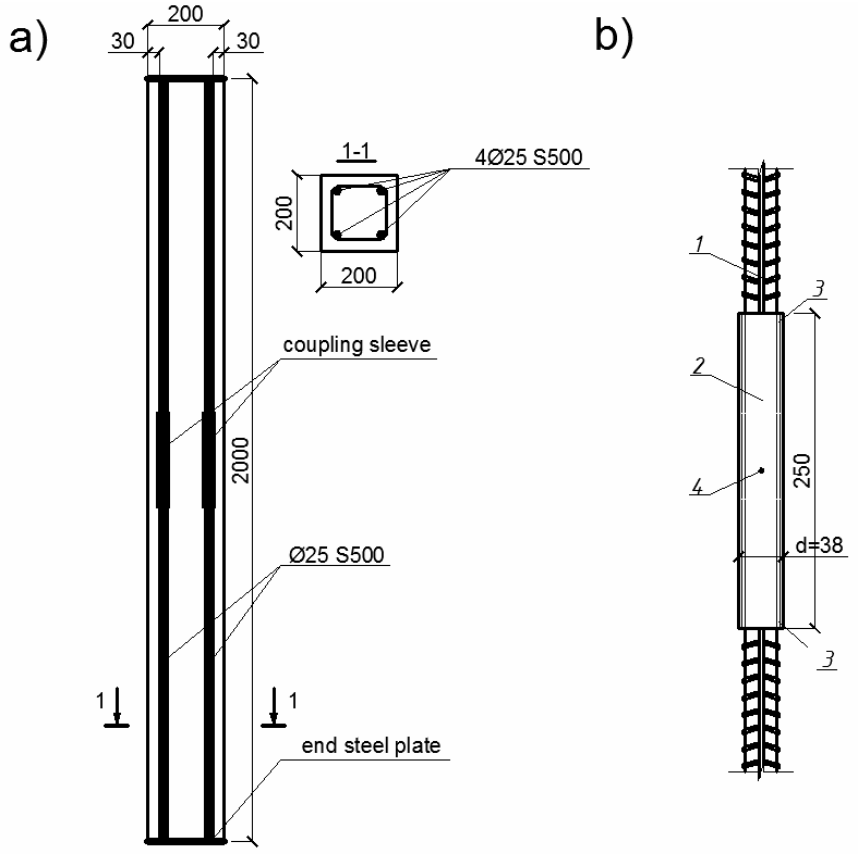

Fig. 1 a) Scheme of longitudinal reinforcement samples columns; b) construction coupler connection reinforcement bars:

1 – docked rebars ∅ 25 S500; 2 – coupling of d = 38mm pipe with wall thickness of 4mm; 3 – resin composition; filler – silica sand; 4 – 3mm diameter hole

Samples were reinforced with working longitudinal reinforcement in the form of four rods of 25 mm diameter grade S500 (At 500C), one type of connection ends of the rods shown on fig. 2(b). Columns were

tested for central compression. For variable factor of experimental study was taken location of data joints in test samples 3 types of location couplings were used for columns:

- four connections at one level;
- four off set connections;
- two connections.

The cross reinforcement of columns performed curved clamps envelopes working longitudinal reinforcement. Connection of longitudinal reinforcement and binding wire clamps performed. At the ends of the columns used headroom with end plates welded to the longitudinal reinforcement.

This type of device is characterized by simplicity and minimal cost of production [3, 4]. Selection of the binder material in the joint part in the form of the polymeric composition based on epoxy resins due to the possibility to obtain high-strength quick-material for a day. Connection length in the initial combination is taken to be 250 mm (10 diameters abutting rods) based on tests tensile samples of compounds with different length sleeves. With a length of pipe – clutch 10 ∅25 tests showed stable values gap in median plane of the compound in efforts relevant interim resistance steel pipe.

All the experimental part of the work carried out with this type of mechanical coupling. We used rebar diameter 25mm, smelting 10103 A500SP made by TU 14-1-5497-2004, of RUE "Belarusian Steel Works." In terms of tensile tests on the average yield strength of 551 MPa steel, tensile strength 687 MPa, which corresponds to the requirements of the fixture class S500 (A500). Couplings used for the manufacture of welded steel pipes produced by JSC Moscow Pipe Plant "Philetus" made according to GOST 8734-75 , an outer diameter of 38mm and a wall thickness of 4mm . On the inner surface of the tube were cut depth protrusions 1 – 1.5 mm, to improve adhesion. According to the results of tensile tests on the mean values of yield strength steel clutch 360MPa, tensile strength 504. Strain diagram was constructed for the main steel rods and steel sleeve (fig. 2).

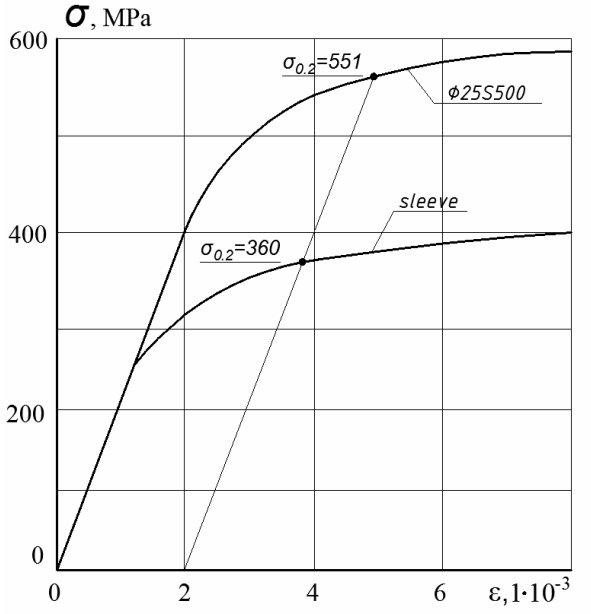

Fig. 2. Strain diagram of steel rods and steel main pipe couplings

When compressing deformation in the coupling sections considerably smaller deformations abutting rods at all stages of the load (fig. 3). Explanation for this is the lower intensity of stress on greater cross-sectional area. In the transition zones at the beginning and end of the sleeve is formed deformation gradient associated with the process of redistribution of stresses between the docked and coupling rods. It is in these areas observed bending of the sample at the time of buckling force threshold compression.

Columns concreting was performed on the basis of Polotsk State University. Concrete was made on PRUE "Novopolotskzhelezobeton" and delivered to the testing laboratory EI "PSU" in the form of ready mix. Concreting samples occurred in the laboratory EI "PSU". Concrete mixture compression when laying concrete in formwork was produced with vibrators.

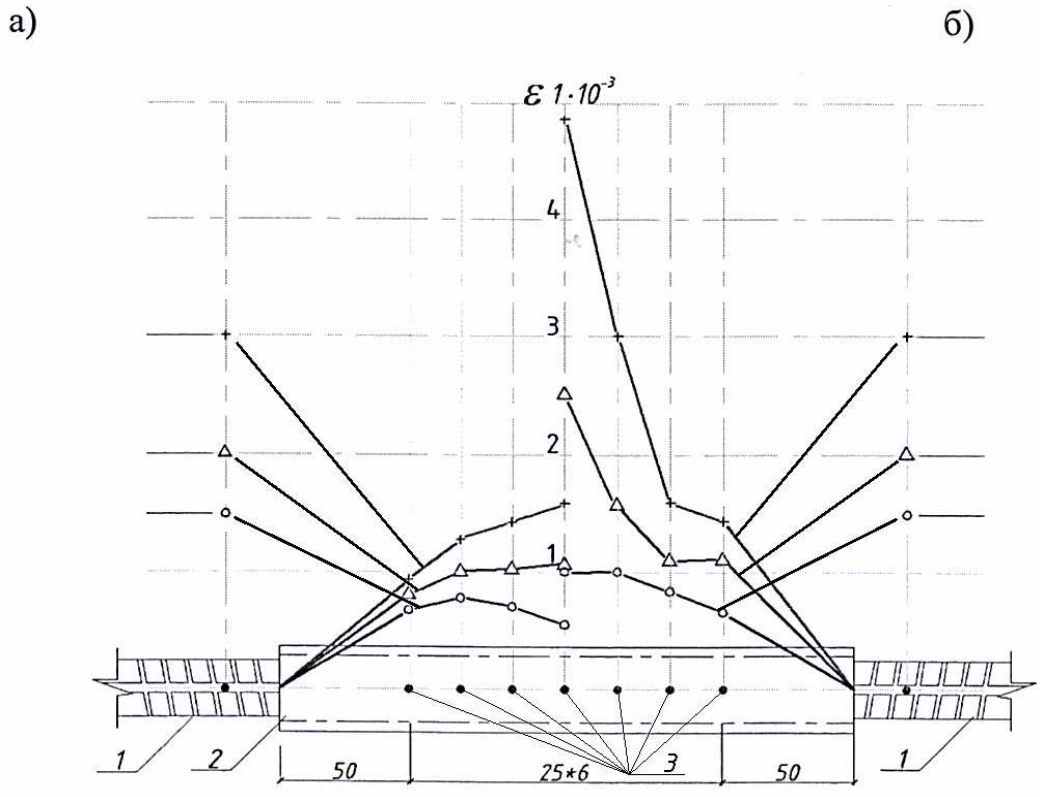

Fig. 3. Strain diagram sample butt joint under compression (a) and tension (b):
1 – docked rebars; 2 – sleeve;
o – strain at the level of loading $0,5N_{max}$; Δ – the same with $0,7N_{max}$; + - the same with $0,9N_{max}$

Columns prototypes were tested on a hydraulic press PR-1000. For uniformity of transmission to the column, immediately prior to the experiment, the headroom between the columns and press plates laid a layer of cement-sand mortar. The load is applied columns was carried out stages – 0.1 N_{destr}delayed 10 minutes. Transverse and longitudinal deformation of concrete were measured at the interface using strain gauges and dial indicators.

Table1 – Characteristics of full-scale samples – columns

№	The code sample	Characteristics of the sample and the symbol	The prism Strength of concrete,MPa	Destroying the longitudinal force, kN
1	К-1	Control samples without connections (•)	33,5	2100
2	К-2		45,8	2420
3	К-3	Four connections in the same level (x)	33,5	2140
4	К-4		45,8	2500
5	К-5	Fourconnectionswithoffset(▲)	45,8	2400
6	К-6		45,8	2490
7	К-7	Two connections(v)	45,8	2450
8	К-8		33,5	2200

The results of processing of the measurements were constructed graphs showing the dependence of the relative transverse deformations of concrete columns of the applied load (fig. 4).

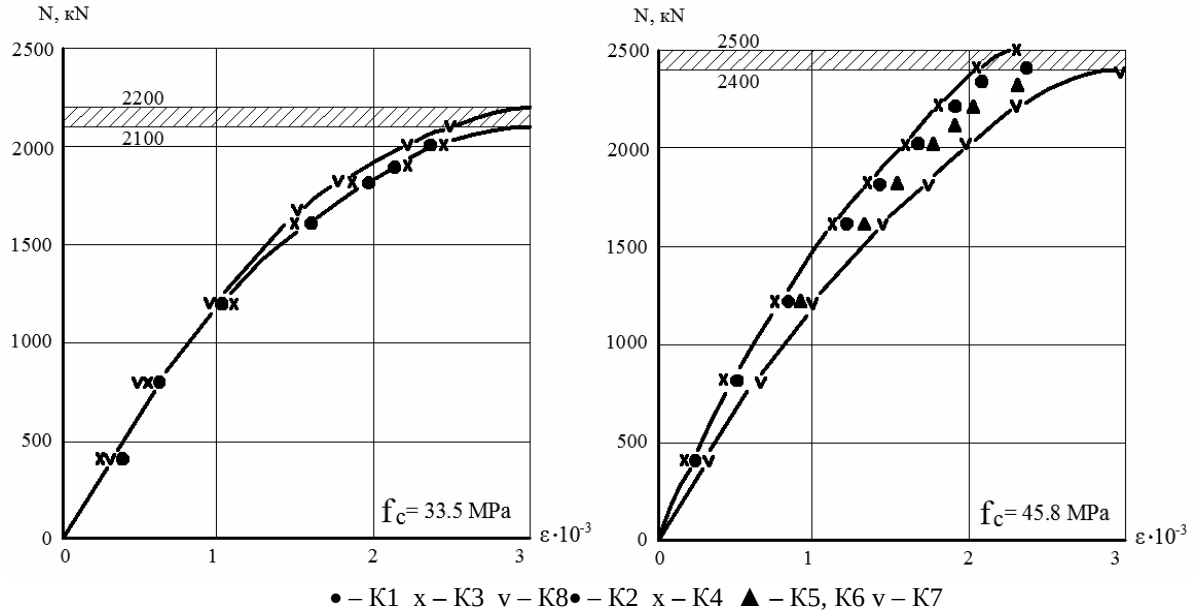

Fig. 4. Relative cross deformation of concrete of prototypes columns

– Character of the strain distribution was set along the length of prototypes couplings and its compliance as a linear displacement relative to the coupling rods abutting. The areas of strain concentration along the length of the connection were creating.

– Experimental tests of columns with coupling sleeve gave possibility to determine the strength of prototypes columns at the central compression.

– Placing a mechanical connection in the compressed zone did not lead to additional significant strains in concrete and did not affect the strength, and there were no influence on stiffnessof tested concrete columns.

– The obtained results allow us to recommend new construction mechanical connections for practical application.

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UDC 72 (Architecture); 502/504 (Environmental science)

ECOLOGICAL TRENDS IN THE BUILDING INDUSTRY

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The article discusses the criteria for environmental assessment of buildings and the various methods of environmental certification. Sustainable building is based on the use of environmental technologies, such as non-waste technologies, low emission technologies and renewable energy sources, reducing of energy consumption and use of ecological materials.

The building sector is a sector of the economy, which has a very strong impact on the environment, among other things; it is responsible for the consumption of 42% of energy and emission of approximately 35% of greenhouse gas emissions in the EU. At the same time construction in the EU market is buoyant (10% of GDP and 7% of the workforce), with a high potential for innovation. The implementation of the concept of sustainable development in the construction industry includes environmental aspects, social aspects and economical aspects. The chances of improvement in the housing sector, responsible for 26% of total energy consumption are substantially higher than in commercial construction. Comprehensively assessing the environmental impact of a building, usually shall be taken it impact on the enhancing of the greenhouse effect, the ozone layer depletion, consumption of primary energy, water consumption and water pollution (eutrophication and acidification), generation of waste and emissions of hazardous substances and the impact on the local microclimate.

The Assessment of the impact of the building on the environment is to determine the interaction of process and environmental and quantify of resources and energy flows charged from environment and emitted into the environment [5].

To assess the impact of the building on the environment throughout the life cycle analysis is used LCA (Life Cycle Assessment) (Fig. 1).

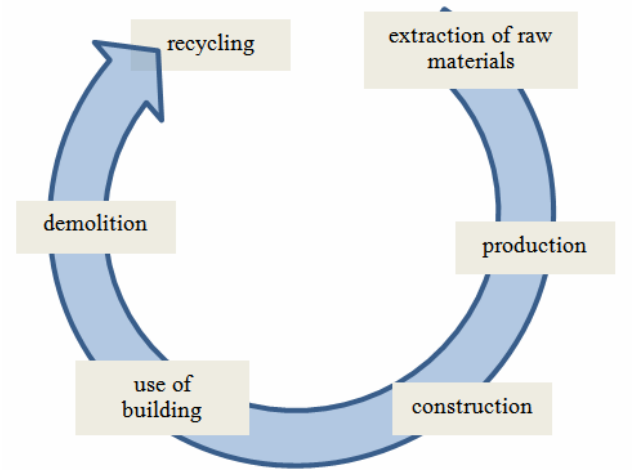

Fig. 1. Life Cycle Assessment of building

In the life cycle analysis of a building the environmental impact of all stages is considered : extraction and processing of raw materials, the manufacturing process, transportation, distribution, design, construction, operation and repair, end of life, change the way of use and re-use of waste. At each of these stages, a building strongly interferes on the environment, and interference may have either a negative or positive impact. The overall impact on the environment is determined by the balance of positive and negative impacts. LCA of buildings can be seen in the context of the analysis of the environmental impact of individual building materials.

The longest stage in the life cycle of the building is its use. The average person spends 80% of his life in building, therefore comfort and indoor environment are it is very important things. Analyzing the quality of life, most often is taken into account criteria such as health, safety of life, the environment and housing situation [niezabitowska]. The quality of the building, according to the POE (Post-Occupancy Evaluation) can be viewed in terms of technical quality, functional quality, behavioral quality and organizational and ecomonical effectiveness. By ABSIC (Advanced Building Systems Integration Consortium) the quality of the building can be assessed in terms of quality of space, thermal comfort, air quality nad acoustic and visual quality [5].

Among the tools used to assess the quality of the building include:

– REN (Real Estate Standards) – Dutch norm of real estate, constituting a systematic checklist, that allows to determine needs through discussions (helpful for architects when determining the requirements of the investor).

– PBAP & MM (Physical Building Audit Procedures and Maintenance Management) – it is the procedure for checking the physical condition of the building and its maintenance management – expert method for Facility Management in intelligent buildings.

– LCA & LCCA (Life Cycle Analisis & Life Cyclec Costs Analisis) – analysis of life-cycle costs of the building, allowing for the evaluation and calculation of economic justification of modernization [3, 5].

The implementation of objectives of sustainable development with regard to construction is reflected primarily on tightening requirements for thermal insulation of external walls and reduce the seasonal demand for energy for heating the building. So every building that meets the criteria for sustainable building must be, by definition, energy-efficient building. Criteria for assessment of buildings, in terms of its compliance with the criteria established for sustainable construction is shown in Fig. 2 [4].

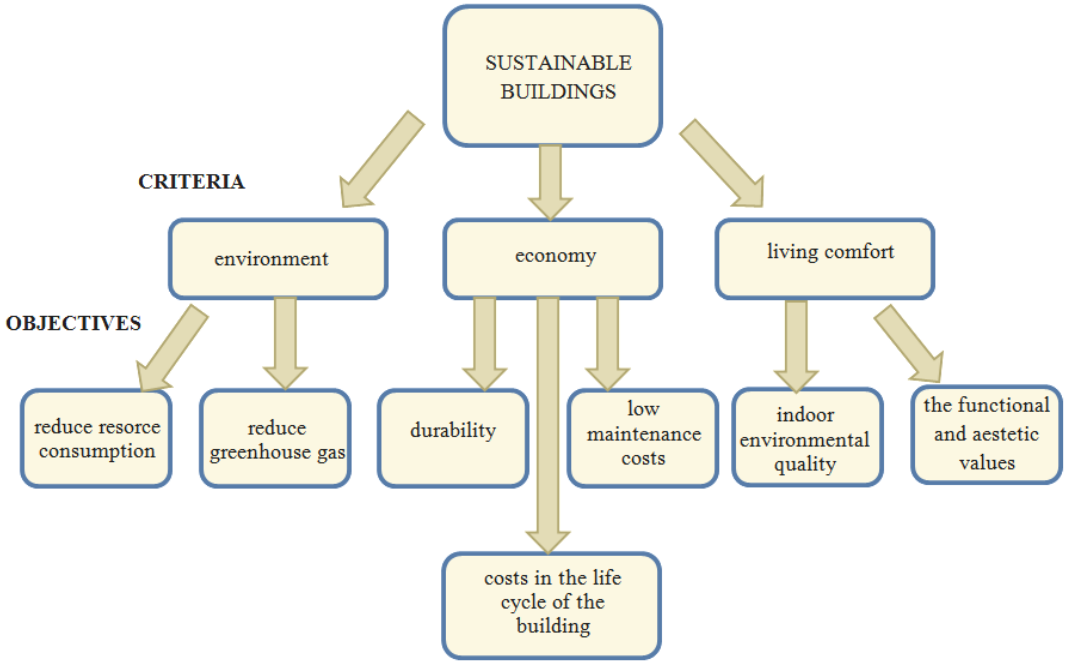

Fig. 2. Evaluation criteria for sustainable buildings [4]

For the assessment of buildings in terms of environmental requirements apply multi-criteria evaluation systems are used. They take into account the impact of buildings on the environment and quality of life of residents. The most commonly used systems are BREEAM and LEED.

The British system – BREEAM (BRE Environmental Assessment Method), which is also used in the international version, takes into account local conditions and law regulations in each country. BREEM takes into account many features of the building including indoor environment quality, energy efficiency, availability of transport, materials and design, exploitation and implementation, water and waste management [1, 2].

LEED (Leadership in Energy and Environmenral Design) is a certification system recognized internationally. It refers all the parameters, that are most important for buildings and society, as energy saving, rational water consumption, reduction of CO2 emissions, improved indoor environmental quality, resource management and well-being of inhabitants. The system is very highly flexible and can be used both in residential and commercial. LEED is recognized and used throughout the world, however, does not seem exam in tropical climates.

There are also local environmental building assessment systems that are used at national or regional level. The German Sustainable Building Certificate – DNGB – based on the concept of integral planning, that determines the character of the building at the planning stage. DNGB system considered issues such as ecology, economics and social quality, technical quality, process quality, and the quality of the location. Among the environmental certification systems should also include a system developed for the European Union – EU GreenBuilding, Geeen Star (Australia), HQE (France) and the system CASBEE (Japan) [2, 3].

Sustainable development in the building industry is carried out by balancing production and consumption patterns in relation to local conditions, the promotion of sustainable energy management system and sustainable transport system in residential areas. In the last years there are many initiatives to promote the locations of settlements in the industrial, devastated areas with a risk of biodiversity. Areas for building are beginning to be treated as a natural resource, which could be depleted. In the sustainable building industry, much attention is paid to the protection of the environment, mainly by the energy management (reduction of energy consumption, thermal modernization of buildings, installation of RES) at all stages of the LCA, the use of low- or non-waste technology, low carbon emission technology, promoting clean production systems and BAT technologies. In

order to maintain the quality of products there is used classification and labeling of chemical products specifying the risks of their use, the marking of construction products and equipment (in terms of energy consumption and eco-design of energy-related equipment, as Energy Label, Ecodesign) and their impact on the environment (Eco-label). Implementation of the concept of sustainable development in the building industry should be preceded by legislative procedure, adapting national legislation and national strategies related to construction (eg, energy, environmental protection, sustainable development strategy), as well as a comprehensive examination of the environmental problems in the legislation, planning and management. The implementation of the economic criteria should be based on the develop of economic and ecological account system , efficient use of available economic instruments and market conditions, such as the green procurement, green tax reform, green jobs [4, 5].

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UDC 691-405

MODELLING OF THE BASIS OF SOIL OF VARIOUS RIGIDITY

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The model of the basis of soil of various rigidity which provides rigid structure is offered and represents a monolith which doesn't give in to shrinkage. It is an important factor for design of highways as the problem of shrinkage of the basis is actual today. For a thorough assessment of soil, we have to go deep into structure of a monolith, into its packing, and also consider boundaries steam channels.

In one of his books the American scientist James D. Watson not without humor and a fair share of sarcasm tells about, how he together with British Frensis G. Shout and Maurice X. F.Uilkinsom opened structure of a gene spiral. These three scientists received the Nobel Prize in 1962 for this discovery. If to trust Watson, he carried out the most part of time in search of entertainments and only sometimes for own pleasure reflected on how to construct gene model of small balls. The task consisted in that, knowing approximate number and sequence of an arrangement of atoms in DNA molecule, to construct its model of balls and cores. The sizes of balls in model corresponded to the extent of atoms in DNA molecule. Their work which has become nowadays classical, – a striking example of how, playing balls, it is possible to get the Nobel Prize.

In a chain of reasoning about the most dense spherical pickings somebody was come, probably, to mind by thought that such pickings are capable to arise not only by careful laying of atoms one to one, but also is casual. For the sake of experience it would be possible to take a box with spheres, to shake it properly and then to investigate packing structure. Such experiment also was carried out. However, thus, the densest packing of spheres with volume filling in 74% never turned out, usually density of packing made about 60%. It is obvious, that crystals get the structure not in a random way, and there is some regularity. Not by gift a paper bag with peas or grain it is always used only for 50 – 60% of the volume.

Fritz Laves investigated the Dutch crystallographer a question of what most friable (least dense) packing of atoms, in general possible in crystals. It after all has to be constructed so that some atoms nevertheless adjoined among them, differently there won't be able to be a firm body. Laves came to a lattice with volume filling to 5,5%. However in the nature, apparently, such crystals don't exist.

After scientists understood a structure of crystals, they undertook determination of their theoretical durability. It in principle is very simple. Between atoms the communication forces which size with a sufficient accuracy is established by physics of a firm body work. From such private forces, naturally very small, there are general total forces. Wish to break off someone a metal crystal and it should overcome these total forces of communication.

Whether it so means, what the theory of forces of communication in crystals is incorrect? Some generations of researchers reflected over this question. Calculations and experiments validated theories. However packing of crystals, alas, isn't so faultless, as in a case with our balls for Ping-Pong. And here too it is found out that though the nature is in general constructed symmetrically, in trifles it allows deviations.

All our crystals contain defects, or as tell crystallographers, dislocations. Theoretically these dislocations reduce the possible durability of crystals more than by 90%. Now we already learned to grow up quite or nearly the faultless crystals, which durability 10 times more values, than at earlier known materials. Unfortunately, such crystals are very insignificant. Once you grow up them larger, again there are defects. In equipment similar faultless high-strength crystals of metals or carbon call threadlike. There is no doubt that in the foreseeable future it will be possible to create methods of production of faultless materials of the big sizes.

Nevertheless we can state the following: time in real crystals symmetry "up to the last atom" isn't maintained, it is impossible to use the theoretical values of durability calculated for ideal crystals. As soon as the problem of creation of faultless materials commercially, our bridges, railway cars, cranes and will be solved [1].

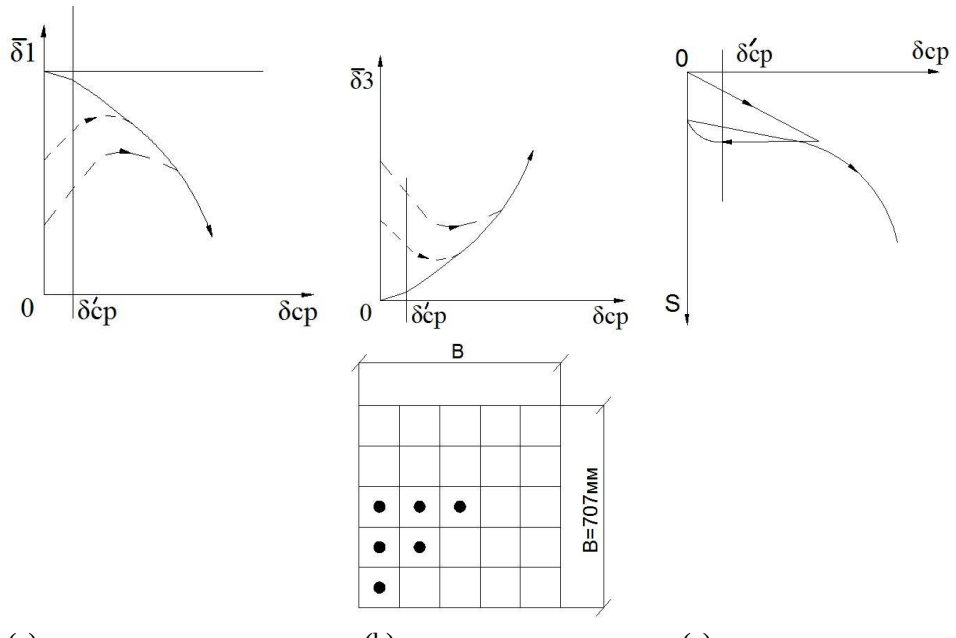
To reproduce static work of the model similar to work of a construction in nature in experiment, it is necessary that materials of models of separate parts of a construction and the basis had the same ratio of rigidity that willows to nature. Rigidity of rocky materials and concrete in calculations can be estimated in sizes of their modules of elasticity of E. Sledovatelno, it is necessary to apply materials to separate parts of model of a construction and its basis, the ratio of which modules of elasticity would be approximately same, as well as in nature. For example, if the module of elasticity of the rock appears twice less, than at concrete, in model of the basis it is necessary to use a material with the elasticity module twice smaller, than at a material of model of a construction. Existence in the basis of layers from materials with various mechanical characteristics is reproduced on model materials of various pliability.

Thickness of model of the basis on each site is appointed proportional to a ratio of modules of elasticity of materials of considered sites of model.

On model the part of the basis of a construction so-called "an active zone" outside which tension and deformations of the basis it is insignificant can be reproduced only are small [2].

On picture 1 (a, b) the continuous line showed trajectories of change of dimensionless ordinates in points 1 and 3. At cyclic loading unloading in a static mode of the loading, carried out within work of basis redistribution of contact tension with a tendency of smoothing of a form эпюры and its approach to more uniform is observed.

The ordinate of distribution diagram in each characteristic point has the main branch of change (the continuous line on rice 1, a, b), defined by behavior of basis at the first loading. At repeated loadings change of ordinate is characterized by a redistribution branch (a dotted line on fig. 1, a, b).



(a) (b) (c)

Fig. 1

Regularities of change intense the deformed condition of the basis at the first and repeated loadings testifies that as theoretical model of the incoherent soil environment it is necessary to accept model of an elastoplastic bodies with hardening. As justification the following features serve:

a) the schedule form a precipitation of the basis is characteristic for deformations of an elastoplastic body with hardening;

b) there is no unambiguous communication between the size of external loading, the contact tension and a basis precipitation to the same average pressure upon the basis σcp there can correspond an uncountable set of values a deposit. (fig. 1, c) and ordinates distribution diagram contact tension (fig. 1, a, b), depending on background of loading.

The solution of a problem of increase of durability the primer concrete of massifs and reliability of antifiltering veils at development of underground space, their stability at various aggressive influences, possibility of management of curing process in the conditions of low positive and negative temperatures, is reached by use of impregnating compositions on the basis of the fine mineral knitting. The analysis of the world market of construction materials showed that receiving fine mineral compositions by a way of air separation the ground mineral components can be previously the most effective solution of objectives.

Theoretically also possibility of increase of physic-mechanical properties of soil and defective underground parts by impregnation by the nanomodified suspensions on the basis of fine knitting with a size of grains from 0,2 to 6 microns is experimentally proved. The colloidal solutions which were formed thus as a result of hydration with a size of particles of 1 – 100 nanometers, have high level of superficial energy and serve as the crystallization centers as on a surface of steam space of an inject material, and in steam space promoting formation of the crystal joint consisting of hydrous silicate of various basicity, hydrous silicate of calcium, Sa (IT) 2, hydro aluminum sulfate and hydro sulfate calcium. Thus, the main volume of products of hydration is presented by gel structure in which dispersive phases are субмикрокри-сталлы calcium hydro silicates [3].

Wells of 1 (fig. 2) drill from two parties of a road bed 2. In the course of drilling the polymeric punched upsetting pipe 3 through which the polymeric structure forming with strengthened soil cylinders 4 is forced under pressure is inserted into a well. Couples of wells are drilled from one point to the right and to the left at an angle, for example 45°, to an axis at distance from each other, for example 4 m. The distance choice between wells is defined by need to provide uniform distribution of forced polymeric structure under all strengthened platform of a cloth. The spatial design consisting of two lattices is as a result created [4].

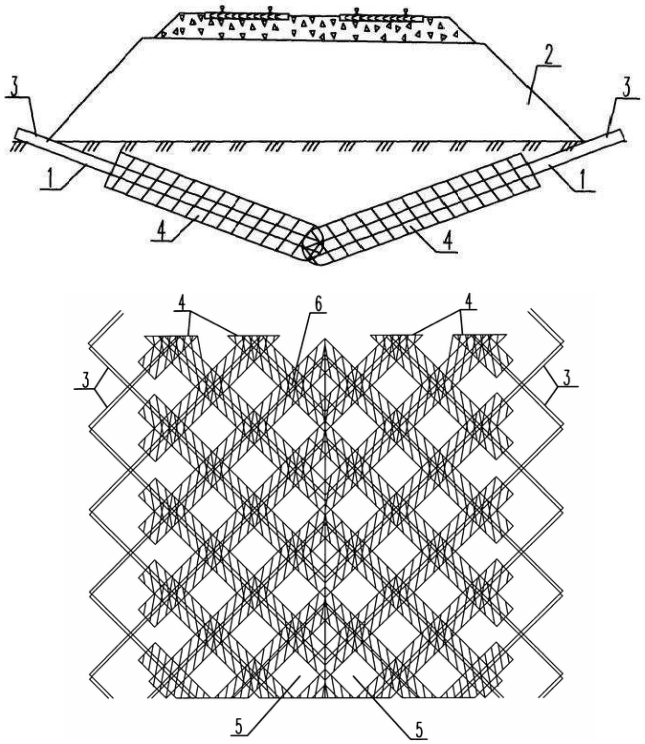


Fig. 2. Limiters of a mortar of soil:
1 – well; 2 – earthly linen, 3 – polymers the punched pipe; 4 – cylinders; 5 – grid; 6 – grid

On these researches we created the option of model which consists of packing of spheres through which time there passes a concrete mix and the monolith (fig. 3) is created.

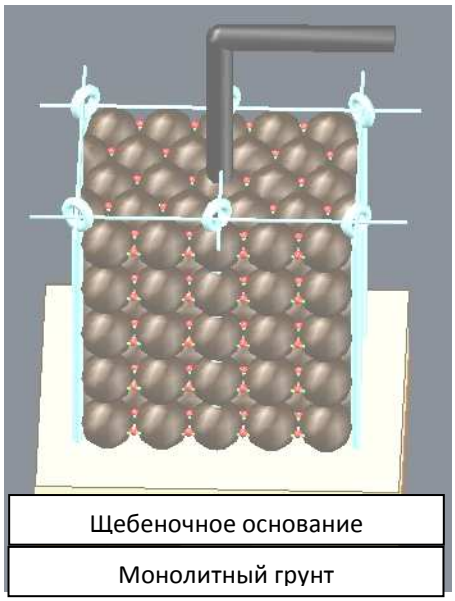


Fig. 3. Model of packing of spheres

We created the road which meets the requirements which we put before ourselves. Namely: to create soil of various rigidity, to create the monolithic basis and the main thing, the road which can be applied in design presently (fig. 4).

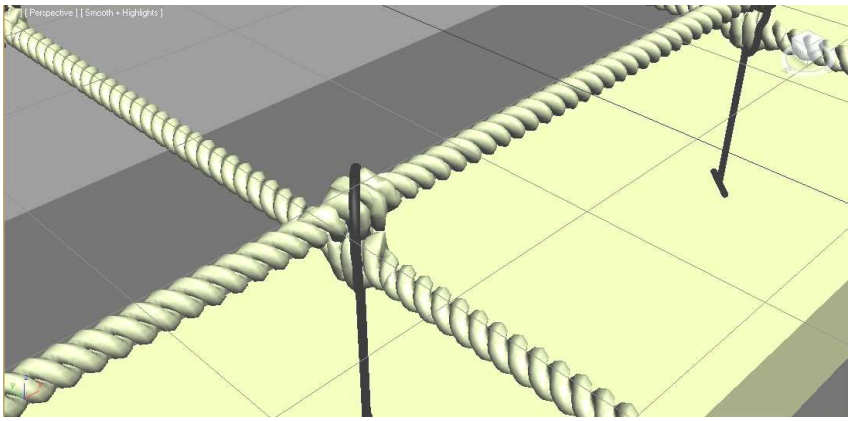


Fig. 4. Highway

Modeling of the bases of soil of various rigidity represents process of creation of the nonshrinking, strong highway which can come instead of existing roads. At the basis we have soil and rubble which provides rigidity of the basis and above we use a mix which represents set of various layers. In our opinion, such scheme of design of the highway is successful and it will be used in practice.

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UDC 72.03

THE HOLY EPIPHANY MONASTERY

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Polotsk, one of the oldest cities in Eastern Europe and Belarus, was first mentioned in the annals of 862. The Principality of Polotsk was one of the biggest Slavic states, which became a center for the development of crafts and culture and occupied an important geographical position on the route "from the Varangians to the Greeks". However, in spite of numerous historical shocks, Polotsk was and remains one of the main cultural cities of Belarus.

The Holy Epiphany Monastery is located in the center of Polotsk, on the right bank of the Western Dvina. It includes the Holy Epiphany Cathedral and a dwelling house [1].

In 1582 the king Stephen Bathory gave two areas for its building and exempted it from taxes. It was originally a wooden structure. The Holy Epiphany Monastery obeyed the Kiev Metropolitanate and the Patriarch of Constantinople. The Monastery was approved as an orthodox one by the diploma of Wladyslaw IV in 1633 [2 – 3].

In June 1683 the city was on fire. As a result, the monastery suffered too. After another fire in 1757, the Holy Epiphany Cathedral was built of stone from 1761 to 1779.

Today the Holy Epiphany Church is a building having a Greek cross in its plan, one apse and two single-stage towers on the west facade (fig. 1). The Church is completed by a high light drum with a spherical dome, topped with a faceted lantern. The facade towers are topped with the same elements in smaller size, besides the northern tower was a belfry. There is a choir gallery with a forged decorative fence in the western part of the church above the entrance. The walls, the towers and the facets of the lantern are cut with high semicircular window openings. The interior is lit by two ranges of windows. In the center four massive square pillars support the arches, the brattice and bear the spherical dome with a lantern.

Fig. 1. The Holy Epiphany Cathedral

After her visit to Polotsk in 1780, Catherine II allocated some funds to streamline the monastery. In 1782 the famous architect Giacomo Quarenghi designed the project, according to which it was planned to arrange the composition of a group of buildings along Nizhnepokrovskaya street. In the early 20th century there were 28 monks in the monastery. During the years of Soviet power there was a gym in the church. After its restoration in 1981, the Holy Epiphany Church was an art gallery for almost 10 years. In 1991, the church was handed over

to the Orthodox diocese and it is now the cathedral of the Diocese of Polotsk – Glubokoe. The Epiphany Monastery was founded in the 16th century and for many years it became a major center of Orthodoxy in Polotsk. The training and education, carried out there, were not only religious by its nature. Children of the orthodox gentry, clergy, artisans and merchants studied the Slavic, Greek and Latin languages, singing, rhetoric, arithmetic. There was a so-called school theater under the brethren's school. The Brotherhood didn't want to be inferior in anything to the Jesuit college and was trying to compete with it in the education and formation of Polotsk youth. In the second half of the XVII century Simeon of Polotsk worked as a teacher in the brethren's school under the monastery.

The monastery building is L-shaped (fig. 2). In its east wing there were the monks' cells, the Father Superior's room, in the angular part of the building there were two winter churches dedicated to St. Catherine and to St. Euphrosinya. The monastery complex is now monument of Baroque architecture with some elements of classicism. It is supposed that the project of the famous St. Petersburg architect Giacomo Quarenghi was used during its construction in the XVIIIth century.

Fig. 2. Monastery building

Today this former brethren's building is now housing the Polotsk museum of Belarusian printing and the Museum-Library of Simeon of Polotsk. The museum often hosts the readers' conferences and organizes meetings with Belarusian writers [4 – 5].

The Holy Epiphany Monastery has a tragic history: has experienced countless fires, rearrangements, attacks from the Jesuits and non-believers, was rebuilt. And no matter what, even now, in the 21st century, The Epiphany Monastery is not only a valuable historical monument, but also a spiritual center of Polotsk and of the whole country.

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UK 674.012.45.042

CALCULATING THE STRENTH OF THE LIFTING ASSEMBLY IN NON-FORMING MOULDING SLABS WITH MOUNTING TABS AT THE ENDS OF PRODUCT

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The calculations of the strength of the lifting assembly are made for non-forming moulding slabs with the installation of mounting tabs into the ends of the product. The data are obtained on the strength of the lifting unit, the required diameter of the hinge pin, the length of the anchoring loop.

Non-forming molding technology of hollow floor slabs does not provide for the installation of mounting hinges and fixings. This caused some difficulties when applying such types of slabs due to lack at many construction sites of special traverse equipped with carrying devices for lifting, transportation and assembly. There are various ways to install mounting tabs into such slabs. The peculiarity of these methods is that the mounting tabs are installed into freshly molded products while providing for upper slab plane collapse at loop installation sites.

Study of these problems led to the conclusion about the possibility to make mounting tabs with unilateral anchors and to place them in the slab voids at the ends of products [1, p. 69]. The developed solution to place mounting hinges at the ends of products has been patented. Lifting assembly design is a mounting loop embedded in monolithic concrete in the hollow channel at the slab end (Fig. 1).

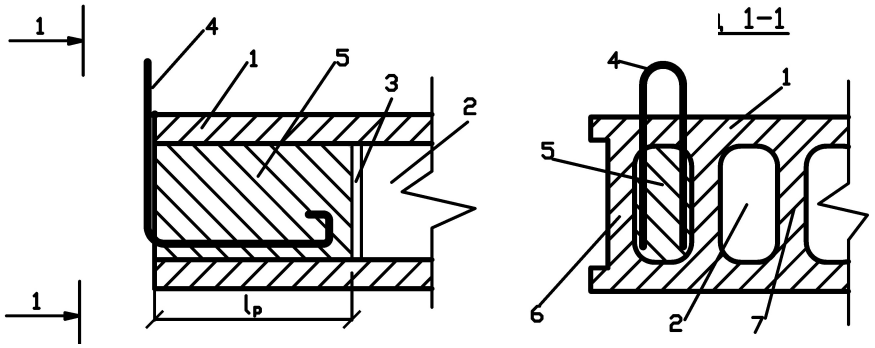

Fig. 1. Installation scheme of one-sided anchor loop:
1 – hollow slab; 2 – void (channel); 3 – partition; 4 – loop with unilateral anchors;
5 – reinforced concrete; 6 – extreme rib; 7 – middle rib

For the application of the developed version of slinging further slab field testing are required with such loops at the ends of products. Before proceeding to full-scale research it is necessary to calculate the strength of the lifting assembly which will include the selection of the diameter of the hinge pin, loop anchoring length calculation and determination of the carrying capacity of the lifting assembly.

Selection of the diameter of the hinge pin is performed by the method described in [2, p. 86]. According to this method, the weight when lifting the structure can be passed to three loops. Load on a single loop, taking into account the maximum allowable angle of sling set 90^0 ($1/\sin 45^0 = 1/0.707 = 1.4$) is equal to:

$$N = G \cdot 1.4 / 3 \tag{1}$$

Weight of a slab as long as 7.2 *m* (a slab of exactly this length is planned to be tested in the future) is equal to 2,640 *kg* (26.4 *kN*), and hence the load on one loop will be:

$$N = 26400 \cdot 1.4 / 3 = 123.2H$$

Given that the dynamic factor when lifting is 1.4 and that efforts are accepted by one branch of the loop, the section will be determined using the following equation:

$$A_s = 1.4 \cdot N / R_y \tag{2}$$
$$A_s = 1.4 \cdot 123.2 / 218 = 0.79 см^2$$

The selected diameter of the hinge pin is 12 *mm*, reinforcement class is S240 (= 1.131 cm^2).

Determination of the length of anchoring loop will be done on the basis of the methods of concrete fracture mechanics [3, p. 13], where, along with the concrete strength the aggregate size, thickness of the product and the distance to the edge or opening, as well as specific designs for strapping are taken into account [3, p. 119]. Seeding depth (anchoring) of a loop [3, p.120] to be lifted (*m*) is determined basing on possible panel destruction due to concrete puncturing:

$$l_{an} = \left[N_n \gamma_d / \left(1.25 \alpha h K_{Ic} \eta\right) \right]^2, \quad (3)$$

where γ_d – the dynamic factor equal to 1.5; α – lifting loop factor, α = 0.92; h – member panel thickness (0.22 *m*); K_{Ic} – the calculated value of the critical stress intensity factor equal to, determined from table 7.3 [3 p. 120]; η – the coefficient is equal to 1, taking into account the ratio of the distance between the detail and the edge of the product b to the depth of embedment parts l, determined from table 7.4 [3 c. 121], *Nn* – normative load on the item (weight is passed to three loops).

Thus regulatory load on the item will equal:

$$N_n = 26.4 / 3 = 8.8 \kappa H = 0,0088 MH$$

Bearing this load in mind, anchoring loop length will be:

$$l_{an} = ((0.0088 \cdot 1.5) / (1.25 \cdot 0.92 \cdot 0.22 \cdot 0.4 \cdot 1))^2 = 0.0169 ì$$

Loop termination length is accepted as 250 *mm*, since the length of anchorage must be at least 15*d*, and at least 250 *mm* [4, p. 54].

We define the carrying capacity of the lifting assembly. Mounting loads affecting the loop at the node from the slab in the absence of shear reinforcement (in non-forming moulding slabs only longitudinal pre-stressed reinforcement is provided) are accepted only by the concrete of tension intervoid ribs [5, p. 113]. For sealing of mounting tabs inside hollow channels we initially assume the same concrete as for C25/30 slabs. Sealing concrete function is as follows: to prevent mounting tabs from extension and slipping under the mounting loads [5, p. 114].

Determination of the strength of the load-carrying unit will be done basing on the same procedure used by Belevich V.N. in 2009 for the calculation of the load-carrying unit with spatial loops for slabs made on line «Weiler Italia» [5, p. 115]. Minimum load bearing capacity of the lifting unit can be determined by the strength of concrete of two closest to the loop intervoid ribs on the axial extension from the condition:

$$F = A_{c,eff} \cdot f_{ct} \ , \quad (4)$$

where *F* – load on the product lifting assembly; $A_{c,eff}$ – sectional area of concrete of slab intervoid ribs at mounting tab site; f_{ct} – concrete resistance to axial tension of 1.8 *MPa*.

Calculated effective area of the concrete of slab intervoid ribs is conditionally equal to:

$$A_{c,eff} = 2 b_r l_s \ , \quad (5)$$

where b_r – intervoid rib width, equal to 41 *mm*; l_s – the projected length of the mounting tab according to the calculations performed, equal to 250 *mm*.

Thus the minimum load capacity of the unit will be:

$$F = 2 \cdot 41 \cdot 250 \cdot 1.8 = 36.9 \kappa H$$

Given that the load from the slab is transferred to three loops and, respectively, three lifting units, the total carrying capacity of lifting devices when lifting a slab is equal to 110.7 *kN*. This strength is enough. For testing we use the following calculation results:

- assembly loop $\varnothing$ 12, S240 (A_s =1.131 cm^2);
- planting depth is 250 *mm*;
- loop sealing concrete is C25/30.

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INNOVATIVE MODERNIZATION IN HEATING AND AIR SUPPLY OF LOFT BUILDINGS WITH HINGED VENTILATED FACADE SYSTEMS CONDUCTING LIGHT

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Research refers to the technique of heating and ventilation and is proposed for use in the town- planning industry for energy- and resource- saving of heating and air supply to buildings with modern warm attics and ventilated transparent facade systems.

In all kinds of energy transformation at present because of the imperfection of the technological processes to final consumption is lost over 60% of the potential energy resources used. Energy-saving priorities is of particular significance for countries importers of fuel-energy resources, and the Republic of Belarus. At the State level in recent years adopted a series of measures to enhance the energy saving mode. Developed and approved the State program for energy development and energy conservation for the near term, the Cabinet of Ministers established the Committee on energy efficiency and energy oversight, a number of fundamental decisions aimed at strengthening the work in the national economy for energy efficiency.

The largest consumers of energy in the Republic of Belarus, with its temperate climate after industrial facilities are the engineering systems of buildings, where heat supply and ventilation spent about 35% of all kinds of solid, liquid and gaseous fuels, which is a heavy burden for the economy of the entire national economic complex of the country. On the basis of the above, the scientific and technical development in the field of energy saving are relevant and a priority.

In practice, urban planning widely use attics in buildings. Some functional and structural characteristics can be named: warm, ventilated and cold.

Warm attics are intermediate sectional extraction of 3-d cameras, which offer all of the exhaust channels organized system and exhaust ventilation located within one section of the building, followed by the removal of the warm exhaust air via a separate sectional shaft into the atmosphere.

In ventilated attics exhaust channels are also open in sectional volumes of attics, but instead separate sectional shaft to remove air in the atmosphere through the ventilation openings in the side opposite walls of the attic through cross-ventilation.

In buildings with cool verandas all exhaust pipes separate transit pass through volumes of attics and emit warm air through individual shaft directly into the atmosphere.

When garret buildings for a warm and ventilated attics under the influence of the bias, the pulsating wind pressure due to the difference of the aerodynamic pressures on the windward side and the facade is leeward formation of garret volumes, pressure increase, which is effect of reverse circulation or "rollover" ventilation, exhaust ventilation or completely off or converted into intake with air exchanges and regulated microclimate parameters of ventilated premises. In cold attics organized air exchanges is more resistant, but to all the garrets of buildings the main drawback is the warm exhaust air emission into the atmosphere without prior selection of the heat consumption for heating outdoor cold inlet air heating systems through infiltration.

Photoconductive ventilated facade systems with air gap not only provide excellent appearance of buildings for years to protect enclosures from external climatic influences of humidity and low temperatures, but also significantly increase their heat-shielding characteristics.

Energy efficiency, adaptability, durability, reliability and respectability of hinged ventilated translucent systems evaluated by the builders and operators of buildings of various purposes in all civilized countries of the world and, since the 90 's, are widely used in urban planning and reconstruction of old buildings [1].

Solar energy [2] in the form of direct and diffuse radiation influences the building, equipped with a hinged ventilated light noise facade systems in such a way that the capacity of conventional silicate glass façade almost completely passed through a the rays heat energy in the spectrum of visible light wavelengths, 380 – 750 nm and infrared optical zone of the solar spectrum with wavelength within the 750 – 2500 NM, all this warmth is perceived by external surfaces of enclosing constructions which when heated become secondary sources of thermal energy in the form of infrared radiation with wavelengths from 7.5 to 14 mm. For radiation with a wavelength range of ordinary glass becomes a screen, because its transmission is limited by the wavelength of about 5 mm.

So the radiant energy of the Sun under the influence of greenhouse effect convertible into heat, the accumulated air which is in the slot area, limited hinged ventilated of light-transparent the facade and the outer surfaces of the building envelope, causing it to heat up. When heated air rises, its temperature and decreases the density that promotes the movement of the forces of gravity from the bottom up, giving the effect of natural air circulation.

Outside air that fills the slot channel simultaneously accumulates not only heat from solar radiation coming through the front system from the outside, but warmth, lost transmission building through exterior fencing from the inner side of the slotted feed not only during daylight hours, and 24 hours a day throughout the heating season.

On the basis of the foregoing, it is appropriate to abolish the high quality energy efficiency fenestration hinged ventilated facade systems

Completed staircase-lift volume, usually placed inside buildings and occupy up to 20% of the heated space, is not binding, as in the heating period the tenants are in them in warm clothing.

By design completed staircase-lift volumes of high-rise buildings represent a huge shaft, vertical passing through the entire building, constantly opening through exterior entry doors from below into the atmosphere, and are also linked to the atmosphere through the machinery space elevators and reinforced ventilation pipes with a diameter of 500 mm with deflectors from remove debris systems. Such constructive solutions to buildings violate aerodynamic and powerful rising air stream that arises under the influence of the force of gravity, not only blows, but also disrupts the operation of ventilation systems, causing it to "rollover".

Under the current regulatory framework in the residential buildings to remove exhaust air is organized through volumes of kitchens L_{ud} = 90 m^3/h of toilets and bathrooms L_{ud} = 25 m^3/h and for combined toilets in L_{ud} = 50 m^3/h.

The driving force of airflow in ventilation vertical exhaust pipe (mine) is the gravitational pressure, whose value is estimated (by) of the expression:

$$P_{gr} = hg\left(\rho_n - \rho_v\right), \quad (1)$$

where h – is the excess of the mouth of the canal above the middle exhaust grilles, m;

g – is gravitational acceleration, m/s^2;

ρ_v – density of air inside the ventilated premises, kg/m^3;

ρ_n – density of air inside the ventilated premises, kg/m^3.

Braking force of the air flow in the channel (mine) is the aerodynamic resistance, which includes friction pressure loss of length and local resistance and is determined by the formula:

$$S = \sum\left(R \cdot l \cdot \beta + Z\right), \quad (2)$$

where $R = \frac{\lambda}{d} \cdot \frac{\rho v^2}{2}$ – is the resistance to movement of the air flow inside the channel (mines) from the friction of the surface roughness of the walls, Pa/m$

l – length conductive air channel (duct, mines), m;

β – wall pipe roughness coefficient (mines, air);

λ – drag coefficient of friction;

d – channel diameter, m;

v – velocity of air movement in the channel, m/s;

ρ – air density in kg/m.

The resistance coefficient of friction is determined by the formula:

$$\lambda = 0{,}11 \cdot \left(\frac{K_э}{d} + \frac{68}{\mathrm{Re}} \right)^{0{,}25}, \quad (3)$$

where $K_э$ – is the absolute equivalent roughness of the surface of the pipe (duct), m;

d – duct diameter, mm;

v – velocity of air flow in the duct, m/s;

$\mathrm{Re} = \frac{\upsilon \cdot d}{v}$ – Reynolds number;

υ – is the kinematic viscosity of air (temperature dependent, for ventilation when t_V = 20°C, $\upsilon = 12{,}59 \cdot 10^{-6}$ m^2/s).

As the basic prerequisite for sustainable operation of natural ventilation is significant excess (more than 10%) magnitude of the gravitational pressure of the P_{gr} over the forces of air motion resistance S in real variables operating systems, this condition is almost not doable, especially for the upper floors of high-rise buildings in the approximation of external and internal temperatures, as in the formula (1) value of h is minimized, and the value $(\rho_n - \rho_v)$ generally tends to zero. In these real world conditions of natural ventilation does not work with all of the negative effects of the gas, water, reduce heat-shielding properties of exterior fencing, mould, rotting wooden structures, destruction of finishing materials and the like.

Thus, the regime organized the aerodynamic ventilation of residential buildings excludes the unorganized flow of external air in ventilated premises through infiltration and the creation of a compulsory regulatory air exchange on sanitary-hygienic requirements.

Based on the above, the main conclusion is that the design and construction of residential buildings with external enclosures with increased thermal insulation and tightness, that in the conditions of contemporary urban development is required, preferably use organized filing outdoor ventilation air inlet, structurally and methodically set out in papers [1-22] using the latest effective energy technology, waste energy recovery, recovery of assimilating low heat emissions and natural sources of solar radiation and wind energy.

In order to reduce material and energy spent on housing and garret heat and power supply public buildings using ventilated translucent systems requires a functional modernization of warm attics with converting them from intermediate bulk section exhaust vent chambers for removing the warm exhaust air to the atmosphere through the sectional extraction mine ventilation air volume camera technology to capture previously heated in slot conductive air channels formed by hinged ventilated conducting light facade systems and external vertical structures, protecting outdoor ventilation air inlet and then serving it via "tube inside the ventilated premises.

Energy efficiency technological scheme heating and air supply loft buildings with external enclosures with increased thermal insulation and tightness, hinged ventilated conducting light systems and upgraded warm verandas is presented on Fig. 1, which shows a fragment of the attic of the building with a regenerative device influx-and-extract ventilation, proposed for implementation in urban planning practice.

Regenerative device and exhaust ventilation of the building includes a vertical air guide channel 1, formed translucent hinged facade 2 and the outer surface of the external load-bearing design 3 and bottom slotted hole 4 the whole width of the facade 2 for fresh intake of external air, and at the top of the opened in the warm attic 5. In the warm attic 5 is a central plate heat exchange 6 with four ports:

- inlet first opened in volume 7 of the warm attic 5;
- another nozzle 8 is connected with vertical suction air duct chassis 9, to which are attached the floor flat horizontal ventilation ducting 10 with adjustable grates for airflow 11;
- the third tube 12 connected with vertical exhaust air duct chassis13, to which are attached the floor flat horizontal exhaust ducting 14 with adjustable grates 15 to remove air from the ventilation of the premises;
- the fourth tube 16 compounds from shafted 17 which was reported to the atmosphere from above through roof fan 18 or 19 the air valve.

Works regenerating device and exhaust ventilation as follows.

Fresh outdoor air under the influence of the natural gravitational pressure or by forced circulation comes out from the bottom through the slotted hole in the air Guide 4 channel 1, which is a preview of his heated through a hinged ventilated facade light transparent 2 through direct and diffuse solar radiation during the day and through the outer surfaces of enclosing constructions 3 constantly day and night during the heating period, foregone the transmission of heat. Outdoor air in the air Guide Channel 1 enters from the bottom through the

slotted hole 4, and the top opens in warm attic volume 5, which also sees the lost building transmission warmth through the ceiling of the top floor, as well as direct and scattered solar radiation through a topcoat of warm attic 5. In the warm attic 5 pre heated inlet ventilation air inlet 7 passes through the Central plate 6 heat exchanger, which selects the heat of the exhaust air vent, and enters through pipe 8 in vertical supply air duct 9 continue on experiencing horizontal venting the air ducts through 10 through the adjustable grilles for air flow 11 comes in ventilated premises from which the warm exhaust air is removed through adjustable grille 15 floor apartment horizontal exhaust ductwork 14 vertical exhaust duct hose 12, 13 operation 6, 16, 17 shaft tube, fan 18 or 19 the air valve to the atmosphere.

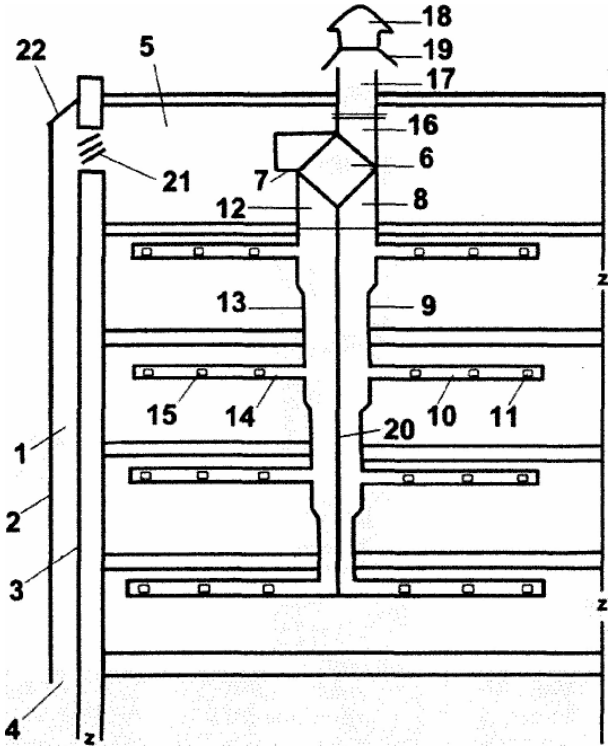

Fig. 1. Regenerative device and exhaust ventilation building

Vertical supply air duct and exhaust air duct vertical 9, 13 to have a common wall, 20, is transit heat exchange between suction and exhaust airincreasing effect of recovery and increasing the thermal efficiency of the entire system of heat and air supply buildings increased thermal insulation and tightness.

To ensure effective summer operating mode in order to avoid overheating the building under the influence of solar radiation at the top of the pipe conducting air, 1 provided 21 adjusting device which closes, and the air valve opens the 22 that creates air cooling mode of irradiated by the Sun outdoor enclosures with hinged ventilated facade systems to skip.

Analyzing and summarizing the results of the executed two State scientific and technical programs GTIN 1.5.159 "to develop and implement energy saving materials and technologies in the construction and operation of buildings and structures and the GTIN 4.02.08". "To create and introduce new materials, technologies and design system for resource savings, homes, reducing resource and energy consumption during the construction and operation of housing", and based on many years of theoretical, experimental and patent research, multi-year survey of the existing housing stock with the best world experience and achievements of science and technology in the area of housing are justified the proposed innovations.

In order to create a favourable and comfortable microclimate of dwellings with a minimum of material and energy, achieving a significant reduction in the consumption of thermal energy in the urban sector of the economy requires the following changes to buildings with external enclosures with increased thermal insulation and tightness, used for mass housing development model.

1. Completed staircase-lift in a spatial volume of the building is necessary to make inside the building and position adjacent to the Northern face milling in facade without heating as tenants in the heating period are in warm clothes and use it as a platform.

2. A warm attic functionally modernized with the transformation of its volumetric of the exhaust chamber to remove warm air into the atmosphere in large intake sectional camera to gather pre heated outdoor fresh air blower and then heated in recuperate with heat of exhaust air.

3. Use the external decoration of the building ventilated curtain facade system, which not only improve the aesthetic appearance of buildings, but for years to minimize the heat power for spending when their exploitation at the expense of the greenhouse effect.

4. In order to significantly reduce energy consumption, heat buildings recommend for wide introduction in practice of authentic urban development of regenerative devices supply and exhaust ventilation under the patent of the Republic of Belarus using the latest energy-efficient and resource-efficient technologies, a three-stage scheme of waste energy recovery, recovery of assimilating low heat emissions and using the natural heat of solar energy.

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UDK 69.04

METHOD OF CALCULATING SPACE OF MULTISUPPORTS CONSTRUCTION

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This paper presents a) the method of calculation of the spatial multisupport construction.

Two-moment bending torsion theory together with the methods of construction mechanics makes it relatively simple to calculate the spatial systems such as a thin-walled one, having in a span an arbitrarily given points intermediate supports. Such systems include, in particular, the design of beam bridges with diagonal supports (Fig. 1), the design covers like ribbed vaults shells with respect to the longitudinal edges of the support rod (Fig. 2). For simplicity sake we shall assume that the system in cross section has a vertical axis of symmetry.

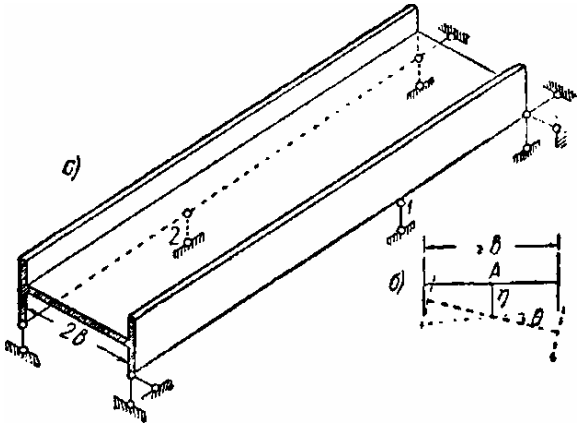

Fig. 1. Design with diagonal supports

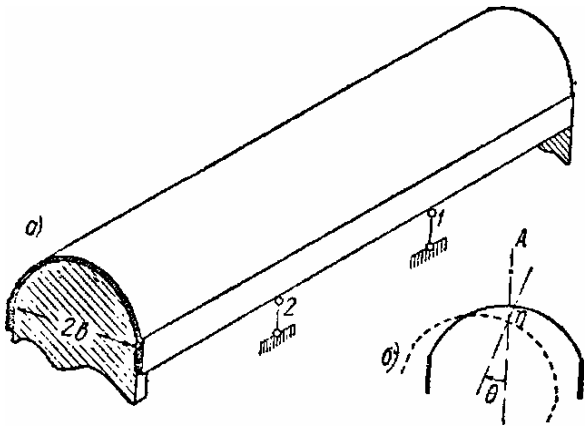

Fig. 2. Strain model

Suppose that such a system is under the influence of the vertical load, for which the resultant transverse strips of unit width in the plane of symmetry of the profile. An example of such a load is the weight of its own design. This load in the absence of asymmetric support connections according to the above theory, cause a bending deformation only. A torsional deformation is absent, since the load will pass through the center line of bending, also lying in the longitudinal plane of symmetry. In the presence of links arranged at a certain distance from the axis of symmetry of the profile design, along with the bend and will experience torsional deformation caused by reactions of reference relationships. To determine these reactions, we can use the methods of structural mechanics, extending and generalizing these methods to be

considered here walled spatial system. We will proceed from the force method. We choose as primary thin-walled single-span structure, obtained from the set by dropping the intermediate support connections. Strain state of the system at any complex loading can be determined by applying the elementary conditions of bending and torsion of the bending. Since in our example the external load and the supporting communications vertical, the states of elementary basic system we are interested in the status of the two species, namely, pure bending and bending-torsion (Fig. 1, b, 2, b).

Action reaction of any of the support rod, not passing through the center of curvature, can be reduced to the busy main system concentrated vertical load in the plane of symmetry and causing pure bending deformation, and concentrated torque that causes the bending deformation of the torsion. Vertical deflection γ1 = γ1 (z, t) of the rod in any section z = const of a concentrated vertical load P acting along the axis of symmetry in any other section t = const with hinged support rod ends determined by the formulas:

values for $l \geq z \geq t$

$$\eta(z,t) = \frac{P(l-z)t}{6EI_x l}\left[l^2 - (l-z)^2 - t^2\right]; \tag{1.1}$$

for values of $t > z \geq 0$

$$\eta(z,t) = \frac{P(l-t)z}{6EI_x l}\left[l^2 - (l-t)^2 - z^2\right]. \tag{1.2}$$

Equations (1.1) and (1.2) can be prepared either by the method of initial parameters for the differential equation in Equation beam bending system, or by applying the general Mors formula for the displacement.

$$\eta(z,t) = \int_0^l \frac{M_z(s)M_t(s)}{EI}ds, \tag{1.3}$$

where M(s) and Mt(s) – the bending moments from the individual forces applied at two different points with the beam axis and z abscissae t. Formula (1.1) and (1.2) are a function of influence (Green's function) for the problem of bending of the single beam with hinge supports at the ends. Torsion angle in arising in any section z = const of torque concentrated H = D acting in the plane of any other section *t* = const, is determined by the formulas:

values for $l \geq z \geq t$

$$\theta(z,t) = \frac{H}{GI_d}\left[\frac{t}{l}(l-z) - \frac{l}{k}\cdot\frac{sh\ \frac{k}{l}t}{sh\ k}\cdot sh\ \frac{k}{l}(l-z)\right]; \tag{1.4}$$

for values of $t > z \geq$ about

$$\theta(z,t) = \frac{H}{GI_d}\left[\frac{l-t}{l}z - \frac{l}{k}\cdot\frac{sh\ \frac{k}{l}(l-t)}{sh\ k}\cdot sh\ \frac{k}{l}z\right]. \tag{1.5}$$

These formulas presented the influence function (Green's function) for the problem of single-span flexural torsional thin-walled beams, having the ends of the hinge bearing also.

Formula (1.4) goes into the formula (1.5) by replacing *z-t*, which is in accordance with the symmetry of Green's function, and the reciprocity theorem Betty movements: in (*t*, *z*).

In the case of ribbed vaults shells used in the construction business, as well as in the case of cylindrical and prismatic shells open profile, widely used in aviation and shipbuilding, stiffness GJd Sen-Venan's torsion factor is secondary importance foam values. Assuming that the stiffness and hence the magnitude of k, equal to zero, we can simplify the formula (1.4) and (1.5). To do this, expand the hyperbolic functions included in the formula (1.4) and (1.5) in a row, two terms expansion for each function, and take the limit.

We simplify, for example, formula (1.4):

$$\lim_{k\to 0}(z,t)=\lim_{k\to 0}\frac{H}{GI_d}\cdot\left(\frac{t}{l}(l-z)-\frac{l}{k}\cdot\frac{\frac{k}{l}t\left(1+\frac{k^2}{6l^2}t^2\right)\frac{k}{l}(l-z)\left(1+\frac{k^2}{6l^2}(l-z)^2\right)}{k\left(1+\frac{k^2}{6}\right)}\right)=\lim_{k\to 0}\frac{H}{GI_d}\frac{t(l-z)}{l}\times$$

$$\times\left(1-\left(1+\frac{k^2}{6l^2}t^2\right)\left[1+\frac{k^2}{6l^2}(l-z)^2\right]\left(1+\frac{k^2}{6}\right)\right)=\lim_{k\to 0}\frac{Hk^3}{6GI_d}\frac{t(l-z)}{l^3}\left[l^2-(l-z)^2-t^2\right]= \quad (1.6)$$

$$=\frac{H}{6GI_\omega}\frac{t(l-z)}{l^3}\left[l^2-(l-z)^2-t^2\right]$$

Formula (1.6) is valid for values of $l \geq z \geq t$. For values of $t > z \geq 0$ from (1.5) we obtain

$$\theta(z,t)=\frac{H}{6EI_\omega}\frac{z(l-t)}{l}\left[l^2-(l-t)^2-z^2\right]. \quad (1.7)$$

Formulas (1.6) and (1.7) have a similar structure to the formulas (1.1) and (1.2) and differ from them in quantities related to the displacements, the load and to the generalized geometric characterization. The identity of these formulas is also a consequence of us made up the general provisions relating to the mathematical analogy in the theory of rods in bending and torsional flexural.

We now give a formula for the deflection of the main system outward transverse uniformly distributed load q, acting in the plane of symmetry:

$$\delta_{ij}=\eta_{ij}+b\theta_{ij} \qquad (i,\ j=1,\ 2,\ 3,\ldots,\ n),$$

$$\delta_{iq}=\eta_{liq} \qquad (i=1,\ 2,\ 3,\ldots,\ n),$$

$$\eta(z)=\frac{qz}{24EI_x}\left[l^3-2lz^2+z^3\right]. \quad (1.8)$$

Knowing the strain our basic system considered here its elementary states; we can now easily obtain the equations for the unknown force method reactions vertical piers. These equations when the number n of intermediate supports is of the form:

$$\left.\begin{aligned}&\delta_{11}X_1+\delta_{12}X_2+\ldots+\delta_{1n}X_n+\delta_{1p}=0,\\&\delta_{21}X_1+\delta_{22}X_2+\ldots+\delta_{2n}X_n+\delta_{2p}=0,\\&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\&\delta_{n1}X_1+\delta_{n2}X_2+\ldots+\delta_{nn}X_n+\delta_{np}=0.\end{aligned}\right\} \quad (1.9)$$

Here, the desired reactions, {*i* = l, 2, 3, ..., n) with positive considered positive if they comply with the stretchable support links.

Coefficients and the free terms of the equations (1.9) are calculated by the general formulas: where *i* and *j* – the serial numbers of equations and unknowns; – Deflection of the *i*-th section of the support unit concentrated force corresponding to the desired reaction *j*-th support; – Torsion angle in the *i*-th section of support from the local, single torque *Hj = b*, acting in a plane passing through the *j*-th support.

The *b* value represents the half width of the structure (torque shoulder). In accordance with the rule of signs, this value will be positive for poles located on Fig. 1 and 2 to the right of the axis of symmetry and to the negative poles to the left of the axis.

Free term b, *i*-th equation is calculated by the formula (1.8) as deflection for a given load in the section passing through the *i*-th prop. Determined from the equation (1.9) support reactions, we can then use the above formulas for elementary states the basic system by the method of superposition to get deflections *m* angles of twist given spatial multisupporting system. Normal and tangential stresses in the cross-sections of the system, in the case considered here should be calculated on the binomial formula:

$$\sigma(z,s)=-E\left[\eta''(z)y(s)+\theta''(z)\omega(s)\right]$$

$$\tau(z,s)=E\left[\eta'''(z)\frac{S_x(s)}{\delta(s)}+\theta'''(z)\frac{S_\omega(s)}{\delta(s)}\right].$$

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UDC 624.159.4.111

STRENGTHENING OF FOUNDATION BY BUILDING-UP WITH RIGID REINFORCING

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This article treats methods of strengthening of strip foundations by increasing the base of foundation. Structural concepts providing joint work of elements of existing foundations and concrete building-up are analyzed. It's shown that reinforcement of gripper-arm interface by rolled profiles allows more stringent and more reliable interfacing of new and old elements of foundation. Construction diagrams of installation of metal-rolling profiles in reinforced foundation are shown. Technology of strengthening of foundation by building-up with the use of rigid rebars is described.

When reconstruction of buildings and constructions takes place there is often necessity to strengthen the foundations. Mostly this problem should be solved when superstructure of additional floors, increasing the span between the supporting structures, changing of scheme of support of overlapping elements etc. Strengthening of the foundations is also made during the stabilization of ground foundation deformations of a building that is in an emergency condition.

As it is shown by building practice, works of foundations strengthening are labor-consuming and quite expensive. Cost of foundations strengthening works can compose more than half of cost of all works during buildings reconstruction. In many instances, reconstruction, connected to strengthening of the foundation, becomes economically impractical.

Working-out of new structural concepts of the foundation strengthening that satisfy requirements of manufacturability, security, minimal consumption of materials and labor intensity will allow to reduce considerably the cost of such works and to make projects of reconstruction of buildings more attractive for investors.

The most widespread method of strengthening of strip foundations is increasing the base of foundation by building-up the reinforced concrete mantle both from one side, and from the other side of reinforced foundation. At present, there are some methods of broadening the strip foundation base by building-up protrusions: with the use of anchors (fig.1,a); with the installation of reinforced construction under the base of existing foundation (fig. 1, *b*); with the use of perforating anchors (fig. 1, *c*); with a simultaneous injection of foundation (fig. 1, *d*).

Joint work of reinforcement elements with existing foundation in abovementioned methods is provided by:

- arrangement of concrete dowels, projections in recesses of existing foundation or supporting structures of building;
- arrangement of anchors embedded into body of existing foundation;
- arrangement of perforating armature;
- welding of armature of elements of broadening with bared fittings of reinforced foundation;
- with the use of special support elements: struts, unloading metal or reinforced concrete beams.

In this work the method of strengthening of strip foundations by building-up with use of rigid reinforcement. As rigid armature can be used rolled profiles in the form of channel sections, T-beams or I-beams, installed into drilled by diamond crowns holes. Scheme of strengthening is shown on fig. 2

In proposed method, metal-rolling profile will allow creation of rigid connection between existing foundation and construction of reinforcement that cannot be provided fully with the use of anchors. Besides, there is no need in installation of longitudinal dowels or metal beams over the entire length of reinforced foundation, thus, the step of installation of rigid reinforcing element is determined by the condition of providing the strength of concrete extrusion of the existing foundation.

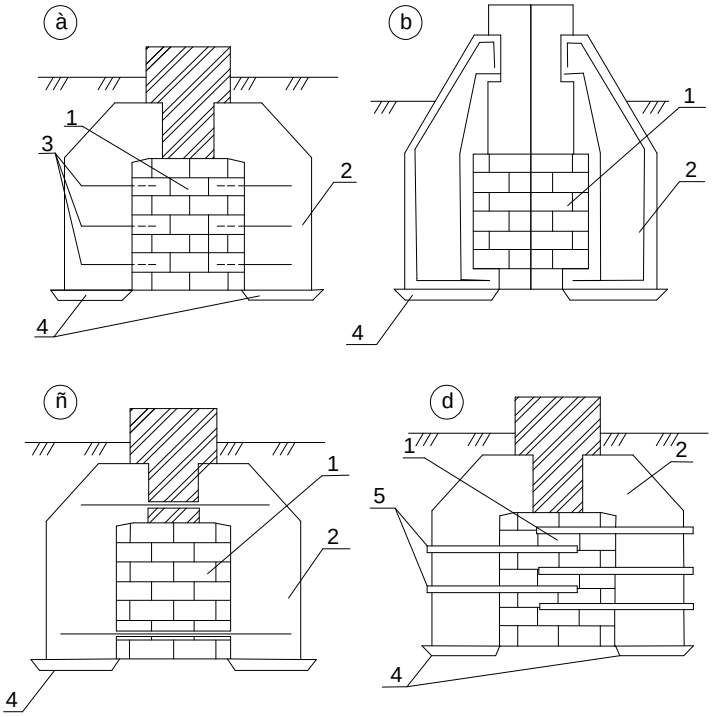

Fig. 1. Broadening the base of strip foundation by building-up the protrusions:
a – with the use of anchors; *b* – with the installation of reinforced construction under the base of existing foundation; *c* – with the use of perforating anchors; *d* – with a simultaneous injection of foundation;
1 – existing foundation; 2 – building-up the protrusions; 3 – anchors; 4 – preparation; 5 – injection tubes

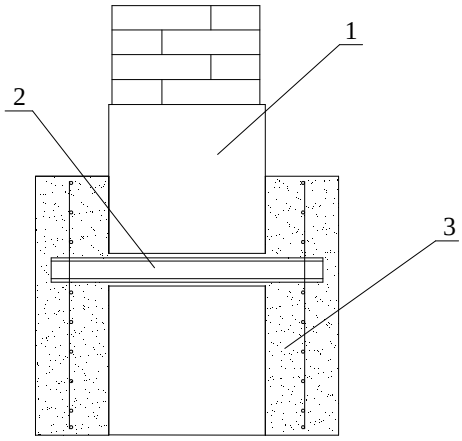

Fig. 2. Structural scheme of installation of metal-rolling profiles in reinforced foundation:
1 – reinforced foundation; 2 – transverse metal beams installed into holes punched in a wall of foundation;
3 – tides of concrete; 4 – concrete preparation

The method in question is less labour-consuming and safer in comparison with currently used methods of strengthening of strip foundations because there is no need to weaken the foundation during the installation of reinforced construction under the base of existing foundation.

Structural scheme of installation of metal-rolling profiles into reinforced foundation should correspond to equal load transfer from overlying constructions to the foundation. It can be reached upon the condition of installation of closely-spaced rigid armature but it's impossible to affect the integrity of reinforced foundation because it can cause the loss of supporting capacity of the foundation as well as deformation of overlying supporting structures.

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UDC 711. 346

REVALORIZATION OF INDUSTRY TERRITORIES OF SUBURB RURAL SETTLEMENTS AS A COURSE OF IMPROVEMENT OF ENVIRONMENT OF HUMAN VITAL FUNCTION

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Modern condition of productive territories of suburb rural settlements was observed, stages were defined, preconditions and courses of renovation, trick of transformation of productive territory and re-profiling it into living was mentioned on a real example.

The influence of economic crisis is sharply marked on productive territories both metropolises and suburban territories which are zones of common interests of territorial communities of city and village. The best part of subjects of business drop in production, consequently productive territories went into liquidation completely or partly. It concerns the most part of rural settlements – the emplacements of former departments of farm business, so-called "brigade villages". These processes gain the intricate character both negative and positive. It is known from the analysis of project documentation and in-place tests of development of suburb rural settlements (SRS) that buffer breaks between residential areas and productive objects not always conform to the normative, but often absent at all. Lockup of such manufacture certainly is a positive occurrence for improvement of living environment not only rural population but urban population too. The problem of using white lands and their rational functional organization appears.

Studies by Biryuk S., Gabrel M., Donenko V., Zinchenko A., Korol Y., Mazur T., Silogayeva V., Semenova V., Shtompel N., Scherbyna L., Shtoda O. [1 – 5, 7] and other authors are dedicated to the problems of renovation of productive territories. The most part of these studies purpose researching the problems of industrial zones of cities, searching the ways of revalorization of industrial giants' territories of important industrial centers, cities and megapolises etc. Some approaches to the problems of reconstruction of productive territories principally farming of central village [6, 7] and reorganization of social infrastructure of village were outlined in the last researching conducted on the rural territories (Stepanyuk A., Ogonyok V.).

The purpose of the article is the analysis of modern state of productive territories of suburb rural settlements, finding of territories that can be subject of revalorization, foundation of renovation's courses.

The transition to postindustrial period which characterizes with stopping of extensive development of the factory-farm complex, polyfunctionalization of town-building space, alteration of socioeconomic orienting points of society, transition to the type of economy with predominance of service and high technology industry, with searching of directions of rising of efficiency using of existent industrial projects or redevelopment of those plants which went into liquidation [1] are taking place on the modern development stage. Functional transformation of productive territories comes through some stages in its development.

Owners of existent productive objects which greatly cut or completely went out of their business are giving in a lease to other subjects of entrepreneurial activity isolated playgrounds, buildings, building elements inside of which different of outset activity is implementing, on the starting. Owners of such objects have an intention to vest interest to use realty and siting with the aim of optimization of activity with the development of production. Partial transformation happens on the level of inner transition of building and facilities as the result of redemption of leased objects. Existence of few objects of production results to individualization all of them into detached object and accordingly disintegration of continuous territory on isolated areas. The functional transformation of productive object (fig. 1) happens as the result of such processes.

Renovation of these objects occur expedient in the case if productive objects were disposed with big normative sanitary break (from 300 metres: hog farms, fowl-farm, calf house, market-milk diary etc.), and direct in the residential area of settlement. The word "renovation" is understandable in the meaning of updating, adaptive using of building, facilities, and complexes under change of functional destination. Wasteland and nonfunctional productive territories help to save farming land at that and the process of transformation get features of self-organization, i.e. outlet from the orderless system (chaos) to the order.

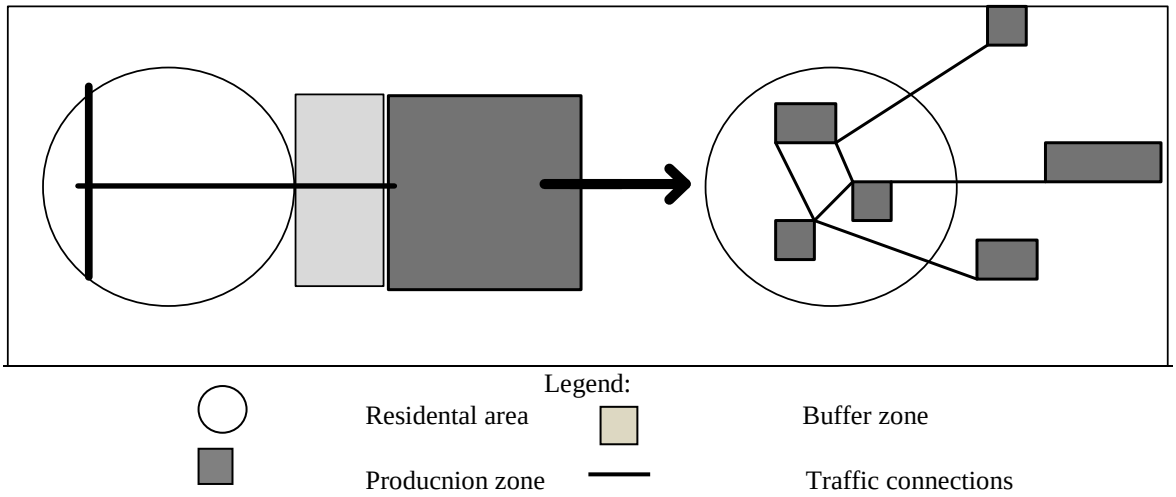

Fig. 1. Sort of fragmentation of productive zone on range of small firms and farms

Thereby such transformation is a promising course of improvement living environment. It defined such courses of renovation [2]:

- Change of function on living (social housing, loft apartments);
- Educational course (preschools and schools);
- Cultural diversions (cultural centers, concert halls, museums);
- Public-service industry;
- Sporting sanative course;
- Planting course;
- Administrative arrangements;
- Supporting centers which will keep for the account of funds, charitable foundations (for the vagabonds, homeless children, juvenile mothers, aged, former prisoners etc.).

It is found examples such transformation (villages Bayrak, Kalashnyky, Kovalivka, Machukhy etc.) with in-place tests of suburb rural settlements of neighbour surrounding Poltava city when factory farm divided on some farms. So livestock farm in the village Machukhy being situated in the center of the village with normative buffer zone 300m went into liquidation. The farm was far from the residential area only with a street that certainly is not enough. We have an example of environment's improvement with enhancement of ecological situation in this case. But it is permeated among the village negative attitude to the liquidation this farm. On the one hand – loss of jobs, on the other hand – evicted farm have sufficient unpleasant form over a distance of 20 years and tumble into ruins. Organization of enterprise of IV – V category which doesn't claim of great buffer break in these agricultural production buildings happens rational. Village Machukhy is situated at the distance of 12 km from Poltava city, trunk traffic with metropolis not worse than with its uptowns. Invention of such enterprise would have positive meaning both for city and for village: providing of people with job-placement, transit of production from the city with drawing it in close vicinity to residential of free labor resources (in the village Machukhy great reserve of free labor – 309 persons of unemployed people, and 1162 persons working in metropolis and make daily migratory relocations). There are many such rural settlements in the first belt (to 20 km) of Poltava city, for example Rossoshentsi, Abazivka, Shcherbani, Tahtaulove, Petrivka, they are a zone of common interests of metropolis's habitant and suburb rural settlements in a clear understanding. Released productive grounds of rural settlements are quite often being restructured into living territories. The example of such solution is in the village Verkholy – transformation of former productive territory of livestock farm and restructuring its into living.

This transformation passed in some stages:

- Producing department (cattle farm 300 head) went into liquidation;
- Housing district was constructed beyond of buffer zone in the northern part of village (building land for home building was allotted), agricultural production building which doesn't function, dismount;
- Block of integrated housing with civic center was planned on the white land;
- Another new block with building area 20 ha was planned on land reserve between two residential communities. Shopping and entertainment center next to thoroughfare and entrance to the settlement provided on the same territory. So

forming of plan structure of village continues and simultaneously optimization of social amenities of suburban zone's habitants and metropolis's habitants continues.

It is defined preconditions of expedience of outfit's renovation in the rural settlements:

– Existence of great free labor;
– Positive demographic situation;
– Distance to the metropolis less than 20 km.

The potential of productive territories is so great that expedience their renovation has not only architectural but also economic and social implications. Renovation of productive territories of residential areas will improve on ecological environment and standards of population's living due to creation of new jobs. Improvement of environment occurs herein both in city and in village: providing the jobs for unemployment people and removing of production from the metropolis which claims great territories and dislocate integrity of development.

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UDK 69.04

STABILITY OF PLATES SUPPORTED BY STIFFENER

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Critical loads for plates depend on the cylindrical stiffness *D*. Stability can be increased by making the plate thicker. This solution is not economical. The best solution is to increase the rigidity of the introduction of stiffeners. As an example, consider a plate with freely supported edges, compressed by forces applied at the edges *x=0* and *x=a*. Plate supported by a single stiffener (Fig. 1). Let's take the form of deformation during the loss of stability as:

$$W = A \cdot \sin m\frac{\pi}{a}x \cdot \sin n\frac{\pi}{b}y \tag{1}$$

Changing the potential energy of deformation δV will consist of the potential energy of the plate:

$$\delta V = \frac{1}{8}DA^2\pi^4 ab\left(\frac{m^2}{a^2}+\frac{n^2}{b^2}\right) \tag{2}$$

and potential energy of deformation stiffener which bulges together with plate:

$$\delta V_2 = \frac{1}{2}B\int_0^a \left(\frac{\partial^2 W}{\partial x^2}\right)^2_{y=\frac{b}{2}} dx \tag{3}$$

B – flexural rigidity.

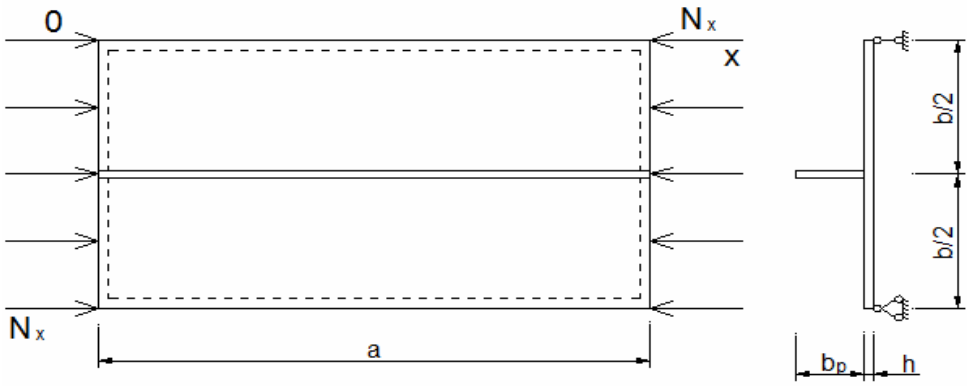

Fig. 1 Scheme

ValueδA will consist of work forces N_x, which compress the plate:

$$\delta A = \frac{1}{8} N_x A^2 \pi^2 m^2 \frac{b}{a} \tag{4}$$

and work force P, compressive stiffener:

$$\delta A_2 = \frac{1}{2} P \int_0^a \left(\frac{\partial W}{\partial x}\right)^2_{y=\frac{b}{2}} dx \tag{5}$$

We calculate the integrals in (3) and (5):

$$\left(\frac{\partial W}{\partial x}\right)_{y=\frac{b}{2}} = Am\frac{\pi}{a}\cos m\frac{\pi}{a}x \sin n\frac{\pi}{2};$$

$$\left(\frac{\partial^2 W}{\partial x^2}\right)_{y=\frac{b}{2}} = -Am^2\frac{\pi^2}{a^2}\sin m\frac{\pi}{a}x \cdot \sin n\frac{\pi}{2};$$

$$\int_0^a \left(\frac{\partial^2 W}{\partial x^2}\right)^2_{y=\frac{b}{2}} dx = A^2\pi^4\frac{m^4}{a^4}\cdot\frac{a}{2}\sin^2 n\frac{\pi}{2};$$

$$\int_0^a \left(\frac{\partial W}{\partial x}\right)^2_{y=\frac{b}{2}} dx = A^2\pi^2\frac{m^2}{a^2}\cdot\frac{a}{2}\sin^2 n\frac{\pi}{2}.$$

Changing of the potential energy of deformation:

$$\delta V = \delta V_1 + \delta V_2 = \frac{1}{8} DA^2\pi^4 ab\left(\frac{m^2}{a^2}+\frac{n^2}{b^2}\right) + \frac{1}{4} BA^2\pi^4 a\frac{m^4}{a^4}\sin^2 n\frac{\pi}{2} \tag{6}$$

Work compressive forces:

$$\delta A = \delta A_1 + \delta A_2 = \frac{1}{8} N_x A^2\pi^2 m^2\frac{b}{a} + \frac{1}{4} PA^2\pi^2\frac{m^2}{a}\sin^2 n\frac{\pi}{2} \tag{7}$$

Equating $\delta V = \delta A$ and reducing by we obtain:

$$\pi^2 D\frac{a^2}{m^2}\left(\frac{m^2}{a^2}+\frac{n^2}{b^2}\right)^2 + \frac{2B}{b}\pi^2\frac{m^2}{a^2}\sin^2 n\frac{\pi}{2} = N_x + 2\frac{P}{b}\sin^2 n\frac{\pi}{2}$$

Represent this equation as:

$$\frac{\pi^2}{a^2}D\left[\left(m+\frac{1}{m}\cdot\frac{a^2}{b^2}\cdot n^2\right)^2 + 2\frac{B}{bD}m^2\sin^2 n\frac{\pi}{2}\right] = N_x\left(1+\frac{2P}{bN_x}\sin^2 n\frac{\pi}{2}\right)$$

Denote $$\gamma = \frac{B}{bD};\ \delta = \frac{P}{bN_x} = \frac{\sigma b_p t}{\sigma b h} = \frac{b_p t}{b h}, \quad (8)$$

obtain an equation for the critical load:

$$N_x^{kp} = \frac{\pi^2}{a^2} D \frac{(m + \frac{1}{m} \cdot \frac{a^2}{b^2} \cdot n^2)^2 + 2\gamma m^2 \sin^2 n\frac{\pi}{2}}{1 + 2\delta \sin^2 n\frac{\pi}{2}}, \quad (9)$$

Single out particular cases.

1. $n = 1$, $\sin^2 n\frac{\pi}{2} = 1$:

$$N_x^{kp} = \frac{\pi^2}{a^2} D \frac{(m + \frac{1}{m} \cdot \frac{a^2}{b^2} \cdot n^2)^2 + 2\gamma m^2}{1 + 2\delta}, \quad (10)$$

To determine m calculate its derivative and equate the derivative to zero.

$$\frac{d}{dm}\left[\left(m + \frac{1}{m} \cdot \frac{a^2}{b^2}\right)^2 + 2\gamma m^2\right] = 2\left(m + \frac{1}{m} \cdot \frac{a^2}{b^2}\right)\left(1 - \frac{1}{m^2} \cdot \frac{a^2}{b^2}\right) + 4\gamma m = 0;$$

$$(1 + 2\gamma)m - \frac{1}{m^3}\frac{a^4}{b^4} = 0; m = \frac{a}{b}\frac{1}{\sqrt[4]{1 + 2\gamma}}, \quad (11)$$

m must be an integer.

2. $n = 2$, $\sin^2 n\frac{\pi}{2} = 0$:

$$N_x^{kp} = \frac{\pi^2}{a^2} D (m + \frac{4}{m} \cdot \frac{a^2}{b^2})^2, \quad (12)$$

Consider as a plate without stiffener with $b_1 = \frac{b}{2}$.

3. $n = 3$, $\sin^2 n\frac{\pi}{2} = -1$:

$$N_x^{kp} = \frac{\pi^2}{a^2} D \frac{(m + \frac{9}{m} \cdot \frac{a^2}{b^2})^2 + 2\gamma m}{1 + 2\delta} \quad (13)$$

Here we have a plate of buckling toward y.
The case of $n > 3$ in this case is unlikely.

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UDC 69.01

DESIGN FEATURES OF OPERATED ROOF

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This article describes the design features of operated roofs in the city, as well as types and properties of used construction materials.

The idea of using flat roofs always attracted architects. Use of vacant space of the roofs in large cities, where the cost of the land is very high, is especially relevant. Intensive development of the huge empty areas of

flat roofs began after the appearance of a new generation of roof materials and introduction of the most progressive technologies in building practice. There are the most common two types of operated roofs in modern designs: green roofs and roof-terrace. Often, especially in the design of large-scale residential and commercial-recreational complexes, a combination of the various options is used. Moreover, the establishment of gardens on the roof terrace, due to the scarcity of green areas in the ground level, is becoming an important compositional and spatial component of not only space-planning, but also urban-planning structure [1].

When we design operated roof, we need to take into account several features. The design of operated roof must withstand significant operational load:

- the radiation exposure;
- atmospheric precipitations;
- temperature differential;
- load from exploitation (walking, car movement);
- materials gravity load;
- wind load;
- snow load.

At the device of 'green roofs' it is also necessary to create a watering system and remove excess moisture through the drainage system , to solve the security problems associated with evacuating people from the operated roof, to provide the necessary fire prevention measures.

To repair the operated roof, in contrast to conventional, is difficult. Therefore, it is necessary to use such technical solutions and materials that guarantee the highest possible maintenance-free service life. There are some main elements that make up the design of operated roofs: supporting structures, waterproofing, heat insulation, vapor barrier, drainage and cover (Fig. 1).

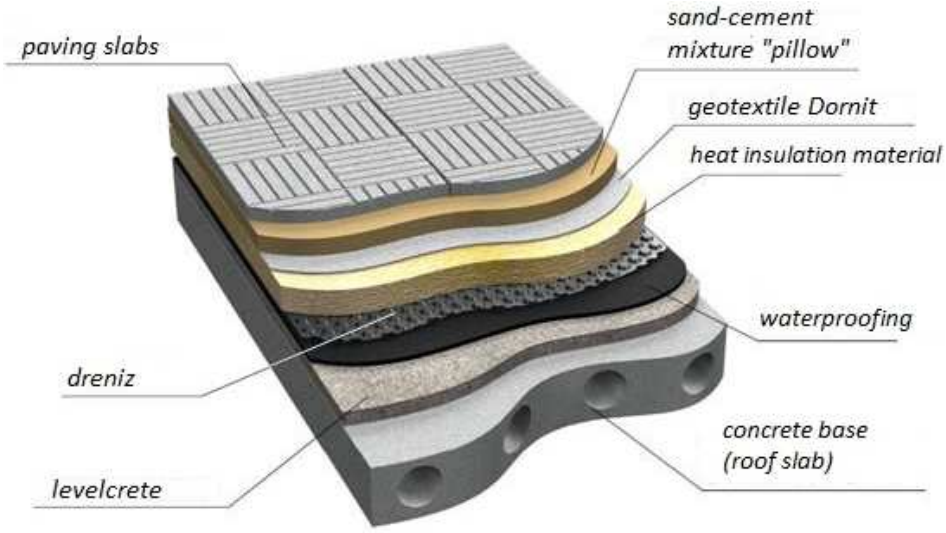

Fig. 1. The design of operated roof

Supporting structures can be: prefabricated reinforced concrete slabs, beams, etc. Standard methods are used for calculation supporting structures of operated roofs such as precast concrete roofs. However, it is necessary to take into account a number of additional loads, in particular, vibrational. During the design it is necessary to consider deflections of bearing beams, fixation of overlap relatively to supports building and resistance to compression of all involved in the roofing materials 'working' on the distribution of loads.

Waterproofing layer is in the design of a 'pie' roof. Therefore, when we choose the type of waterproofing and technology of installation, they should be guided by considerations of the greatest reliability. There are some main characteristics of the coating materials used for waterproofing flat operated roofs:

- elasticity;
- resistance to mechanical impacts;
- fire resistance;
- lifetime;
- manufacturability stacking;
- the safety of fixed properties when temperature changes (from -50 to +50).

Today the building market offers a wide range of roof materials: rolled materials (stekloizol, stekloelast, rubiteks, polysilicon, ELAST), which are based on bitumen, fiberglass or polyester and without polymer rolled bituminous or mastic asphalt roof. etc.

These materials have a relatively high lifetime before repair (from 15 to 75 years), so their exploitation is much more advantageous than using standard ruberoid.

Roofing materials based on bitumen have resistance to plant roots (up to 90 days) and special antiroot additives introduced in modern coatings. Filter layer made of special geotextile which does not allow flushing to drain small soil particles, prevent siltation of the drainage system and improve its effectiveness inserted between the drain and the soil in case of roof installation with a layer of vegetation.

Material for paving a surface of operated roof must be not only attractive, but also strong enough to withstand heavy traffic and pedestrians. Besides it must securely protect the underlying layers from mechanical damage (bituminous, liquid mastic, asphalt pavements and also tiles is used for exterior applications).

The application of special liquid compositions, in particular made of polyurethane for surface of operated roof is very promising. They provide resistance to high intensity loads and retain tightness in the range of operating temperatures (from -50 ° C to 100 ° C) for more than 15 years. The layer of gravel or shingle, as a rule, is poured on heat insulation for the protection roof from wind action. In addition, it greatly reduces the undesirable effects of ozone and UV - radiation, and in some cases it is a prerequisite for compliance with fire safety.

Drainage system must ensure collection and diversion of flows formed from rainfall and snowmelt, as well as the water, that is used for watering plants (in the case of 'green roof'). In this case we must consider the size of the surface, slope, the presence of vegetation, soil type, etc. (Fig. 2).

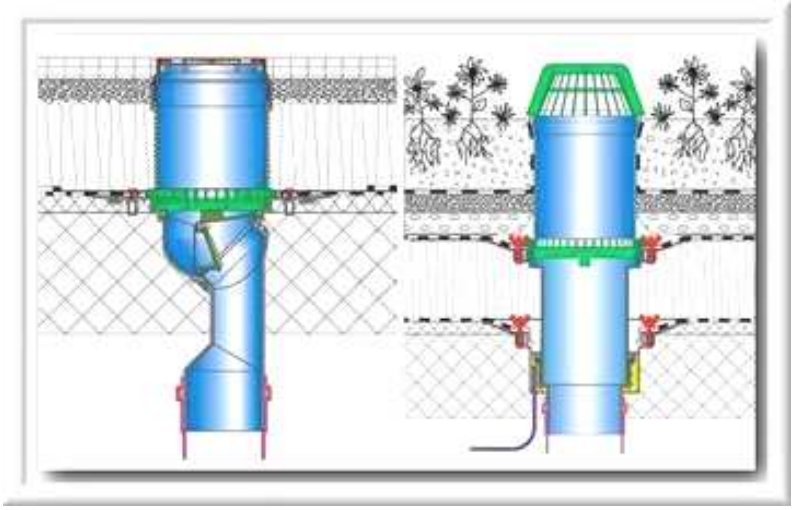

Fig. 2. Water drainage from the surface

As a rule, the materials used for paving surface of operated roof, may in time lose the tightness due to the partial destruction, mechanical displacements and deformations as a result of impact of loads or moisture. Therefore, besides providing necessary roof pitch, in the structure of the roof 'pie' provide for special drainage layer freely permeable water. It may consist of a porous concrete, pea gravel, pure coarse-grained sand etc.

When we design an operated roof we should provide measures for regular cleaning of the surface of the excess snow mechanical or otherwise. Method of removing snow by heating, both of the surface of coating and funnels gutters and trays proved itself [2].

The most important issue in the design of operated roofs is the choice of material for heat insulation and locating heat insulation layer in the roof structure 'pie'. For a long time on flat roofs for the protection heat insulation from getting wet - it was over waterproofing. Now these roofs are called traditional. Use of heat insulation materials with low water absorption on the roof have allowed waterproofing underneath. These roofs are called inversion or inverted. Such a method of stacking materials can increase the lifetime of the waterproofing carpet. Thermal resistance is 6,0 of the TAP.

When we made traditional flat roof waterproofing insulation is laid on top, and when the device inversion vice versa. The seams of protective carpet of waterproofing materials are soldered and then bitumen that coated on a polymer waterproofing is melted by gas burner. Places contiguity waterproofing with roofs elements shall be waterproof, it provides sealants and mastics based on polyurethane resins. The edge of roof waterproofing

plant on the vertical plane is at a height of 20 cm. As the roof waterproofing material is used as a stone grit and bitumen-polymer waterproofing and waterproofing PVC membrane.

In order to make the flat roof "breathe" so that moisture doesn't accumulate in the insulation on the roof surface uniformly, we should set aerators. Contiguity to the parapet and plums requires careful execution. For this the junction of heat insulation slab to lanterns roof make the transition bumpers. For insulation of flat roofs we should use rigid insulation materials. And we should lay cables for heating of the roof, so that water near the drain funnels doesn't freeze.

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UDK 624.078.4

CALCULATION METHODS OF BENDING MOMENTS ON SUPPORTS IN PRECAST PRESTRESSED HOLLOW-CORE SLABS WITH PLATFORM JOINTS

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Experimental results of intermediate floors strength with precast prestressed hollow-core slabs with platform joints are presented. Precast prestressed hollow-core slabs with ∅5mm reinforcement of high-strength wire are produced by a continuous formless molding method, which imposes particular features on its reinforcement such as absence of transverse reinforcement near joints and danger of its destruction from shear on supports.

Nowadays production of precast prestressed hollow-core formless molding slabs is launched in Belarus. These slabs have longitudinal reinforcement from high-strength wire or strand of S1400 steel. Production technology of such slabs, unlike the aggregate flow production, completely eliminates the installation of transverse reinforcement, horizontal grids in flanges, embedded steel plates and tie-down loops in such slabs, which imposes definite restrictions on the application of such slabs in designing floors.

Singularity of designing floors with platform joints of hollow-core slabs and wall panels is in emergence of bending moment on supports [1], п 6.4. [2]. In hollow-core slabs made by aggregate-flow or conveyor technology emergence of negative bending moment after cracking is perceived by longitudinal bars of upper support steel reinforcement grid and by vertical support steel frames. In precast hollow-core slabs bending moment on supports is generally perceived by concrete cross-section because minimal size of support amounts 80…120mm. Estimated length of zone of stress transfer zone for reinforcement strands and high-strength wire amounts correspondingly 500mm and 330mm. Cracking pattern of similar precast prestressed formless molding hollow-core slabs by "MAX ROTH" production in support zone testifies the danger of destruction from shear near support in the place of normal crack formation.

Herewith [2] it is recommended not to take into consideration appearing bending moments on supports when slabs are supported by masonry walls including monolithic belts made in this types of masonry. At the same time typical series [3] requires to take into consideration appearing bending moments on supports when slabs are supported by block masonry walls.

The value of negative bending moment on supports when using platform joints of precast prestressed hollow-core slabs with wall panels varies in different sources. In [1] bending moment on support for precast prestressed formless molding hollow-core slabs by "MAX ROTH" production which are reinforced by high-strength wire VR-II with 5mm diameter is defined by the coefficient of anchorage degree to the value of bending moment on support which is defined from anchorage condition of the slab in the wall panel. Herewith coefficient K=0.51…0.79 is taken according to anchorage length and stress from pressing of wall panels. In typical series for precast prestressed formless molding hollow-core slabs by "Weiler" (Italy) production which are reinforced by seven-wire steel strands with diameter 6mm, 9mm, 12mm and 15mm [3], bending moment on supports is taken equally to $M_O = ql^2/17$, where q – effective distributed load. In typical series for precast prestressed formless molding hollow-core slabs by "Vibropress" production [4] which are reinforced by high-strength wire made of S1400 steel and with 5mm in diameter bending moment on support should not exceed 11.9…14.9 kNm according to concrete class, otherwise strengthening of supporting zone is required with corresponding

reinforcement. In recommendations [2] estimated value of bending moment on support is taken equally to $M_{sup} = M_1 + M_2$, where M_1 is bending moment from vertical reaction on support, M_2 is bending moment from frictional forces reaction.

Experimental averages of negative bending moments in the platform joint zone in the moment of destruction of experimental samples of platform joint fragments PJ-1 and PJ-2 and also calculated by [1], [2] and [3] are presented in Table 1

Table 1 – Bending moments on support in the moment of destruction

Element	Bending moment on support (experimental average), kN·m	Bending moment on support [1], kN·m	Bending moment on support [2], kN·m	Bending moment on support [3], kN·m	Bending moment on support [4], kN·m
PJ-1	-30	-32,52	-6,08	-11,9	-21,1
PJ-2	-34,56	-33,9	-40,53	-11,9	-21,1
Ancorage	-45,8				
Swivel	0				

Comparison of experimental values of bending moment on supports of platform joint fragments with estimated values shows satisfactory convergence with proposals [1], which consider the influence of pressing on supports on the value of negative bending moment of support in the platform joint zone. Methods described in [3] and [4] evaluate bending moment on support more carefully and with low pressing in [2]. Method [2] with high pressing overestimates appearing negative bending moment on support in the platform joint zone.

Examined methods consider the value of negative bending moment on support only in critical strength state. Methods which consider the actual performance of precast prestressed hollow-core slabs in the platform joint zone and allow to define internal forces and respectively stress-strain state in hollow-core slabs in any time of its load including effective loading. The existence of negative bending moment in hollow-core slabs in the platform joint zone reduces span bending moment and deformations of the floor, enhances crack resistance. It enhances the value of critical force in critical strength state.

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UDK 697:721.011.25

RESTRUCTURING OF HEAT AND AIR SUPPLY SYSTEMS OF BUILDINGS WITH RECYCLING OF LOST HEAT

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The possible options and solutions of the efficient heat and air supply energy of multi-story buildings with exterior fences with increased thermal protection and impermeability in which it is possible to use energy resource efficiency techniques to reduce energy consumption due to the recovery of heat, the heat recovery of the removed ventilation air and the study of the natural heat of solar radiation.

In order to implement organized and comfortable thermal air treatment facilities it is necessary to exclude the influence of external factors and make manageable, and thus managed, the processes of heat transfer in buildings, which requires the following basic conditions:

- Make the room completely sealed;
- To ensure the continued removal of harmful emissions (carbon dioxide, excess heat and moisture) by means of local exhaust ventilation in volume of air current;
- To make technical means for the orderly admission of fresh outdoor air;
- Provide a comfortable indoor climate, corresponding to modern sanitary requirements.

In addition, all received constructive and technological solutions must meet the basic requirements of modern reliability, durability and economy of energy and raw materials.

To fulfill the first condition of sealing the premises, completely unorganized filtered air through the outer fence should be excluded.

Filtration through the exterior building envelope space is disorganized under the influence of pressure difference on both sides of the fence, created by gravity and wind, because of leaks in the construction and air permeability through the cracks, pores and cracked floor, ceiling and walls. Moistening of the material building envelope constructions is due to the effects of precipitation on the outside and the allocation of household and technology of indoor moisture, resulting in moisture exchange across barriers that reduce not only the heat-shielding properties, and in general durability of buildings.

To reduce heat loss irrecoverable, durability and efficiency in buildings is necessary to consider the dynamics of the formation of indoor climate, taking into account the laws of heat and mass transfer, since the action of connective and radiate heat transfer and mass transfer processes, the internal air temperature and internal surfaces offences are interdependent and have a significant impact on health-sanitary environmental conditions in the area of permanent or long-stay human.

The objective of this research is to study ways of creating a microclimate ventilated houses and public buildings with outdoor enclosures increased tightness. Protecting designs isolate buildings from external space weather impacts and allow you to create them artificially at the expense of specialized engineering of heating, ventilation and air conditioning desired microclimate.

On the thermal regime of the space in a building is influenced by multiple permanent and temporary factors and processes that form the thermal environment, which must be considered in close connection with each other, as their combined effect can repeatedly change the parameters of the microclimate. For example, filtering the air through the outer fence and hydration structures can be several fold increase in heat loss from the room.

The first condition of normalization of the microclimate associated with sealing exterior walling provides significant savings in thermal energy by reducing air flow through the building and connected with air filtration irretrievable loss of heat. At the same time a positive effect in terms of increased tightness of the outer fences in residential buildings and public facilities disturbed the normal mode of airspace.

Under the existing process flow ventilation hazard removal from the premises (household humidity, carbon dioxide from human and technological combustion of gaseous fuels in the pelvic plates) is carried out together with return air through the exhaust system of natural or forced ventilation.

In a closed volume sealed room ventilation effect creates a vacuum that will soon equalize the disposable pressure exhaust systems, after which the movement of indoor air is completely stopped, although the exhaust system continues to operate.

For violation of air space results in the accumulation of excess moisture and carbon dioxide in indoor air spaces of residential and public buildings by people and domestic use hot water and gas, which adversely affects human health, reduces the recovery function of the human body that affect productivity, and ultimately make the premises unfit for long-term and permanent residence in these people's medical and biological reasons.

In addition to these violations of sanitary requirements for buildings social housing and cultural life, the accumulation of moisture in the air space leads to waterlogging of building structures, which reduces not only their thermal insulation properties, but also the strength characteristics affecting the durability of structures and buildings in general.

To solve this major problem for modern urban planning it is necessary to create as soon as possible an industrial basis in large volumes of new construction and renovation of existing facilities of social housing and cultural life with latest technical means for the orderly flow of fresh outside air into the ventilated space enclosing structures of buildings with high air-tightness.

Researches in this direction are made by many research organizations, not only in our country but throughout the civilized world [1]. Similar studies in the framework of the state scientific and technical program

1.5.159 "Building Materials and Technologies" on the instructions of the Ministry of Architecture and Construction of Belarus 02/02/04, held in Polotsk State University, Department of heat and ventilation, Faculty of Civil Engineering [2].

The results of the investigations are designed, manufactured and tested experimental lots of technical means for the orderly flow of fresh outdoor air in ventilated rooms of residential and public buildings enclosing parts of high integrity.

The main advantages offered for the widespread introduction of ventilation supply unit in front of all the known world analogues is the ease of application design, efficiency in the manufacture, use standardized elements of conventional materials, the ability to preheat outside air through the heat recovery leaving the possibility of preliminary mechanical adjustment during commissioning work and the ability to automatically maintain the regime constant flow rate of supply air without additional specialized automation equipment.

In addition, the marked structural and technological advantages offered by the technical innovation meet the basic requirements of modern reliability, durability and economy of energy and raw materials, that is a world standard and make it competitive not only in domestic, but also foreign markets.

Apart from the previously mentioned technical and economic advantages, the offered technological innovation corresponds to the fourth condition, since under the current process of ventilation flow the outdoor air, passing through the slit porch of window frames and balcony doors, dramatically reduces the temperature of the indoor air, especially during windy days and because of the unmanageable processes of heat and mass exchange there is a discomfort zone near the outer walling.

Under the proposed technology of ventilation of residential and public buildings with high-seal structures for the supply of fresh outside air into the ventilated space there is a special multifunctional air supply device, which, first of all, does the recovery function of the heat exchanger in which the preheating of the outdoor air is done by an outgoing transmission heat flux through the complex and efficient heat transfer processes under construction device.

Secondly, in the construction of the proposed device air inlet there is a two-step mechanism of regulation of the used air flow and the rate of its release into the work area of the room, in which the mobility of air is regulated by norms to a strictly limited range - 0.1 + 0.3 m / s, for example, for premises [3].

Thirdly, the proposed innovation when installing it on the facades of buildings facing the noisy city highways provides insulation effect, because it reduces noise levels to acceptable standard limits.

The possibility of quantitative regulation of air flow through the air inlet device is also a very important advantage of the new ventilation technology of residential and public buildings, especially in high-rise design. In high-rise buildings at the existing technological scheme of ventilation much more fresh air goes in the room than in similar areas in terms of the upper floors because of the fact that the natural draft is created in the exhaust ducts due to gravitational forces, proportional to the difference in density between the indoor and outdoor air and a height of exhaust channels for different floors, which is variable. Although the project uses techniques to equalize the flow, by creating more resistance to the movement of air decreasing living section and ventilation channels (regulated) lattices, to take into account additional factors influence atmospheric (barometric pressure, wind, etc.) is not possible.

Methods of calculating the design parameters of the proposed device allows the air at the design stage to ensure a strictly normalized parameters on air consumption 3 m3/ch-m2 floor space, located on different floors of multistory buildings. In addition, the design of the device, an additional manual adjustment of air flows during start-up operations.

Thus, the proposed process of ventilation flow of buildings fully corresponds to the condition of normalization of microclimate on health and hygiene requirements, as the outside air is not only preheated, but also available in a ventilated room with low velocities and in the right quantity, without compromising the comfortable parameters and of insulation from external sources.

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UDC 624-2/-9

CALCULATION OF THIN-WALLED RODS BY NUMERICAL METHODS

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Thin-walled steel structures are used extensively in construction. They have become a common design solution for low-rise building, attics, walling multistory building.

When modeling thin-walled structures the integrated system SCAD Office is widely used.

SCAD Office is a suite of programs designed to perform the calculations of the strength and structural design of various kinds. The system, in particular, includes a program for creating spatial models, forum, formation and calculation of geometrical characteristics of sections, consul strength calculation of structures, SCAD. Modeling of thin-walled elements can be carried out easily in the Forum included in SCAD Office, or directly SCAD.

The main objective of this work was to develop a technique for constructing finite-element simulation models of such elements.

Building a profile to begin tracing its sectional cuts in AutoCAD (or other graphics program), the file is saved as dxf. Then dxf-file with the section profile import preprocessor program "Forum" (Fig. 1).

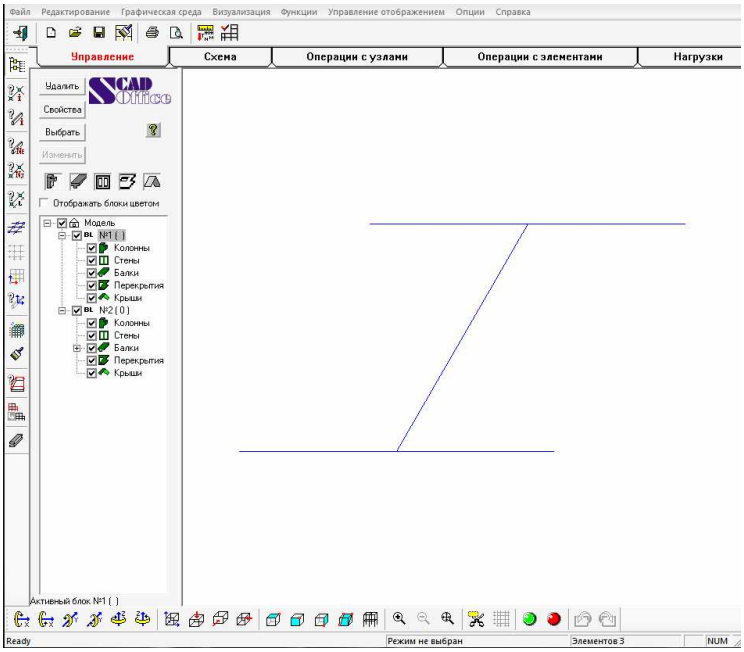

Fig. 1. Result of export dxf-file to the preprocessor "Forum"

Section on individual segments produce consistent formation shelves profile by selecting the function "wall" in the tab "scheme" with the job she needed parameters. Thus the length of the rod is set in "height of the wall". Passing successively from segment to segment, form the whole profile (Fig. 2).

If necessary to form a beam or a thin-walled element with perforations, choose the item in which to perform the holes. Further note the plane in which it is assumed the formation of holes in the left pane, select a function Forum "change". When this function is activated automatically switched to the program Consul.

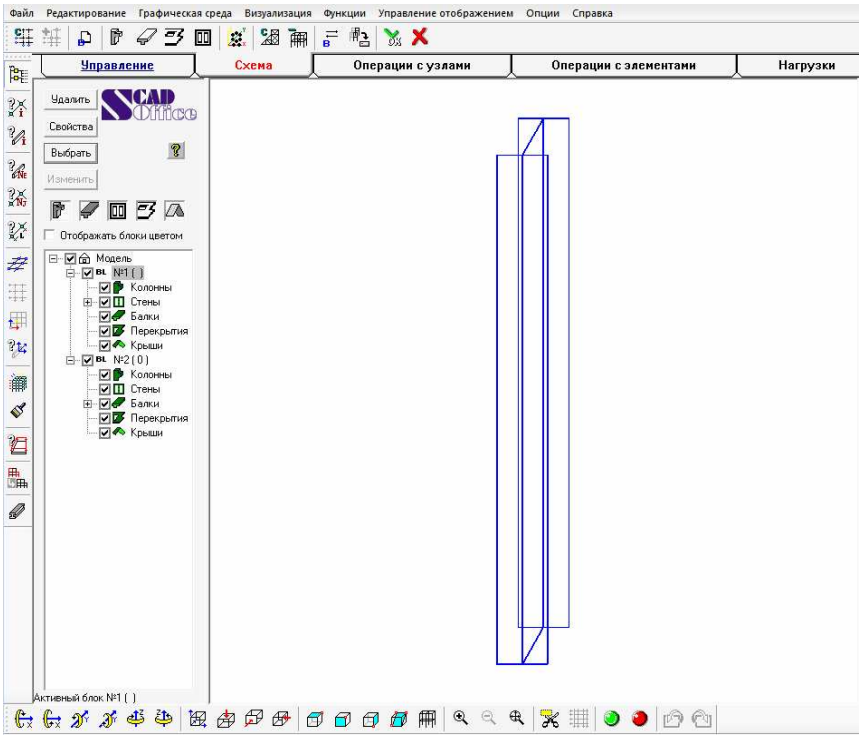

Fig. 2. Shaped profile

For further markup section must create grid. To do this, on top of the selected function, "grid", which set the new window. Option "Show / Hide grid" make the grid visible. The settings are snapping to the grid. Next, choose the function "inner loop" and the element, focusing on the grid nodes, specify the desired shape holes. It must be remembered that the circuit must be closed. When creating a design model is recommended to smooth corners holes that usually corresponds to the actual shape of the rod hole in the shelf. To do this, select a function to "smooth corners" and set the desired radius of curvature.

If necessary, create a circular hole in the tab "edit" choose function "given radius circular hole" in the dialog box set the radius of the hole. Precise positioning of the hole in two ways. Easier to use a reference to the grid step. In more complex cases, you can use the left panel, which displays the coordinates of all points of the holes, and change them.

To create a duplicate can be created opening holes rip through a predetermined distance. To do this, in the tab "edit" function is selected with the "copy inner loop". Noting right-click the hole open a window in which you specify the step of copying one or two coordinates.

Described sequence of steps provides a model of the complex profile.

If the calculated design has transverse stiffeners constructing sequence is as follows:

1) it is necessary to calculate the coordinates of points of intersection with the walls of the ribs and shelves beams;

2) create knots on the edges of shelves and wall beams considering the coordinate system in a given pattern;

3) create transverse stiffeners using the "Overlay". Operations to create shelves and walls will be similar to that described above. The convenience of such techniques job stiffeners that team "Overlap" allows you to create not only the plate perpendicular to the axis of the rod. Sequential assignment of the corner points of the plate allows you to place it in the inclined planes [1].

Formed of a preprocessor Forum enlarged model of the rod with holes and / or transverse ribs generated finite element project SCAD. The key here is to choose the partitioning steps into finite elements (Fig. 4).

One of the important features of the profiles with holes are its size, expressed in hundredths of a millimeter. For correct operation of the program SCAD to adjust some settings, namely, select "Setting environment" and in the tab "design scheme" set assembly accuracy and precision of the estimate coincident nodes 0.001 mm [2].

Since the task loads, fixing conditions and calculation directly considered beams similar to any other structures, will not consider these points. Dwell only on the task types of finite elements and their stiffness.

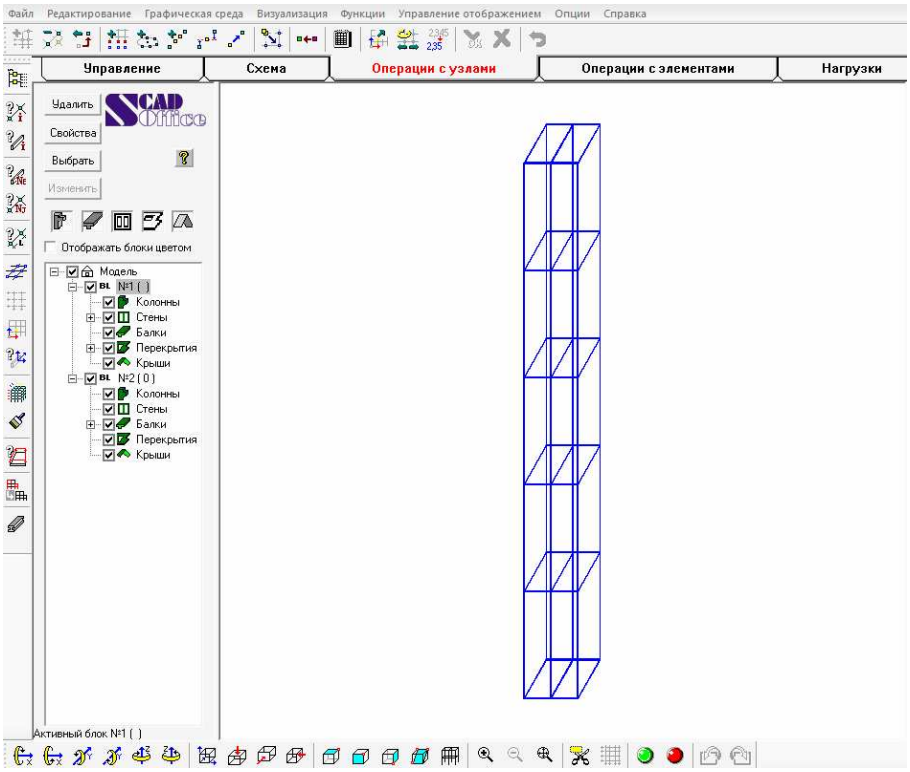

Fig. 3. Beam with transverse stiffeners

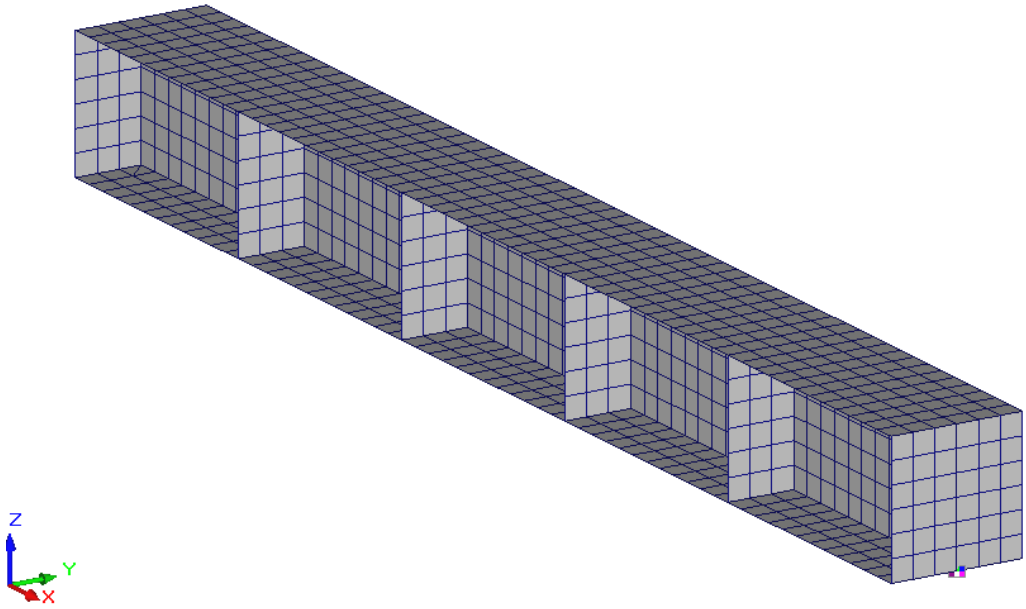

Fig. 4. Finite element design SCAD, presentation graphics

Finite elements library computer system allows the calculation of the most complex designs. It includes a variety of finite elements (FE). Each finite element in the library assigned type – serial number. Table 1 gives a classification of types of FE possible signs of a design scheme for their work, the identification of calculated forces (stresses).

Table 1 – FE classification

Type of FE	Content	Signs scheme	Calculated efforts
1 – 10	Rods		
	1 – flat farm	1, 2, 4, 5	N
	2 – flat frame	2, 5	N, M(My), (Qz)
	3 - beam raft foundation	3, 5	Mк(Mx), My, Qz
	4 - spatial farm		
	5 - spatial	4, 5	N
	6 - taking into account the spatial shear	5	N, Mk, My, Qz, Mz, Qy
	7 - beam on an elastic base raft foundation	5	N, Mk, My, Qz, Mz, Qy
	10 - universal	3, 5	*Mk (Mx), My, Qz* depending on the type of circuit
11 – 20	Plates	3, 5	Mx, My, Mxy, Qx, Qy
21 – 30	Elements for solving the plane elasticity problem tense (beam-wall) and the calculation of plane strain 21, 22, 29, 30, 23, 24, 27	1, 2, 4, 5	For flat-hard problem: Nx, Ny, Txz; For plane strain: Nx, Ny, Nz, Txz
31 – 40	Elements to solve the bulk of the elasticity problem	4, 5	Nx, Ny, Nz, Txy, Txz, Tyz
41 – 50	Shells	5	Nx, Ny, Txy, Mx, My, Mxy, Qx, Qy
51 – 60	Elastically pliable connection		
61 – 70	Elements for the solution of the axisymmetric problem of elasticity theory	11	Nx(r), Ny(),Nz(z),Txz(Trz)
71 – 80	Elements for the calculation of multilayer shallow plates and shells, taking into account the transverse shear, compression layers and curvature	8	Nx, Ny, Nz, Txy, Txz, Tyz, vertical movement at the boundary layers
81 – 90	Elements for the calculation of multilayer shallow plates and shells, taking into account the interlayer shifts and curvature	9	
150 – 160	Zero elements for calculating effort to questions	1-5	
200	Empty element	any	

Forces and stresses are evaluated at the beginning and at the end of the rod, and for other types of finite element – the center of gravity calculation serves to support the rods in the intermediate sections, other types of finite element – at the nodes.

Typically, the stresses and strains in the FE calculated in the local coordinate system. For rods such, that the major axis of the cross sections of the flexible portion. If the figure in the table element is not specified local coordinate system X1Y1Z1, then the stresses and strains are calculated in the global coordinate system. For all flat and spatial FE is possible to set the coordinate system computing effort.

Universal finite elements for the solution of the plane problem of elasticity theory can count as flat-tight and flat deformable systems. In the most general case, each node of finite element has three degrees of freedom: U - axis of linear movement along X; V - linear movement along the axis Y; W - linear movement along the axis Z [3].

Degree of freedom, V is absent in all the elements that can only lie in the plane XOZ: 21, 22, 29, 30.

In type elements 23, 24, 27 which may lie freely in the space, it is introduced to the docking space of the structure.

The complex SCAD includes the following FE solutions for the plane problem:

1) rectangular elements such as 21 (in the plane XOZ) and type 23 (an arbitrary position in space);
2) triangular elements 22 type (belongs to pl . XOZ) and type 24 (arbitrary position in the space);
3) quadrangular elements with the number of nodes from 4 to 8, type 30 (mp lies . XOZ) and type 27 (an arbitrary position in space. Besides the quad on each side may be one more node. Numbering nodes 5 to 8-th – arbitrary;
4) quadrilateral element with the number of nodes from 4 to 12 in the plane XOZ type 29. Besides the quad on each side may be even up to two nodes. The numbering of nodes from the 5th to the 12th arbitrary.

Elements beams, walls often located in the plane XOZ common system of coordinates (and planes parallel to it). In this case such elements are represented by the local coordinate axis system elements when the element lie in the plane of the axis X1 and Z1, and an axis Y1 perpendicular to its plane.

If the beam-wall is not in the plane XOZ (or in a plane parallel to it), and arbitrarily located plane (as part of a spatial structure), it uses elements of the same kind of shape (rectangular, triangular, rectangular), but they will treat other types than those described above.

Force (tension) in the plane problem is calculated either in the center of gravity or more elements (as indicated by calculators) and element nodes.

As a result, bills are calculated move nodes in the global coordinate system, as well as efforts at the center point (center of gravity) of the element in the local coordinate system (the default) or any other (by the user) coordinate system, the position of which is determined by the data specified in the document. Nodal reactions are only issued in the local coordinate system.

Positive displacement directions are coincident with the corresponding directions of the basis vectors (right Cartesian coordinate system).

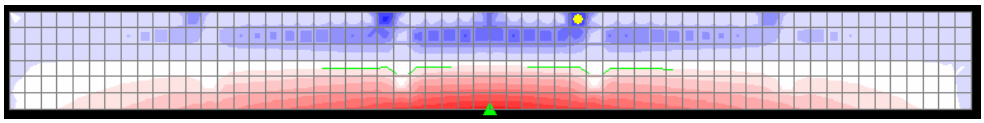

Fig. 5. Example display contour plots of stress Nz wall-beam.

The list and the rules of reading effort and nodal reactions are shown in (table 2). The dimension is given for the case of job stiffness characteristics, origin and loads in tons and meters. If other units of measurement results of the calculation will be prepared according to the selected measurement units.

Table 2

Type of FE	Indexation	Description	Rule of signs
a)			
21 – 30 41 – 50	N_x (σ_x)	Normal stress acting along the axis X1	Positive sign corresponds to tension
21 – 30 41 – 50	N_y (σ_y)	Normal stress acting along the axis Y1	Positive sign corresponds to tension. For items 21 – 30 is calculated only for plane-deformed systems
21 – 30	N_z (σ_z)	Normal stress acting along the axis Z1	Positive sign corresponds to tension
41 – 50	T_{xy} (τ_{xy})	Shear stress	Shifting section belonging end member in directions opposite to the axes X1 and Y1
21 – 30	T_{xz} (τ_{xz})	Shear stress	Shifting section belonging end member in directions opposite to the axes X1 and Z1
b) Bending stresses (forces)			
11 – 20 41 – 50	M_x	Moment acting on the cross section orthogonal to the X axis	The positive thing is stretching the lower (relative to the axis Z) fiber cross-section
	M_y	That is, the orthogonal axes Y	The same
11 – 20 41 – 50	M_{xy} Q_x	Torque (acting in section orthogonal to the axis X1) Shear force in a section orthogonal to the axis X	Rotation section belonging to the end of the element counterclockwise when viewed from the end of the axis X1 Positive shearing force acts in the direction of Z axis on the part of TFE, wherein the missing node 1

11 – 20 41 – 50	Q_y	That is, orthogonal to the axis Y	
11 – 20 41 – 50	RZ	Reactive soil resistance when calculating shell plates on elastic foundation	Positive force acts in the direction of the axis Z (minus sign indicates that the soil is compressed)
c) Nodal reaction			
21 – 30 41 – 50	RX	Horizontal force in the *i*-node finite element coinciding with the direction of the X axis direction	The positive force exerted on the *i*-th node in the direction of the axis X
41 – 50 23, 24, 27	RY	Horizontal force in the *i*-node finite element coinciding with the direction of the Y-axis direction	The positive force exerted on the *i*-th node in the direction of the axis Y
11 – 20 21 – 30 41 – 50	RZ	Horizontal force in the *i*-node finite element coinciding with the direction of the Z-axis direction	The positive force exerted on the *i*-th node in the direction of the axis Z
11 – 20 41 – 50	RUX	The reactive moment in the *i*-node FE relative to the axis X	Positive moment acts on the *i*-th node counterclockwise when viewed from the end of the X axis
11 – 20 41 – 50	RUY	The reactive moment in the *i*-node FE relative to the axis Y	Positive moment acts on the *i*-th node counterclockwise when viewed from the end of the Y axis

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PRECAST BENDING REINFORCED CONCRETE CONSTRUCTIONS

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Currently, precast reinforced concrete constructions are widely used in the building industry of the Republic of Belarus. They are used both in the reconstruction of buildings, structures and in new construction. The advantage of precast structures is associated with the possibility of connection of multiple layers with different properties in one construction. The versatility of precast construction includes the use of positive properties of each layer separately and joint work of layers as a single unit up to structural failure.

So, during the reconstruction of buildings and structures a method of enlargement of the cross section of a construction to reinforce steel bending concrete structures is commonly used. It is a fairly simple way of reinforcement. It allows to increase the structural strength and to reduce the time of strengthening. The use of other ways of strengthening is limited by weight and overall dimensions of structures, as well as the use of large construction equipment.

The efficiency of reinforcing work technique is based on the use of a horizontal surface of a former construction as a fixed formwork. Reinforcement can be carried out under total or partial discharge or under a load. Reinforcement-under-the-load-activities are the most profit-proved. The works are carried out with minimal efforts. So, for example, there is no need to dismantle and then mount back the work equipment which can remain non-removable. Besides it is practically impossible to relieve a fully unloaded structure. The proper weight of an item is a minimum load.

As a result of such reinforcement a precast and cast-in-situ construction, which combines at least two layers of different properties, is made. And the mode of layers' deformation can be various.

The use of precast and cast-in-situ constructions is relevant both to a new low-rise building and laps' replacing under strained conditions of reconstruction. The use of precast and cast-in-situ constructions in this case allows reducing the cost of construction significantly, eliminating the use of hoisting machines and mechanisms during the mounting of structures. As a result a several layer structure is made, and the mode of layers' deformation can be various.

Modern precast and cast-in-situ flexible constructions, such as lap-slabs, are very diverse. They mainly consist of prefabricated beams with reinforcement and block-liners. Large-span slabs of the German system "ALBERT", polish "TERIVA FLOOR" slabs [1], Belarussian "Dakh" [2], the Russian system of prefabricated concrete slabs "Marko" [3] and many other systems are widely known.

In general, precast and cast-in-situ system consists of three parts:

1. Reinforced concrete beams with a spatial reinforcing bar structure in the form of a light truss of a triangular cross-section. The basis of the farm is immersed into concrete. The truss consists of three bars. The diameter of the bars depends on the length of the beams and a required strength of laps.

2. Hollow block-liners that fill spaces between beams and serve as a fixed formwork. Material for hollow blocks can be different: ceramics, haydite concrete, foam concrete, cellular polystyrene concrete, etc.

3. In-situ concrete, after its curing, makes a precast and cast-in-situ construction.

Fig. 1 shows the "Dakh" system developed in PSU.

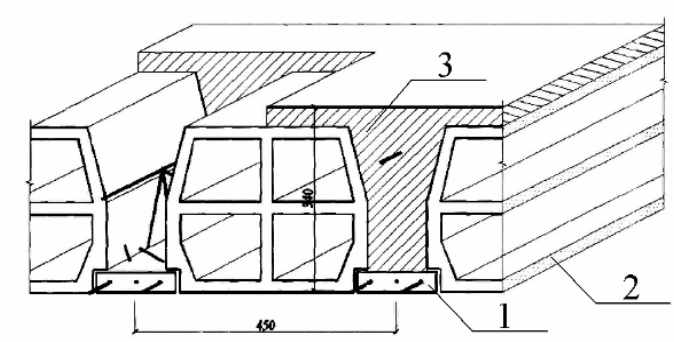

Fig. 1. General arrangement of a composite precast and cast-in-situ slab "Dakh"

Theoretical studies and experimental researches of precast and cast-in-situ constructions are carried out in many countries of the world, such as Germany, Poland, in the CIS countries – Russia, Belarus, Ukraine, and many others. The structural elements are elaborated in all systems; durability, fracture strength, toughness of the whole construction is investigated as well. This clearly proves the relevance of this type of structures. But questions about the influence of initial deflected mode caused by concrete shrinkage of a cast-in-situ unit of a construction on the entire system up to destruction are still in the dark. Besides, there is a question about the influence of the load on the structural strength in reinforced constructions.

Joint work of the precast and cast-in-place concrete in a unit, both in new constructions and renovated ones, makes conditions on a composite deflected mode, which is different from conventional reinforced concrete beams or slabs.

The researches of precast and cast-in-situ systems used in new constructions and renovated ones have already being carried out in PSU for 20 years. The research is carried out by the staff of Department of Constructions. Among them are candidate of technical sciences V.D. Hrinev, candidate of technical sciences A.H. Kremneva [4], Dr. Lazouski D.N. [5], candidate of technical sciences Popkov Y.V., and master of technical sciences Kovalenko A.A. In the labs experimental research of precast and cast-in-situ slabs "Dakh", slab constructions forced under a load or without it, is carried out .

Various deformation models are used for the analysis of experimental data and assessment of the gained results. More than 500 calculations are made using these models. At the same time, for confirmation and a more detailed analysis of precast structures work theoretical calculations, based on the deformation model using the system of lapping "Teriva", Poland, are also proposed.

Today the university staff are carrying out the researches on influence of initial deflection mode of a precast construction on fracture strength of such systems:

– the impact of shrinkage of cast-in-situ concrete, including modified admixtures is being studied;
– the effect of load on the prefabricated structure, in particular reinforced by means of enlargement of the cross section of a construction is being examined.

Theoretical studies and experimental researches allowed assessing the percentage of reinforcement of precast and cast-in-situ constructions and the loading level of a precast unit, which influence the fracture strength of the system as a whole.

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UDC 72.05

THE DEVICE OF A WINTER GARDEN AND THE GLASS HOUSE

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Ways of building and prominent features of glass houses and winter gardens are considered and analysed. Stages of building of constructions of the given sort are presented.

All people like nature and its unusual "design", but let's think of it a little. If you suddenly wanted to have a slice of this nature at hand at any time you should reflect on such construction as a winter garden (fig. 1).

Fig. 1. A winter garden with a glass roof

It has been noticed that winter gardens, as well as glass houses, are most claimed by people who are interested in the nature and want to be closer to it.

Glass in such house or a garden can be transparent or matte, get effect of an easy misting or be partially decorated stained pattern. Now designers try to use actively glass in an interior. Interroom doors, tables, chairs, cases, regiments and so on are made of glass. Modern production techniques of glass allow

using transparent walls and roofs as the excellent building decision of a thermal insulation, sound insulation, protection against an ultraviolet, precipitations, at absolute reliability of a transparent design.

Installation demands the separate designing including difficult calculations of all design and each of its elements. Complexity of works will turn out extremely high, at comparison with usual civil work on facing of a facade of a building.

The installation principle does not differ. Panels are fixed on a standard purlin, or are straight on a wall. They screw component parts for fixture, using two variants, with visible system of fixture or hidden. If bracing elements are visible, heads screws, rivets, clamps, used for fixture, are decorated or painted.

Grooves from the interior of panels prepare for concealed fittings. Glass blocks are attached through them to load-carrying structural components.

Before starting to build such a construction it is necessary to think whether it will stand separately or will be attached to already constructed house.

If a winter garden is attached to a ready-made house, the main task - to avoid mutual motions of a building and an annex. A driving depth of the bases, as a rule, is made identical. Thus, it is useful to add a base design with the screw adjustable bearers necessary for elimination of shrinkable warps. Over the base necessarily stack a waterproof finish. Over the base necessarily stack a waterproof finish from two layers of the rolled material pasted on bitumen mastic. For designs of roofs this variant is not absolutely approaches. One of widespread ways of a waterproof finish is processing to isolating materials on the basis of a water glass.

Front systems are universal: for walls and a roof the same set of racks, beam heads and the angle units made of hollow profiles is provided. Steel and aluminum in a profile are of great popularity. The steel section has the highest durability and can bear the greatest area of a glassing. A profile lack is big enough mass of a framing and susceptibility of a steel (even processed by anticorrosive structures) rust. For this reason, steel constructions demand regular protective treatment. Aluminum in the profile provides high durability of a framing at a low mass. It reduces loading on load-carrying structures, increasing reliability of all system as a whole. An aluminum lack is its high heat conductivity that increases a thermal loss through a roof.

It is possible to enter a winter garden in architectonic shape of the building constructed in modern style. To achieve this it is possible to use a special type of a glassing on a roof (or in all design) - so-called structural. Special aluminum profiles and non-standard double pane units (their exterior glass more internal thanks to what the ledge closing a profile of a framing) are formed for this purpose. The usual plain glass for the design of roofs, open sheds or transparent walls impressing in the sizes does not approach – it is too fragile, heavy enough, and at the slightest blow breaks up into sharp-edged pieces (so being under such a roof is extremely unsafe). Besides it spends heat too much (that is in the summer it can be too hot indoors, and in the winter too cold), therefore use double pane units.

Double pane units mount by means of only cold-resistant joint sealant, doing without clamping laths. Result is the smooth glass surface which differs the original exterior and possesses one conclusive advantage: snowflakes and rain drops easily roll down from it. As alight-transmissive fill frames in the walls and roof of the winter garden mainly glazing is used. For walls use two-chamber with wide chambers and power saving up glass, for roofs - only single-chamber with low-emissivity glass (not to increase loading by a framing).

For security glazing for the roof must be made not of ordinary glass, and laminated glass (inner) and tempered (external). Experience shows that the most reliable framework system for conservatories is made of galvanized steel profiles closed section. This is evidenced by cases where the roofs on the adjacent conservatory goes wet spring snow with ice blocks, and these designs provide reliability. Need to focus attention on the triplex.

So, let's talk about the triplex. It does not impact crumbles, only crack: get a stone into it and it will crack, but pieces will not fall out of the glass roof. Secret triplex special gluing layer of polymer is sandwiched between two sheets of glass. Another advantage of triplex - good soundproofing. Lack of material - large and because of the thickness of said multilayer weight. So before using the triplex, it is necessary to strengthen a roof framing fairly. And here the tempered glass fairly approaches for sleeping rooms as it does not injure gallets at infringement of integrity of glass. The tempered glass has practically forced out usual as its application is safer for manufacturing of furniture, tables and cases. Besides advantages such glass has essential lacks. Drilling also it is sharp such material it is almost impossible so to give to glass the necessary form and to drill apertures it is desirable before spending its temper.

An excellent example is built in Singapore (fig. 2.).

Fig. 2. A winter garden in Singapore

Tempered glass use is not desirable at a glassing of roofs. Let it also will not wound, but, it is unpleasant, when on a head pours a glass medley. In addition, a few years later tempered glass with age cracks and crumbles on its own, without any external influence, according to professionals; this is a maximum of ten years.

That's how you build a conservatory its mast [1, 2].

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STRENGTH OF REINFORCED CONCRETE BEAMS, STRENGTHENED WITH ADDITIONAL PRESTRESSED TRANSVERSE REINFORCEMENT

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In this article the author gives the results of the experimental and theoretical studies of the strength of the reinforced concrete beams, strengthened with additional pre-stressed transverse reinforcement.

For obtaining new experimental data about the behavior of reinforced concrete beams, strengthened in shear zone, under load, experimental studies were conducted. The studies included testing of experimental beams that were strengthened in shear zone with the additional pre-stressed transverse reinforcement. The strengthening was at the initial stress-strain state and under the load action also.

Test Procedure [3]. The experimental studies were conducted on the test beams with the rectangular cross-section (175 mm (*b*) x 400 mm (*h*). The length of the test beams was 3m. As varied factors in the experiment, shear span (ranged from 1,5*d* to 2,5*d*) and the value of load under which strengthening occurred (from the initial load level (the dead weight and the weight of the test equipment) to the load value, corresponding to 71% of failure load).

During the experimental studies, three series of test beams were tested. Each series consisted of three beams. First test beams in each series were tested with different shear spans without strengthening as reference. The second and the third test beams were tested after their strengthening at the initial stress-strain state and under the load action respectively.

Test beams of the I series were tested with the shear span 1,5*d*, II – 2*d*, III – 2,5*d* respectively.

The actual cross-sectional dimensions of the test beams, transverse reinforcement characteristics before and after the strengthening, shear spans, the value of load, acting at the strengthening of the test beams are shown in Table 1.

Table 1 – The Characteristics of test beams

Series	Beam identifier	The size of the cross-section, mm	Transverse reinforcement before the strengthening, step, mm	Additional transverse reinforcement, step, mm	Prestress of the add. transverse reinforcement, MPa	Load level at the strengthening	Shear span
I	Б-1-1	175x401	2Ø6,5 S240 s=150	-	-	-	1.5*d*
	Б-1-2	176x400		1Ø12 S240s_{ad}=150	97,2	V=0	
	Б-1-3	176x400		1Ø12 S240s_{ad}=150	114,3	V=0.71V_R	
II	Б-II-1	176x399		-	-	-	2*d*
	Б-II-2	176x400		1Ø12 S240s_{ad}=150	98,1	V=0	
	Б-II-3	175x399		1Ø12 S240s_{ad}=150	98,5	V=0.57V_R	
III	Б-III-1	176x402		-	-	-	2.5*d*
	Б-III-2	176x400		1Ø12 S240s_{ad}=150	96,5	V=0	
	Б-III-3	174x401		1Ø12 S240s_{ad}=150	108,4	V=0.49V_R	

The experimental studies of the test beams were conducted in the laboratory of the EE "PSU". Only checked equipment was used. The load was applied to the sample by means of the press PR-1000. To control the magnitude of the applied external load press dynamometer was used.

During the test, to obtain the data about the stress-strain state of the test beams shear zones, the measurements of the basic and additional transverse reinforcement strains, as well as shear zone concrete strains were conducted.

The strengthening scheme of the test beams is shown on Fig. 1.

The experiment showed that all test beams, strengthened in shear zone by installation of an additional pre-stressed transverse reinforcement, collapsed in the shear zone by the critical inclined crack with the attainment of the basic and additional transverse reinforcement strains values, corresponding to the yield strength.

The ultimate strength calculations were performed using the real physical and mechanical characteristics of steel and concrete, which were obtained from the experiments. The calculation results, that were obtained using the limit equilibrium method [1], strut and tie method [4], limit equilibrium method for bending structures, strengthened in shear zone [5] and proposed method, based on the Modified compression field theory and general deformational model [2], as well as the relationship of experimental data to the calculated values are shown in the Table 2.

1. It was experimentally confirmed the efficiency of the strengthening of the reinforced concrete beams by installing the additional pre-stressed transverse reinforcement in shear zone in the initial stress-strain state and under load action also.

2. The results of the experimental and theoretical studies have shown the satisfactory convergence between the experimental data and data, calculated using proposed method, based on the modified compression field theory and general deformational model [2].

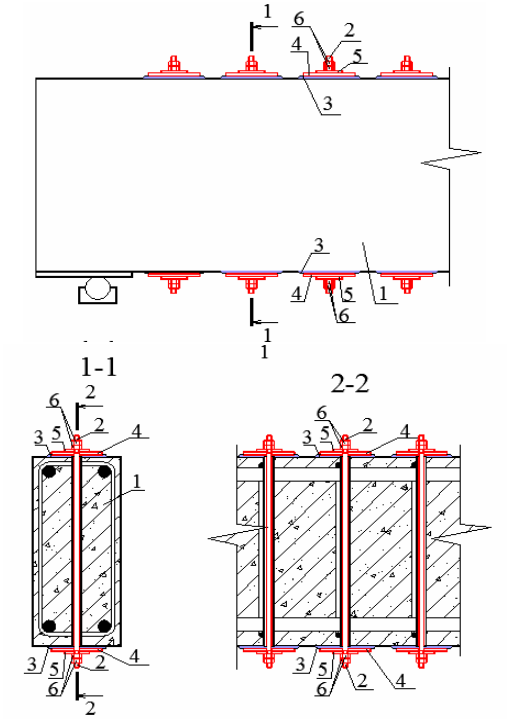

Fig. 1. The strengthening scheme of the test beams:
1 – strengthened beam; 2 – additional ransverse reinforcement ∅12 mm; 3 – gupsum slurry layer;
4 – steel distributor plate 100x100x5 mm; 5 – steel plate washer 50x50x5 mm; 6 – nut and lock nut M12

Table 2. – The tested beams shear capacity

Beam identifier	V_{exp}, кН	V_{th} , кН [1]	$\frac{V_{exp}}{V_{th}}$ [1]	V_{th} , кН [4]	$\frac{V_{exp}}{V_{th}}$ [4]	V_{th} , кН [5]	$\frac{V_{exp}}{V_{th}}$ [5]	V_{th} , кН [2]	$\frac{V_{exp}}{V_{th}}$ [2]
Б-I-1	283.3	281.05	1.01	50.34	5.63	-	-	267.3	1.06
Б-I-2	482.8	398.01	1.21	143.44	3.37	-	-	465.5	1.04
Б-I-3	460.8	398.01	1.16	143.44	3.21	384	1.20	445.3	1.03
Б-II-1	244.5	252.5	0.97	50.34	4.86	-	-	236.3	1.03
Б-II-2	351.4	351.74	1.00	143.44	2.45	-	-	363.2	0.97
Б-II-3	335.6	351.74	0.95	143.44	2.34	344.7	0.97	348.5	0.96
Б-III-1	184.8	224.5	0.82	50.34	3.67	-	-	176.3	1.05
Б-III-2	315.6	323.7	0.97	143.44	2.20	-	-	290.9	1.08
Б-III-3	295.4	323.7	0.91	143.44	2.06	316.7	0.93	276.4	1.07

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APPLICATION OF WASTE WOOD FOR RECEIVING BUILDING MATERIALS

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Organic building materials include wooden materials and items, polymer-based materials and also organic binders and bitumen-based materials. The properties of wood, its application are described in the article.

Organic building materials include wooden materials and items, polymer-based materials and also organic binders and bitumen-based materials.

Wooden Materials and Items

In modern building practice wood is extensively used for walls and floors of buildings, carpentry and graded plank items, as well as prefabricated standard wooden cottages. A great quantity of wood is consumed in building and installation work for making piles, poles, various loads-bearing components, casings, scaffolds.

Glued wood components – beams, trusses, arches, frames and roofs of buildings and installations — are very effective in chemically aggressive environment because their life span is 1,5 times greater than that of steel or reinforced concrete.

In building conifer (pine, spruce, larch, fir) and broad-leaved (oak, birch, alder, aspen, beech, lime, maple) wood species are used. Pine is used for building walls of dwelling houses, bridges, poles, window sashes, transoms, floors. Larch is used for the manufacture of poles, girders, and in general hydraulic engineering construction. Broad-leaved species mostly used in building practice for trimming work because it has a pleasant texture and color.

Structure and Properties of Wood

Wood is organic natural, fibred, porous (macrostructure) material, which consists of living and dead cells of various size and shape (microstructure). A living cell provides of trees with growth. After a while these cells die and become hard and strong. Macrostructure of wood is studied by cutting the trunk in three directions: cross-sectional, radial cut and tangential. The cross-section has layers formed during the growing season (spring-autumn). They are called annual rings. Each annual ring consists of light (early) wood resistance and strong. The higher the percentage of the late wood, the stronger the wood is.

Wood as a building material has a great number of valuable properties: high compressive and bending strength, small true and average density, low heat conductivity. Wood has several negative properties: its anisotropy results in different strength, heat conductivity and electrical conduction in length and across fibers; wood is a hydrophilic and combustible material.

Properties of wood are greatly affected by moisture content. Therefore its principal properties (strength, average density, heat conductivity) calculated with the use of standard moist are equal to 12%. Wood may contain water in three forms: capillary (of free), hygroscopic and chemically bonded. Moisture content of wood exposed to prolonged contact with air of constant relative humility and temperature is called the equilibrium moisture content. Because of structural differences wood shrinks during drying or swells irregularly in various directions. Linear shrinkage along the fibers lies between 0,1 and 0,3%, in radial direction between 3 and 6%, in tangential direction between 7 and 12%. Wood is dried from 15 to 20% (air-dry) and is suitable for the open air application; and it can be dried from 8 to 13 % (room-dry) as well and is applied indoors. These measures allow to avoid shrinkage of the material during its exploitation.

The following drying methods are in current use: air (natural), chamber, electric, in hot liquids, the chief methods are air and chamber drying.

The true density of wood is approximately equal to all species and averages 1,54 t/m^3.

Due to anisotropy, the resistance of wood to mechanical action differs the fiber orientation. Compressive strength parallel to fibers of wood at 12% moisture content varies greatly with wood species, the range from 30 to 100 MPa, and compressive strength perpendicular to fibers of wood amounts from H to 25 MPa.

Decay of wood stops as soon it dries, and all the fungi perish. Wood in construction items or in storage may be attacked by fungi and insects. Wood can be protected against decay and its life span in structures increased by preventing its humidification by structural means, such as painting or coating, leaching and impregnating with antiseptics. Antiseptics are substances which are poisonous for wood-attacking fungi. They should be harmless to man and domestic animals. Antiseptics are subdivided into water-soluble, oil and paste varieties.

Water-soluble antiseptics are used for making wood moistureproof. Because of high inflammability and sharp odour, oil antiseptics are used only for impregnating or coating wood placed in the open air, soil or water. Antiseptic pastes are subdivided according to their binders into bitumen, silicate, etc., varieties.

Wood preservation with liquid compositions includes surface preservation, impregnation in hot-cold and high-temperature baths, impregnation under pressure.

Wood is very inflammable, this being one of its major shortcomings. Wood can be protected against fire by plastering, coating with gypsum or asbestos-cement sheets or surface treatment with fire resistant substances. There are two surface treatment techniques, namely, painting and impregnation with fire protection compounds, or antipyrines.

Materials, Items and Structures from Wood

Building logs from conifer and broad-leaved species should not be less than 14 m thick at the top and 4 to 6,5 m long. Logs are used for hydraulic engineering structures, bridge elements, power transmission and communication lines, railway tracks.

Sawn timber is obtained by longitudinal cutting of logs planks, sleepers. By finish, sawn timber falls into clean-cut variety in which both edges have been cut throughout their length and non-trimmed variety in which the edges are not cut or cut less than half their length. Sawn timber for glued items and structures (archs, beams, farms) should have a moisture content not more than 15%, and that for bridge span structures and other load-bearing constructions should carry not more than 25% moisture.

Factory plank used for various building applications include platbands, plinths, finished floor boards, handrails for barriers, treads, window-sill board and exterior sheathing of house.

Floor materials include piece parquet, parquet boards, finish flooring boards, wood chipboards, wood laminates and fiberboards.

Wood chipboards are sheet materials manufactured by hot-moulding of wood chips, impregnated with polymers. In the course of hot-moulding, chips are compacted, and the viscous polymers harden, to cement the filler into a monolithic material. Wood chipboards are made of wood of conifer and broad-leaved species. Resistance of wood chipboards to water biological agents and fire is enhanced by treating chips with antiseptics and antipyrens.

Wood fiberboards are sheet materials composed of organic fibrous fillers (wood, reed, hemp) polymer-bonded together by hot-moulding. Culled wood is first cut into chips, than into fibers. Fibrous pulp is diluted with water and pumped to a reservoir for mixing with a solution of phenol-formaldehyde polymer (4-5% of the dry mass weight), hydrophobic additives, antiseptics and antipyrens. Fibrous pulp is pumped from the reservoir to a long mesh moulding machine for dehydrating and moulding the pulp into a continuous sheet, which is passed to a machine where it is cut into boards. By their average density, wood-fiber boards are available in three kinds: semi-hard (not less than 400 kg/m^3), hard (not less than 850 kg/m^3) and extra-hard (not less than 950 kg/m^3). Soft boards are used for heat-insulating of walls and floors, semi-hard and hard boards are used for facing walls and the extra-hard ones, mostly for floors.

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ENERGY CONSUMPTION REDUCING IN THE ASPIRATION SYSTEMS AT THE WOODWORKING ENTERPRICES

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The article deals with traditional and modernized aspiration systems at woodworking enterprises. It presents some activities for aspiration systems technology improvement, which help to reduce energy consumption. It researches a volume vertical packaged collector application in the aspiration system; it

introduces graphical dependences of aerodynamic parameters and waste catching degrees during the modern aspiration system working. It contains the analysis of the results and recommends methods, which improve aspiration system working.

The woodworking enterprises produce a good deal of waste: wood chips, saw dust and dust. Wood wastes are removed from the room by bush aspiration systems, which contain waste and air receivers, duct pipelines, cyclones and ventilators.

The bush aspiration systems don't only serve for the moving of materials, they are also used as local retractable ventilation systems. It is a specific characteristic of bush aspiration systems. The pressure decreases in the system due to duct pipeline wall friction of transported materials and transported air, material particles surface friction of the air, that have less speed, and also friction of material particles. Shaped parts of the duct pipeline and the used equipment have increased resistance. There are energy expenses for overcoming the material weigh [1].

In view of aspiration systems features, we can offer to improve technology of these systems and significantly decrease the length of material transportation or energy consumption decreasing. That's why we offer to install volume vertical packaged collector [2] in the middle of the machines location, where large particles of the transported material precipitated. Cyclone is installed after the packaged collector. It clears only medium and small dispersion dust (fig. 1).

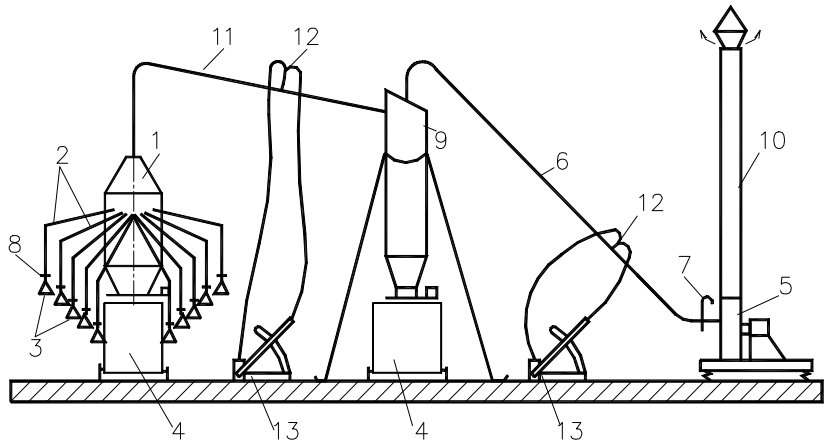

Fig. 1. Scheme of modernized bush aspiration system

1 – vertical packaged collector; 2 – duct pipelines; 3 – dust receptacle casing; 4 – truck; 5 – ventilator; 6 – packaged duct pipeline; 7 – damper; 8 – ventilation valve; 9 – cyclone;10 – exhaust pipe; 11 – packeged duct pipeline; 12 – pneumatic tubes; 13 – micromanometer

The most widely used at the enterprises are the bush aspiration systems. Every such system unites more than ten woodworking aggregates. In the middle of the aggregates location and their suctions *3* we offer to situate the vertical packaged collector *1* [2], which is appended in the top part of duct pipelines *2* from waste receivers. The waste receivers connect with machines. The main function of packaged collator is to drop out the basic weight of wood waste particles from the air flow. Such accumulation takes place due to fast decrease of the air speed at the collector, which has the biggest diameter (8-10 times) than the pipeline diameter from the waste receivers.

Wastes accumulate in the vertical collector under the own influence of weigh. Fallen wastes don't transpose and don't have cyclone purification *9*. It is a reason of energy consumption reducing on 15-20 %. The cyclone *9* and the ventilator *5* are situated at some distance of collector and it's usually situated outside. Waste removal from the collector is produced by the air outlet to body truck 4 or to conveyer.

Air quantity, which is drawn out by ventilator *5* on the packaged duct pipeline *6* according to the number of synchronous working machines, is controlled by ventilation valves *8*. These valves are mounted in pipelines *2* directly near the every machine suction *3*. All the currently inactive machines disconnect automatically of the aspiration's net, thanks to ventilator valves, which are electrically connected with machines. In result the ventilator *5* draws out less air quantity and therefore it consumes a reduced power, through the so-called, net throttling. However transporting speed is fast reduced in the packaged duct pipeline 6, when the small quantities of machines are synchronously working. It makes the purification efficiency of dust worse in the cyclone *9*.

That's why it is necessary to provide the installation of the speed reactor *9* at the air inlet in the cyclone. Speed reactor will maintain the air speed at the allowable level and it doesn't matter how many machines are synchronously working [3]. Wood dust, which was caught by cyclone, is periodically unloaded from the bunker in the truck *4* or to the conveyer.

The air speed on the net part can be less than transporting speed or more than terminal velocity, because only dust is transported in the duct pipeline and the mass concentration of aero mixture is negligible.

Transporting speeds and terminal velocities of wood dust can be determined from the formula [2]:

$$\upsilon_{mp} = c \cdot \left(4 \cdot \mu \cdot \frac{\upsilon_в}{\upsilon_м} + 0{,}01 \cdot \rho_м + b \right) \cdot \sqrt{\frac{1{,}2}{\rho_в}} =$$

$$= 1{,}1 \cdot \left(4 \cdot 0{,}02 \cdot 1{,}1 + 0{,}01 \cdot 500 + 7\right) \cdot \sqrt{\frac{1{,}2}{1{,}2}} = 13{,}2 \text{ m/sec}.$$

where c = 1, 1-the coefficient, which considers the speed decrease in the local consumptions; $\rho_м$ – the density of the material, kg/m^3; $\rho_в$ – the density of the air, kg/m^3; μ – the concentration of material, kg/kg; $\upsilon_в$ – the air speed, m/sec; $\upsilon_м$ – the material speed, m/sec; b – the experienced coefficient, which depends on the kind of the transporting material (for dust b = 7).

$$\upsilon_s = 0{,}14 \cdot \sqrt{\frac{\rho_м}{\left(0{,}02 + \frac{a}{h}\right) \cdot \rho_в}} = 0{,}14 \cdot \sqrt{\frac{500}{\left(0{,}02 + \frac{0{,}9}{3}\right) \cdot 1{,}2}} \approx 5 \text{ m/sec}$$

where a = 0,9- the coefficient, which depends on the shape of particle; h – particle thickness, mm.

According [4] the values of the dust transporting speeds belong to the interval:

$$m \cdot \upsilon_s < \upsilon_{mp} < n \cdot \upsilon_s$$

where $m \cdot \upsilon_s$ – the minimum value of the diphasic flow speed according to the kind of the transporting material, m/sec; $n \cdot \upsilon_s$ – the maximum value of the diphasic flow speed according to the economic conditions of the aspiration systems operation, m/sec.

The minimum value of the dust transporting speed is 9...10, 5 m/sec for the experimentally received meanings m = 1, 8, n = 2, 1. Satisfactory air speed by dust outlet will be about 6 m/sec in the duct pipeline. This air speed is scarce for the cyclone work, so it is necessary to install a speed reactor in the cyclone inlet.

Experiments were conducted with changing air consumption from 120 to 180 m^3/h. The aero mixture concentration was accepted within 0, 1…0, 5 kg/m^3. Results of the experiments are presented in the form of graphs (Fig. 3, 4).

Based on the graphic dependences in Fig. 3, 4, we can make the following conclusions:

– aerodynamic characteristic and, therefore, the consumption of the packaged duct collector net with 10 modes constitute insignificant part of all installation consumption;

– disconnection of temporary inactive machines from the aspiration net significantly reduces energy consumption for material transportation, although net consumption is increasing due to decrease of the air consumption. If you accept the coefficient of the synchronous working machines as 0, 6, that power consumption of energy consumption will reduce on 21, 2% in the experiment;

– the main wood waste mass (86-90%) falls in the vertical collector, thus it isn't necessary to transport it by expensive pneumatic methods, which need large energy consumption. There is a tendency to some insignificant decreasing of the accumulated waste mass with the increasing of synchronous working suctions. It can be explained by the difference between modes of the waste entrance in the collector shell. It is necessary to connect air channel of the suction to the collector shell, which is leaned angle 40 – 50º;

– the additional economy of energy consumption is about 40%, what is achieved by the main mass of large wood waste transfer induct pipelines on the short distance from machines to the packaged collector. It is helping to reduce pressure loss;

– only 8 – 13% of small factions of all waste mass gets in the cyclone, besides, the load slightly increases in the cyclone with the increase of the synchronous working machines quantity, although, the purification degree stays on the constantly high level (93 – 97%). It can be explained by the presence of speed reactor and small mass of the fine-dispersed dust ejected in the atmosphere.

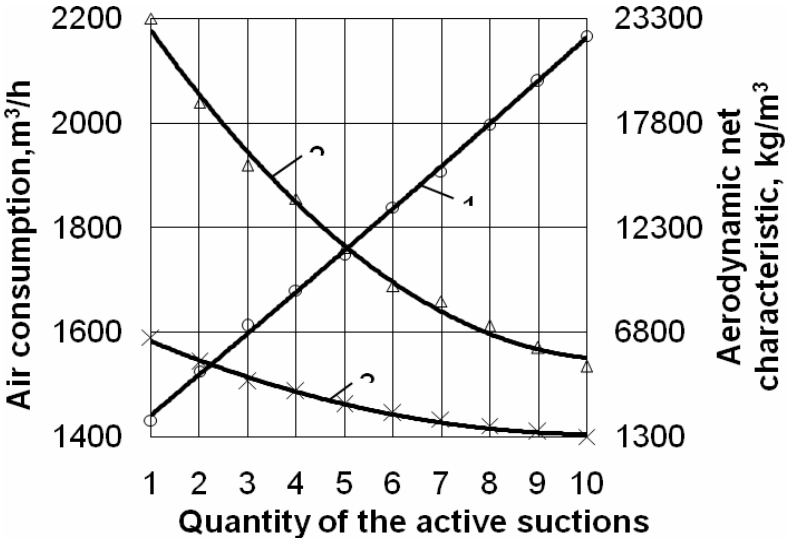

Fig. 2. Aerodynamic parameters of the aspiration system:
1 – air consumption; 2 – aerodynamic characteristic of the aspiration system;
3 – aerodynamic characteristic of the packaged collector net

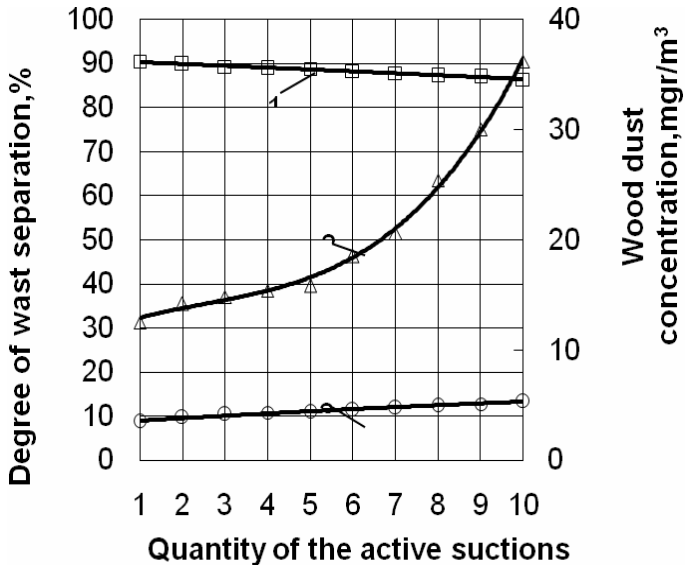

Fig. 3. The degree of waste separation with the improved aspiration system:
1 – waste quantity, which was separated in the packaged collector; 2 – dust concentration in the air ejections;
3 – waste quantity, which was separated by cyclone

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THE SYSTEMATIC APPROACH IN THE SOLUTION OF MODERN PROBLEMS OF ARCHITECTURE DEVELOPMENT

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Nowadays, the method of "systematic approach" is the most efficient in the solution of challenging tasks, incidental to the modern stage of development of planning and designing practice.

This approach is in some way universal methodology for investigation of urban development, architectural, esthetic, and artistic problems, etc. Today, there is no thought wave as for concrete content of "systematic approach". Furthermore, there are no terminological definitions of terms (i.e., the terms "theory of systems", "system analyses", "systematic investigation", "systematic methods" are widely used), but certainly, it is general principle, which requires investigation of objects and processes in their integrity.

The terms "theory of systems" and "systematic investigation" are clearly defined since their appearance. So, in the works of L. von Bertalanffy, the last stresses that the "theory of systems" investigates the principles related to the systems in general. As for "systematic investigation", it should be understood that it means "the complex of scientific and technical problems, tasks and developments, which having all different specificity are alike in dealing with the systems of one or other kind and nature. On the basis of this method any object of science or practice could be considered as the system".

The systematic approach to the solution of problems in architecture is set as top priority deductive analysis of problem – from the most complicated urban development systems to simple architectural tasks. So, it means the investigation from the functioning of the system in general to investigation its simple parts. The movement from up to down during the analysis of architectural systems is reasonable not because of great influence of human upon the nature, but because of the fact that decisions made, i.e., on the level of city system, are more responsible and important for all lower architectural sub-systems. That is why, taking up and investigating of architectural-territorial systems reasonably should be started from the top level. It is also necessary to take into account the fact that architectural-territorial systems are the component elements of a more complicated ecological system.

The human ecological systems could be divided into natural, artificial and mixed types. The pure artificial ecosystems nowadays are developed only in cases when human cannot exist in natural environment (in space, under water, etc.). The natural ecosystems are impossible on the modern stage of mankind evolution. That is why all human ecological systems, which are in the area of architectural investigations and designing, including trading services system, are mixed systems, which contain both artificial and natural elements.

Nature as environment of society life, impacts on it with its factors, making necessary the creation of artificial environment, which provides the conditions of protection and consumption of this objective, energy and information impact. The population impacts on nature and changes it only using "another nature". During interaction with the nature, the society is in functional unity with the objects of artificial (architectural) environment – with premises, buildings, urban areas, machineries, communications, etc. Undoubtedly, the human influences upon nature also directly, but these contacts are only of "passive" character and specific for biological systems. That is why only direct link "nature-population" exists.

In interaction of demoecosystem with the nature, it is the human who establish tactics and strategy, being in this system as motivator, means that here the main criteria are different from those generally accepted technical-economic criteria.

In the process of scientific analysis depending on the investigation task set, the architectural objects could be divided into components by two characteristics – functional and areal. As a rule, one of the above-mentioned characteristics is not enough to solve the task that is why in the majority of cases appears the necessity to create two interrelated models. The systematic approach requires first of all, the functional analysis of the object – its dividing into qualitatively different from the functional point of view elements.

V.A. Lefebvre investigating the problems of the objects as system, wrote the following: "when we look at human as functional element of social organism, then the human only due to its external relations is in integral unity with the elements of technics, household, sign system and finally, with its activity. And here, the special principles for dividing, not areal and time, but functional, are necessary."

So, the components of architectural object should reflect necessary from the functional point of view (system creating) kinds of activity, which characterize him as integral system. On the basis of this principle, all

kinds of activity, taking place in architectural system, can be conditionally divided into two groups: productive and communicative.

The first group includes the processes, which reflect the purpose of one or another system. The communication activity serves for material, energy and information transfer between all without any exception, components of the first group. Certainly, each component of these two groups of activity can in its turn be divided into its specific components. For example, the material element includes reproduction of population, creation of artificial environment (machinery, premises, buildings, etc.); the energy element can be represented as complex of activities for energy production and energy raw materials for machinery, foodstuffs for people; information element includes scientific, leading activity, etc.

Once again it is necessary to stress on conditionality of this division, which follows from necessity of accuracy of functional analysis: so, for example, for information activity the system needs materials and energy, which provide production, storing, transporting of the information of this type at the distance set, etc.

The division of architectural objects into functional components is qualitatively different from its areal division, where the population is separated as areal localized object and is a subject of structural analysis in the same way as artificial and natural environment. Certainly, during designing and forecasting of development of different levels integrity architectural systems, the more detailed division of system components is possible. And in this case it is necessary to follow strictly the correspondence of this or another area component to the level of hierarchy of the following system or subsystem.

The principle of interrelations of different levels architectural systems in that the result of formation of the system of the following level determines the area for possible decisions for the system of lower level. The detailed analysis can retrace, split any object into simple components, but it does not mean that on the basis of empirical knowledge after this analysis it is possible to create the integral structure needed, which is the most viable from the point of view of society vital function.

The general, formal definition of object and subject of investigation is insufficient for determination of structure and level of architectural system organization. It is necessary to determine clearly the borders of the system by the way of separation of main system creating elements and to disregard elements and relations which are unessential for decision making. The authenticity of scientific results depends upon the correctness of execution of this stage.

If refer to existing practice of determination of borders of architectural objects of different levels of complicity, then in number of cases it will be obvious that the optimization of objects which have no functional integrity, took place. So, for instance, it is difficult to make conclusions as for volume and area organization and economic practicability of the shop without taking into account the information on demography, level of welfare of population, etc.; it is impossible to tell about the practicability of shopping center not knowing the level of integrity and self-sufficiency of this object from the functional point of view. On some stages of urban development there were some attempts to build "optimum" city; with expansion and development of knowledge about mechanism of cities development it was stated that on modern stage of urbanization city is relatively integral object in functional sense, and its growth and functioning depend on character of the system of populated areas, the organic part of which it is. So, the background of formation and development of city are determined on higher level of architectural hierarchy.

TECHNOLOGY, MACHINE-BUILDING, GEODESY

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CARTRIDGE TOOLHOLDERS AND BORING HEADS FOR HIGH-PRECISION HOLES TREATMENT

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The analysis of cartridge tool holders and boring heads constructions was done, the constructions of micrometer adjustment of blades were considered, models and results of stress, displacement and safety factor for split bushing are shown.

One of the perspective ways of boring tools constructions development is using the principle when they are made from different modules. When we use this principle we increase the safety during their work and maintenance conditions by reducing the amount of module constructions. In addition the using of this modules in projecting reduce time and labor content for engineer this constructions, give the opportunities for using new methods of engineering.

Special attention is given for the constructions of micrometer adjustment and movement of cutting blades assemblies, cartridges and cutting blocks as well.

In connection with that there was the task to design block and module boring heads with micrometer blade adjustment for surfaces treatment that make it possible to:

- reduce the boring tooling variety that are used and thereby to reduce the cost for tool production;
- produce boring heads at the enterprises that are located in Belarus.

Foreign analog. Modern boring tool system includes: boring heads, single-point tool or cartridge tool holders (blocks or modules) for holders or block-module boring tool systems.

The major manufacturer of those tools at territory of CIS is JSC "Vint" (Russian Federation) [1]. The manufacturer offers hole boring systems in which are used single-point or double-point tool cutting blocks, tool holders for cutting tools mounting, cylindrical pilots with reducing bushings for cutters' mounting, cylindrical pilots for microbors' mounting.

The analyses of the patents. During the analyses of the patents of the boring heads were found out the next inventions.

In [2] is shown a boring head (Fig. 1), that consist of micrometer screw that is used as a tool holder1. On one end of the tool holder 1 is done a slot for a cutting blade 2, that is fastened for instance by clamping 3 with a help of screw 4 and on another end is based a key 5. The key 5 has an opportunity to slide by key slot of the cylindrical pilot 6 and prevents the spinning of the tool holder 1 round his axis. Index plate 7 and bushing 8 are joined with the tool holder 1 by thread. Index plate 7 is installed in body 9 with turning capacity. On the face of the body 9 for the accurate adjustment of the tool holder 1 the vernier 10 is done. Between bushing 8 and the body 9 the springing element 11 is installed.

a) b)

Fig. 1. Boring head. Sectional drawing (a) and assembly (b)

In boring head [3] the generation of the radial oversize in thread is made automatically by installing the boring head body into the cylindrical pilot. It could be done because the boring head that includes the body with the vernier, the index plate and the tool holder, with a shape of a micrometer screw on, one side of that is

fastened a cutting blade and on the other side is fastened a key. The tool holder is joined by thread with two nuts, which are separated in the axial direction by springing elements. One of the nuts is inflexibly joined with index plate and another is fixated in the body with a C-ring.

During the projecting process and development of the new boring instruments with micrometer adjustment of the cutting blade the main task was to solve the problem with clearance adjustment (to reduce for the necessary value) in the thread connection of the boring head. It was revealed that some factors that influence on the clearance value: the parameters of the slots on the bushing body and the stresses of prior pressing or wedging (for prior oversize).

For the purpose of estimation of slots influence on the accuracy of the thread connection was done the plan-matrix of the complete factorial experiment (CFE). In our case there were three factors: width of the slot, step and depth of the slot. To reduce the number of models we used two levels of each factor. Thereby we had 8 models [4]. The plan-matrix of CFE is shown in table 1.

Table 1 – Plan-matrix of CFE

№	Width, mm	Step, mm	Depth, mm
1	0,5	1	18
2	0,5	2	18
3	0,5	2	21
4	0,5	1	21
5	1	1	21
6	1	1	18
7	1	2	18
8	1	2	21

For bushings estimation during it's stressing according to the plan-matrix of the experiment was done eight models and their analysis (Fig. 2).

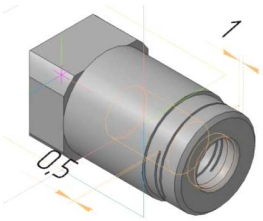


Fig. 2. Solid model of the bushing

All models were divided into final elements with a help of KOMPAS 3D V13 SP1 APM FEM library while stressing them were gotten data about stresses, displacements and safety factors of models. The results were shown as distribution maps of stresses, displacements and safety factors (Fig. 3).

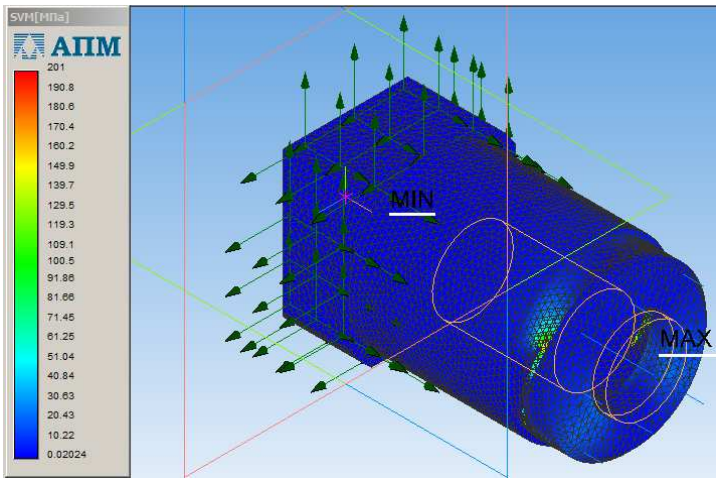
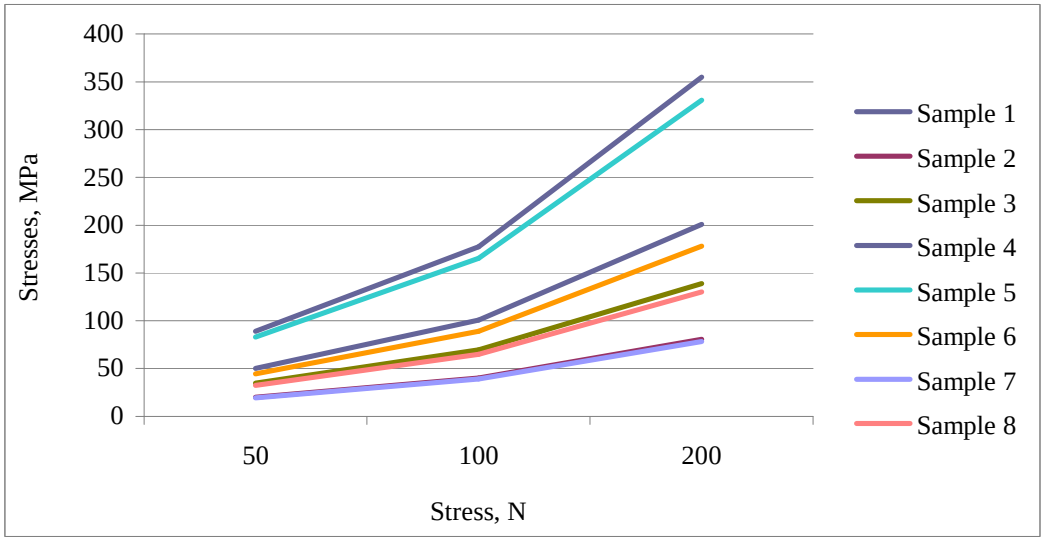


Fig 3. Example of distribution map of stresses

The results of distribution maps analysis is shown on fig. 4.



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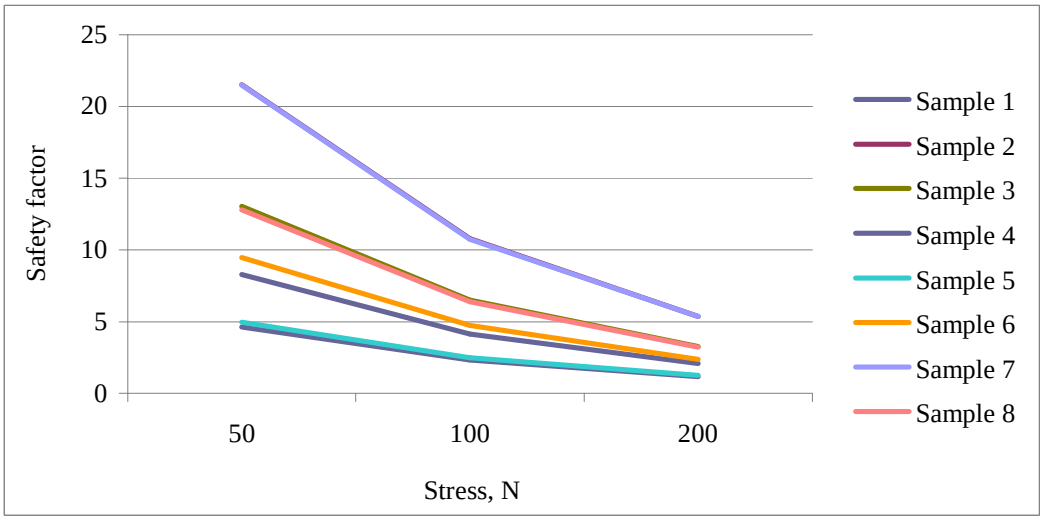

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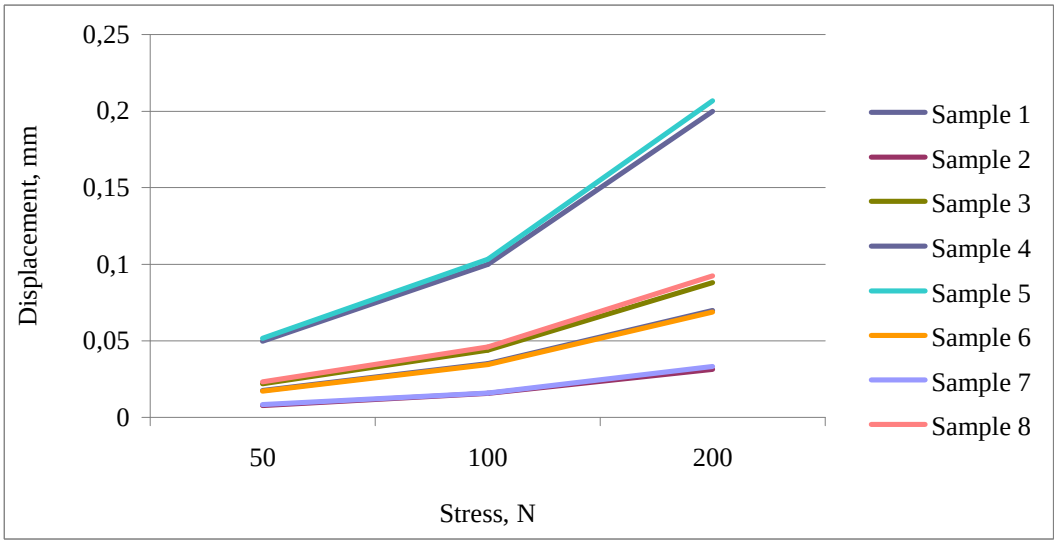

c)

Fig. 4. Dependence of stresses (a), safety factors (b) and displacements (c) in split bushing from stress

It is evident from these dependences that the most acceptable for the further experiments are samples 3, 5, 6 and 8, because they don't have so many stresses, because that could cause very high value of safety factor. From all this factors we choose the most rational sample 5, because it has the highest level of displacements and secures the minimum clearance in the thread connection at any stress.

During the projecting of new boring heads and cylindrical pilots the foreign products of the world's leaders of instrumental industry, the analyses of the patents were done. The prior investigations of construction were done, the best results had the split bushing that had width and step of the slot twice longer then thread pitch and depth of the slot was 4/5 of bushing diameter. In further experiments we plan to ascertain which of the methods prior resize (pressing or release) is better for in thread connection and when the clearance in the thread connection will be at its minimum level.

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KINETIC REGULARITIES OF THE DIESEL FUEL HYDRODESULFURIZATION AT THE L-24/6 UNIT

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In accordance to Technical Regulations of the Customs Union TR TS 013/2011, the marketing of the diesel fuel class lower than K5 will be prohibited in the Republic of Belarus from the 1st of January 2015. The K5-class diesel fuel is produced on L-24/6 unit of JSC Naftan since 2012. The results of the study of the unit operation are presented in this article.

Hydrotreating is the process of the heteroatoms (S, N, O) removing from the feed by the hydrogenation of sulfur compounds, nitro compounds and oxygen compounds. Simultaneously the hydrogenation of unsaturated and polycyclic hydrocarbons occurs; the metal atoms also are removed [1]. The requirements of the technical, normative and legal documents limit the sulfur and polycyclic aromatic hydrocarbon content. It is not difficult for JSC Naftan to achieve the requirements for the latter due to the nature of the feed. To reduce the sulfur content to 10 ppm (environmental class K5), a deep modernization of equipment is required. With this aim the new reactor block has been built at the L-24/6 unit, which is the part of the Complex of Hydrotreating, Mild Hydrocracking and Rectification.

Since the main goal of the hydrotreating process is to remove sulfur compounds, the kinetics of the desulfurization reactions is studied in this research. The process takes place in an axial multibed reactor. The molecules of liquid and partially vaporized feed react with hydrogen molecules on the catalyst surface. In this reactor the Albemarle's catalyst system is loaded. This system is a combination of inert compounds, auxiliary low-active catalysts and main Cobalt Molybdenum hydrotreating catalyst KF-757. The scheme of the reactor is shown in Fig. 1.

The kinetics of the hydrotreating process is influenced by many factors, such as the reaction temperature, the time that reactants contact with catalyst, hydrogen partial pressure, total system pressure, boiling range of the feed, hydrosulfide partial pressure, uniform distribution of liquid flow through the reactor section, catalyst life-cycle, etc. [2] Some parameters are uncontrollable; some are nondescript in commercial unit conditions. The control of hydrotreating process primarily carried out by temperature change in the reaction zone. The temperature is a part of the Arrhenius equation – one of the main chemical kinetics equations [3]:

$$k = A \cdot e^{-\frac{E_a}{RT}},$$

where k – rate constant;

A – pre-exponential factor, which characterizes the frequency of interacting molecules collisions;

E_a – activation energy;

R – universal gas constant;

T – temperature.

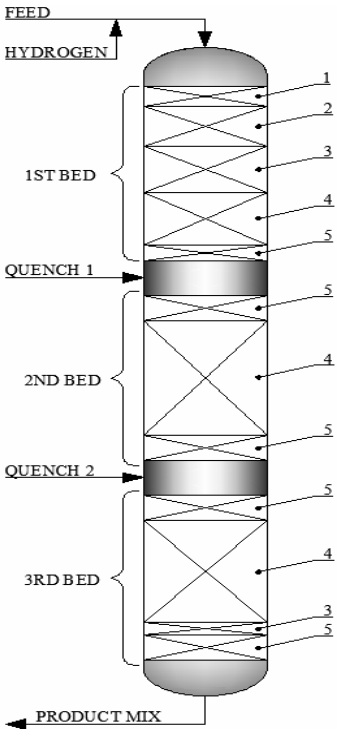

Fig. 1. The scheme of the reactor P-201:
1 – inert filling KG-55; 2 – olefin hydrogenation catalyst KG-542; 3 – denitrification and hydrogenation catalyst KF-841; 4 – desulfurization catalyst KF-757; 5 – inert filling (ceramic balls)

As the temperature changes along the reactor height, so the weighted average bed temperature (*WABT*) is considered commonly:

$$WABT_i = \frac{1}{3} T_{i,in} + \frac{2}{3} T_{i,out},$$

$$WABT = \frac{\sum (WABT_i \cdot V_i)}{\sum V_i},$$

where $WABT_i$ – weighted average bed temperature of the i-th catalyst layer;

$T_{i,in}$, $T_{i,out}$ – inlet and outlet temperature of the i-th catalyst layer accordingly;

V_i – volume of the i-th catalyst layer.

The using of the Arrhenius equation for the calculations allows to establish the relationships between such important and available for analysis parameters, such as reaction time (or inverse value – liquid hourly space velocity, LHSV), the sulfur content in feed and product, weighted average bed temperature [4, 5]. In this case the influence of other parameters is not considered. Typically, the value of these parameters (hydrogen content; the system pressure; flow rate of recycle gas, make-up gas and purge gas) does not vary significantly throughout the unit operation time.

As a result of study there was obtained dependences shown in Figures 2 – 5. The average annual technological and quality values were taken to make calculations:

volume feed rate	108,4 m^3/h;
sulfur content in feed	0,886 %wt.;
sulfur content in product	9,083 mg/kg.

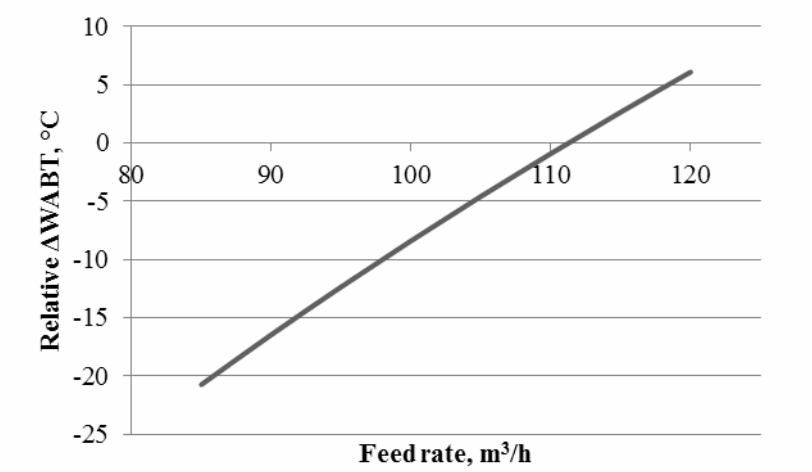

Fig. 2. Variation of weighted average bed temperature versus volume feed rate

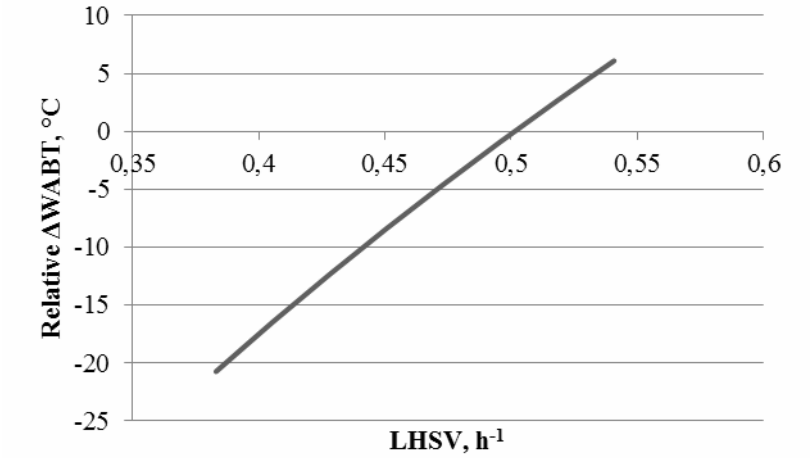

Fig. 3. Variation of weighted average bed temperature versus liquid hourly space velocity

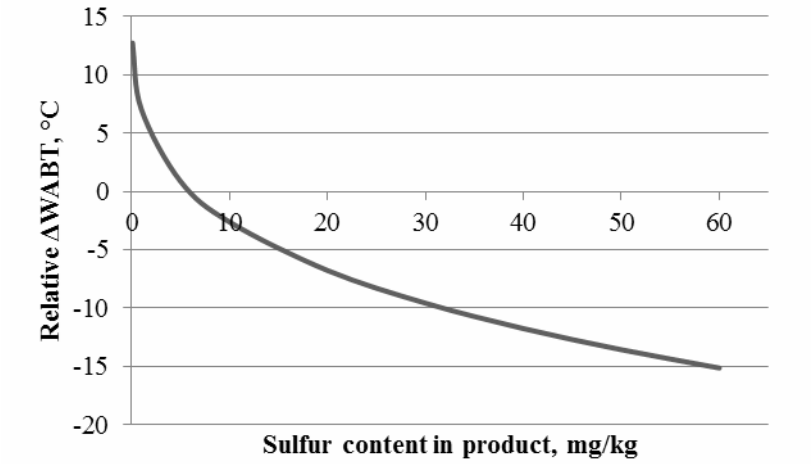

Fig. 4. Variation of weighted average bed temperature versus sulfur content in product

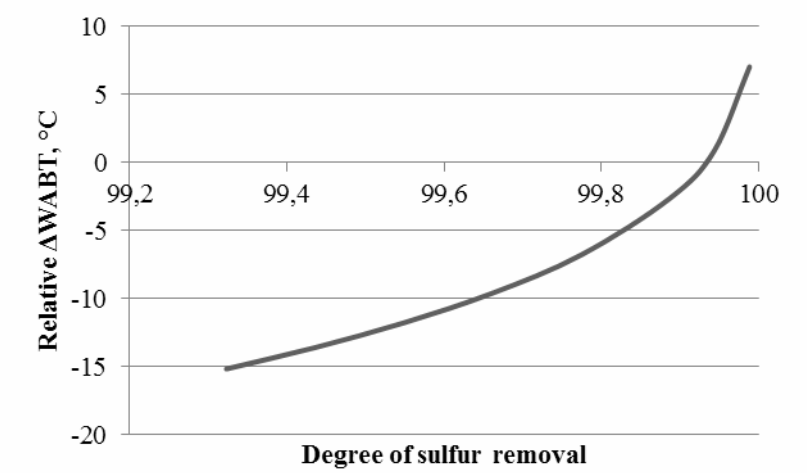

Fig. 5. Variation of weighted average bed temperature versus degree of desulfurization.

Due to the obtained graphs listed above, there is the possibility to predict required increasing or decreasing of the temperature in reaction zone. These changes can be caused, for example, by variations in productivity of the unit or by changes in desired degree of sulfur removing.

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TECHNOLOGICAL CHARACTERISTICS OF THE SURFACE OF THE CUTTING TOOLS AFTER THERMOCHEMICAL TREATMENT

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In modern machine industry more and more attention is paid to reliability and durability of the cutting tools. As a consequence, a large number of experiments and research for the purpose to increase life duration of cutting tools and their operating reliability is carried out. One of the methods to improve these characteristics is a thermochemical treatment.

Thermochemical treatment (TCT) is a universal method of surface alloying which provides formation of diffusion coatings on steel, cast iron, hard alloys.

Roughness of surface is one of the most important characteristics defining the operating characteristics of the cutting tool. Its value influences on the resistance of the cutting tool and on temperature and wear rate both of the front surface and the back surface.

Influence of the application of the diffusion layers on the surface roughness of the cutting tool is shown in Table 1. The surface roughness of the samples before and after saturation is evaluated on profilograph (model 201 according to State Standard 2789-73). Class of roughness was determined by the magnitude of the arithmetic average of profile R_a, which determined at five sites of test surface. Roughness of surface after

application of the diffusion layers exceeds the initial surface roughness by 1-2 classes. The exception is the process of diffusion chromizing, after which roughness is stagnant or even decreases.

Table 1 – Roughness of surface of solid alloys after thermochemical treatment

№ п/п	Type saturation	ВК6		ТТ10К8Б	
		R_a, micrometer	Class of roughness of surface	R_a, micrometer	Class of roughness of surface
1	Basic	0,22 – 0,26	9а – 9б	0,23 – 0,26	9а – 9б
2	Cr	0,19 – 0,23	9б – 9в	0,26 – 0,29	9а
3	Nb	0,66 – 0,77	7в	0,40 – 0,45	8б
4	Cr-Ti	0,61 – 0,62	8а	0,52 – 0,60	8а
5	Ti-Nb	0,61 – 0,72	7в – 8а	0,40 – 0,52	8а – 8б
6	Cr-Nb	0,70 – 0,80	7в	0,90 – 0,91	7б

ВК6, ТТ10К8Б [2].

The surface hardness of the samples after the thermochemical treatment is measured on a Vickers hardness tester of 100 N and a Rockwell hardness tester under load 600 N. The result is determined as the arithmetic average of 10 – 15 measurements.

Application of the carbide layers increases the hardness of samples when measured on Vickers device and slightly reduces the hardness on scale A of Rockwell device (Table 2).

Table 2 – Effect of the application of the diffusion carbide layers on the hardness of hard alloys

№ п/п	Type saturation	ВК6		ТТ10К8Б	
		HV	HRA	HV	HRA
1	Basic	1420	88,0	1530	89,0
2	Cr	1850	85,3	1850	86,0
3	Nb	1680	84,1	1850	83,2
4	Cr-Ti	2290	87,6	3200	88,4
5	Ti-Nb	2830	86,9	1850	87,8
6	Cr-Nb	2320	87,8	2190	88,5

In the process of metal cutting most of the mechanical work, which expended in the cutting process, is converted into heat. The temperature in the cutting zone has a significant influence on the cutting process and tool wear.

Carbide layers give high wear resistance at high temperatures to carbide tools, reducing the tendency to seizure and improving chemical stability, criterion which is to enhance the oxidation resistance.

Heat resistance of the samples with and without diffusion layers is determined by the gravimetric method according to State Standart 6130-71. Test temperature is selected to 800°C in an air atmosphere. Selecting the test temperature of 800°C because, when the surface of the metal cutting, inserts is heated to the same a temperature. To simulate the conditions of the real cutting process, the heat resistance inflicted diffusion coatings was determined by cyclic heating samples by measuring the weight gain after 20 minutes of heating at a total exposure time temperature for 2 hours. Each result was obtained as the average of 4 - 5 measurements. The quantity of heat resistance was evaluated by the increase in weight of the sample divided by the surface area of the sample according to the formula:

$$K = \frac{q_1 - q_0}{S_0}, mg / sq.cm \ , \quad (1)$$

where q_1 and q_0 – the mass of samples before and after heating; S_0 – the surface area of the sample before test.

Samples measuring 12,5 x 12,5 x 4,75 mm. The thickness of the diffusion layers was 1-15 micrometer. The test results on the heat resistance of the alloy samples ВК6 and ТТ10К8Б, at two-component saturation (t =

1000°C, 4 hour) showed significant improvements in oxidation resistance (the best score in carbide inserts subjected chromium-titanium).

When oxidized carbide alloy, then cross-section of the oxidized sample in the plane, parallel to the original surface has the shape of a Maltese cross. Appearance of such a sample with outgoing angles at the edges is a typical sign of easily oxidation on the surface of the section metal-oxide [1]. Porosity of scale explained volatility resulting oxide $W0_3$. Tungsten carbide is susceptible to oxidation to a greater extent than titanium carbide.

When happen combined saturation with forming in diffusion layer a titanium and niobium carbides, heat resistance curve has a smooth appearance, that can indirectly serve as proof of the formation of mixture carbides in layer.

Differents in heat resistance of carbides can be explained as follows. When oxidized carbides side by side oxidation of metals, then form gaseous oxides of carbon and nitrogen, that loosen the oxide film. Protective ability of oxides can be roughly estimated by relation Pilling-Berdvards:

$$\alpha = \frac{M \cdot d}{m \cdot D}, \quad (2)$$

where M – molecular weight of the oxide, resulting in the oxidation of 1 mol of a compound; m – molecular weight of the oxidized compound; D, d – density of the oxide and compound.

This relation shows how the specific volume formed by the interaction with the external environment of the oxide is more or less than the specific volume of the oxidized compounds. If the value is $\alpha < 1$ oxide film formed is not solid, that causes a continuous oxidation; if the value $\alpha > 1$ forms a protective oxide layer, hindering the access of oxygen to the compound. For large values of the oxide layer, it receives large internal stresses, has brittleness and loses its protective properties. The greatest protective properties have oxide layers, which somewhat greater than 1. Pilling-Berdvards values for some carbides are given in table 3.

Table 3 – Values of the Pilling-Berdvards' criterion

	T_iC	Z_rC	N_bC	T_aC	Cr_3C_2	Mo_2C	WC	VC
Relation of Pilling-Berdvards	1,53	1,42	2,22	1,91	1,17	3,56	2,72	3,45
$t°$ of active oxidation, °C	1100 – 1200	1100 – 1200	900 – 1000	900 – 1000	1100 – 1200	500 – 800	500 – 800	800 – 900

1. It is revealed that roughness of surface of carbide cutter insert after thermochemical processes increases, excluding the diffusion of chromium plating, after which roughness is stagnant or even falling.

2. After thermochemical treatment of solid sintered alloys, increased their heat resistance and microhardness of the surface layer. Better heat resistance have hard alloys with application of chromium carbide layers, which is consistent with the data obtained by Pilling-Berdvards' criterion.

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UDC 656.051

CROSSROADS

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Traffic on roads may consist of pedestrians, ridden or herded animals, vehicles, streetcars and other conveyances, either singly or together, while using the public way for purposes of travel.

A road junction is a location where vehicular traffic can change between different routes or directions of travel.

Roads were initially built as rights of way to link locations of interest: towns, forts and geographic features like fords. As a result, many such locations formed the meeting point of such roads and they became the first road junctions. Where roads met outside of town, these junctions provided an attractive point to build a new settlement, such that they could receive passing trade from both directions. Scotch Corner is an example of such a location.

In the United Kingdom and other countries there is a practice of giving names to junctions to help travellers find their way. On older rights of way it was often the practice for a pub to be located at the Junction to maximise passing trade, and the junction has since become known by the name of the pub (even in cases where the pub has since been demolished). Other junctions may be named after local natural or man-made features.

However, with the 20th century advent of road traffic, roads became much busier and junctions became clogged with vehicles unable to cross each other's paths. In modern practice, bypasses and ring roads are used to keep through traffic out of major population centres.

Intersections are classified as 3-way, 4-way, 5-way, 6-way, etc. depending on the number of road segments (arms) that come together at the intersection.

– 3-way intersection – A junction between three road segments (arms) is a T junction (two arms form one road) or a Y junction.

– 4-way intersections usually involve a crossing over of two streets or roads. In areas where there are blocks and in some other cases, the crossing streets or roads are perpendicular to each other. However, two roads may cross at a different angle. In a few cases, the junction of two road segments may be offset from each when reaching an intersection, even though both ends may be considered the same street.

– 5-way intersections are less common but still exist, especially in urban areas with non-rectangular blocks.

– 6-way intersections usually involve a crossing of three streets at one junction; for example, a crossing of two perpendicular streets and a diagonal street is a rather common type of 6-way intersection.

– Seven or more approaches to a single intersection, such as at Seven Dials (London) are rare.

– Another way of classifying intersections is by traffic control:

– Uncontrolled intersections, without signs or signals (or sometimes with a warning sign). Priority (right-of-way) rules may vary by country: on a 4-way intersection traffic from the right often has priority; on a 3-way intersection either traffic from the right has priority again, or traffic on the continuing road. For traffic coming from the same or opposite direction, that which goes straight has priority over that which turns off.

– Yield-controlled intersections may or may not have specific "YIELD" signs (known as "GIVE WAY" signs in some countries).

– Stop-controlled intersections have one or more "STOP" signs. Two-way stops are common, while some countries also employ four-way stops.

– Signal-controlled intersections depend on traffic signals, usually electric, which indicate which traffic is allowed to proceed at any particular time.

– A traffic circle is a type of intersection at which traffic streams are directed around a circle. Types of traffic circles includeroundabouts, 'mini-roundabouts', 'rotaries', "STOP"-controlled circles, and signal-controlled circles. Some people consider roundabouts to be a distinct type of intersection from traffic circles (with the distinction based on certain differences in size and engineering).

– A box junction can be added to an intersection, generally prohibiting entry to the intersection unless the exit is clear.

– Some intersections employ indirect left turns to increase capacity and reduce delays. The Michigan left combines a right turn and a U-turn. Jughandle lefts diverge to the right, then curve to the left, converting a left turn to a crossing maneuver. These techniques are generally used in conjunction with signal-controlled intersections, although they may also be used at stop-controlled intersections.

A fork (literally "fork in the road") is a type of intersection. When a road splits, the main road steers to the left or right, depending of what side you drive on, and the smaller road heads straight. It is common for 2 lane roads. Heading toward the main road, the traveler must turn left or right. If a road has a curb that sticks out, it is not classified as a fork.

In some places, wider white stop lines (see preceding diagram) indicate where vehicles should stop at an intersection when there is a stop sign or a red light in a traffic signal facing them. Some intersections have pedestrian crosswalks designated on the street pavement. Some possible markings for crosswalks are shown as examples. Note that the stop line is positioned to not allow stopped vehicles to block the crosswalk.

Ghost Island priority junctions are sometimes used in the United Kingdom to provide safer turning areas, which separate turning traffic from through traffic in a similar way to turn lanes (see above).

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UDC 614.8.086:331.453:665.6:681.3.06

FUZZY MODEL OF THE EXPERT ASSESSMENT OF OCCUPATIONAL RISKS ON THE EXAMPLE OF THE WORKING CONDITIONS OF EMPLOYEES AT THE OIL REFINERY PLANTS

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Fuzzy model of the expert assessment of occupational risks to employees' health at oil refineries is presented in the article.

At the present stage of development of socio-technical systems, a convenient instrument of the modeling of complex dynamical processes under conditions of uncertainty and multicriteriality is the application of the fuzzy sets and fuzzy inference theory [1 – 3].

Impact of production factors on oil refinery employees is difficult to predict and depends on various circumstances and conditions. Therefore, the decision making procedure to determine the professional risks level is a complex of variables of different nature. For this reason it is expedient to use fuzzy model for occupational risk assessment.

This paper presents fuzzy model and results of using fuzzy model for occupational risks assessment of the employees' health at oil refineries.

The fuzzy model includes three fuzzy inference system FS_1, FS_2 and FS_3 (Figure 1) [4 – 5]. Input variables of the first fuzzy inference system are the probability (frequency) of hazard (P_i), which considers prescription of accident (K_i), severity of the consequences of hazards influence (S_i), and the duration of hazards exposure (D_i). An output variable of the first fuzzy inference system is occupational risks level ($R_{ОПФi}$), which caused by unsafe hazard. The occupational risks level is used as a basis for making a decision about the necessity of risk management actions.

Two variables are accepted in second fuzzy inference system: class of working conditions – ($КУТ_i$) and relative risks (OP_j) for a certain class of diseases. The result of the fuzzy inference of the second system is a linguistic variable – "professional risks of occupational hazard effect "($R_{ВПФi}$).

The first variable of the third fuzzy inference system – is hazard index ($ИВ_k$) for a certain profession or a structural subdivision. The second variable ($FS_{3)}$ is a number of temporary disability cases due to all illnesses per 100 employees ($ЗВУТ_k$). An output variable of the third fuzzy inference system is "occupational risks of complex effect of production hazards" ($R_{ВПФk}$).

One of the steps of fuzzy inference is a development of rule base by expert. There are 125 rules for FS_1, and 25 rules each for FS_2 and FS_3.

On the basis of expert assessment and the principle of linguistic pattern recognition, it is determined that the changes of input variables can be most thoroughly described by terms, which have triangular membership functions (except the input variables OP_f and $ИВ_k$ and output variables $R_{ОПФi}$, $R_{ВПФi}$, $R_{ВПФk}$, which are characterized by trapezoidal membership functions).

As an algorithm for fuzzy inference algorithm Mamdani is adopted. Assessment of the professional risks level to employees of oil refineries caused by *i*-th hazard (for the *k*-th profession) consists of the following steps:

1) identify input parameters $FS_{1–3}$ by recognized expert and statistical methods;

2) perform fuzzification of input parameters values by finding appropriate graphic framework of the membership function terms ($X_{1j} – X_{7j}$) on the basis of the values of quantitative or qualitative criteria in step 1 (i.e, the values of P_i, S_i, D_i, $КУТ_i$, $ИВ_k$, OP_f, $ЗВУТ_k$);

3) determine the degree of validity conditions for each of the fuzzy rules productions;

4) construct the resulting membership function for the output parameters ($R_{ОПФi}$, $R_{ВПФi}$, $R_{ВПФk}$) in relation to the degree of the validity of all production rules;

5) calculate the resulting (fine) value of output parameters ($R_{ОПФi}$, $R_{ВПФi}$, $R_{ВПФk}$) by defuzzification using the center of mass method;

6) decide on the admissibility and the need for preventive managerial impacts on set in step 5 professional level.

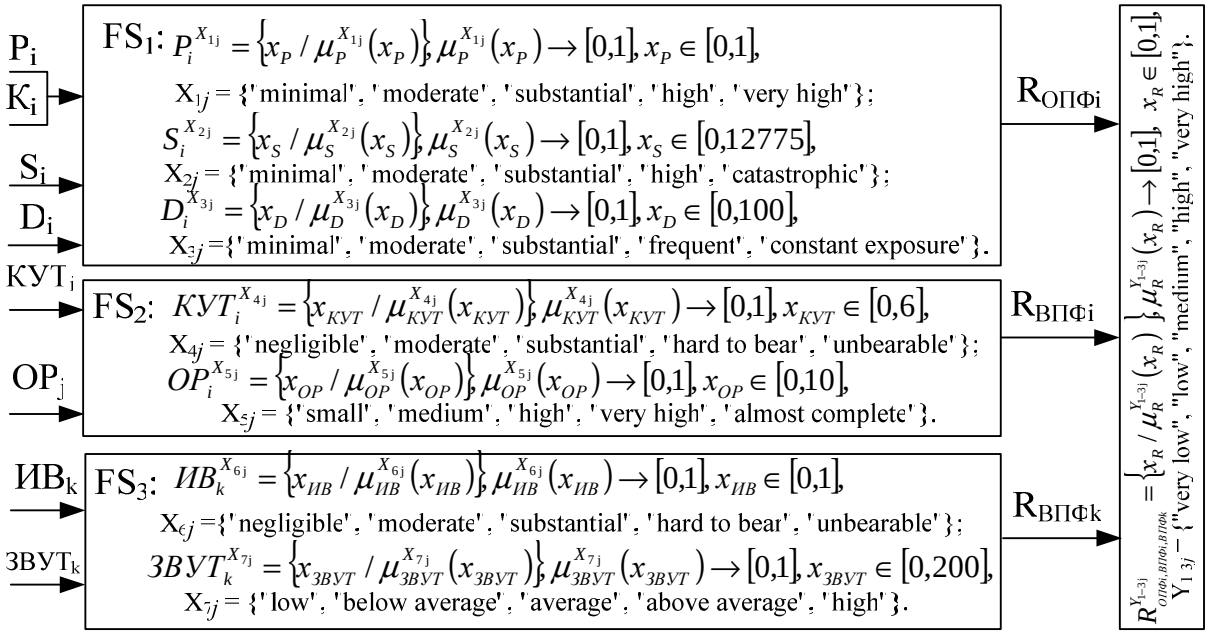

Fig. 1. Fuzzy inference system in occupational risks assessment model: X_j, Y_j – values of linguistic variables (terms). Expression: $A = \{x/ \mu_A(x)\}$ – a set of ordered pairs of fuzzy subsets of A, where $\mu(x)$ – the membership function of the underlying variable x to a subset A

This model is used for simplification and improvement of the quality assessment of the level of occupational risks. The model was implemented in software on programming language C# in the development environment of Microsoft Visual Studio 2010 Express Edition. The results of occupational risks assessment for workers at JSC «Naftan» which were obtained based on FS_3 software are presented in table 1.

Table 1 – Occupational risks assessment for workers at JSC «Naftan»

Structural subdivision	Level of the risks	Confidence level, %	Risk category
Petroleum fuels and aromatic hydrocarbons	0,47	100	middle
Production of lubricating oils and bitumens	0,51	100	middle
Repair production	0,70	100	high
Production of electricity and wastewater treatment plants	0,54	100	middle
Tankage facilities	0,70	100	high
Workshop electricity	0,50	100	middle
Workshop of instrumentation and automation	0,56	94	middle
Central Laboratory	0,50	100	middle
Motor transport workshop	0,51	100	middle
Workshop equipment base	0,70	100	high
Production of additives	0,54	100	middle
Oil refinery as a whole	0,59	56	middle

According to presented result employees of following subdivisions are exposed to high level risk of complex influence work environment: tankage facilities, base equipment and repair department. There is a need to develop preventive control solutions to reduce risks.

Application of the proposed fuzzy model of occupational risks assessment for the health of employees at oil refinery plant could facilitate taking adequate administrative decisions on elimination or limitation of the negative impact of production factors under uncertainty and, as a result, improve the quality of the occupational health and safety management system.

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UDC 681.5

APPLICATION OF TECHNOLOGY OF LASER SINTERING OF METAL POWDER

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One of perspective directions of creation of automated production is using technology of direct metal laser sintering (DMLS). The essence of this technology is paired computer-aided design (CAD) with auto manufacturing parts using special devices – 3D printers.

In view of the development of scientific and technical progress, we have an actual problem of complex automatic and robotic equipment. Moreover, due to the massive creation of flexible production it is necessary to develop mobile, single and small-scale manufacturing units. A feature of these developments is that most of the issues involved in creating technological complexes fall in the conjugation technologies, such as mechanics and electronics, electronics and IT. That is why most discoveries nowadays raise issues of interfacing technologies. This technology covers metallurgy, electronics, optics, quantum physics and IT.

Laser sintering of metal is a kind of additive synthesis technology.

Direct metal laser sintering (**DMLS**) is an additive manufacturing technique used for the low volume production of prototype models and functional components (fig.1) [1].

The technology has many benefits over traditional manufacturing techniques. The ability to produce quickly a unique part is the most obvious advantage because no special tooling is required and parts can be built in a matter of hours. Additionally, DMLS allows for more rigorous testing of prototypes. Since DMLS can use most alloys, prototypes can now be functional hardware made out of the same material as production components [2].

So, the benefits are:

- a significant increase in production flexibility;
- an excellent mechanical properties of items;
- improving the competitiveness of production;
- reduction of production costs, especially for a small-scale production;
- greatly reduces computer numerical control (CNC) & electrical discharge machining (EDM) costs;
- reduction the time to market new products;
- the integration of computer technology and CAD systems [3].

The main problem is the hardware to ensure accuracy in the manufactured products. Key issues to ensure accuracy are the following:

- preparation of metal powder for sintering;
- selection of lasing mode;
- ensuring of the positioning of the reflecting mirror;
- focusing of laser beam.

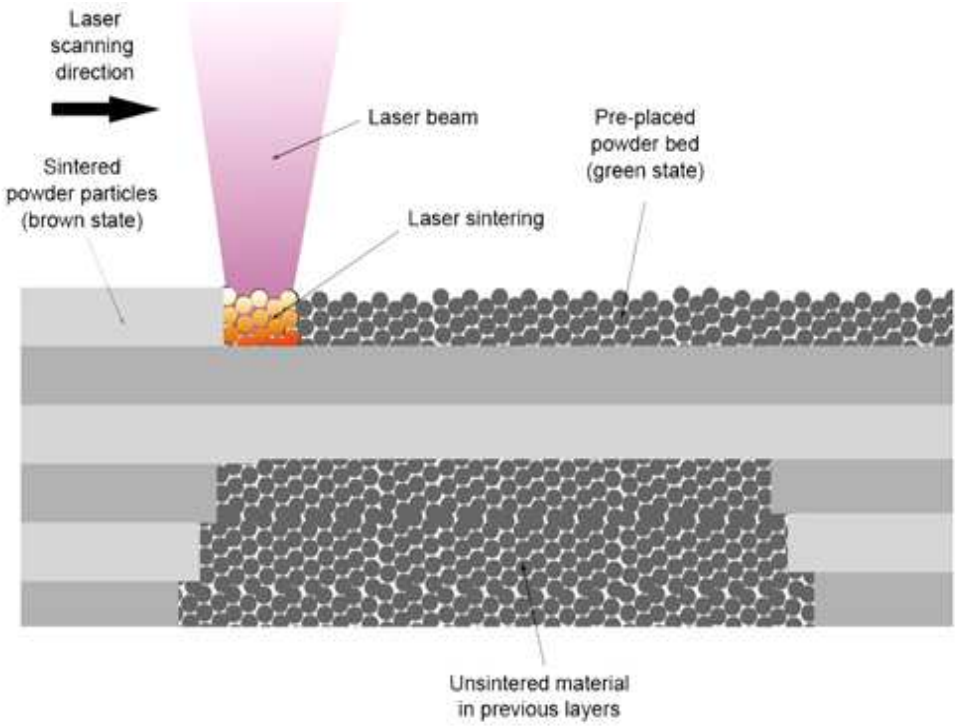

Fig. 1. Process of laser sintering

Before laser sintering (scanning) a powder mixture is aligned by a special roller (fig. 2). One of the most difficult problems of the sintering process of metal soot is heat transfer in porous environment, i.e. investigation of thermal fields arising in the powder layer with pulsed laser treatment.

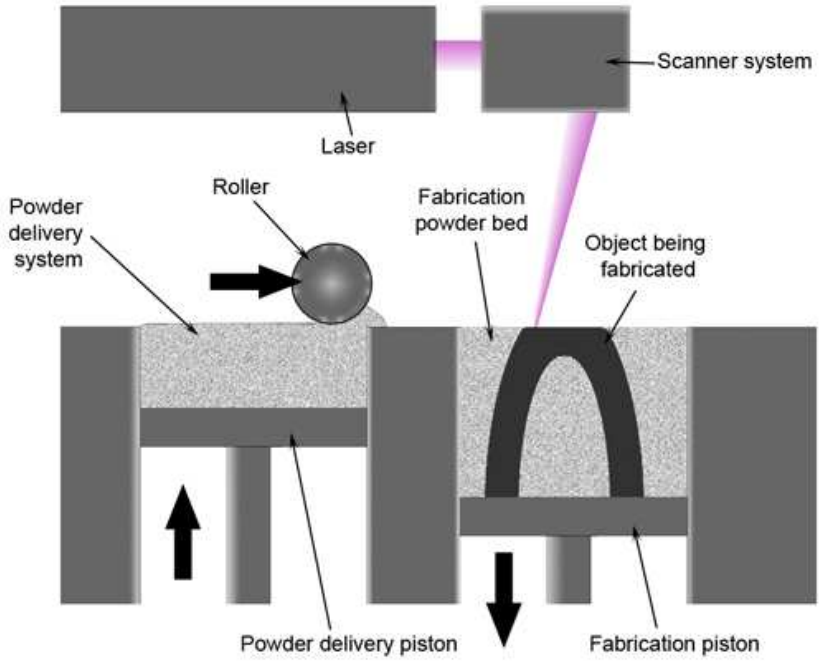

Fig. 2. Process of laser sintering

In laser 3D-printers an executive body uses solid-state lasers. As the active body used a rod of ruby or glass doped with neodymium or YAG doped with neodymium or ytterbium. It is located in the lighting chamber. To excite the atoms of the active body a lamp pump is used. The lamp pump creates a powerful flash of light.

Power of laser is chosen according to the boiling point of the powder, the thermal diffusivity, the shape and the average particle size to prevent burning of the sample. It is extremely difficult to pick out empirically the optimum value of power. The need to achieve a state in which the liquid phase in the powder layer is about 15% does not allow preventing the melt to be overheated, leading to the formation of a fluidized layer.

There are servo motors as components of precise equipment in printer. The basis of a sensor system consists of different contact and contactless sensors.

3D-printers software is divided into three categories (fig.3):

1) Computer-aided design. In a few minutes, you can create three-dimensional physical body and even assembly units of any complexity.
2) Drivers and utility programs that convert files with 3D-object in a machine understandable byte code.
3) SCADA-systems are used for industrial purposes in lasting production processes.

Fig. 3. Stages of manufacture: from modeling to fabrication of a physical body

This technology is used to manufacture direct parts for a variety of industries including aerospace, dental, medical and other industries that have small medium size, highly complex parts and the tooling industry to make direct tooling insert.

With this technology, you can make parts of any complexity.

Technology of DMLS allows to prepare implantsprosthetics and guides for surgery (fig. 4) [4].

Fig. 4. Printed jowl implant

No less interesting direction of DMLS is micromachining (fig. 5) [5].

Fig. 5. Elements of micromachining.

The process of creating of 3D-models has ceased to be difficult and time-consuming. Furthermore, now it is more economical and allows increasing significantly the flexibility of production. Moreover, it reduces the number of technological processes in production.

The use of this technology is especially important in mobile and rapidly developing IT-industries because the equipment for such production can be easily transported and operated. This technology allows producing an original product – machine parts or components of a piece of equipment – in any conditions.

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APPLICATION OF POLYACRYLAMIDE IN MODERN WORLD

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This article is about the industrial application of such a perspective material as polyacrylamide.

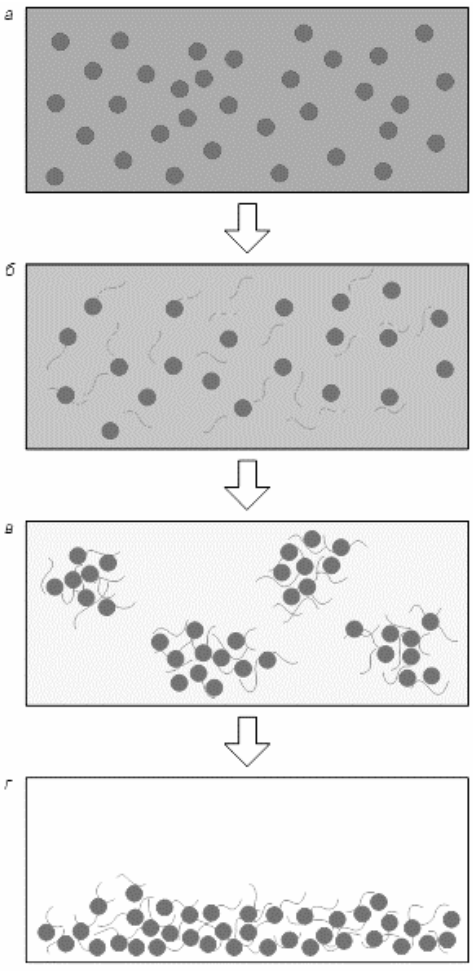
Currently ecology becomes a strategic industry, affecting on all spheres of political and economic prosperity of the state . Natural resources, quality of life, health and life span and even future of the country – all of them depend on the ecological situation of the environment.

Protection of the environment from pollution is one of the major problem of modern society. Environmental pollution can be primarily seen in the quality of surface and groundwater that is used in water supply. The organoleptic and chemical properties of water deteriorate from the inflow of wastewater, stormwater and meltwater [1].

This happens due to the change in the structure of industry, physical and moral deterioration of sewage treatment plants, absence or lack of funds from enterprises, the weakening of control over their water protection activities.

In this regard, in the 21st century the main strategic direction of reconstruction of water supply for industrial enterprises is the creation of closed water systems, which is impossible without alteration and improvement of existing treatment facilities and introduction of advanced technologies and equipment. New perspective methods of wastewater treatment are flocculation, sorption, membrane and oxidative methods [2].

Among the effective ways of intensifying existing technologies of natural and waste waters purification is the use of high-molecular flocculants alone or together with inorganic coagulants. Only due to the widespread introduction of physico-chemical treatment of industrial wastewater using coagulants and flocculants can provide effective 97-98 % removal of colloidal and finely impurities such as oil, grease, dyes, surfactants, etc.



Now a little more about the process of flocculation. Flocculation is the process in which the contamination particle of wastewater and high molecular weight substances (flocculants) interact. Thus, during the flocculation process takes place flocculation (macromolecular substances react with particles in the purified wastewater) and three-dimensional aggregates (flocs, complexes) are formed [3].

The adsorption process occurs in two stages [4, 5]. First, each macromolecule attaches with several segments to a single particle (primary adsorption). Then, free segments fix on the surface of other particles linking them with polymeric bridges (secondary adsorption).

The picture 1 shows a schematic diagram of the binding of the dispersion particles.

Acrylic amide polymer (AAP) is the best substances for all this requirements.

The AAP was obtained for the first time in 1893, but due to poor resource base the development of its industrial production began only in the early 1950s. The AAP has an ability to polymerize in the presence of radical initiators and possesses multipurpose properties. That ensured the rapid establishment and expansion of the production of polymers. Initially, these polymers were used as flocculants for sedimentation and filtration of phosphate sludge processing technology of uranium ores and strength additives for paper, and later became widely used in various industries, agriculture and medicine as flocculants , thickeners , adhesives , lubricants, nucleators, and film formers. Despite the wide range of important civilian applications of the AAPs, their use in the defense industry has substantially limited the availability of scientific information about them. As a result, until the early 1970s there was little information in the literature on the production technology of polymers. In recent years, with improvement of the resource base it has been created a scientific base for the targeted development of polymers with desired properties, developed advanced methods for the synthesis of polymers – polymerization and copolymerization of acryl amide in concentrated aqueous solutions and dispersions. Methods of chemical modification of polymers have been developed. Currently the AAPs are produced by large firms in the U.S., Japan and many developed countries in Europe. They are the main suppliers of polymers on the world market, and in Russia, China and South Africa polymers are produced only for domestic consumption. The production of the AAP continues to grow steadily and by the end of the century is going to reach 400 thousand tons per year. However, growth rates do not satisfy the needs of production, which increases annually by 8 – 10%. It is, therefore, relevant to develop new and improve existing methods for the synthesis of perspective the AAP, its derivatives and copolymers of AA.

The AA polymers possess a unique set of useful properties and are widely used in various fields of engineering and technology. Now a few worlds about different applications and usages of polymers.

The AA water-soluble polymers are widely used as flocculants for efficient purification of natural and industrial wastewater, capture and release of ions of heavy metals and toxic substances. Their use contributes to environmental protection, and in particular the protection of natural waters [6]. The effective bonding of settling particles is promoted by the increase of the size of macromolecules in an aqueous medium as a result of increasing the ionic content of the molecular weight and the links in the chain. Small additions (0.02%) of partially hydrolyzed AAP are used in water reservoirs, irrigation ponds and swimming pools to decrease (up to 14%) the evaporation rate of water. Experts predict that in the future environmental degradation will inevitably cause the increase of polymer use for the treatment of natural and industrial wastewater. The AA polymers are also successfully used as flocculants in medical, microbiological and food industries, e.g. for the purification of sugar syrups and fruit juices.

One of the traditional application areas of the AAP is pulp and paper industry. Used as a pulp binder, the AAP additives help to retain filler and pigments in the wet and dry pulp and improve the structure of paper sheet surface and paper properties. For example, partially hydrolyzed AAP additive (2 – 23% hydrolyzation at pH 6 – 9) increases retention of the kaolin in the paper pulp by 30 – 35% [7].

Introduction of small additions of the AAP in water (0.001%) for cutting marble doubles the efficiency of a water jet cutter. The cutting effect of the water jet is similar to that of sand and water mixture, but does not destroy pipes and pumps of plant. Dust particles treatment with aqueous solutions of partially hydrolyzed AAP is successfully used to reduce dust in coal mines, refineries, asbestos plants, and during drilling.

Currently, due to the worsening energy crisis the AAP are becoming important in the oil industry. In this field, the polymers are used for different purposes. For instance, the polymers are used in the process of drilling as stabilizers, filterability regulators, boring accelerators, rock and soil forming agents for strengthening the walls of the well. During secondary oil production the AAP additives reduce the mobility of water injected into the reservoir, which helps to displace oil from porous rocks. Derived anionic and cationic AAP are used for the creating of aquifer protective screens and decreasing of water content in the produced oil. Aqueous solutions of the partially hydrolyzed AAP (with molecular weight = $(3,5 – 8) \cdot 10^6$ and the degree of hydrolysis of 1 – 30%) for the treatment of 400 wells over six years have yielded a profit of 2400%. The use of 1 ton of the "Temposkrin" reagent in the secondary oil production, obtained on the basis of AAP, can provide the extraction from a borehole of extra 1200 – 1500 tonnes of oil [4, 7].

Summarizing, we can say that today the leading position in producing and using belongs to such polymers as polyamides, acrylic and polyacrylic acid, a variety of analogues based on them. The reason for this, apparently, is the high effectiveness of this reagent, combined with the desired hydrophilicity, relatively low toxicity against lower animals. Relatively easy production of basic polymers (polyacrylamide, polymethyl methacrylate), universal and simple ways to modify them are also important factors for their wide use.

However, there is no AAP production on the territory of the Republic of Belarus, which makes actual the subject of the study. The existing technology of producing monomers on the plant"Polymir" of the JSC "Naftan" allows the production of acrylonitrile, which, in its turn, can be used for the production of polyacrylamide. Therefore, the aim of further research is to find the technology for industrial producing of AAP in Belarus.

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MUNICIPAL UTILITY WATER TREATMENT

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For more than 20 years there has been remarkable growth in the need for quality water purification by all categories of users – municipal, industrial, institutional, medical, commercial and residential. The increasingly broad range of requirements for water quality has motivated the water treatment industry to refine existing techniques, combine methods and explore new water purification technologies.

Water treatment can be defined as any procedure or method used to alter the chemical composition or natural "behavior" of a water supply. Water supplies are classified as either surface water or groundwater. The majority of public or municipal water comes from surface water such as rivers, lakes, and reservoirs. The majority of private water supplies consist of groundwater pumped from wells.

Most municipal water found in a city or community today has been treated extensively. Specific water treatment methods and steps taken by municipalities to meet local, state, national, or international standards vary but are categorized below [1].

Screen prefiltration. A coarse screen, usually 35 to 140 microns, at the intake point of a surface water supply, removes large particulate matter to protect downstream equipment from clogging, fouling, or being damaged.

Clarification. Clarification is generally a multi-step process to reduce turbidity and suspended matter. Steps include the addition of chemical coagulants or pH-adjustment chemicals that react to form floc. The floc settles by gravity in settling tanks or is removed as the water percolates through a gravity filter. The clarification process effectively removes particles larger than 25 microns. The clarification process is not 100% efficient; therefore, water treated through clarification may still contain some suspended materials.

Lime-soda treatment. The addition of lime (Ca) and soda ash (Na_2CO_3) reduces the level of calcium and magnesium and is referred to as "lime softening". The purpose of lime softening is to precipitate calcium and magnesium hydroxides (hardness) and then clarify the water. The process is inexpensive but only marginally effective, usually producing water of 50 to 120 ppm hardness.

Disinfection. Disinfection is one of the most important steps to municipal water treatment. Usually, chlorine gas is fed into the supply after the water has been clarified and/or softened. The chlorine kills bacteria. In order to maintain the "kill potential", an excess of chlorine is fed into the supply to maintain a residual. The chlorine level must be constantly monitored to assure that no harmful levels of chloramines or chlorinated hydrocarbons develop.

PH adjustment. Municipal waters may be pH adjusted to a pH of approximately 7.5 to 8.0 to prevent corrosion of water pipes, particularly to prevent dissolution of lead into the water supply. In the case of excessive alkalinity, the pH may be reduced by the addition of CO_2 [2].

Tank-type pressure filters. A typical filter consists of a tank to house the filter media and a valve or controller to direct the filter through its various cycles–typically service, backwash and rinse. Easily the most critical aspect of pressure filter performance is the relationship of flow rates to filter media surface area. This relationship is the primary cause of failure or trouble in filter systems. If problems develop, the most common reason is that many filters are inaccurately "sized" for the job. Some examples of pressure filters and their applications are [1, 3]:

1. **Sand filters**. Sand or other filtration media are used to remove turbidity. However, the location of the fine media on top of the coarse media causes the sand filter to clog quite quickly and the coarseness of sand allows many smaller impurities to pass through.
2. **Neutralizing filters.** Neutralizing filters usually consist of a calcium carbonate calcite medium (crushed limestone or marble) to neutralize low pH water.
3. **Oxidizing filters**. Oxidizing filters use a medium treated with oxides of manganese as a source of oxygen to oxidize and precipitate iron, manganese, hydrogen sulfide, and others.
4. **Activated carbon filters.** Activated carbon (AC) is similar to ion exchange resin in density and porosity. It absorbs low molecular weight organics and reduces chlorine or other halogens from water, but does not remove any salts. These filters must be changed periodically to avoid bacterial growth, but are not easily reactivated in the field. Accumulated solids require frequent backwashing of the filter unless installed after reverse osmosis or ultra filtration.
5. **Dual- or multi-media filters.** Dual-media filters remove suspended solids to as low as 20 microns in size, but no dissolved solids. The top layer is a coarse anthracite followed by fine sand.
6. **Pre-coat filters.** Usually with a media of diatomaceous earth, pre-coat filters remove very small particulate matter, including some bacteria (fig. 1). They are practical only for limited volume applications but are common for swimming pools, beverage plants, and small installations.

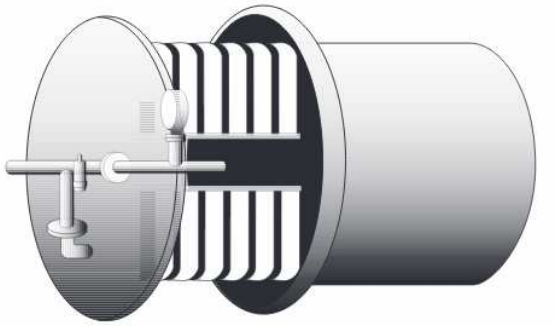

Fig. 1. Pre-coat filter

7. **Cartridge filters.** Cartridge filters can now be described two general ways: as depth filters or surface filters.
8. **Depth cartridge filters.** In a depth cartridge filter, the water flows through the thick wall of the filter where the particles are trapped throughout the complex openings in the media. The filter may be constructed of cotton, cellulose, synthetic yarns or "blown" micro fibers such as polypropylene. The best depth filters have lower density on the outside and progressively higher density toward the inside wall. The effect of this "graded density" is to trap coarser particles toward the outside of the wall and the finer particles toward the inner wall. Depth cartridge filters are usually disposable, cost-effective, and are in the particle range of 1 to 100 microns. Generally, they are not an absolute method of purification since a small amount of particles within the micron range may pass into the filtrate.
9. **Surface filtration–pleated cartridge filters.** Pleated cartridge filters typically act as absolute particle filters, using a flat sheet media, either a membrane or specially treated non-woven material, to trap particles. The media is pleated to increase usable surface area. Pleated membrane filters serve well as sub-micron particle or bacteria filters in the 0.1 to 1.0 micron range. Newer cartridges also perform in the ultra filtration range: 0.005 to 0.15 micron.

Electrodialysis (ED) and electrodialysis reversal (EDR) employ electrical current and specially-prepared membranes which are semipermeable to ions based on their charge, electrical current, and ability to reduce the

ionic content of water (fig. 2). Two flat sheet membranes, one that preferentially permeates cations and the other, anions, are stacked alternately with flow channels between them. Cathode and anode electrodes are placed on each side of the alternating stack of membranes to draw the "counter" ions through the membranes, leaving lower concentrations of ions in the feedwater [1].

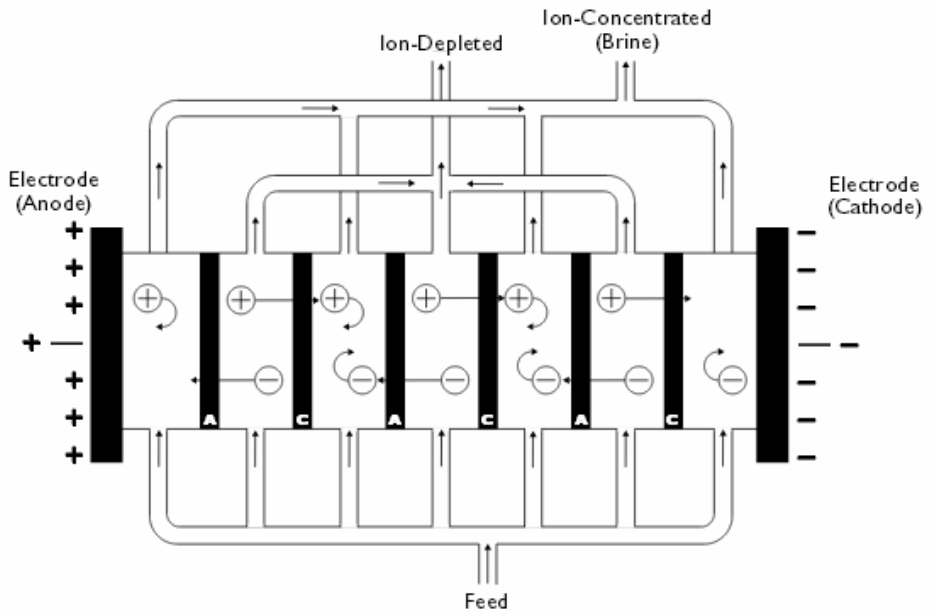

Fig. 2. Electrodialysis

The efficiency of electrodialysis depends on the ionic solids and fouling potential from organics and particles in the feedwater, the temperature, the flow rate, system size and required electrical current. Organics and weakly-charged inorganics are not removed by ED. Recent developments have improved the efficiency of ED by reversing the polarity of the electrodes periodically.

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UDC [544.725:66]=111

ABOUT THE APPLICATION OF INORGANIC MEMBRANES IN MODERN INDUSTRY

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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. Some examples of developments of new technology will be given.

Separation systems are a vital part of industrial processes. These systems account for a large fraction of the equipment and operating costs of industry. Separation processes are needed for everything from feed stock materials to pure end products. Inorganic membranes have the potential for significantly reducing both the equipment and operating costs associated with these separation. In addition, there is a serious emerging systemic problem of how to

reduce or eliminate waste and environmental pollution created by these processes. Inorganic membrane separations can recover and recycle materials; this will significantly reduce or eliminate waste streams.

Where are inorganic membranes now? Ten years ago industry all over the world showed a great deal of excitement about the potential use for inorganic membrane. Jean Charpin, in his plenary address to the First International Conference on Inorganic Membranes, gave the French CEA (*Commissariat à l'énergie atomique*) credit for that industrial interest in inorganic membranes because of their technology transfer program. It was very well deserved credit. The release of their inorganic membrane, an outgrowth product from their gaseous diffusion program, was a major contribution. It has stimulated a very large amount of new research. That program, which began in the late 1980s, gave the first commercially useful inorganic membranes. While there is a significant current market for the French membrane (manufactured by the French Company SCT and marketed by the US company *US Filter*), it is limited to a few special applications in nano- and ultra-filtration and its cost is high. Since then, there has been a large amount of useful research including modifications of the French membranes that resulted in demonstrations of large separation factors at a broad range of operating conditions. However, the availability of new commercial inorganic membranes has been very disappointing. Commercial development has been slow and the cost of methods to produce new membranes continues to increase. Industry appears to be losing much of the earlier excitement for the promise of inorganic membranes. Some experts (North American Membrane Society annual meeting, May 1994) believe that useful inorganic membranes simply are not viable. Nevertheless current research is gaining momentum. It has broad ranging, innovative, and producing good promising results and significant new exciting scientific information. Now some words about need of inorganic membranes for acceptance by industry. There are a number of criteria essential for inorganic membranes to be accepted by industry:

1) Large separation factors are needed to achieve economical enrichments in a single stage. The use of multiple stages is always a possible means for achieving a desired enrichment (e.g. uranium enrichment by gaseous diffusion), but multiple stages greatly reduce the economic potential.

2) High permeance is needed to reduce the size of the stage. However, the permeance of inorganic membranes is not as serious a problem as is usually perceived. The perception is that a large amount of membrane area is needed to produce a given amount of product. Large areas of organic membranes (spiral wound or hollow fibers) can be assembled into a given size module. Because of the configuration of inorganic membranes (usually tubes), the perception is that a much larger module is needed to assemble enough membranes to achieve the same throughput. For a given module size, organic membranes can be assembled with 1,000 to 10,000 times the amount of membrane area than can be achieved with inorganic membranes. But it is also true, for many applications, that inorganic membranes can be produced with 1,000 to 10,000 times the permeance of organic membranes. Therefore, it is reasonable to expect that the size needed to produce a given volume of product is about the same for inorganic membranes as for organic membranes.

3) Cost of the membrane modules must be reasonable and competitive. At present, the cost per unit area of inorganic membranes is about 100 times greater than the cost per unit area of organic membranes. However, as in the case above, if a given module requires 1,000 to 10,000 times more area than the inorganic module to produce a given volume of product, then the inorganic module would cost less than the organic module with respect to the amount of membrane required by the module for the same output. Because of this large difference in the permeance and thus smaller membrane area required for inorganic membranes, it is perhaps not appropriate to price inorganic membranes by the unit area.

4) Reliability is generally recognized to be inorganic membranes best advantage. They can be expected to have significantly longer useful lifetimes. They can be used in much more harsh corrosive environments. In addition, the openness and favorable hydrodynamics that can be achieved with smaller areas of inorganic membranes can significantly reduce fouling problems.

In order to achieve acceptance by industry, it is essential that scientists concentrate on developing practical working systems that can demonstrate the cost effectiveness and reliability of inorganic membrane systems.

The above comments were not intended to imply that inorganic membranes should be considered competition for organic membranes, only that the difference in cost is not nearly as large as is generally perceived. I do believe that inorganic membranes will eventually replace many of the organic membrane (but not all). However, at present, the most important applications for inorganic membranes are in processes for which the organic membranes cannot be applied. The major advantage of inorganic membranes is their operating range. That operating range includes high and low temperatures, high and low pressures, and all kinds of corrosive environments. The operating condition range not only allows the inorganic membrane to be used in these harsh environments, but also adds more freedom to the design of separation processes. By choosing the appropriate inorganic membrane and operating conditions, given processes can be optimized in terms of separation factors, permeance, and cost effectiveness.

In order to achieve a given separation, it is essential to choose a process in which the components have velocities that are as largely different from each other as can be achieved. Ideally, the component to be separated should have a velocity high enough to be economical, and the other component or components should have a zero velocity. The real beauty in inorganic membranes is the large number of transport mechanisms that can be utilized. These many transport mechanisms provide a large number of parameters that can be considered in designing an inorganic membrane to achieve a given separation. Included are such parameters as the physical and chemical properties of the material used, pore size, void fraction, and membrane operating conditions. When designing membranes it is important to have a theoretical basis for the design process instead of using the Edisonian or trial and error approach.

Inorganic membranes have the real potential for revolutionizing a large number of industries. That revolution can be in terms of the way the industry functions, the cost of doing business, the safeness of doing business, and the environmental soundness of doing business. Efficiency improvements and revolutionary changes can be made in many industries and separation processes such as those shown in the tables below.

Table 1 – Application of inorganic membranes in different industries

Industry	Application
Environmental Restoration	Recovery and Decomposition
Food Processing	Sterilization and Heat Recycle
Gas Production	Low Cost Purification, Replace Distillation
Microelectronics	Low Cost Ultrapure Water
Petrochemical	High Yield Membrane Reactors, Replace Distillation
Petroleum Refining	Recover and Recycle Hydrogen, Replace Distillation
Pulp and Paper	Closed Cycle Processing, Recovery from Waste Streams
Waste Management	Volume Reduction, Recycle
Water Purification	Sterilization, Ultrapurification, Replace Distillation

Table 2 – Potential for successful implementation of inorganic membranes for separation different substations

Separation Process	Potential For Successful Implementation of Inorganic Membranes
Hydrogen From Coal Gas	Excellent
Hydrogen From Methane/CO_2	Excellent
Hydrogen From Catalytic Reactors	Excellent
Photocatalysis	Excellent
Micro-Ultra-Nano Filter	Excellent
Cleanable Gas or Liquid Filters	Excellent
Reverse Osmosis	Excellent
VOCs From Air	Good
CO, From Methane	Fair
Nitrogen From Methane	Fair
Oxygen From Air	Fair

Inorganic membranes have great flexibility for assembly into almost any size module for commercial applications. For example, a small module might be made to produce a few gallons per day of potable water for home use. A large example might be a module assembled to produce millions of pounds per day of enriched natural gas. A real example of such a commercial size is a diffusion stage, near the feed point, in the U.S. gaseous diffusion plant where the interstage flow is about 100 million pounds per day when the plant is running at full power. The modular structure of the membrane units can be adapted to almost any configuration and environment for specific applications.

In conclusion we can say this paper presents beginning formalism towards understanding transport mechanisms important in engineering the design of inorganic membranes for the discussed applications and many more. The gaseous diffusion process for enriching uranium isotopes, still used around the world, has shown that inorganic membranes can be manufactured on a large scale. Inorganic membranes' potential for producing a new industrial revolution depends on the ability to understand and choose transport mechanisms, to precisely engineer membranes, to economically manufacture them and to rapidly transfer the appropriate technology to industry. National laboratories and private industry must form partnerships and begin working together doing what each does best in cooperative agreements to share their individual expertise in order to accomplish this goal.

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MECHANICAL CHARACTERISTICS OF SINTERED HARD ALLOYS WITH CARBIDE LAYERS

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Cutting tools made of hard alloys allow to improve the processing of parts for their cutting speed is 2-4 times higher than that of the tools made of high speed steel (HSS). In addition to this, a solid carbide tool can process hard materials that are difficult to process or not treatable at all by a HSS tool. The operational stability of carbide inserts is greatly influenced by mechanical properties changing during the deposition of carbide layers by CTP. This paper deals with the study of the mechanical properties of hard alloys with carbide layers.

In the process of thermochemical treatment of standard grades of carbide it is a change of chemical composition and structure of the surface layers, as well as the occurrence of internal stress, which has a certain influence on the mechanical and cutting properties of hard alloys.

Diffusion saturation surfaces of the insert of hard alloys simultaneously by two or more elements (multicomponent saturation) allow a much greater modification of the properties of the surface layer than that of the one-component saturation.

Cementation process is conducted in alumothermal mixtures on separate embodiment, a preliminary restoration of the mixture at a temperature of 800 – 1100◦C using reagents classification "chemically pure", "W".

Before performing the processes carbide plate was degreased, and then packed in a refractory vessel with a saturating mixture. For sealing the container shutter fuse boric anhydride was used. Maintaining the desired temperature in the furnace was realized automatically during the process of saturation.

The performance properties of the alloys with carbide deposited layers are influenced by the strength of adhesion layer with the substrate material, the ability of the diffusion layer to withstand static and dynamic loads, the absolute value and the nature of the residual stress distribution in the layer [1].

The study found that there is an optimum thickness of the diffusion layers, equal to 3.10 microns, at which mechanical properties of coated carbide maximized. The sharp decrease in values for carbide layers thicker than 10 microns says the deterioration of the adhesive strength of the layers obtained with the base, the accumulation of structural stress, the nature of the phase, which leads to chipping layer.

Carbide cutting process is a subject to high unit loads (both static and dynamic). For this reason, the output of their failure often occurs as a result of mechanical failure, which is why the mechanical properties of hard alloys largely determine their performance characteristics.

The most common measure used in the evaluation of mechanical properties of hard alloys is tensile strength transverse bending (determined according to GOST 20019-74).

The samples are used for testing ground capping (size 5 × 5 × 35 mm carbide TT20K9 GOST 3882-74). Tests were concentrated load applied at mid-span at the loading rate of 1 mm/min. Tensile strength transverse rupture was calculated by the formula:

$$\sigma_{изг} = \frac{M}{W}, \quad (1)$$

where M is a maximum bending moment; W is a moment of resistance.

For specimens of rectangular cross section transverse bending

$$M_{изг} = \frac{F \cdot l}{4}; \quad (2)$$

$$W = \frac{b \cdot h^2}{6}; \quad (3)$$

$$\sigma_{изг} = \frac{3 \cdot F \cdot l}{2 \cdot b \cdot h^2}, \quad (4)$$

where F is a breaking load, N; l is a span (distance between supports), mm; b, h are width and height of the sample, respectively, mm.

The results of investigation of the saturation conditions and the type of carbide layers on the tensile strength transverse bending carbide TT20K9 are given in table 1.

Table 1 – Tensile strength transverse bending carbide TT20K9 with different carbide layers

№ p/p	thermochemical treatment	Saturation mode, time 4 hour					
		t = 1000°C			t = 1200°C		
		$\sigma_и$, МПа	$\sigma_и/\sigma_{orig,}\cdot 100\%$	f, %	$\sigma_и$, МПа	$\sigma_и/\sigma_{orig,}\cdot 100\%$	f, %
1	Original alloy (uncoated)	1611	-	17,2	1611	-	17,2
2	(TiO_2:Nb_2O_5 =3:1)	1329	82,5	3,5	1158	71,9	4,8
3	(TiO_2:Cr_2O_3=1:1)	1331	82,6	5,3	958	59,5	5,9
4	(TiO_2:Cr_2O_3=3:1)	1333	82,7	6,1	1086	67,4	8,2
5	(Cr_2O_3:Nb_2O_5=1:1)	1041	64,6	3,8	980	60,8	4,4
6	chromium-plating	1222	75,9	3,0	1124	69,8	6,9

In all cases, after saturation at 1200◦C the greater decrease in strength of carbide than after saturation at 1000ºC was detected. This is due to the growth of the carbide layer, and as a consequence, increasing the thickness of the brittle η – phase.

Plate with carbide deposited layers is characterized by considerable homogeneity properties, which is very important when they are used as the material of the cutting tool on automatic, CNC machines and slot machines.

The table shows that the tensile strength in transverse bending after thermochemical treatment is reduced to 20 %, which is consistent with the results of [2], which refers to a decrease in flexural strength alloys of VC and TC for coating carbide titanium.

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UDC 621.81.004.67(035)

RESTORATION OF SHAFTS OF AGRICULTURAL MACHINERY

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Technical progress in agriculture is continuously connected with the constant improvement of repair production. Nomenclature of parts whose recovery is advisable for most repair facilities is continuously expanding. An important condition is to achieve quality of new parts at low costs. These circumstances necessitate the development and implementation in the repair manufacture resource saving technologies.

Limited public stocks of fuel and materials in Belarus cannot provide adequate reproduction of vehicle fleet forces and engineering along with its preservation, maintenance require the development of production, which saves a lot of labor and materials. Overhaul require, for example, seven thousand harvesters, 20 thousand tractor engines, 50 thousand vehicles, 150 thousand units of process equipment. Repair is economically feasible. About a quarter parts repair fund is not frayed or worn within acceptable limits and can be reused in their cost of 2-3%, and about half of the parts can be used after restoration at a cost of 15 – 30% of the price of new parts , respectively [1, 2]. Parts restoration retains a large number of materials, energy and labor.

Most agricultural machinery include internal combustion engines, and among the items to restore, crankshafts occupy a special place. The cost of one crankshaft domestic engines ranges from 10 to 25%, and foreign – from 20 to 50% of the motor [3]. During the operation they are subjected to torsion and bending lose initial accuracy and partially margin.

Wide application of coatings to restore crank allows you to return the functional properties of the surface and increase the structural strength of the product. Tensile strength and viscosity changes with applied coatings reducing or changing the chemical composition of the deposited alloy. The creation of various structures in the coating nonequilibrium transition zone increases the strength, hardness, wear resistance, but it lowers the fatigue strength.

During the deposition, in areas which are heated to a temperature above the phase transformation due to the rapid cooling , and , as in the weld metal, and the transition zone the following processes occur: burning of alloying elements, the occurrence of residual internal stress, formation of non-equilibrium structures such as carbon supersaturated and alloying elements, solid solutions, and increase the grain size (area of overheating), which have different effects on the performance of the shafts.

On the one hand, the metastable none quilibrium structures provide high hardness, strength and wear resistance of the surface layer parts, but on the other hand, the surface layers none quilibrium structure, increased grain size, internal residual tensile stress and lower the resistance to cyclic impact loading.

Because of uneven wear necks, short time overload motor uneven fuel into the cylinders, the cylinder displacement of supports due to the aging of the metal, and for other reasons there is a condition in which the crankshaft is working with congestion. As a result, there are places with most intense fatigue damage.

It has been found that the endurance limit of extremely worn crankshafts to restore was reduced by 25 – 30% [4]. The main dangerous load for diesel engines is the bending moment, and for gasoline – torque. Typical fracture crankshafts first occur on the cheeks, secondly – on the cervix. When rounding shaft gasoline engines are removed from the surface layers of the necks of accumulated fatigue damage, and their capacity leads to unload most intense metal layers. All this contributes to the restoration of their resource. Completely to remove a manner extremely destroyed layers of metal shafts in the area of diesel engines fillets is difficult, so their life cannot be restored.

Thus, the range of items to be restored continues to grow, expanding repair production leads to the introduction of resource-saving technologies , welding is widely used to restore crankshafts of agricultural machinery, the main parameters determining post-restoration engine hours are wear resistance and fatigue strength . To improve post-restoration operated internal combustion engines it is necessary to improve operational performance such as wear resistance and fatigue strength, which are influenced by the material and the resulting microstructure of the coating.

The aim of improving the fatigue strength and wear resistance is in the reduction shaft agricultural machines.

The material used for the manufacture of steel samples 45. The samples were prepared in accordance with GOST 25.502-79.

Used for coating wire marks U7 and 08H13. Coating on the samples were applied by using electric welding environment [Ar + (20 ... 30 % CO_2)] .

Then surfacing was carried out on samples of grinding machines mod. 3A151 to a roughness Ra 0,32 ... 0,63 m.

Fatigue tests were carried out on the machine UKI-10M. Destruction of the sample, the machine stops and the counter allows to determine the number of cycles prior to destruction. Type of loading for all cases was the same – cantilever bending torsion, in which the voltage varies over a symmetric cycle (skewness $R\sigma = -1$). The external environment for all testcases was constant.

The results of experimental studies of fatigue curves were constructed samples weld various brands of wires (Fig. 1). Coatings resulting from the welding are characterized by high hardness and wear resistance, but they are characterized by high brittleness, as it occurs with the formation of coatings significant heat input [6], and as a consequence there is a decrease in fatigue strength.

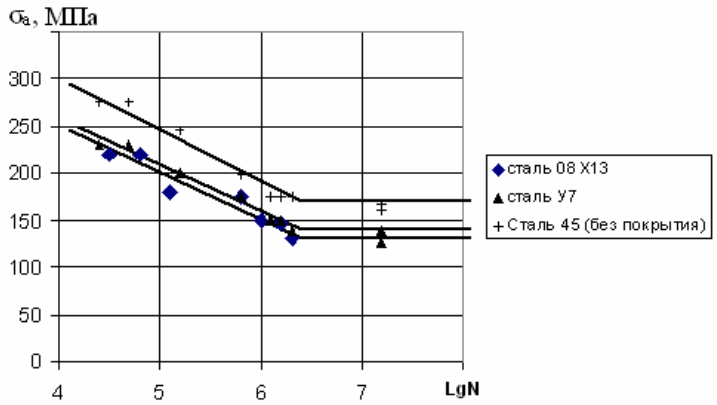

Fig. 1. Fatigue curves of samples with weld deposit:
$\sigma_a$and – voltage in a dangerous section of the sample, N – number of loading cycles

Maximum values of the fatigue strength obtained during surfacing wire U7. In this case the hardness of the weld metal is determined by the carbon content: the higher the carbon contenti, the higher the hardness. Wire carbide contains alloying elements, however during surfacing, more intensive burning of carbon, as well as stirring with a basis (Steel 45), which leads to lower hardness of the coating material, but this increases the fatigue strength of samples. The coating hardness weld wire U7 HRC 35 ... 40. After surfacing due to the high cooling rates formed quench structure (martensite-troostite).

The hardness of the coating produced by welding wire 08H13 – HRC 30 ... 33. One indicator of the properties of the weld metal is hardness, which is sometimes identified with the wear resistance, but when assessing the durability necessary to consider the structure of the obtained coatings hardness of the matrix, the presence of carbides and their dimension, fastening carbides in the matrix. The microstructure of the coating is a "solid solution + chromium carbides". Alloys with similar structure with a low content of carbon have the ability to significantly increase the hardness, strength and wear resistance as a result of work hardening (when plastic deformation with a significant degree of plastic deformation), the use of surface plastic deformation after welding wire 08H13 improves fatigue strength of 25 ... 30%.

Implementing recovery technologies crankshafts promotes saving, as the cost of crankshafts on domestic engines ranging from 10 to 25%, and foreign – from 20 to 50% of the cost.

To restore steel crankshafts surfacing medium [Ar + (20 ... 30% CO_2)] 08H13 wire diameter of 1,6 mm is recommended, followed by hardening of surface plastic deformation .

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ASSESSMENT OF HEALTH STATE OF WATER TREATMENT WORKERS OF AN OIL REFINING ENTERPRISE

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The influence of harmful production factors on human health is analyzed. The negative impact of those factors on morbidity with temporary disability of the water treatment workers of JSC "Naftan" is established.

In the current conditions of the development of Belarusian leading industries the problems of efficiency and reliability of professional activity, as well as health protection and working capacity under the impact of unfavorable factors are becoming the main directions of occupational health and safety policy [1, p. 22].

A third of their lives people are busy with working activity. Therefore, it is very important that occupational conditions don't do any harm their health. The working activity of a person is necessarily influenced by various factors of the production environment, difficulty and intensity of labor process.

It is repeatedly proved that adverse production factors have negative impact on workers' health, cause all professional pathologies and account for up to 30% of the cases of morbidity with temporary disability. All these unwanted implications demand essential material inputs on carrying out medical and preventive measures, as well as on social benefits and compensations related to adverse working conditions [2, p. 67].

It is also necessary to consider that unfavorable economic situation of many enterprises caused by the financial crisis considerably complicates the solution of many problems of labor protection. Among the most serious problems

of the kind are difficulties in choosing priority preventive measures which may result in decreasing the workers' morbidity with temporary disability up to a certain acceptable level at the lowest cost [3, p. 88].

Morbidity rate with temporary disability in the statistics of general morbidity takes a special place reflecting state of health of the working population which is considered, in its turn, both as a prerequisite and one of ultimate goals of social and economic development of Belarusian state. Results of the analysis of morbidity with temporary disability allow to define not only the level and structure of morbidity of the working population or those of its separate groups, but also to a certain extent characterize the current condition and qualities of medical and sanitary service, help to control efficiency of health improving measures and medical care [4, p. 57].

It is well known that the majority of enterprises of oil refining industry in the Republic of Belarus are referred to a class of the maximum professional risk. There is a high probability of impact on workers with dangerous and harmful factors of production environment because of particular characteristics of a profession or special working conditions. Technological processes used at the oil refining enterprises are the source of air pollution. As a result, working zones at these enterprises get inevitably polluted by harmful substances, mostly by hydrocarbons and their derivatives. Such chemical environment strongly influences human body and leads to emergence of work-related diseases [5, p. 202].

Taking into consideration all said above, the analysis of workers' morbidity with temporary disability in a form of the statistical reporting No. 16 – VN for 2009–2011 on one of productions of the leading oil refining enterprises of the Republic of Belarus – water treatment works of JSC "Naftan Novopolotsk" was carried out.

In the sick lists analysis with temporary disability the standard indicators were used: indicator of cases of temporary disability due to illness, characterizing the frequency of cases of temporary disability due to illness per 100 workers; indicator of days of the temporary disability, characterizing the frequency of cases of temporary disability due to illness per 100 workers.

In compliance with the data presented in recent research, the most characteristic diseases of employees of the oil-processing enterprise were chosen, namely: malignant, good-quality and new growths formations of uncertain character, blood diseases and haematogenic bodies, endocrine system, gastrointestinal path, cardiovascular system of respiratory organs.

The analysis of dynamics of indices of indicators of incidence with temporary disability showed that in number of cases the increase by 1,1 times, in number of days of temporary disability in a little smaller degree – by 1,03 times is received.

The most significant growth was registered on the following diseases: sharp respiratory infections of the top airways (5,48); arterial hypertension (0,17); eye diseases of and their additional device (0,19); good-quality new growths and new growths of uncertain character formations (0,43).

It is noteworthy that incidence indicators in separate years for the studied period fluctuate in considerable limits. So, for example, the number of cases per 100 working emergence of good-quality formations and formations of uncertain type was registered the minimum quantity in 2011 – 1,15, and in 2010 – 2,11. But the growth of malignant formations is observed twice as many.

Observed growth of cases of malignant formations and diseases it is proved by the numerous literary data on cancerogenic and danger of mineral oils of oil genesis and their adverse influence on the condition of cardiovascular, nervous systems, systems of blood supply, respiratory bodies that allows to make some assumptions: periodic excess of maximum-permissible concentration of separate components in the air of a working zone; influence of chemical and physical factors; individual sensitivity of each person.

Thus, impact of harmful production factors on health water treatment workers at the oil processing enterprise during the small period of time can entail development of a large number of diseases and a variety of reasons for disability.

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AERODYNAMIC AND THERMOTECHNICAL TEST RUN OF AN AIR-GAS REGENERATIVE HEAT EXCHANGER

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The article represented the experimental test bench, methods and results of aerodynamic and thermotechnical investigations of characteristics and operation modes of shell-and-tube direct flow heat exchanger.

The plant (fig.1) consists of a heat source 1, heat exchanger, including calefacient flue 4 of circular section, with the diameter d_g, a boiler air heater of square section with inlet and outlet pipe branches.

For registering temperatures of calefacient and heated carrier and temperatures of surfaces, glass 3, 5, 8 and contact 9, 10, 11, 12 thermometers are set down.

For registering speed of movement and consumptions of calefacient and heated air carrier, vane anemometers 13, 14 are used on the plant. For determining the consumptions of flared gas on the plant, gas meter 15 is used, and micromanometer 16 is used for registering gas pressure.

When kindle gas, using a burner 6, products of gas combustion and induced air form mixture of heating gas, directed to a flue 4 by a convective flow, which has inlet $t_{PG}^{\acute{i}}$ and outlet $t_{GC}^{\hat{e}}$ temperature, registered by a thermometer 5. Mean temperature of the heat-release surface $t_{9,10}^{\text{ср}}$ of a flue 4 is measured by contact thermometers 9, 10 and found from the formula:

$$t_{9,10}^{\text{ср}} = \frac{t_9^{\text{н}} + t_{10}^{\text{н}}}{2}, \qquad (1)$$

where $t_9^{\text{н}}, t_{10}^{\text{н}}$ are respectively inlet and outlet temperatures of the surface of a flue, °C.

Amount of heat Q_{GCP}, extended for warming ventilation air from the surface of flue, will be defined according to the formula:

$$Q_{\text{гсп}} = K_{\Gamma} \cdot F_{\text{ПГ}} \cdot \left(t_{9,10}^{\text{ср}} - t_{8,14}^{\text{ср}}\right), \qquad (2)$$

where $\hat{E}_G$ – is a heat-transfer coefficient through a flue wall 4, Вт/м^2 °C;

F_{PG} – heat-release surface of a flue, sq.m;

$t^{\text{ср}}_{9,10}$ – mean temperature of mixed gas in a flue, °C

$t^{\text{ср}}_{8,14}$ – mean temperature of warmed ventilation air, °C.

a heat-transfer coefficient K is defined by the following formula:

$$K = \frac{1}{\frac{1}{\alpha_{\hat{A}}} + \frac{\delta}{\lambda} + \frac{1}{\alpha_{\acute{i}}}}, \qquad (3)$$

where δ – is wall thickness of a flue, m

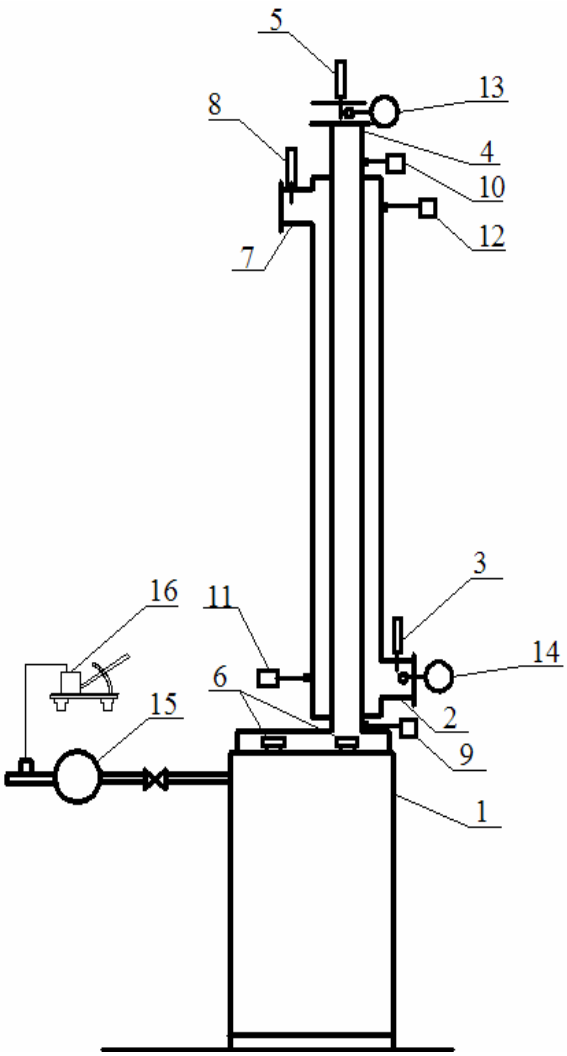

Fig. 1. The plan of the experimental test bench for testing a heat exchanger

λ – is thermal conductivity of the wall material of a flue, W/m of °C;

$\lambda_{Â}$ – is surface heat exchange coefficient from mixed gas to inner surface of a flue, which is defined by the following formula:

$$\alpha_{Â} = \frac{q}{\pi \cdot d_{Â} \cdot (\tau_{Â} - \tau_{ÂÍ})}, \quad (4)$$

q – heat loss, classified to running meter of the length of an air flue.

d_B – is the bore of an air flue, m

τ_B – is mean temperature of the outside surface of a heat pipeline, °C;;

$\tau_{ÂÍ}$ – is temperature of the inner surface of an air flue wall, °C;

$\alpha_Í$ – is heat-transfer coefficient from the outer surface of a flue, which is defined according to the formula:

$$\alpha_Í = 11,6 + 7\sqrt{V_{BB}}, \quad (5)$$

where V_{BB} – speed of warming ventilation air when moving inside a heat exchanger.

Heat-release surface of a flue is defined according to the formula [1],

$$F_{Í Ã} = \pi \cdot d_g \cdot l_T, \quad (6)$$

where d_g – is the bore of a flue, m

l_T - is length of a heat exchanger, m

Under such conditions, amount of heat Q_{GCP}, transferred through the fuel's wall, is equal to the amount of heat, passing to warmed ventilation air inside the heat exchanger, i.e.

$$Q_{GCP} = Q_{PG}. \quad (7)$$

Q_{PG} is a numerically equal to the amount of abstracted from the surface heat fuel of a fuel, i.e.

$$Q_{PG} = \alpha_Í \cdot F_{PG} \cdot \left(t^{ñð}_{GC} - t^{ñð}_{ÂÂ}\right), \quad (8)$$

where all input values are known and defined by computing or experimentally.

Having found the value Q_{PG} from the formula (8), including the formula (7), we will define $t^{ñð}_{GC}$ according to the formula (2):

$$t^{ñð}_{GC} = t^{ñð}_{ÂÂ} + \frac{Q_{GCP}}{k \cdot F_{PG}}, \quad (9)$$

and $t^{Í}_{GC}$ according to the formula:

$$t^{Í}_{GC} = 2 \cdot t^{ñð}_{GC} - t^{ê}_{GÑ}, \quad (10)$$

Values of Re for defining $\alpha_Â$, are computed by calculating,

$$\mathrm{Re} = \frac{\upsilon_{GÑ} \cdot d_g}{\nu}, \quad (11)$$

where d_g – is a flue's bore 4, m

$\upsilon_{GÑ}$ - speed of mixed gas movement, measured with an anemometer experimentally (fig. 1), m/s;

ν – is a kinematic viscosity coefficient (for mixed gas mean temperature).

Details and results of the research are represented in the tables 1.1 and 1.2.

Table 1.1 – The results of the research

	t_3	t_8	t_5	t_9	t_{10}	t_{11}	t_{12}	$\Delta t_{3,8}$	$t^{ñð}_{9,8}$	$t^{ñð}_{11,12}$	n_1	$n_1/60$	n_2	$n_2/60$	υ_1
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	20,5	35,3	74	28,8	41,0	28,2	27,2	14,8	34,9	27,7	85	1,4	129	4,3	0,7
2	21,0	42,0	89	31,4	43,0	29,0	28,5	21,0	37,2	28,8	91	1,5	145	4,8	0,75
3	21,0	44,0	98	30,0	45,0	27,0	25,0	23,0	37,5	26,0	75	1,25	135	4,5	0,63
4	22,0	48,0	110	34,0	48,6	33,6	27,6	26,0	41,3	30,6	98	1,6	173	5,7	0,78
5	22,0	50,5	119	37,0	53,5	31,0	29,5	28,5	45,3	30,3	105	1,75	173	5,7	0,84
6	22,5	52,0	129	39,0	54,0	31,5	30,2	29,5	46,5	30,8	113	1,88	184	6,1	0,89
7	22,0	55,5	140	42,0	60,0	32,4	31,6	33,5	51,0	32,0	120	2,0	187	6.2	0,92

Table 1.2 – The results of the research

υ_2	L_1, м^3/с	V_T	α_f	Q_{PG}, Вт	Δt_{in}	Δt_{out}	$\ln\frac{\Delta t_{in}}{\Delta t_{out}}$	$\Delta t_{in}-\Delta t_{out}$	$\frac{\Delta t_{in}}{\Delta t_{out}}$	$t^{\circ}_{3,8}$	$\Delta t_{ñð}$	K	Re
17	18	19	20	21	22	23	24	25	26	27	28	30	31
2,0	0,0067	0,22	14,9	82,4	8,3	5,7	0,375	2,6	1,456	27,9	6,92	15,7	8070
2,2	0,0071	0,24	15,0	67,5	10,4	1,0	2,340	9,4	10,4	31,5	4,02	21,25	8877
2,1	0,006	0,2	14,7	58,1	9,0	1,0	2,200	8,0	9,0	32,5	3,64	20,2	8473
2,7	0,0074	0,25	15,1	75,2	12,0	0,6	3,000	11,4	20,0	35,0	3,8	25,05	10895
2,7	0,008	0,27	15,2	108,7	15,0	3,0	1,610	12,0	5,0	36,25	7,45	18,5	10895
2,8	0,0085	0,28	15,3	111,8	16,5	2,0	2,110	14,5	8,25	37,25	6,87	20,6	11298
2,9	0,0087	0,29	15,4	149,0	20,0	4,5	1,490	15,5	4,44	38,75	10,4	18,14	11702

According to the data above, we developed the method and obtained the experimental results for updating regularities of changing intensities of a direct flow of heat exchanger productivity for the purpose of using it in the systems of energy-efficient buildings.

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MATHEMATICAL MODELS FOR CHECKING LEAKAGE IN THE COMBUSTION CHAMBER OF AN INTERNAL COMBUSTION ENGINE

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We propose a mathematical model to present changes in the pressure within the above-piston space of an internal combustion engine depending on the temperature within the compression chamber. The model takes into account leakage through the piston ring-liner sealing.

Investigations referring combustion engine failures show that 31 % of combustion engines failed due to faults in the cylinder piston group, whereas 45 % of failures are due to the faults in fuel system [1]. Wear and tear of the engine may cause leakage of the working fluid through the piston rings or intake valves. The main leakage of the working fluid from the cylinder body occurs through the piston ring joints. These findings result from the numerous measurements conducted for the leakage of the working fluid down the piston rings [2]. With successful break-in of unworn set of piston rings, 80 % of leakage is due to expansion gaps in the piston rings [3]. The flow of the working fluid down the piston ring joints is at 250-300 m/sec. Thus, the contact time between the working fluid and piston ring sides is minimal, and the gas flow process may be regarded as adiabatic.

The given mathematical model was developed for internal combustion engines and can be used to simulate the engine performance and engine output modes. Therefore, it is significant for defining mechanical conditions of the cylinder-piston group and monitoring the overall performance of the engine.

Meanwhile, it should be noted that mathematical models proposed by Prof. V.G. Dyachenko are best applied to simulating complex physical processes within the combustion chamber of a diesel engine, and can be utilized for the processes of mass and heat transfer in the above-piston space. In the cases of compression travel, changes in the pressure can be determined using the following formula:

$$dp=\frac{kp}{V}\cdot\left[-\frac{1}{p}\cdot dM_{YT}+\frac{(k-1)}{k}\cdot\frac{(\pm dQ_T)}{p}-dV_{\Pi}\right] \quad (1)$$

where dM_{YT} = the decrease of the working fluid mass in the above-piston space caused by the leak of the working fluid down the valves, $d\tau$ = piston rings over the computed period, ; k = adiabatic exponent of the real working fluid under temperature values as of the initial computed time interval; dQ_T = loss of heat energy of the piston walls surface to and from the working fluid within the computed time interval; dV_{Π} = volume changes of the above-piston space caused by the piston transfer over the computed time interval; P и V = respectively pressure and volume of the mixture at the start of computed time interval.

On the other hand, the model used to measure gas pressure between the rings of an engine cylinder is described in the works by Prof. R. Petrichenko by the following formula:

$$\frac{dM_i}{d\phi} = \frac{1}{6n} \cdot (\pm G_{i-1} \pm G_i), \quad (2)$$

where G_{i-1}, G_i = working fluid flow through the piston ring joints.

Taking into account transformations to models (1) and (2), as well as assessment data for leakage devoid of the working mixture fire, the processes under investigation are given by

$$dp = \frac{kp}{V} \cdot \left[-\frac{1}{p} \cdot \left(\frac{dM_i}{d\phi}\right) + \frac{k-1}{k} \cdot \frac{(\pm dQ_T)}{p} - dV_\Pi\right] \quad (3)$$

Therefore, the final value for the calculated interval $\Delta\tau$ (final value for the crank angle is given by $\Delta\phi = 1-5^\circ$), pressure, volume, mass and temperature of the working fluid, as well as the amount of heat from the walls to the working fluid, and back from the working fluid to the walls of the above-piston space at the end of the calculated interval, can be determined by the following formulas:

$$p_{i+1} = p_i + \Delta p_i; \quad (4)$$

$$T_{i+1} = \frac{p_{i+1} \cdot V_{i+1}}{M_{i+1} \cdot R}; \quad (5)$$

$$M_{(i+1)} = M'_V; \quad (6)$$

$$V_{(i+1)} = V_V + \Delta V_\Pi; \quad (7)$$

$$Q_{T(i+1)} = Q_{Ti} \pm \Delta Q_{Ti}, \quad (8)$$

where p_i, p_{i+1} = pressure values at the start or end of the calculated time interval; R = a universal gas constant per 1 kg of the working fluid; M'_V and V_V = mass and volume of the working fluid at the start of the calculated time period.

With the final value of the calculated time period $\Delta\tau_i$ (crank angle $\Delta\phi_i$), the formula for the compression travel will be as follows [5]:

$$\Delta p_i = \left[\pm \frac{k_i - 1}{k_i} \cdot \frac{\Delta Q_{Ti}}{p_i} - \Delta V_{\Pi i}\right]. \quad (9)$$

The values for the eat interchange ΔQ_{Ti} from the surface of the above-piston walls to the working fluid within the calculated time period are given by [5]:

$$dQ_T = \sum_{j=1}^{j} \alpha_{T.j} \cdot (T - T_{CT.j}) \cdot F_j \, d\tau, \quad (10)$$

where $\alpha_{T.j}$ = gas side heat transfer coefficient for the wall surface of the working body «j» characterized for physical properties in terms of convective heat transfer; T = current values for gas temperature in the above-piston space; $T_{CT.j}$ = average surface element temperature «j»; F_j = surface area for the above-piston space walls.

Thus the above equation can be used for changes in the pressure at the end of the compression stroke (within the calculated time period $d\tau$) taking into account leakage of the working fluid through the engine cylinder with misfiring, which is important to diagnose engine problems. The conducted experiments proved analytical calculations. Application of the above dependences will produce the resources for proper assessment of the engine sealing, and determine optimum intervals for diagnosis of the cylinder piston group.

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UDK 621.787

IMPROVING PERFORMANCE OF SHAFT SURFACE PLASTIC DEFORMATION

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In this work one of ways of a naplavka is considered at restoration of shaft by superficial plastic deformation, on completion of work the result about influence of superficial plastic deformation on endurance and intensity of wear of a cranked shaft was summed up.

The main causes that explain the need for repair of machines, are fraying and fatigue destruction of parts operating in conditions of exposure periodic loads. Typical load detail, requiring increased wear resistance and fatigue strength are the crankshafts of internal combustion engines. If there is a loss of efficiency, there is a need for crankshafts of their recovery, as they are steel-intensive and expensive parts, replacement of new products economically impractical. To restore the crankshafts are widely used various ways of surfacing. Hard-facing of wear resistant surfacing materials allows you to restore the geometry and coating with high wear resistance, fatigue strength of remanufactured shafts are reduced by 25-30%.

Negative effect of welding on the fatigue strength of these parts can be significantly reduced by applying the technology of repair of surface hardening plastic processing methods-surface plastic deformation (SPD) [1].

The aim of this work is to improve the performance properties of shafts of the restored building-introduction to technology repairs SPD.

As a material for manufacturing samples used worn crankshafts, constructed of steel 45 with a given chemical composition for obtaining the required technological strength, but prone to hardening structures and, as a result, cracks [2]. Fatigue tests were carried out on the car the UKI-10 m on samples manufactured in accordance with GOST 25.502-79. The tests were conducted to complete destruction of the samples. Wear rate was determined according to the scheme "disc-pad" (paper liners bearings AO20-1) by car friction SMC-2 by defining mass intensity of wear, in kg · cm-2 for 1000 m friction GOST 17364. As your welding material used wire 1.6 N-08X13.

Using wire 1.6 N-08X13 to prevent the formation of cracks due to minimize the transition zone.

Hardness of coatings obtained by welding wire Mw-08X13-HRC 30-33. One of the indicators of the properties of deposited metal is the firmness with which sometimes equate durability, but when evaluating durability must be taken into account and the structure of coatings: matrix hardness, presence of carbides and their dimensions, consolidation of carbides in matrix. Microstructure of coatings obtained by welding wire 08X13 is a solid solution with chromium carbides. Alloys of similar structure, with low carbon content has the ability to significantly increases the hardness, toughness and wear resistance as a result of testing (with plastic deformation with a considerable degree of deformation). As a result of the SPD in the surface layer of deposited coating is formed texture with high concentration of lattice defects that inhibit the sliding plane, making it difficult for their further spread. Just after the TTD cover arise internal residual compressive stress, which block the disclosure of the fatigue cracks, turning them into a wide range of stresses in unspreadable.

Introduction to the technology of repair when welding wire shafts 1.6 N-08X13 operation of surface plastic deformation increases the fatigue limit of the recovered shafts on 25-30%, and the wear rate is reduced by 15-20%.

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UDK 621

VISCOUS LUBRICATION

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Viscous lubrication – the most common type of lubricant – its structure, composition, basic properties, as well as advantages and disadvantages are studied in this paper.

Viscous lubrication (greases) is used to reduce friction and wear of those units which cannot be treated by forced oil circulation. Easily penetrating into the contact friction parts, greases hold on the friction surfaces and do not flow down from them, as is the case of oil. Greases are also used as protective or tightening materials.

Viscous lubricants or consistent greases are pasty lubricants produced by introducing solid thickeners in liquid petroleum or synthetic oils and mixtures thereof. Generally, viscous lubricants are colloidal ternary systems containing a dispersion medium (liquid base), discontinuous phase (thickener), and structure modifiers, additives (fillers, additives). Due to the high concentration of colloidal particles greases form a thickener spatial structural framework, where oil is firmly held in its cells. Most viscous lubricants have a fibrous structure. The high degree of structuring of the dispersed phase gives greases elasticity and other useful properties which distinguish them significantly from the liquid lubricants. At low loads or in their absence greases exhibit the properties of solids, do not spread under their own weight, hold on vertical surfaces, and cannot be easily discharged from moving parts by inertial forces. However, at some critical pressure (typically of 0,1 – 0,5, rarely of 2 – 3 kPa) exceeding the tensile strength of the structural frame, the so-called thixotropic transformation takes place: greases get destroyed and begin to deform (to flow) as though plastic body without discontinuities. After removing the load the flow stops, the deformed frame restores itself and greases acquire the properties of solids again.

Oil is a base of lubrication (see below), and the former accounts for 70 – 90% of its weight. Oil properties define the basic properties of the grease.

Thickener creates a lubrication space frame. Simply put, it can be compared with foam, holding oil by its cell. The thickener constitutes from 8 to 20% of the mass of lubricant.

To improve the performance properties of viscous lubricants the following preparations are needed:

• additives are mostly the same as those used in commercial oils (motor oils, transmission oils, etc.); additives constitute oil-soluble surfactants and comprise 0,1 – 5% of the weight of lubricant;

• fillers improve anti-friction and tightening properties; they are solids, usually inorganic, insoluble in oil (molybdenum disulfide, graphite, mica, etc.) constitute 1 – 20% of the weight of lubricant;

• structure modifiers contribute to a more durable and elastic structure lubrication; represent surfactants (acids, alcohols, etc.) constitute 0,1 – 1% of the weight of lubricant.

Assessment of the quality of viscous lubricants includes defining properties that underlie the selection and application of lubricants (e.g. shear strength, minimum load, causing a transition from elastic-plastic deformation to the flow of lubricant). With temperature increase, lubricant generally reduces. The temperature at which the strength limit of material approaches zero, characterizes the upper limit of viscous lubricant performance. Strength assessment is made with a rheometer: shift lubrication is carried out in a special finned capillary under the pressure of thermally expanding fluid. For most viscous lubricants shear strength constitues 0,1 – 1,0 kPa (at 200°C). Lubricant viscosity determines pumpability at low temperatures and the possibility of filling with it friction units. For viscosity measurements capillary viscometers are used. Rheological properties of lubricants, that is their ability to recover from destruction, are characterized by mechanical stability. Mechanical stability – change of the strength of the viscous lubricant during its deformation – is measured with a taximeter.

Penetration is an indicator of the strength of lubricants. The immersion depth of the standard weight cone for 5 seconds in the lubricant, expressed in tenths of millimeters, is called a penetration number. The softer lubricant, the deeper the immersion of the cone in it, and the greater penetration number of the cone. This indicator is used to establish the identity of recipes and compliance with production technology of lubricants. Penetration number of the viscous lubricant is 170 – 420.

Colloidal stability describes the ability of greases to resist oil separation (due to temperature, pressure and other factors, or due to structural changes, such as its own weight) during storage and operation period. Colloid stability of greases is determined by the perfection of their structural frame and viscosity of the dispersion medium: the higher the viscosity of oil, the more difficult it flows out of a lubricant volume. Many industrial lubricants based on low viscosity oils or with a low content of thickeners are not colloidally stable enough. To prevent or reduce oil separation out from the greases, the latter are packed in small containers. Colloid stability is measured by the share of oil (%) in mass of the

molded grease at room temperature for 30 min; for viscous lubricant it should not exceed 30% in order to avoid a sharp hardening, violation of its normal admission to the lubricated surfaces and deterioration of viscosity and lubricity.

Chemical stability is a grease resistance to oxidation by atmospheric oxygen (in a broad sense – the absence of changes in the properties of lubricants when exposed to acids, alkalis, etc.). Oxidation leads to the formation and accumulation of oxygenated compounds in lubricants, reducing their strength and deterioration of colloid stability, and other factors. Chemical stability of viscous lubricants can be promoted by careful selection of base oil and thickeners, introduction of antioxidant additives, and technological change in production modes. Resistance to oxidation is particularly important for those lubricants which are tucked in friction units 1-2 times in 10–15 years, operate at a high temperatures in thin layers and contact with ferrous metals. Most methods for determining this index are based on viscous lubricant oxidizability blocked in a thin layer on the surface (glass, steel, copper) at a high temperature, and measured by the induction period and rate of oxygen uptake.

Thermal stability is the ability of lubricants not to change their properties and not reinforce themselves by a short-term exposure to high temperatures. Thermostrengthening hampers the delivery of lubricants to friction units, impairs their adhesive properties. Thermal stability of a viscous lubricant is measured with an instrument called strength meter by changing the limit of the strength before and after it exposure to high temperature.

Volatilization is an indicator of stability of lubricants during storage and use. It depends primarily on the volatility of the oil: the higher the volatility, the lower the chemical stability of the lubricant, and the thinner and larger its surface. Quantitative assessment of volatility of greases is based on measuring the loss of mass (in %) of the sample which is maintained under standard conditions for a specified time at a constant temperature.

Microbiological stability is a resistance to change of lubricant composition and properties under the action of microorganisms. To prevent the microbiological destruction, in lubricants can be introduced microbicides, antiseptics (e.g., salicylic acids, phenols, organic derivatives of *Hg*, *Sn*, etc.) and some additives. This index is evaluated by the absence or growth, for example, fungi on the surface of the grease in Petri dishes or on metal plaques.

Radiation resistance is an indicator of the stability of greases under the influence of high-energy radiation (α- and β-particles, γ-quanta, free electrons). Resistance to radiation of greases is largely determined by the composition of the dispersion medium. Depending on the type of thickeners, greases can acquire "induced" radioactivity. Most easily become radioactive *Na*-greases. Radiation resistance of grease can be assessed by changing its properties after irradiation with certain intensity.

Dropping point is the minimum temperature at which the fall of the first drop of the heated grease occurs; it conventionally characterizes the melting temperature of thickener. Maximum application temperatures of greases are usually taken at 15–200°C lower than the dropping temperatures. However, maximum application temperature does not allow all greases to be properly assessed in respect to their high temperature properties. Thus, the dropping temperatures of *Li*-greases are different from the temperature of the upper limit of their performance at 40–70°C.

To evaluate the anticorrosive properties of greases, metal plate was immersed therein at high temperature depending on the dropping temperature. About the aggressiveness of lubricants can be judged by a change in state of the surface of the plate. Antiwear properties of a viscous lubricant are defined with a four-ball wear test machine. Limit values of wear beads are set depending on the purpose of greases and their operating conditions. Protection (conservation) properties of a viscous lubricant can be evaluated when it deposited on a metal plate and exposed to high humidity and temperature, fog and other corrosives. The evaluation of properties of viscous lubricants also includes determination of water content, the free acids and alkalis therein.

The advantages include their ability to hold on surfaces, not to leak and not to be squeezed out of the unsealed friction nodes, as well as wider temperature operating range than that of oil. These advantages allow to simplify the design of friction units and, therefore, to reduce their metal content and cost. Some grease has good sealing ability and good conservation properties.

The main drawbacks of greases are confining in them the products of mechanical retention and corrosion, which increases the rate of destruction of the rubbing surfaces, and poor heat transfer from the lubricated parts.

A favorable combination of properties of liquids and solids in viscous lubricants can be used in a variety of friction units: open, unsealed, hard-to-reach, angled toward the horizon, and operating in a wide range of temperatures and speeds. Viscous lubricants operate effectively in a vacuum; in the mechanisms, where greases can be rarely changed; in media in which there is a need of specific environmental precautions in respect; in situations of forced contact with water, etc.

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IMPROVING OF FIXING SYSTEM OF CUTTING PLATES IN BLOCK-MODULAR CUTTING TOOLS

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The paper present research system of fixing cutting plates and blocks in block-modular cutting tools.

Reliability teams cutting tools to a large extent determined by the reliability of fixing plates in the housing. There are many designs of clamping mechanisms, taking into account the working conditions of the cutting tools and features for their manufacture. These systems reflect the current trends in the design of cutting tools: high precision of manufacturing of cutting plates, the closed grooves and precisely manufactured to accommodate the cutting plates, the cutting plates clamping mechanisms with a minimum number of structural elements, such as a screw or a lever. The implementation of such systems in terms of domestic production tool is not always possible, as it requires special equipment and precise, high-quality components elements. Therefore urgent to establish a system fixing cutting plates technological conditions for domestic production and not inferior to the best foreign systems reliability.

The system of fixing cutting plates, including the following key elements (Fig. 1): the cutting plate (pos. 1) is set to open width direction groove cutting block (pos. 2). Fixing module of (pos. 3) is configured as a "T-shaped" strap, "the horizontal shelf" which is introduced into one part of the cutting plate hole and is pressed against the front surface of the cutting plate, while the other part is brought into contact with the bevel of the cutting block. The "horizontal shelf" of "T-shaped" strap is installed by planting in open longitudinal groove the cutting block. "Vertical shelf" of strap is designed as a screw threaded into "horizontal shelf" of strap and installed in the "oval-shaped" hole of the cutting block. When the strap screw is performed simultaneous movement of strap in horizontal and vertical directions, and the strap of the cutting plate on the base, the side surface and the hole.

In the proposed system, the grooves are made open and reliability of fixing of cutting plate is provided except moves in radial, axially and tangentially relative to the machined surface of the work piece.

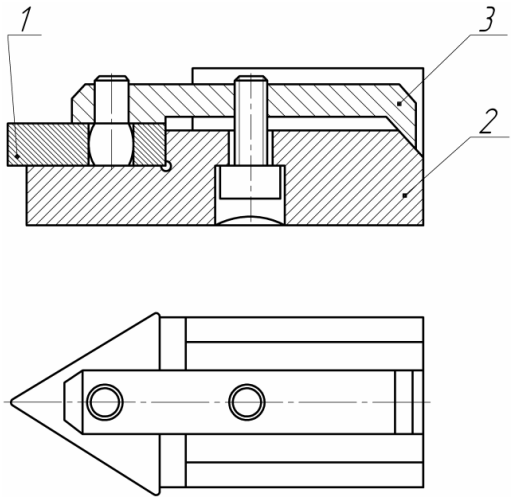

Fig. 1. The system of fixing cutting plates

The design of the cutting block (Fig. 2) includes a cutting plate with hole installed into the transverse open groove relative to the geometric axis of the housing at a certain angle α. Clamping of plate provided a "T-shaped" strap placed in an open longitudinal groove of the housing of block and having formed at an angle α "strapping planar part" and "support part" in the form of plane or spherical surface. In the strapping part is a pin incoming hole of cutting plate. Strapping planar part in contact with the front surface of the cutting plate and support part – with a flat surface of the housing of block arranged at a predetermined angle ψ. Clamp of strap by using screws threaded into it and freely entering the "oval-shaped" hole in the housing of block.

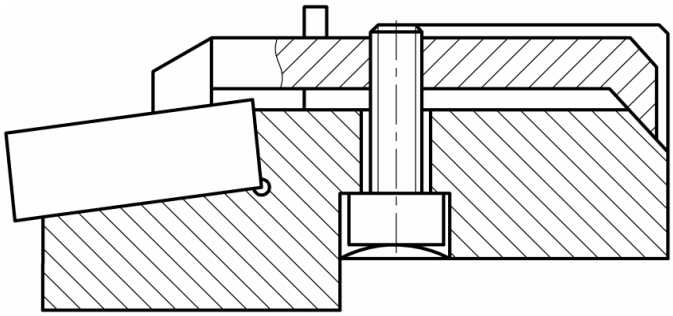

Fig. 2. The design of the cutting block

Proposed design of cutting block differs from known analogues following:

1. Clamp made T-shaped as opposed to most similar found structures (the L-shaped). And strapping part has «leverage» smaller than the reference.
2. Clamp is placed in a groove of the housing on the landing provides free movement in the longitudinal direction and fixed in the transverse, i.e. clamp works as a "yoke", the retaining plate on the transverse displacements.
3. Strapping part has a bevel at an angle α, the value of which is chosen as the value of the posterior angle of the cutting plate and a few adjusted for self-locking angle for the contacting materials.
4. The supporting part is performed flat or spherical and contacts with beveled angle ψ plane of housing of cutting block, whose value is chosen based on the possibility of longitudinal displacement of strap.
5. Pin included in the planting to hole of strapping part and has a spherical end (part of the hole of cutting plate).
6. Clamping screw enters freely into the housing bore and is slid able transversely direction in relation to its axis.
7. Housing of block is cylindrical, allowing its installation in the housing module whole tool and clamp two hollow cylindrical elements with radius "samples" of the corresponding cylinder of the housing, and a tightening screw them.
8. Design of elements of clamping as cutting plates and housing of cutting block provides action of clamping forces on the direction of the cutting force components that ensures additional sampling possible gaps in the design of the cutting process.

Fixing system of the cutting block in the housing module (Fig. 3) also technological and reliable. Cutting block mounted on the cylindrical surface in the hole, where previously through the other hole entered into one element of the clamping mechanism ("cotter"). Then introduced another "cotter" and both "cotter" tightening screws, thus providing reliable clamping of cutting block between two "cotters" and exclusion of movement of cutting block in all directions. The exact location of "cotters" relatively cutting block considers direction acting on cutting plate cutting forces – clamping force directed along the cutting forces, which eliminates gaps in the contact elements during vibration system.

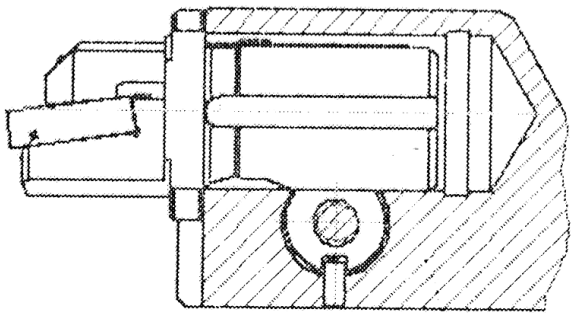

Fig. 3. Fixing system of the cutting block in the housing module

Thus, the reliability of the proposed design of block-modular cutting tools is dependent on the accuracy of performing linear and angular parameters of the components, material selection and details of the heat treatment, and compliance with the sequence of assembly and adjustment tool.

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RESEARCH OF PRESSURE DROP AND EFFICIENCY OF NEW DESIGN OF VALVE TRAY

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The article represents a new type of valve tray which is used in tray columns. This type is the result of optimization of the common valve tray. This article includes a design of a new type of the valve tray and experimental results of its efficiency and pressure drop which are illustrated in the diagrams.

Separation of mixtures is considered a major operation in the chemical industry and related branches of production. Separation processes based on the principles of mass transfer require effective columns to approach the perfect separation of mixtures. Trays, random packing, or structured packing can be used inside of columns. They use different mechanisms of mass transfer, but the main feature for all is a good approach to equilibrium through the generation of large amounts of interfacial area. This interfacial area results from the passage of vapor through the perforations of trays, or the spreading of liquid on the surface of packing [1]. The choice between a tray and backed column for a particular application can only be made with complete assurance by costing each design. However, this will not always be worthwhile, or necessary, and the choice can usually be made, on the basis or experience by considering main advantages and disadvantages of each type like. For example, tray column can be designed to handle a wider range of liquid and gas flow-rates than packed towers; packed columns are not suitable for very low liquid rates and the efficiency of tray can be predicted with more certainty than the equivalent term for packing and we usually get a higher efficiency in trays than in packing. For these and many others reasons, we have preferred column trays [4].

The bubble-cap tray is a flat perforated plate with risers around the holes, and caps in the form of inverted cups over the risers. The caps are usually equipped with slots or holes through which the vapor comes out. Sieve tray is a flat perforated plate. The most common type of tray is a valve tray [2]. In valve trays, perforations are covered by lift able caps. Vapor flows lift the caps, thus creating a flow area for the passage of vapor. The lifting cap directs the vapor to flow horizontally into the liquid, thus providing better mixing than it is possible in sieve trays.

Sieve and valve trays have comparable capacity, efficiency, entrainment, and pressure drop. Bubble-cap trays have lower capacity and efficiency, and higher entrainment and pressure drop than sieve and valve trays. The cost of bubble-cap trays is the highest. Sieve trays are the least expensive, but valve trays do not cost much higher than sieve trays. Maintenance, fouling tendency, and effects of corrosion are the least in sieve trays, although they are not much greater for valve trays. In general, bubble-cap trays are mainly used in special applications. For most other services, either sieve or valve trays are the best choice. Sieve trays have advantages when the service is fouling, or corrosive, or when turndown is unimportant, while valve trays are preferred when turndown is essential. With high energy costs, the energy saved during even short turndown periods usually justifies the relatively low cost difference between valve and sieve trays. This has made valve trays most popular in the industry [2, 3].

For these reasons we have chosen valve tray for developing and designing a new type of valve tray. We will pursue the following optimization goals: high efficiency, low moderate pressure drop, high capacity, and low cost.

Principle of work of the tray is shown at the following (Fig. a). The valves will move up and down in response to changing vapor flow rates. At normal flow rate, the valve is roughly in the middle position. At low vapor rates, the valve settles over the perforation and covers it to avoid liquid weeping. The valves should be heavy enough to prevent excessive opening at low vapor flow rate. As the vapor rate is increased, the valve (1)

rises vertically. The upward movement of the valve is restricted by retaining cage (2). Liquid enters the tray from the down comer (3) of the tray above. The liquid entering the tray is aerated with vapor rising from the tray below to form froth on the tray. The froth flows across the tray until it reaches the outlet weir (4). The froth then flows over the weir into down comer, where the vapor is disengaged from the liquid.

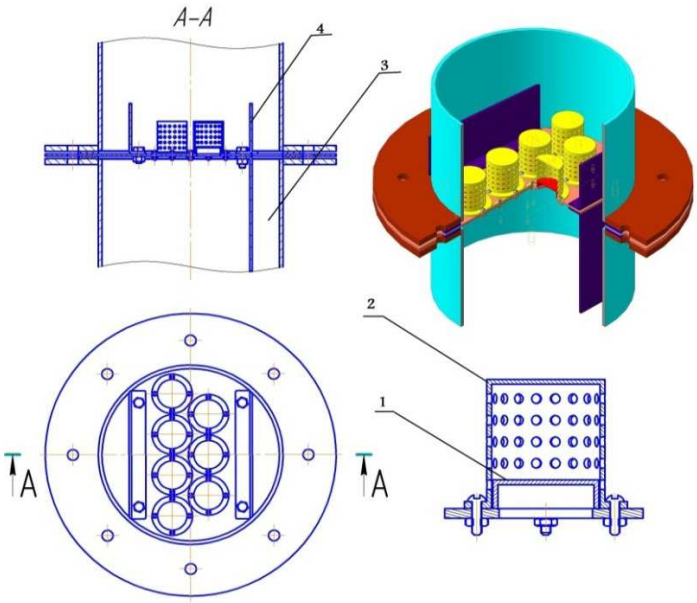

Fig. A

Experimental studies for designing valve trays were made on two models:

1. Desorption of (CO_2) from water
2. Evaporation of water from the tray

Pressure drop for tray is determined by a difference between static pressure above and below tray. Effectiveness of mass transfer could be determined by the changes upon liquids (p h), and humidity of air, in the entrance and outlet of the columns. During the experimental studies desorption (CO_2) of water efficiency valve tray can be determined by the equations (1) and (2):

$$E = \frac{C_{in} - C_{out}}{C_{in}} = 1 - 10^{-(ph_{out} - ph_{in})} \quad (1)$$

$$C = 2.69 \cdot 10^{3-ph} \quad (2)$$

Such that C_{in}, C_{out}: concentrations (CO_2) in water in the column entrance and outlet ($^{kg}/_{m^3}$).

Efficiency of evaporation of water was determined on air-water system by basing on the humidity of air in the entrance and outlet of the column by the equation (3)[5]:

$$E = \frac{X_{out} - X_{in}}{X_{100} - X_{in}} \quad (3)$$

Such that x_{100}: absolute humidity of saturated steam ($^{kg}/_{m^3}$).

Experimental results are presented in Figures (1) (2) and (3).

From figure 3 a dependency may be noted that the pressure drop of the tray is within the range of 0.255-0.454 k pa at a gas speed less than 1.4 m/s.

The range of stable operation of the valve tray there is enhanced with increasing the air velocity from 0.65 to 1.36 m/s. When liquid flows down the column through down comer and then across the tray deck, while vapor flows upward through the liquid inventory on the tray. Then gas liquid dispersion-foam occurs on a tray. In this mode, the gas-liquid contacting occurs on a surface of the bubbles, the gas spray and liquid drops on the surface, which in large quantities over a bubbling layer are forming at the outlet of the gas bubbles from the bubble layer, and the destruction of their shells. In the foam surface mode phase contact on the tray is maximum contact.

The efficiency of tray ranges from 86.7% – 96.4% at desorption of (CO_2) (fig. 2) and 91% – 98% at evaporation of water (fig. 1). When comparing the effectiveness of different constructions trays, we can conclude that the efficiency of the new valve tray higher than the efficiency of other trays.

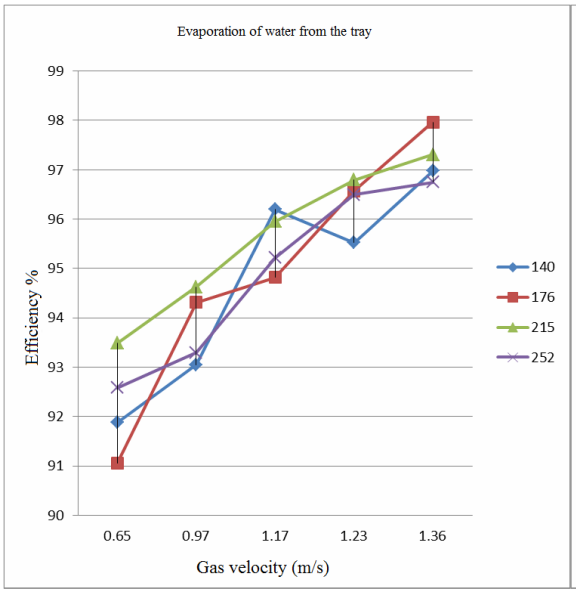

Fig. 1

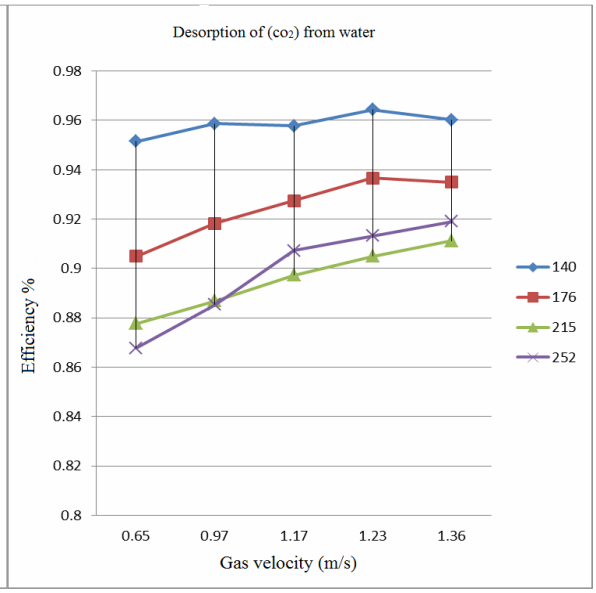

Fig. 2

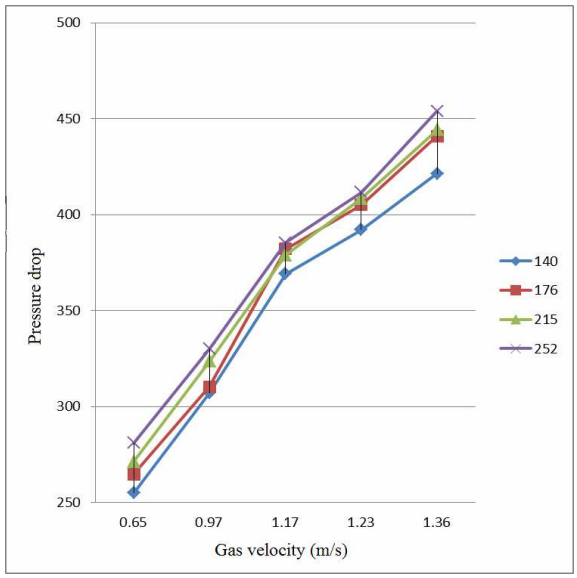

Fig. 3

Based on the studies, the following conclusions can be made:

1. The pressure drop value of the new valve tray developed is proportional to the square of the gas average velocity in the column range of (0.255–0.454) k pa.

2. The efficiency of the new valve tray, increases proportionally to the square of the gas average velocity in the column, with range (86.7- 96.4) % at desorption of (co_2) and (91-98)%at evaporation of water.

3. Tray has a wide range of stable operation, relatively low pressure drop and high efficiency, which makes extensive use of such trays for mass transfer processes.

4. The efficiency of the new valve tray doesn't dependent on the liquid flow rate in evaporation of water and this considered good properties on the work of column tray in the Chemical Industries.

5. We noted the quantity of entrainment is low to moderate in the new type when comparing with other trays, and this quantity increases proportionally with the gas velocity.

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UDC 355.58

NATURAL EMERGENCY SITUATIONS, CHARACTERISTIC REPUBLIC OF BELARUS FOR VITEBSK AREA

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The analysis of possible natural emergency situations, characteristic for Vitebsk area of Republic of Belarus is carried out. Numerous consequences of adverse weather conditions are considered. Population actions are specified during dangerous meteorological processes and the phenomena.

According to numerous observations in the Vitebsk region may be hazardous meteorological processes and phenomena (hurricane force winds, snow blizzards, whirlwinds of large diameter, thunderstorms), dangerous hydrological phenomena and processes (floods anthropogenic and natural), wildfires.

Hurricanes usually form in the equatorial zone. Their appearance is due to the uneven heating of different areas of the rotating earth. Equator is heated more poles – less. The heated air rises , forming a region of high pressure, which combined with the rotation of the earth, the air mass by friction surface layer, the influence of the moon and other planets causes the nucleation of vortices of large diameter (hundreds of kilometers), which moved into the northern and southern latitudes and eventually scattered. Wind speed in the surface layer of such a vortex of hurricane force reaches 200 km / h and more.

Ravages of strong winds intensified loss of heavy rains, flying through the air objects. On the approximation of strong winds population notified storm warning. Upon receipt of such notice must close the windows, doors, hold fixing work, swept away by the wind objects sturdy shelter in the building.

With the approach of winter snowstorms is recommended that a number of the activities listed above, as well as stock up on food and water.

Vortices of large diameter – is an air funnel diameter 100 – 1500 m with a pressure drop between the center and the periphery to 8 kPa, which descended from the cloud , leave the terrain wide swath of destruction a few tens or hundreds of meters and a length of several hundred meters to tens of kilometers or more. These vortices cause very great destruction: scratching trees, destroy buildings, rip and move large objects on the ground . In the equatorial zone, these vortices are called tornadoes.

Approximation of such vortices cannot be long-term forecasting. In this case, you have to be very attentive. Seeing the approaching cloud of dust, the impending destruction of the countryside in a narrow band, you need to determine the direction of the vortex, quickly leave the area of his actions and thus save themselves. Rain – quite widespread and atmospheric phenomena associated with electrical discharges – lightning. The magnitude of the electric lightningtion is 20 – 30 Cl, in very rare cases up to 80 Kl, the force of the discharge current is 200 kA, temperatures up to 40,000°C. Teaching Stock thundercloud has a length of about 2 km, and the duration of the lightning cycle is 30 minutes or more. Lightning strikes cause destruction, causing fires, often lightning killing people and animals.

Ball lightning is in the form of a luminous ball of diameter 20 – 30 cm, driving on the rough path with silent disappearance or explosion, causing damage and casualties. With the approaching storm need to perform the same action (meropriyament), and that the approach of strong winds. Particular attention should be paid to the drafts, because of which the room can get a fireball.

The most dangerous places where you cannot hide from the rain during a thunderstorm are:

– Stand-alone buildings, trees, especially with a strong roofing system, oak, poplar, etc. (out of 100 lightning strikes 54 parishes in oak, poplar, on 24, 10 on the fir, pine 6 to 3 on the beach, lime and 2 for 1 on acacia).

– The hills with dense soils.

– Areas surrounding the lightning rod, etc.

During a thunderstorm, you cannot move on with protruding objects such as shoulder braid, forks, etc. You cannot swim during a thunderstorm. Upon detection of a fireball in any case cannot be run because the air flow can captivate her for a bit and call themselves. It is necessary to determine the trajectory of its total travel and without causing airflow exit zone location.

Flooding – flooding is a significant area in the destruction of hydraulic structures – dams, as well as the rise of the water level in rivers and lakes. Extent of flooding predicted by the intensity loss precipitation of snow, ice thickness, the intensity of their melting.

According to established practice flood is divided into three stages:

– disaster forecasting and organization of work to reduce harm, including notification management and population unit dams to limit the extent of flooding, the preparation of forces and means to fight ;

– implementation of measures to save the people, values, and strengthen the capacity of dams and embankments , survival evacuees;

– recovery housing ; facilities management, commissioning and operation, agricultural rehabilitation, works on flood (deepening riverbeds, dikes, embankments, etc.)

Upon receipt of notice of the flood should have already completed the protection of the population and in the ES (prepare documents, money, place the property, products, food in attics prepare for evacuation and cattle-like). At the announcement of the evacuation, need to come to the assembly point, register and wait for further instructions. A placement in evacuation must comply with the administration of the tent camp or settlement.

After the evacuation should first examine the general condition of buildings, if necessary, work to strengthen them and begin to flood relief .When approaching wave of release should take a hill or upper floors of buildings. Fire – uncontrolled combustion process entailing the destruction of wealth, people. The Republic is most often forest, peat fires and less wild. They occur as the fault of the person, and as a result of spontaneous combustion from the sun or a lightning strike. Statistics show that 80 % of fires occur because of the person, and only about 20% of the fault of nature.

If the hot weather there is no rain 15 – 18 days, the forest becomes a fire hazard. Spontaneous combustion of peat is very rare – in 5 cases out of 100. Most are flammable dead wood, pine young, cutting cluttered, less dangerous and mixed deciduous forests.

Forest fires are:

– Grassroots (lit litter, the propagation velocity of 0.3 to 1.0 m / min to 1 km / h);

– riding (burning crown, the speed of 8 – 25 km / h);

– Stable fires when all lit tree, the speed of 5 – 8km / h;

– Underground (burning peat layer extends at a speed (0.1 – 0.5 m / min);

– runaway fires when burning dry grass (usually in the spring);

– steppe (field) fires occur in the open countryside in the presence of mature breads, dry grass.

The main way to fight forest fires are entanglement, backfill soil, fill with water, creating a barrage band, start a fire at the oncoming wind direction changes by 180 °. With the threat of falling into a forest fire lane must go to the fields, the barrage band, ditches, water bodies. In dry weather, forest protection at the request of visiting forests prohibited.

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ENERGY CONSUMPTION REDUCING IN THE ASPIRATION SYSTEMS AT THE WOODWORKING ENTERPRICES

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The article deals with traditional and modernized aspiration systems at woodworking enterprises. It presents some activities for aspiration systems technology improvement, which help to reduce energy consumption. It researches a volume vertical packaged collector application in the aspiration system; it

introduces graphical dependences of aerodynamic parameters and waste catching degrees during the modern aspiration system working. It contains the analysis of the results and recommends methods, which improve functioning of aspiration systems.

The woodworking enterprises produce a good deal of waste: wood chips, saw dust and dust. Wood wastes are removed from the room by bush aspiration systems, which contain waste and air receivers, duct pipelines, cyclones and ventilators.

The bush aspiration systems don't only serve for the moving of materials, they are also used as local retractable ventilation systems. It is a specific characteristic of bush aspiration systems. The pressure decreases in the system due to duct pipeline wall friction of transported materials and transported air, material particles surface friction of the air, that have less speed, and also friction of material particles. Shaped parts of the duct pipeline and the used equipment have increased resistance. There are energy expenses for overcoming of material weight [1].

In view of the features of aspiration systems, we can offer to improve technology of these systems significantly decreasing the length of material transportation and energy consumption. That is why we offer to install volume vertical packaged collector [2] in the middle of the machines location, where large particles of the transported material precipitated. Cyclone is installed after the packaged collector. It clears only medium and small dispersion dust (Fig. 1).

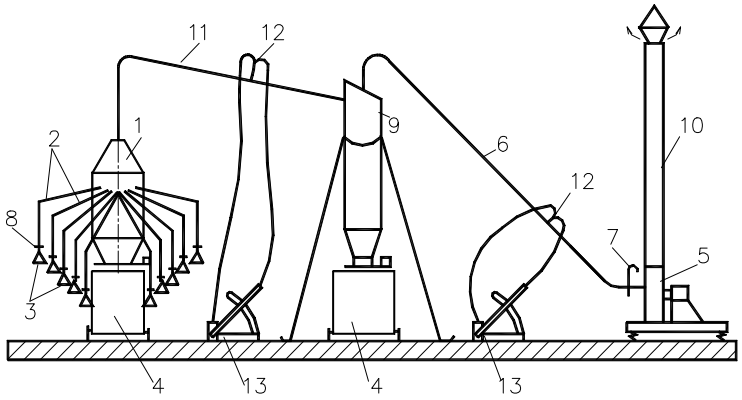

Fig. 1. Scheme of modernized bush aspiration system: 1 – vertical packaged collector; 2 – duct pipelines; 3 – dust receptacle casing; 4 – truck; 5 – ventilator; 6 – packaged duct pipeline; 7 – damper; 8 – ventilation valve; 9 – cyclone; 10 – exhaust pipe; 11 – packeged duct pipeline; 12 – pneumatic tubes; 13 – micromanometer

Bush aspiration systems are widely used at the enterprises. Every such system unites more than ten woodworking aggregates. In the middle of the aggregates location and their suctions *3*, we offer to set up the vertical packaged collector *1* [2], which is appended in the top part of duct pipelines *2* from waste receivers. The waste receivers are connected with machines. The main function of packaged collector is to drop out the basic weight of wood waste particles from the air flow. Such an accumulation takes place due to fast decrease of the air speed at the collector, which has bigger diameter (8-10 times) than the pipeline diameter of the waste receivers.

Wastes accumulate in the vertical collector under their own influence of weigh. Fallen wastes don't transpose and don't have cyclone purification *9*. It is the reason of the 15-20 % reduction of energy consumption. The cyclone *9* and the ventilator *5* are situated at some distance (mostly outside) from the collector. Waste removal from the collector is produced by the air outlet to body truck 4 or to conveyer.

Air quantity, which is drawn out by ventilator *5* on the packaged duct pipeline *6* according to the number of synchronous working machines, is controlled by ventilation valves *8*. These valves are mounted in pipelines *2* directly near suction *3* of each machine. All the currently inactive machines disconnect automatically of the aspiration's net, thanks to ventilator valves, which are electrically connected with machines. As a result, the ventilator *5* draws out less air and, therefore, consumes less power, through net throttling. However transporting speed is reduced in the packaged duct pipeline 6, when the small quantities of machines are synchronous working. It makes the purification efficiency of dust worse in the cyclone *9*. That's why it is necessary to provide the installation of the speed reactor *9* at the air inlet in the cyclone. Speed reactor will maintain the air speed at the allowable level and it doesn't matter how much machines are synchronously functioning [3]. Wood dust, which was catching by cyclone, is periodically unloaded from the bunker in the truck *4* or to the conveyer.

The air speed on the net part can be less than transporting speed or more than terminal velocity, because only dust is transported in the duct pipeline and the mass concentration of aeromixture is negligible.

Transporting speeds and terminal velocities of wood dust can be determined from the formula [2]:

$$\upsilon_{mp} = c \cdot \left(4 \cdot \mu \cdot \frac{\upsilon_{в}}{\upsilon_{м}} + 0,01 \cdot \rho_{м} + b \right) \cdot \sqrt{\frac{1,2}{\rho_{в}}} = 1,1 \cdot \left(4 \cdot 0,02 \cdot 1,1 + 0,01 \cdot 500 + 7 \right) \cdot \sqrt{\frac{1,2}{1,2}} = 13,2 \text{ m/sec}$$

where c=1, 1-the coefficient, which considers the speed decrease in the local consumptions; $\rho_м$- the density of the material, kg/m^3; $\rho_в$- the density of the air, kg/m^3; μ- the concentration of material, kg/kg;$\upsilon_в$- the air speed, m/sec; $\upsilon_м$-the material speed, m/sec;b-the experienced coefficient, which depends on the kind of the transporting material (for dust b=7).

$$\upsilon_S = 0,14 \cdot \sqrt{\frac{\rho_м}{\left(0,02 + \frac{a}{h} \right) \cdot \rho_в}} = 0,14 \cdot \sqrt{\frac{500}{\left(0,02 + \frac{0,9}{3} \right) \cdot 1,2}} \approx 5 \text{ m/sec}$$

where a=0,9- the coefficient, which depends on the shape of particle; h- particle thickness, mm.

According [4] the values of the dust transporting speeds belong to the interval:

$$m \cdot \upsilon_s < \upsilon_{mp} < n \cdot \upsilon_s$$

where $m \cdot \upsilon_s$ – the minimum value of the diphasic flow speed according to the kind of the transporting material, m/sec; $n \cdot \upsilon_s$ – the maximum value of the diphasic flow speed according to the economic conditions of the aspirationsystems operation, m/sec.

The minimum value of the dust transporting speed is 9...10, 5 m/sec for the experimentally received meanings m = 1, 8, n = 2, 1. Satisfactory air speed by dust outlet will be about 6 m/sec in the duct pipeline. This air speed is scarce for the cyclone work, so it is necessary to install a speed reactor in the cyclone inlet.

Experiments were conducted with changing air consumption from 120 to 180 m^3/h. The aeromixture concentration was accepted within 0, 1…0, 5 kg/m^3. Results of the experiments are presented in the form of graphs (fig. 3, 4).

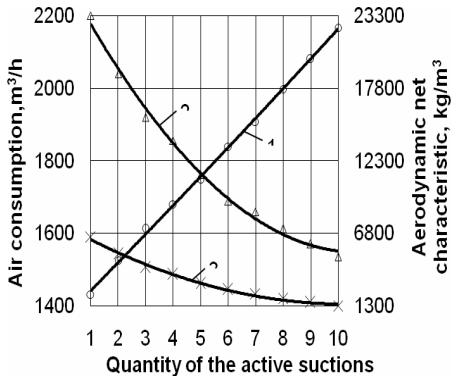

Fig. 2. Aerodynamic parameters of the aspiration system:
1 – air consumption; 2 – aerodynamic characteristic of the aspiration system;
3 – aerodynamic characteristic of the packaged collector net

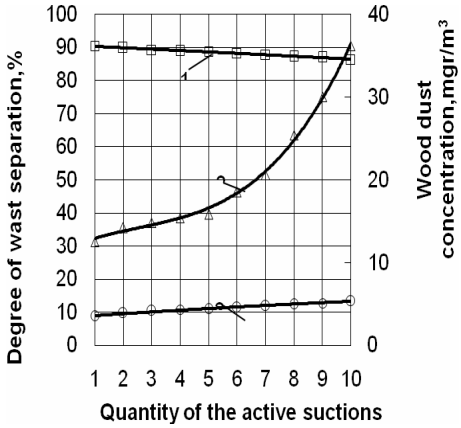

Fig. 3. The degree of waste separation with the improved aspiration system:
1 – waste quantity, which was separated in the packaged collector; 2 – dust concentration in the air ejections;
3 – waste quantity, which was separated by cyclone

Based on the graphic dependences in Figure 3, 4, we can make the following conclusions:

– aerodynamic characteristic and, therefore, the consumption of the packaged duct collector net with 10 modes constitute insignificant part of all installation consumption;

– disconnection of temporary inactive machines from the aspiration net significantly reduces energy consumption for material transportation, although net consumption is increasing due to decrease of the air consumption. If you accept the coefficient of the synchronous working machines as 0, 6, that power consumption of energy consumption will reduce on 21, 2% in the experiment;

– the main wood waste mass (86-90%) falls in the vertical collector, thus it isn't necessary to transport it by expensive pneumatic methods, which need large energy consumption. There is a tendency to some insignificant decreasing of the accumulated waste mass with the increasing of synchronous working suctions. It can be explain by the difference between modes of the waste entrance in the collector shell. It is necessary to connect air channel of the suction to the collector shell, which is leaned angle 40-50º;

– the additional economy of energy consumption is about 40%, what is achieved by the main mass of large wood waste transfer induct pipelines on the short distance from machines to the packaged collector. It helps to reduce pressure loss;

– only 8-13% of small factions of all waste mass gets in the cyclone, besides, the load slightly increases in the cyclone with the increase of the synchronous working machines quantity.

Although, the purification degree stays on the constantly high level (93-97%), it can be explain by the presence of speed reactor and small mass of the fine-dispersed dust ejected in the atmosphere.

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UDC 621.9.04

IMPROVING OF FIXING SYSTEM OF CUTTING PLATES IN BLOCK-MODULAR CUTTING TOOLS

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The paper present research system of fixing cutting plates and blocks in block-modular cutting tools

Reliability teams cutting tools to a large extent determined by the reliability of fixing plates in the housing. There are many designs of clamping mechanisms, taking into account the working conditions of the cutting tools and features for their manufacture. These systems reflect the current trends in the design of cutting tools: high precision of manufacturing of cutting plates, the closed grooves and precisely manufactured to accommodate the cutting plates, the cutting plates clamping mechanisms with a minimum number of structural elements, such as a screw or a lever. The implementation of such systems in terms of domestic production tool is not always possible, as it requires special equipment and precise, high-quality components elements. Therefore urgent to establish a system fixing cutting plates technological conditions for domestic production and not inferior to the best foreign systems reliability.

The system of fixing cutting plates, including the following key elements (fig. 1): the cutting plate (pos. 1) is set to open width direction groove cutting block (pos. 2). Fixing module of (pos. 3) is configured as a "T-shaped" strap, "the horizontal shelf" which is introduced into one part of the cutting plate hole and is pressed against the front surface of the cutting plate, while the other part is brought into contact with the bevel of the cutting block. The "horizontal shelf" of "T-shaped" strap is installed by planting in open longitudinal groove the cutting block. "Vertical shelf" of strap is designed as a screw threaded into "horizontal shelf" of strap and

installed in the "oval-shaped" hole of the cutting block. When the strap screw is performed simultaneous movement of strap in horizontal and vertical directions, and the strap of the cutting plate on the base, the side surface and the hole.

In the proposed system, the grooves are made open and reliability of fixing of cutting plate is provided except moves in radial, axially and tangentially relative to the machined surface of the work piece.

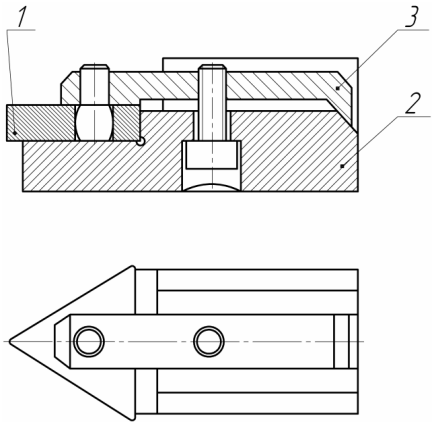

Fig. 1. The system of fixing cutting plates

The design of the cutting block (fig. 2) includes a cutting plate with hole installed into the transverse open groove relative to the geometric axis of the housing at a certain angle α. Clamping of plate provided a "T-shaped" strap placed in an open longitudinal groove of the housing of block and having formed at an angle α "strapping planar part" and "support part" in the form of plane or spherical surface. In the strapping part is a pin incoming hole of cutting plate. Strapping planar part in contact with the front surface of the cutting plate and support part – with a flat surface of the housing of block arranged at a predetermined angle ψ. Clamp of strap by using screws threaded into it and freely entering the "oval-shaped" hole in the housing of block.

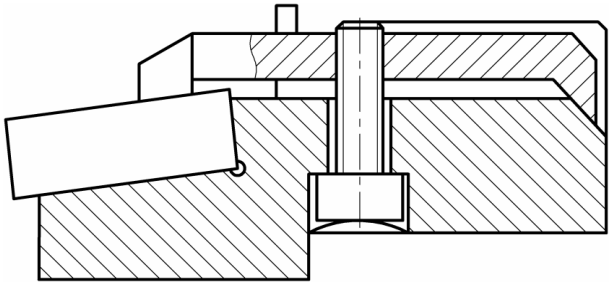

Fig. 2. The design of the cutting block

Proposed design of cutting block differs from known analogues following:

1. Clamp made T-shaped as opposed to most similar found structures (the L-shaped). And strapping part has "leverage" smaller than the reference.

2. Clamp is placed in a groove of the housing on the landing provides free movement in the longitudinal direction and fixed in the transverse, i.e. clamp works as a "yoke", the retaining plate on the transverse displacements.

3. Strapping part has a bevel at an angle α, the value of which is chosen as the value of the posterior angle of the cutting plate and a few adjusted for self-locking angle for the contacting materials.

4. The supporting part is performed flat or spherical and contacts with beveled angle ψ plane of housing of cutting block, whose value is chosen based on the possibility of longitudinal displacement of strap.

5. Pin included in the planting to hole of strapping part and has a spherical end (part of the hole of cutting plate).

6. Clamping screw enters freely into the housing bore and is slid able transversely direction in relation to its axis.

7. Housing of block is cylindrical, allowing its installation in the housing module hole tool and clamp two hollow cylindrical elements with radius «samples» of the corresponding cylinder of the housing, and a tightening screw them.

8. Design of elements of clamping as cutting plates and housing of cutting block provides action of clamping forces on the direction of the cutting force components that ensures additional sampling possible gaps in the design of the cutting process.

Fixing system of the cutting block in the housing module (fig. 3) also technological and reliable. Cutting block mounted on the cylindrical surface in the hole, where previously through the other hole entered into one element of the clamping mechanism ("cotter"). Then introduced another "cotter" and both "cotter" tightening screws, thus providing reliable clamping of cutting block between two "cotters" and exclusion of movement of cutting block in all directions. The exact location of "cotters" relatively cutting block considers direction acting on cutting plate cutting forces – clamping force directed along the cutting forces, which eliminates gaps in the contact elements during vibration system.

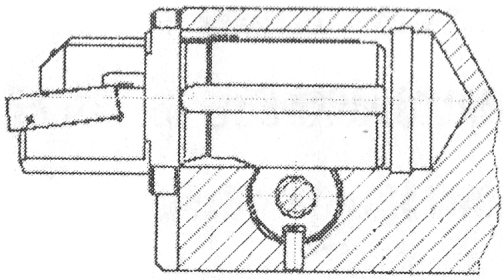

Fig. 3. Fixing system of the cutting block in the housing module

Thus, the reliability of the proposed design of block-modular cutting tools is dependent on the accuracy of performing linear and angular parameters of the components, material selection and details of the heat treatment, and compliance with the sequence of assembly and adjustment tool.

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UDC 517.537.3=111

FINDING OF RADIUS OF CONVERGENCE OF THE POWER SERIES CONTAINING NOT ALL POWER (X-A) WITH THE HELP OF FORMULA BY MEANS OF SIMPLE TRANSFORMATION OF COEFFICIENT OF THE SERIES

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Functional series of the form:

$$a_0 + a_1(x-a) + a_2(x-a)^2 + \ldots + a_n(x-a)^n + \ldots = \sum_{n=0}^{\infty} a_n(x-a)^n , \quad (1)$$

where $a_n \in R$, $n = 0,1,2,\ldots$, $a \in R$ are called a power series. Numbers $a_0, a_1, a_2, \ldots, a_n$ are called coefficients of power series.

If $a = 0$ we receive a series of the form

$$a_0 + a_1 x + a_2 x^2 + \ldots + a_n x^n + \ldots = \sum_{n=0}^{\infty} a_n x^n , \quad (2)$$

we will examine such power series from the point of view that if in series (1) put $x - a = y$ one can always go to a series which looks like form (2).

Abel's theorem implies that if $x_0 \neq 0$ there is a point of convergence of power series (2), the interval $(-|x_0|;|x_0|)$ consists of points of convergence of this series; at all values x out of this interval series (2) diverges. Interval $(-|x_0|;|x_0|)$ called the interval of convergence of power series. Putting the interval of convergence can be written as $(-R;R)$. The number R is called the radius of convergence of the power series.

For finding of radius of convergence of power series (2) in the majority of manuals are offered to use the following formulae:

$$R = \lim_{n\to\infty} |\frac{a_n}{a_{n+1}}| \quad (3)$$

$$R = \lim_{n\to\infty} \frac{1}{\sqrt[n]{|a_n|}} \quad (4)$$

which are derived from Dalamber and Cauchy's criterion. To derive formula (3) one will make a series of modules of members of these power series:

$|a_0|+|a_1x^1|+|a_2x^2|+...+|a_nx^n|+...$ to the turned-out series we will apply a criterion. Assume that there is a limit $\lim_{n\to\infty} |\frac{u_{n+1}}{u_n}| = \lim_{n\to\infty} |\frac{a_{n+1}x^{n+1}}{a_nx^n}| = |x| \lim_{n\to\infty} |\frac{a_{n+1}}{a_n}| \neq 0, x \neq 0.$

On the basis of the d'Alembert series converges if

$$|x| \lim_{n\to\infty} |\frac{a_{n+1}}{a_n}| < 1 \quad (5)$$

the series made of modules of members of series (2), diverges at those values, for which $|x| > \lim_{n\to\infty} |\frac{a_n}{a_{n+1}}|$. Thus, for series (2) the radius of absolute convergence is given by (3).

Similarly, having used Cauchy's radical criterion, it is possible to establish that the radius of convergence can be found by formula (4).

Consider the example of how to use the above formula is the radius of convergence of the power series.

Example 1. Find the radius of convergence of the power series $\sum_{n=1}^{\infty} \frac{x^n}{n}$.

Solution: For the above series $a_n = \frac{1}{n}$; $a_{n+1} = \frac{1}{n+1}$ using the formula (2) we obtain:

$$R = \lim_{n\to\infty} |\frac{\frac{1}{n}}{\frac{1}{n+1}}| = \lim_{n\to\infty} |\frac{n+1}{n}| = 1.$$

But it should be noted that formulae (3) and (4) must be used very carefully, as if the infinite set of coefficients addresses in zero, it is impossible to use the specified formulas. For example, we will take a series $\sum_{n=1}^{\infty} \frac{x^{2n}}{n}$ at it the infinite set of coefficients is zero, namely all coefficients at odd degrees are equal to zero, in too time coefficients at even degrees are other than zero. Applying (3) we receive on the one hand $R = \lim_{n\to\infty} \frac{a_{2n}}{a_{2n-1}} = \infty$, on the other $R = \lim_{n\to\infty} \frac{a_{2n+1}}{a_{2n+2}} = 0$.

We will take any point x_0 other than zero, then, as $R = \lim_{n\to\infty} \frac{a_{2n}}{a_{2n-1}} = \infty$ x_0 is a convergence point, but on the other hand in view of the fact that $R = \lim_{n\to\infty} \frac{a_{2n+1}}{a_{2n}} = 0$ same the point is a divergence point, so we received a contradiction.

This occurs when the number does not contain all power x. For example:

$\sum_{n=1}^{\infty} \frac{x^{2n}}{n} = \frac{x^2}{1} + \frac{x^4}{2} + \frac{x^6}{3} + ... + \frac{x^{2n}}{n}$ (contains only even degrees x) or

$$\sum_{n=1}^{\infty}\frac{x^{2n-1}}{n}=\frac{x^1}{1}+\frac{x^3}{2}+\frac{x^5}{3}+...+\frac{x^{2n-1}}{n}$$ (contains only odd degrees x).

In this regard, many authors recommend to use at determination of radius of convergence of such power series directly Dalamber and Cauchy's criterion without resorting to general formulas for determining the radius, which complicates the calculation limit.

In this report we will consider a method of finding of radius of convergence which allows to work not with the general member of a row as in Dalamber or Cauchy's criterion, and uses only coefficients of the series, by their simple transformation.

Example, our series $\sum_{n=1}^{\infty}\frac{x^{2n}}{n}$ convert to a form that will contain all the powers x. We will divide all coefficients at n into that expression which faces n in an exponent. The exponent is equal in our example 2n respectively we will divide all coefficients at n on 2. $\sum_{n=1}^{\infty}\frac{x^n}{\frac{n}{2}}$

Find the radius of convergence of the series obtained by the formula (3):

$$\mathrm{R}=\lim_{n\to\infty}\left|\frac{\frac{1}{\frac{n}{2}}}{\frac{1}{\frac{n+1}{2}}}\right|=\lim_{n\to\infty}\left|\frac{2(n+1)}{2n}\right|=1$$

Find the radius of convergence of the original series by d'Alembert:

$$\lim_{n\to\infty}\left|\frac{\frac{x^{n+1}}{n+1}}{\frac{x^n}{n}}\right|=\lim_{n\to\infty}\left|\frac{(n)x^{n+1}}{(n+1)x^n}\right|=\lim_{n\to\infty}\left|\frac{xnx^n}{(n+1)x^n}\right|=|x|\lim_{n\to\infty}\left|\frac{n}{n+1}\right|$$

$$|x|<\frac{1}{\left|\lim_{n\to\infty}\left|\frac{n}{n+1}\right|\right|}\to|x|<\frac{1}{1}=1,\ \text{т.к.}\ \ R=|x|,\ \text{то}\ \ R=1.$$

As we can see the result is the same.

We will consider now a series $\sum_{n=1}^{\infty}\frac{x^{an}}{b^{cn}}$, где a,c – coefficients at n, $a,b,c\in R$.

Find the radius of convergence by d'Alembert

$$\lim_{n\to\infty}\left|\frac{\frac{x^{a(n+1)}}{b^{c(n+1)}}}{\frac{x^{an}}{b^{cn}}}\right|=\lim_{n\to\infty}\left|\frac{x^{an}x^ab^{cn}}{b^{cn}b^cx^{an}}\right|=|x^a|\lim_{n\to\infty}\left|\frac{1}{b^c}\right|,$$ on a formula (5) we receive:

$$|x^a|\lim_{n\to\infty}\left|\frac{1}{b^c}\right|<1\to|x^a|<\frac{1}{\lim_{n\to\infty}\left|\frac{1}{b^c}\right|}=\lim_{n\to\infty}|b^c|\to|x|<b^{\frac{c}{a}},\ \text{as}\ |x|=R\ \text{receive}$$

$R=b^{\frac{c}{a}}$. Based on this, I guess in the original series can be divided both coefficients on the same natural number not equal to 0. That is, in the original series coefficients, divide by a:

$$\sum_{n=1}^{\infty}\frac{x^{\frac{a}{a}n}}{b^{\frac{c}{a}n}}=\sum_{n=1}^{\infty}\frac{x^n}{b^{\frac{c}{a}n}}.$$

As you can see, we get a series in which all the powers at present, therefore, we can apply the formula (3) and (4), which greatly simplifies the calculation of radius of convergence.

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UDC 665.76

RESEARCH OF THE ALKYLATION PROCESS OF PHENOL BY TETRAMERS OF PROPYLENE ON ION-EXCHANGE SMOLS

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The article is described the regularity of phenol alkylation process by tetramers of propylene by ion exchange catalyst. This process possesses a current interest in manufacturing of phenol engine additive. Reaction's conversion and selectivity were estimated in different circumstances.

Currently in the process of synthesis of alkyl phenol by phenol alkylation of propylene tetramers used ion exchange the catalyst has a high sensitivity to moisture, even at 3 wt% water using it ineffective until the maximum permissible temperature of operation. Given that the maximum operating temperature sulphocationite TULSJON T-66 is 403 ° K (130 ° C), its application requires the provision of special technological conditions on the content of moisture in the system / 1 /.

Basic physical and chemical properties of the samples of ion exchange resins in passport supplier are shown in Table 1.

Table 1–Basic physical and chemical properties of the samples

Catalyst	Bulk density	Specific surface area, m2 / g	Pore diameter, A	Total capacity, eq / kg	Maximum operating temperature, ° C
Catalyst 1	610	53	300	4,7	120
Catalyst 2	560	50	300	5,0	150
Catalyst 3	770	33	240	5,4	150
Catalyst 4	500	35	450 – 500	4,9	130
Catalyst5	540 – 580	45 – 60	120 – 300	4,7	–

Synthesis alkylphenol based catalysts investigated

Alkylphenol synthesized by apkilirovaniya phenol tetramers of propylene catalyst cation exchange (ion exchange resins) . Temperature range study agreed with the industry and is 130-150 ° C. Diffusion inhibition removable stirrer at a speed above 300 rev / min , and the reaction takes place in the kinetic mode / 1 / . In the studies of the impeller shaft speed was maintained at 350 rev / min.

Study phenol alkylation tetramers of propylene was carried out in a three necked reaction flask using a reflux condenser for condensing the vapor; the reaction temperature was recorded with a laboratory thermometer ; intensive stirring of the reaction mixture was carried out using a laboratory stirrer throughout the alkylation process . The first component introduced into the reaction mixture was phenol. After introduction of the catalyst was filled in phenol required mass quantity by weight of the mixture. The heated mixture was stirred for one hour to prepare the catalyst and swelling ; propylene tetramers further injected into the reaction mixture . Duration of the experiment was 180 min. The ratio of phenol: alkene depending on a series of experiments were on the level:

- 2:1 mol / mol, and a catalyst loading of 20% (wt.) relative to the weight of the reaction mixture - lot 1 ;
- 4:1 mol / mol and a catalyst loading of 20% (wt.) relative to the weight of the reaction mixture - two series ;
- 4:1 mol / mol and a catalyst loading of 10% (wt.) relative to the weight of the reaction mixture - 3 series ;
- 6:1 mol / mol and a catalyst loading of 10% (wt.) relative to the weight of the reaction mixture - 4 series .

Reference points were selected the following indicators:

1) concentration monoapkilfenolov ;

2) the concentration dialkylphenols ;

3) Conversion of propylene tetramer .

As a result, the alkylation of phenol tetramers of propylene to be achieved the highest conversion of alkenes with the highest yield and the lowest yield monoapkilfenolov dialkylphenols . The basic method of analysis is the gas-liquid chromatography / 2 /.

The analysis of the alkylation products Composition of the reaction mass obtained are shown in Tables 2-3.

Table 2 – Results of the chromatographic analysis of phenols in a molar ratio of phenol: propylene tetramers a 2:1 mol / mol and a catalyst loading of 20% (wt.) relative to the weight of the reaction mixture.

The type of the alkylphenol	Content of propylene tetramer	The content of free phenol	Contents of monoalkilpheno l	Contents of dialkilphenol
Catalyst 1	4,59	7,96	70,98	16,47
Catalyst 2	5,88	8,21	71,98	13,93
Catalyst 3	6,01	7,52	73,01	13,45
Catalyst 4	7,31	7,74	68,91	16,05
Catalyst 5	14,43	10,21	69,88	5,48

Table 3 – Results of the chromatographic analysis of an alkylphenol with a molar ratio of phenol: propylene tetramers ratio of 4:1 mol / mol and a catalyst loading of 20% (wt.) relative to the weight of the reaction mixture

The type of the alkylphenol	Content of propylene	The content of free phenol	Contents of monoalkilphenol	Contents of dialkilphenol
Catalyst 1	3,62	25,78	62,63	7,97
Catalyst 2	3,36	28,70	63,91	4,03
Catalyst 3	2,27	27,59	65,71	4,43
Catalyst 4	2,26	22,92	69,56	5,25
Catalyst 5	3,11	28,38	63,81	4,70

According to the results of chromatographic analysis of Table 2 it can be concluded that a molar ratio of phenol: propylene tetramers a 2:1 mol / mol and a catalyst loading of 20% (wt.) relative to the weight of the reaction mixture of propylene tetramer maximum conversion is achieved using catalyst 1, the highest yield of monoalkilfenolov - using sulfonic catalyst 2, the smallest output dialkylphenols - using sulfonic catalyst 3; however, use of catalyst 4 leads to the highest level with the lowest output dialkylphenols conversion of propylene tetramer applying sulfonic catalyst 5 leads to the lower conversion of propylene teramerov ; overall yields alkylphenol fractions and the degree of conversion of alkenes are approximately at the same level for the remaining three catalysts.

According to the results of chromatographic analysis of Table 3 it can be concluded that the molar ratio of phenol: propylene tetramers ratio of 4:1 mol / mol and a catalyst loading of 20% (wt.) relative to the weight of the reaction mixture of propylene tetramer maximum conversion is achieved using catalyst 1 , the highest yield of monoalkilfenolov - using catalyst 2, the smallest output dialkylphenols - using sulfonic catalyst 3; however, use of sulfonic catalyst 2 leads to the highest level of output with the lowest conversion dialkylphenols propylene tetramer . In further series of experiments catalyst 4 excluded from the study of cation exchange resins on the basis of 1 and 2 series of experiments.

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ICT, ELECTRONICS, PROGRAMMING

UDC 004.02

REVIEW OF IRREGULAR CHARACTERISTICS OF PROGRAM CODE

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Analysis of the code used to solve the actual problems of determining the quality, searching plagiarism and authorship of source code. For each specific target can be approached only certain methods and algorithms of analyzing the source code of programs.

In the source code of programs, in addition to the standard features, there are also characteristics peculiar to a particular author (naming of variables, the style of writing, the linguitic peculiarities of comments, the number of different data types, stable level of certain metrics, etc.) [1 – 4], so it is appropriate to use the concept "programmer's handwriting".

The concept "programmer's handwriting" is difficult to define as we are to find code optional characteristics that are inherent to a particular programmer. Programmer's handwriting can manifest itself in the architectural solution, for example, in the abuse of any design pattern or coding rules, nomination of variables, methods, and other structural units of the programming language, such as:

– naming of classes, methods and variables, local variables of the method, method parameters;

– the place of initialization the class variables, creating unused class methods (i.e. excess precision that comes from the design, but isn't used in the current implementation);

– the number of comments, the view of comments, the place of comments;

– the length of method names , the use of types;

– the use of transfers;

– the listing of interfaces, but not the use of polymorphism;

– the use of a specific template in all the programs of the author, a certain standard set of code metrics that have the same value in all programs of a specific programmer, etc.;

Programmer's handwriting should first clearly define the website source code, as well as to find the handwriting of the author in search problems of plagiarism. Since under the programmer's handwriting, we also mean a certain level of supported source code metrics, the quality of handwriting has an equivalent relationship with the quality of software code. Thus, this characteristic simultaneously embraces calculation of code quality, searching of plagiarism and authorship.

Let's consider the concept "native programming language". It is the language the programmer is good at when creating a software product. And when a programmer happens to write a program in a so-called non-"native" programming language, the text manifests a programmer's accent. The programmer's accent is an integral part of the programmer's handwriting. It allows the programmer to focus on selection in addition to greater accuracy in search problems of plagiarism and authorship also conduct statistical research on migration programmers with a particular programming language. And the accent allows determining the compliance with the negative coefficient coding standards for the test code, which in turn is the quality of the code.

Heuristic methods for the isolation programmer's accent must allocate a priori set of mandatory and optional features that are specific to a particular programming language, when reduced to a common class of singularities, and the subsequent search for these features in the source code with a great programming language of this class. This feature can also assume the uncertainty in the case where the source code does not match any of the inspected class accents set , even the class with the certain programming language source code , on which will be analyzed. In this case, it is considered that it is not the focus, but a simple ignorance of programmer.

What is clear is that when searching for a accent this process becomes part of the process of defining a unique programmer's handwriting. Therefore necessarily stylistic features of programming is not a panacea to the action, as it was originally a person can follow the rules , and it is the task of searching the emphasis goes into searching programmer's handwriting. When compared to the literary language, such programmers are illiterate. The latter assumption allocates another metric – *programmer's literacy*.

Literacy of programmer is accordance of source code the programmer to standards proposed and widely used for a specific language. This problem is important, for example, in hiring and monitoring the quality of software code. Solution of the problem reduces to determining the criteria of literacy, layout and more – serial programmer check code for compliance. The rules may include naming of variables, functions, or methods, and then adopted language syntax token sequence. It should also be noted immediately that the design rules for one language do not match the rules of registration for another. Because of this, and there is emphasis on the transition from one programming language to another.

Programmer's literacy, on the one hand, is the opposite characteristics to the accent of programming, on the other – an integral part of programmer's handwriting determines its quality. But beyond that literacy determines the correctness of the instructions and rules that are characteristic for most programming languages.

Programmer's handwriting covers all other characteristics, but not uniquely determines the unique feature that is typical for this programmer. This feature is called the unique style of the programmer who will be calculated by finding the unique performance characteristics and previously considered to have both positive and negative tendency to change the quality of the source code. Typical metrics that reflect the unique style of the programmer can be non-standard commenting source code, adding his own prefixes and suffixes to the classes' names, methods and variables.

A distinctive feature of this characteristic is that it can be deliberately varied by programmer himself. This characteristic can be specifically introduced by the programmer for the protection of its source code. You can also divide a programming style for good and bad with respect to the rules of registration code, respectively, and the quality of software code. And in this context can only mean bad that the author of the source text is not specifically follows the general rules of the programming language , maintains its own because of ignorance , or to leave a unique code. Good style is considered a style that is not contrary to the rules of registration, but has redundant comments or instructions that are hallmarks of the author.

Positive dynamic of these characteristics is proportional to the lowest programmer's accent, zero indicators unique style of programmer, high literacy rate programmer and other indicators of good programmer's handwriting. Is proposed that the code "clean" if it is particularly ideal for solving the problem. The main difficulty in finding this criterion – are predefined ideal solution that is utopian. It is therefore proposed to use this feature only to specific instructions and compliance with design patterns.

Features of team programming. Modern high-load projects are the result of working of not one, but a group of programmers. These can be developed as separate unrelated modules and one class (as a syntax language unit) by team. This feature may require using of the above metrics are not one the programmer and to the team. In this case, it will be a general characteristic of the average of all team members. Also in the case of team programming, if they are known to work every programmer and prefilled reference characteristics for each programmer, it will be possible to carry out analysis on the percentage of participation in writing the source code each programmer in the team.

Another feature of the team programming is a different skill levels every programmer that is expressed in a variety of characteristics, namely indicators of handwriting, literacy, accent, etc. This feature allows you to define the maximum and minimum, and to measure the characteristics of the dynamics of change in the code. This figure will more accurately allocate the overall dynamics of changes in indicators of the team changing its participants.

Also it is worth noting that this feature of the team programming is in conjunction with the development of migration between manufacturing companies and software generates precedents plagiarism. It is understood that the proposed non-standard characteristics above software code after their implementation can be identified and such copyright infringement.

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UDC 629.735.33

DESIGN A CONTROL SYSTEM FOR THE MOVEMENTS OF CAMERA IN UNMANNED AERIAL VEHICLES (UAV)

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This paper describes three controllers designed specifically for adjusting camera's position in a small unmanned aerial vehicle (UAV). The PID, PI controllers were displayed firstly and simulated and the results displayed graphically using MATLAB technique, then we displayed the fuzzy logic controller(FLC) and it was simulated .The goal of this paper is to make a comparison between the three controllers for the desired performance.

Unmanned Aerial Vehicles (UAVs) have been provided with video cameras for feeding video and images back to the ground control stations. Most of the UAV_S use the servo motors for the movements in both roll and pitch. The camera in the UAV is connected to the duel-axis (roll and pitch mechanism), the rotational position is controlled by a tow motors (servo motors or DC motors) position control and feedback circuits. Roll error and pitch error signals obtained from gyro systems in the UAV are subtractive combined with roll and pitch position signals, to generated control signals to be applied to rotate the camera in a way that compensates for the roll and pitch movements of the UAV, and effectively isolates the camera from roll and pitch movements of the UAV and the camera will provide a good photo or video without loss in information [1].

DC-servomotor is one of the most widely used prime movers in industry today. Generally speaking the DC servomotor System is low order (no more 2nd or 3rdorder) and presents no particular design or implementation difficulties. However, the system does contain nonlinearities which have an obstructive influence on system response, such as the load effect. The Servos are used for precision positioning, because of their high reliabilities, flexibilities and low costs, DC servo motors are widely used in industrial applications, robot manipulators and home appliances, also they are used in robotic arms and legs, sensor scanners and in RC toys like RC helicopter, airplanes and cars. Where speed and position control of motor is required [2]. The DC servo motor transfer function can be in the following form:

$$G_p(s) = \frac{\omega_n^2}{s(s + 2\zeta\omega_n^2)} \tag{1}$$

The closed-loop transfer function is:

$$T(s) = \frac{G_p(s)}{1+G_p(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n S + \omega_n^2} \tag{2}$$

From the experiments, the resulting transfer function for servo motor is found to be:

$$T(s) = \frac{17.64}{s^2 + 4.364S + 17.64} \tag{3}$$

The proportional – integral – derivative (PID) controller operates the majority of the control system in the world [10]. It has been reported that more than 95% of the controllers in the industrial process control applications are of PID type as no other controller match the simplicity, clear functionality, applicability and ease of use offered by the PID controller [5]. The PID controller is used for a wide range of problems like motor drives, automotive, flight control, instrumentation. PID controllers provide robust and reliable performance for most systems if the PID parameters are tuned properly [6]. A PID controller is described by the following transfer function in the continuous s-domain:

$$G_c(s) = K_p + \frac{K_i}{S} + K_d * S \tag{4}$$

Fig. 1 shows the simulink model of the PID controller and the plant (servo motor) with unity feedback.

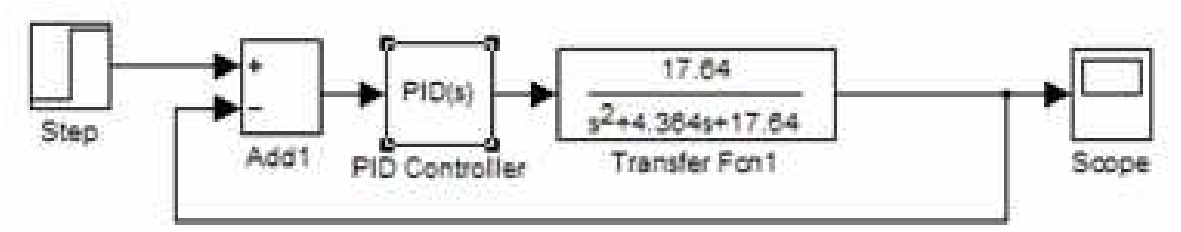


Fig. 1. PID controller system

Fig. 2-a, shows the output signal of the system designed. The final values for the PID controller gains after tuning are determined to be k_p = 10, K_i= 1, and K_d = 1.21 for T = 0.01 sec. As we see that the output has an overshoot and undershoot ripple of 10% but steady state error equal to zero. Let us now use the PI controller and decrease the controller gain Kd and Kp to minimum as possible for the desired response. By adjusting the controller gain Kd=0 and the Ki= 0.864 then the output will be as shown in Fig.2-b

(a) (b)

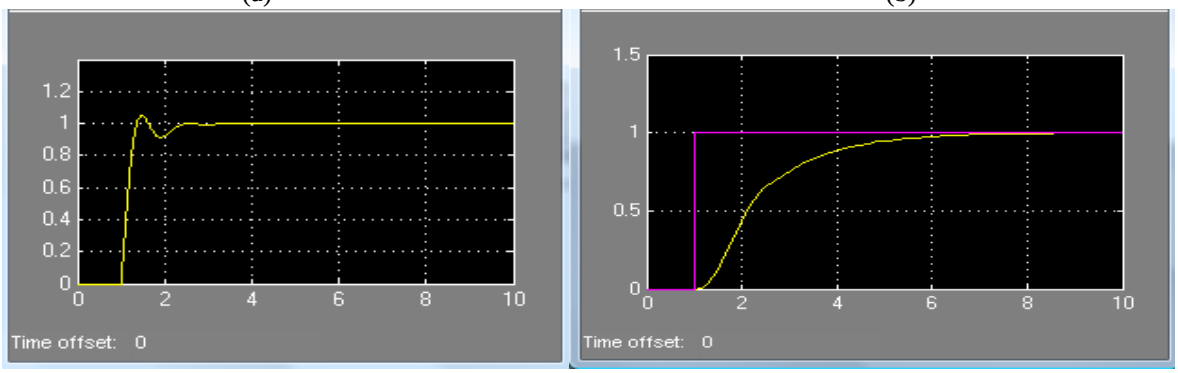


Fig. 2 .Output response for(a) PID controller (b) PI controller

The field of Fuzzy control has been making rapid progress in recent years [7]. Fuzzy logic control has been widely exploited for nonlinear, high order & time delay system [4]. Simulink model of the fuzzy controller and the considered process with unity feedback is shown in Fig. 3. For a two input fuzzy controller usually of (3, 5, 7, 9 and 11) membership functions for each input are mostly used [9]. In this paper, only two fuzzy membership functions are used for the two inputs error (e) and derivative of error (e*) as shown in Fig. 4-a. The fuzzy membership functions for the output parameter are shown in Fig.4-b, where (N) means Negative, (Z) means Zero and (P) means Positive. Depending upon whether the output is increasing or decreasing, 4 rules were conducted for the fuzzy logic controller (Table 1), where the sign of the output takes the sign of the error (e).These four linguistic rules are sufficient to cover all possible situations. The output response of the system is given in Fig. 5.

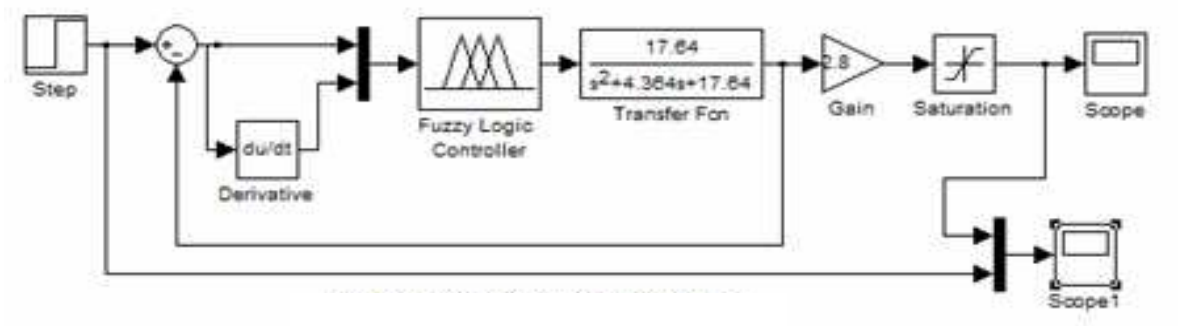
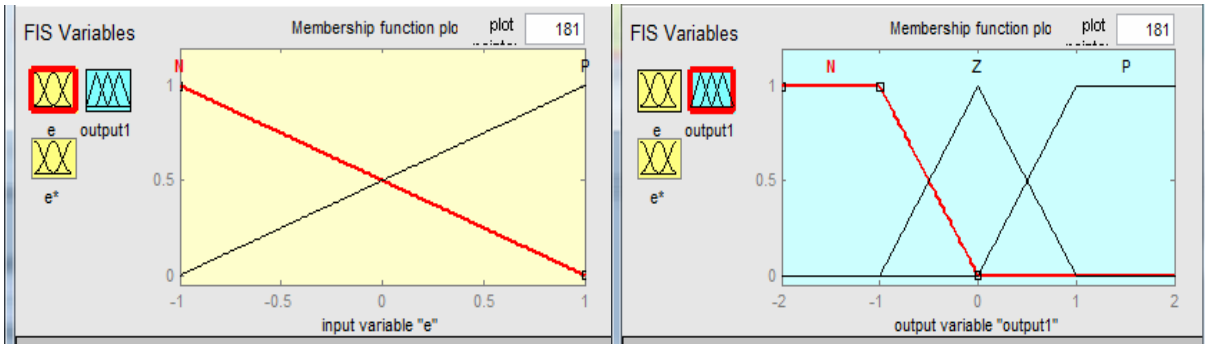


Fig. 3. Fuzzy logic controller scheme



a) b)

Fig.4. Input membership function (a), output membership function (b)

Table 1 – The rules for the designed fuzzy logic controller

e \ e*	N	P
N	N	Z
P	Z	P

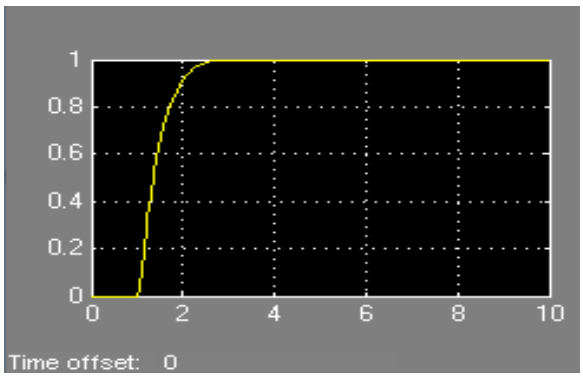


Fig. 5. Fuzzy logic controller output

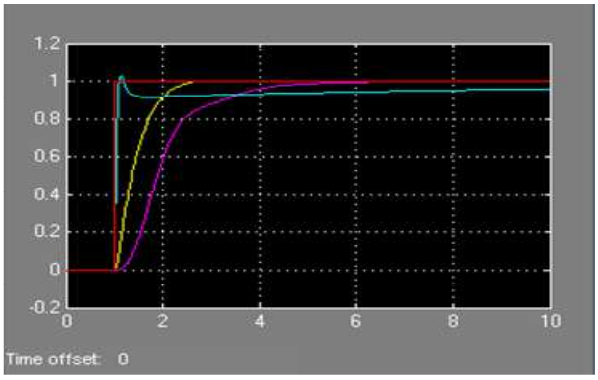


Fig. 6. Output signals for PI, PID and Fuzzy logic controller

The performance time domain specifications are now calculated by observing Fig. 6. These are compared and tabulated as shown in the Table 2.

Table 2 – Comparison between the three controllers

Controller used	Performance parameters			
	Overshoot Mp(%)	Settling time Ts(sec)	Rising time Tr(sec)	Steady state error Ess(%)
PID	10	2	0.1	7
PI	0	3.6	1.7	0
Fuzzy logic controller	0	1.8	0.8	0

The paper presented an overview of PI, PID and fuzzy logic controller using MATLAB / SIMULINK.

Fine-tuned PID controller gives high overshoot and settling time with 7% steady state error.

Fine-tuned PI controller gives high settling time with zero overshoot and steady state error.

The Fuzzy Logic controller gives no overshoot, zero steady state error and smaller settling time than obtained using with tuned PI, PID controllers.

The simulation results confirms that the proposed Fuzzy logic controller with simple design approach and smaller rule base can provide better performance comparing with the tuned PI and PID controllers.

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USING NONSTATIONARY ELECTROLYSIS FOR FORMATION SN-BI COATINGS

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The use of periodic pulse reverse current allows to form tin-bismuth electroplated coatings, with high value of term storage stable solderability. The reseach results of the influence of nonstationary electrolysis on solderability of the Sn-Bi alloy coatings have been demonstrated. The appropriate conditions for obtaining high-quality lead-free coatings with high solderability have been found. The best mode is i^k_{av} *= 1.0 A/dm*^{2}*,* τ_{forw}*:* τ_{rever} *= 4:1, f= 0.1…1 Hz.*

Among the special electrochemical coatings with high quality and reliability of solder joints in electronic equipment, Sn-coatings are especially pointed out. However, pure Sn tends to spontaneously phase transformation at low temperatures and during prolonged operation. Numerous bath compositions for formation of Sn-based alloys are developed in order to eliminate this phenomenon. Zinc, nickel, antimony, silver, copper, and bismuth are used as alloying components in those baths.

Most economical and promising for conditions of mass production of microelectronics are Sn-Bi, Sn-Sb, Ag-Sn alloys [1].

However, existing processes for the formation of deposited by DC Sn-based coatings are inefficient (0,1-0,12 m / h), and don't provide the desired solderability that decreases after three months of storage as a result of high value of porosity and low texturing of the coating.

One way of solving this problem is the use of nonstationary electrolysis. As electrocrystallization current is one of the main factors determining the electrochemical and structural conditions for the cementation, so it can widely control quality of the coatings by changing current according to certain laws.

Using periodic pulse reverse (PPR) current electroplating leads to changing of ordinary way of crystals formation, their growth and properties of coating.

PPR current is sequentially alternating cathodic and anodic processes on one electrode. Periodic dissolving the most active portions of the cathode (usually protrusions) tends to equalize the surface, makes it more uniform. In this case, number of lattice defects, porosity, and content of impurities in the precipitate are reduced [2].

Based on the above mentioned using nonstationary electrolysis for deposition Sn-Bi-coating is current and advanced affairs.

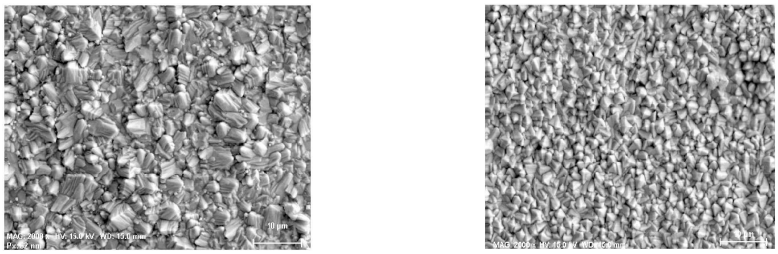
The influence of nonstationary electrolysis was tested on the Sn-Bi-coating. Plating solution contained $SnSO_4$ (50 g/l), $Bi(NO_3)_3$ (1.4 g/l), H_2SO_4 (125 g/l), neonol AF-9-10 (4 g/l), additive CCN-32 (2g/l), which was manufactured by research and production association «SEM.M». Coatings were plated at room temperature.

Electrodeposition was performed by using developed BSUIR power supply SP 24-5. Power supply can form pulses of positive and negative polarity, whose parameters are set by the computer.

According to GOST 9.302-88 the functional properties of coatings were investigated.

Varying the parameters of PPR current leads to the formation of dense, uniform, fine-grained coatings (Fig. 1) and allows expanding the range of operating current densities.

It has been established that the value of the solder spreading factor is reduced from the value from 96% to 87% on a constant current (on the current density from 0.5 to 2 A/dm^2). Solder spreading factor is index of solder wettability of the coatings. Also, this DC technology does not provide long-term storage of solderability due to its high porosity and a coarse crystalline structure.



a b

Fig. 1 The influence of DC (a) and PRC (b) (i_k^{av}=0.5 A/dm^2, γ=1,67, f=0,1 Hz) on the structure of Sn-Bi coating

Reduction of solder spread factor with increasing current density occurs due to the quality degeneration of the coating under higher densities. The quality degeneration of surface is observed by using DC (i_k =1.8 A/dm^2). Using nonstationary electrolysis extends range of operating current densities and allows to increase limit of operating current and to form light metal coatings with high value of the solder spreading factor. Reseach of solderability after three months in laboratory condition was conducted. It has shown that using nonstationary electrolysis leads to forming of coatings with high value of term storage stable solderability (tables 1…3).

Table 1 – Solderability of Sn-Bi pulse electrodeposited alloy (i_k^{av} = 0,5 A/dm^2, f = 10 Hz)

f, Hz	Solder spreading factor, %		Relative variation, %
	as-plated coatings	stored	
1,25	91,8	77,3	15,8
2	91,5	81,9	10,5
2,5	90,9	86,2	5,2
3,33	89,0	82,6	7,2
5	91,3	84,8	7,1

Table 2 – Solderability of Sn-Bi PPR electrodeposited alloy (i_k^{av} = 0,5 A/dm^2, γ = 1,67)

f, Hz	Solder spreading factor, %	
	as-plated coatings	stored
0,1	89	76
1	91	78
10	90	83
100	84	70
1000	90	83

Table 3 – Solderability of Sn-Bi PPR electrodeposited alloy with different ratios of length of the forward and reverse pulse (i_k^{av} = 1,0 A/dm^2, f = 1 Hz)

τ_{forw}: τ_{rever}	Solder spreading factor, %	
	as-plated coatings	stored
3:1	94	88
4:1	93	88
10:1	83	80
20:1	92	89

It's been established, that using PPR current allows to form Sn-Bi coatings with high value of solderability continuing long-term storage.

Optimal conditions for obtaining high-quality lead-free coatings with high solderability were developed. The best PPR mode was selected: i^{k}_{cp} = 1,0 A/dm^2, τ_{forw}: τ_{rev} = 4:1, f= 0,1..1 Hz.

The author would like to thank staff of the Research Laboratory № 10.2 of the research and development department at BSUIR for their support and contributions.

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UDC 501.503.3

MODERN TECHNOLOGIES IN TASKS OF WEATHER FORECASTING

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This article deals with modern technologies of processing of weather information. The model WRF (Weather Research and Forecasting) of weather forecasting is described in it.

In the atmosphere there are the diverse physical processes which are continuously changing its state. The physical condition of the atmosphere near the earth's surface and in the lower 30 – 40 km is called weather. Data for a weather forecast are gathered from various sources: meteorological stations, meteorological balloons, space satellites, etc. World centers of a weather forecast receive information from all over the world and compose global weather forecasts (fig. 1).

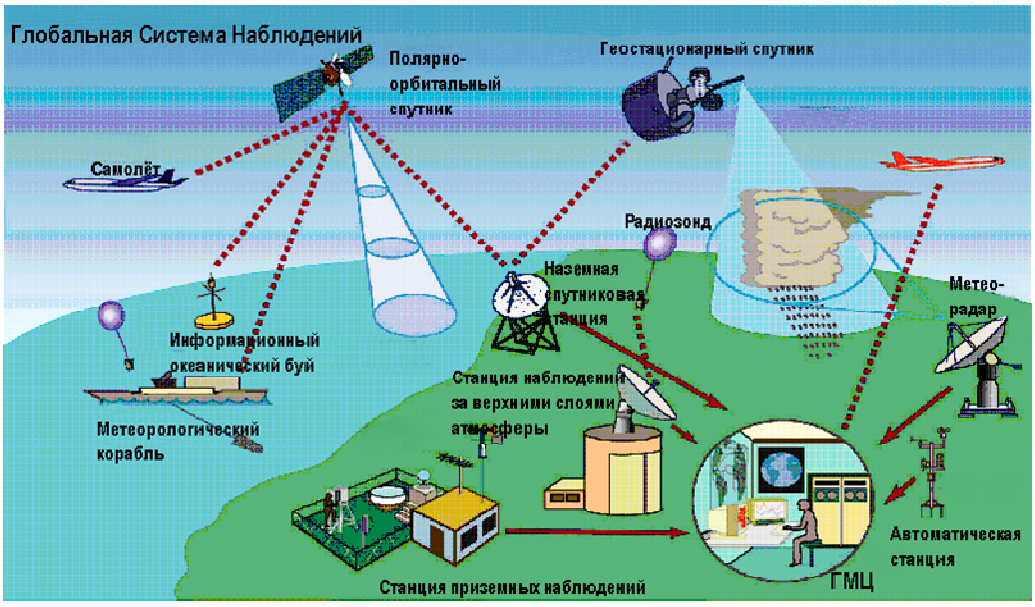

Fig. 1. Composition of global weather forecast

Weather forecasting are used synoptic, statistical and numerical methods. Synoptic method of forecasting is based on the analysis of weather charts. Statistical forecasting methods allow the past and present state of the atmosphere to predict the future state of the weather, i.e. predict changes in various meteorological parameters in the future. Numerical weather prediction (NWP) became a significant source for weather forecasts. NWP model is a modern set of computer programs that contains mathematical and physical equations / algorithms to describe

the atmosphere and its changes over time to create weather forecasts. On scale reproducible processes are global, regional and mesoscale [1].

Nowadays global models of the atmosphere don't consider all local features of territories for which the forecast is formed. Application in daily practice of the mesoscale WRF model (Weather Reseach and Forecasting) allows to reproduce more precisely processes in small scales that is necessary for forecasting of the weather phenomena. Weather Research and Forecasting (WRF) – one of the most modern and developing systems of numerical weather prediction and atmospheric modeling [2].

The main WRF components include dynamic core, program modules of presentation of physical processes (Physics Packages) and the interface of their interaction with dynamic core (Physics Interface), the module of variation assimilation of these meteorological observations (WRF–Var) and model of a chemical composition of the atmosphere (WRF–Chem). The external WRF components are the system of preparation of entrance data of WRF Preprocessing System (WPS), system of the objective analysis of these standard meteorological observations of OBSGRID, various software of visualization and the subsequent processing of the output data of WRF (fig. 2) [3].

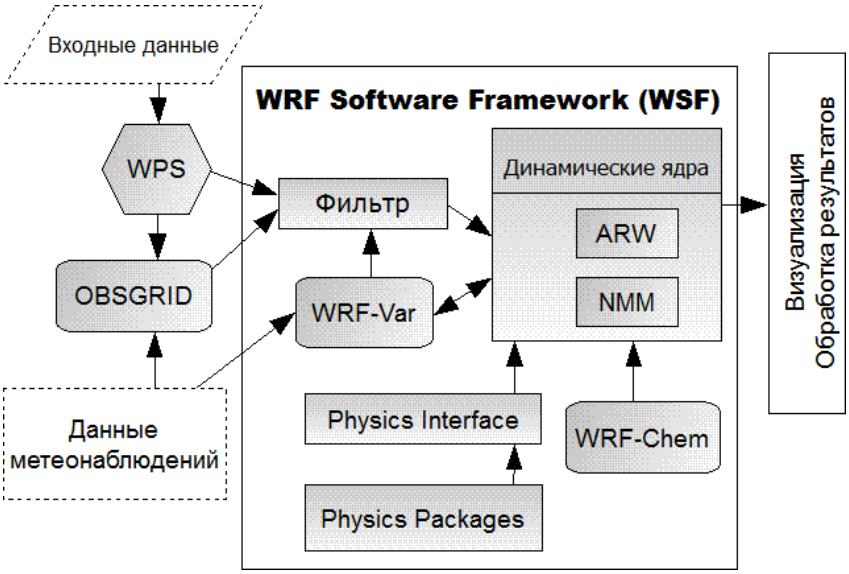

Fig. 2. Components of model WRF

How the model actually works? Downloaded set of input data (the current state of the atmosphere) is the result of another atmospheric model calculations. Then the preprocessing module starts, which consists of three programs: geogrid.exe – process static data (topography, soil types, hydrography); ungrib.exe – unpacks the initial data; metgrid.exe – interpolates the above data in a grid of model. Then the core of the model starts, which with the help of numerical methods solves the nonlinear system of differential equations. It consists of two programs: real.exe – performs vertical interpolation of input data; wrf.exe – solving core (fig. 3) [3].

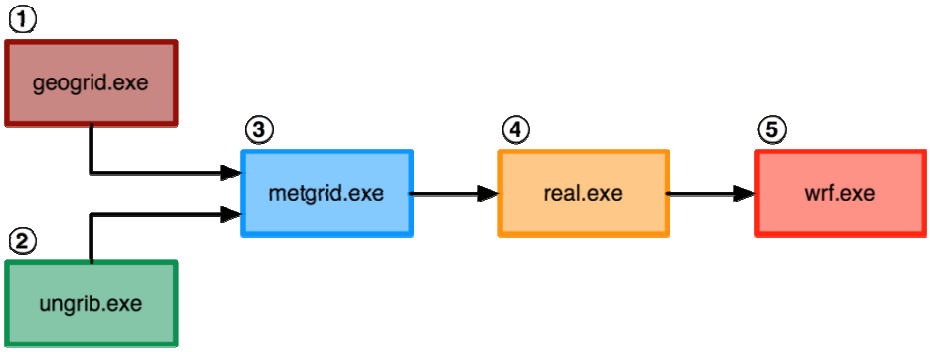

Fig. 3. Programs of the preprocessing module

Modifying different parameters, you can choose different color drawing data, labels etc. For each parameter (temperature, pressure, wind and precipitations) creates a separate file (fig. 4).

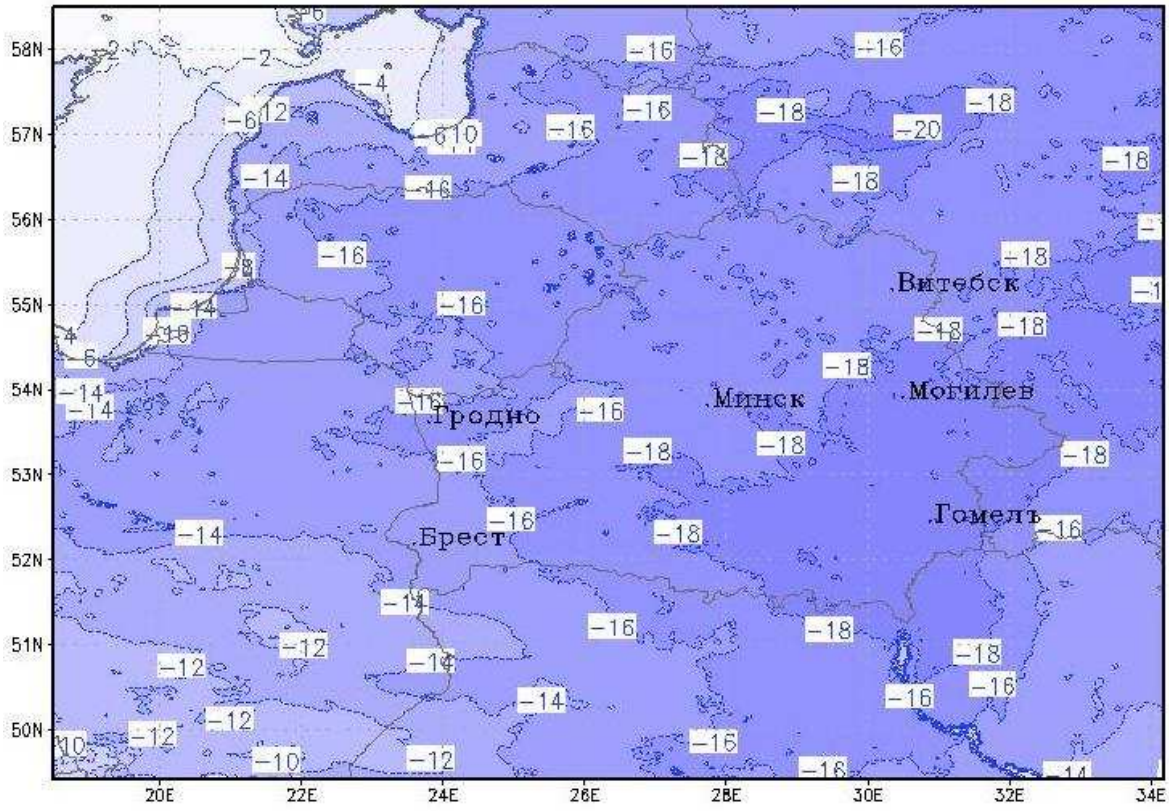

Fig. 4. The result of the work model WRF

The WRF model allows to automate the process of modeling of weather and obtain the necessary information for weather prediction. Being free software, WRF used in scientific and practical purposes in different countries of the world and is continuously developed.

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ELECTRIC DRIVE FED FROM BATTERIES. ANALYSIS AND MODELING OF PROCESSES

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The paper reviews the work of induction motor with three-phase inverter feeds by batteries, which can be used in electric vehicles. Simulation model and transients are presented.

Many manufacturers around the world are investing heavily in the development of electric vehicles, fueled by a steady rise in prices of petroleum products, the need to reduce emissions from the car and the development of energy storage devices, power consumption technologies. The term "electric vehicle", or "electromobile" refers to a vehicle that is driven by one or more electric motors.

This electric motor can be powered by rechargeable batteries, solar batteries or fuel cells. The most widespread construction is electromobile powered by battery. Battery requires regular charging, which can be supplied from external power sources, by recovering the braking energy and from on-board electric generator.

For better representation let's show a kinematic scheme (fig. 1).

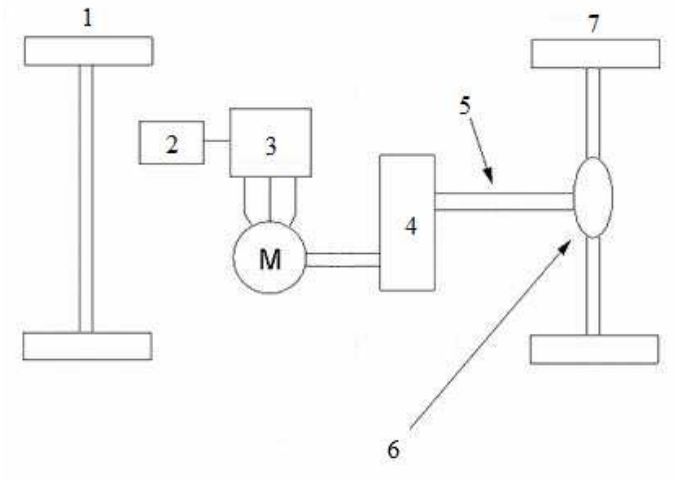

Fig. 1. Kinematic scheme of electric vehicle: 1 – front axle; 2 – batteries; 3 – voltage inverter; M – induction motor; 4 – gearbox or transmission; 5 – main gear; 6 – mechanical differential; 7 – rear axle

As part of this work recuperative braking was reviewed. Graphs that display modes of traction motor were obtained. The next operation mode of traction drive was simulated in the simulation environment Matlab. These modes are:

- acceleration to the rated motor speed;
- work at the rated speed;
- freewheel;
- braking to a low speed;
- low-speed operation;
- final braking.

We are most interested in freewheel mode and braking mode, because they provide energy recovery, i.e. is charging the batteries. Another important factor is the using of pulse-width modulation, which makes working electric drive system to the real conditions.

It was assumed that the selected motor can be installed on a passenger bus MAZ-203. So the engine power 160 kW and synchronous rotation speed 1500 rev/min was adopted according to preliminary calculations [1]. Parameters of the accumulator batteries system were adopted as follows:

Li-ion, nominal voltage 550V, capacity 240 A*h, 100% charge level.

The total voltage of 550 V is obtained from a plurality of cells, each rated voltage of 3.7 V [2]. It is about 149 battery cells. In a subsequent study it is planned to make the calculation and simulation of low voltage induction motor, so that it could be used in passenger vehicles.

But for the bus this choice is justified because the number of batteries will also depend on the electrical energy consumption. And priority will be accounting depending on the distance traveled by electric buses on a single charge.

Let's analyze the work of the resulting model.

This model (Fig. 2) illustrates simulation of a three-phase inverter and discrete three-phase pulse width modulation (PWM) generator. This circuit uses the Battery block of Electricdrivelib™ library [3]. It models a 550 V, 240 Ah Li-ion battery, connected to a Universal bridge. Battery voltage, state of charge (SOC), Motor speed and Motor current signals are available at the output of the block and plotted in Scopes.

The system consists of three-phase PWM voltage source. The Discrete 3-phase PWM Generator block generates pulses for carrier-based PWM converters. Set of three-phase sinusoidal voltages a, b and c is applied to the input of Uref. Time variation for the amplitude, phase and frequency of the fundamental can be pre-programmed. The signal of Phase Locked Loop block is applied to the input of wt. Inverter uses specified power electronic devices are IGBT/Diode pairs [4]. The inverter feeds asynchronous machine (squirrel-cage). All parameters of this motor are calculating in m-file.

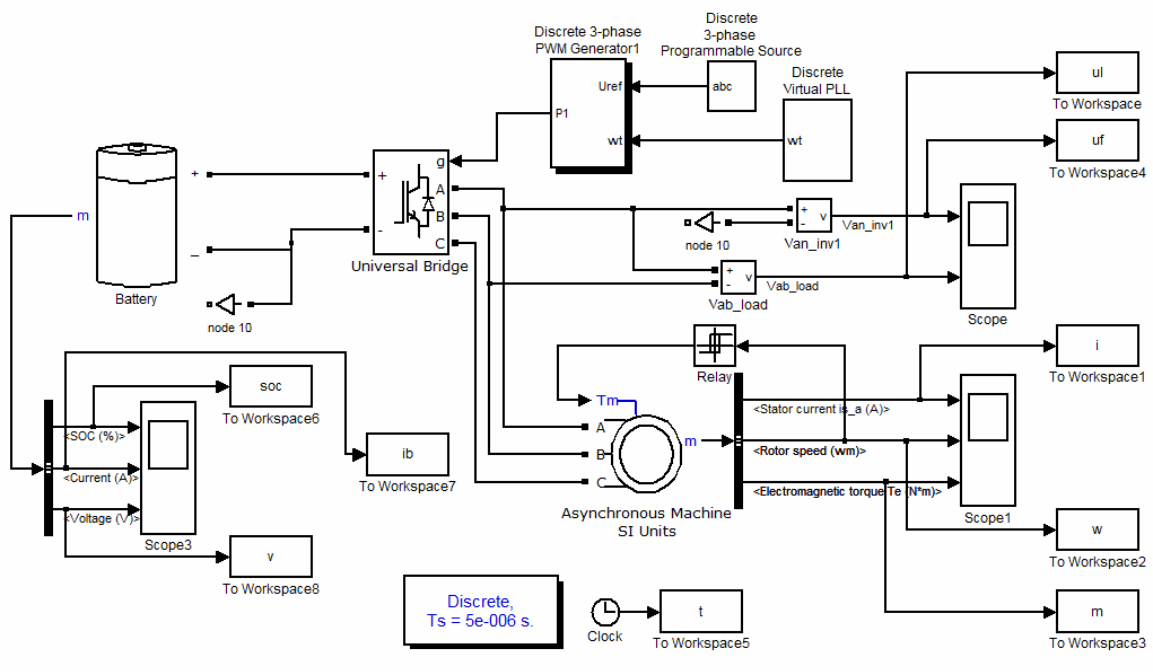

Fig. 2. Three-Phase Three-Level PWM Converter

Demonstration: At t = 0 s the driver pushes the accelerator pedal accelerates the motor to full speed;
At t = 2 s bus moving on the constant speed;
At t = 3 s start the freewheel mode freewheel mode and bus moves inertially until the speed drops by 20%;
At t = 4 s the driver pushes the brake. The motor speed reduce to speed is equal 10 % of nominal;
Followed by work at reduced speed and braking to zero.
The obtained characteristics are shown below (fig. 3, 4, 5, 6, 7, 8, 9).

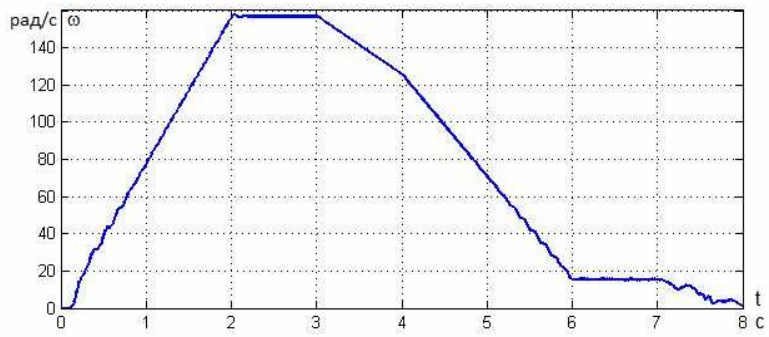

Fig. 3. Motor speed

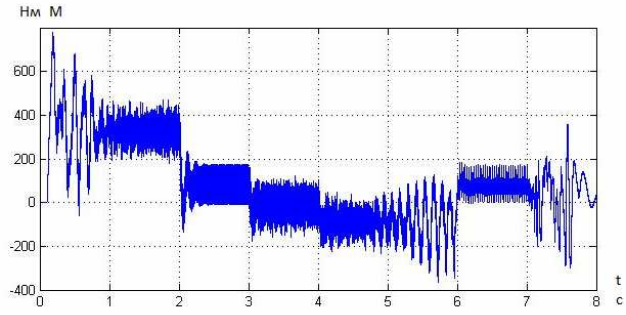

Fig. 4. Motor torque

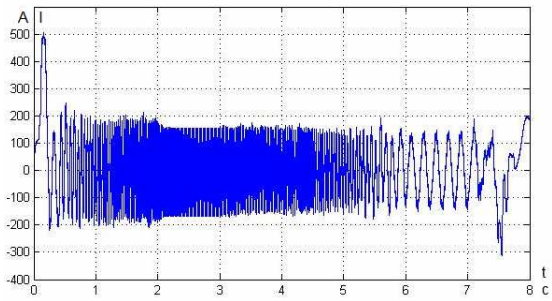

Fig. 5. Stator current during start up

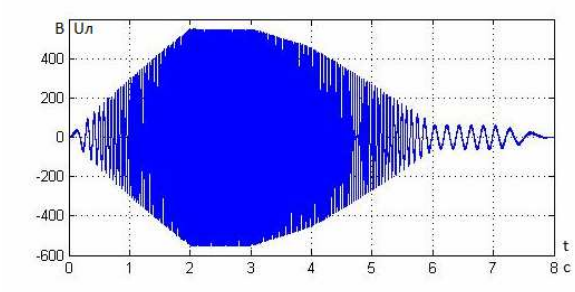

Fig. 6. Line voltage of the motor

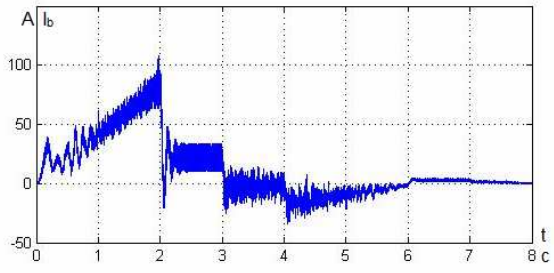

Fig. 7. Battery current

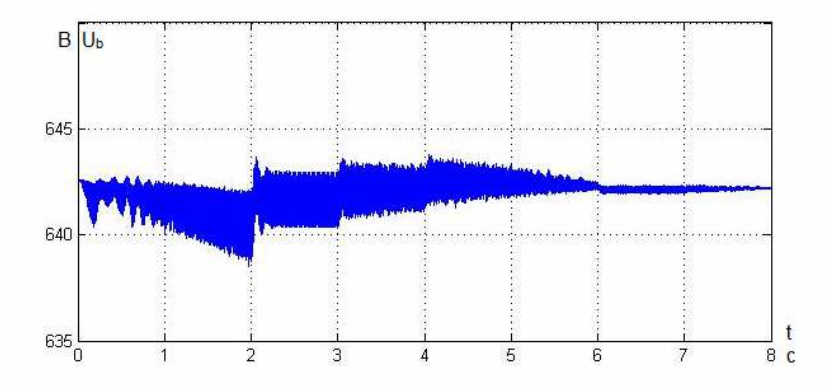

Fig. 8. Battery voltage

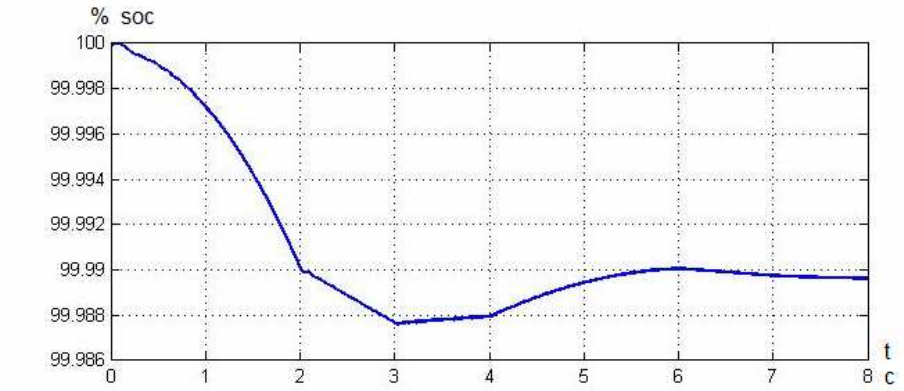

Fig. 9. Battery SOC

Presented simulation model is a suitable tool to study transients of induction motor driven from voltage inverter and accumulator batteries. On the obtained graphs, we can see the change in velocity of the engine, its torque, and most importantly can observe the process of charging the battery at freewheel and braking. Pulsations of torque and speed are due to the fact that scalar model and pulse-width modulation were used.

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A NEW HYBRID ALGORITHM FOR FIRE DETECTION USING CCTV

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This paper proposes a new method to detect smoke and/or flame in real-time by processing the video data from CCTV. Distinctive features of the algorithm is employment of spatial and temporal wavelet analysis for both flame and smoke on the stage of classification and reducing a possibility of false detection by chaotic movement estimation in revealed areas in terms of movement vectors. Experimental results show that the proposed method is successful in detecting fire.

Now CCTV systems are open to a wide class of users and solve effectively many tasks in people's practice [1, 2]. The developing of such systems is connected not only with the increase in video cameras' specifications, but also with the automatization of detection-concerned events that occur in a control area. This automatization is achieved through the development of image sequence (dynamic images) processing methods and algorithms, when images are received from a video camera. Automatic fire detection (including fires in open space) is one of the applied problems of current interest that has recently been solved via machine vision systems and CCTV. In this case, methods of dynamic images procession are focused on automatic detection of basic fire factors that can be caught by a video camera – smoke and free flame [1]. In connection with high actuality and difficulty of the task there is a number of dynamic images processing algorithms for video smoke and flame detection [1, 3]. As a rule, they are focused on the detection of one of the fire features: either flame or smoke. It can be explained primarily by different characteristics of these objects. At the same time, the analysis of intelligent video systems' development and corresponding fields of scientific researches show us that an invention of dynamic images processing algorithms with enhanced functionality, which would be able to detect both fire features, is essential.

To solve the task, a hybrid algorithm was developed. This algorithm enables the detection of smoke, free flame and their complex on dynamic images. The algorithm includes the following operations: colour segmentation, pre-processing, interframe differencing, background update, foreground segmentation, morphological operations, contour analysis, optical flow calculation, random movement estimation, contrast analysis, spatial and temporal wavelet analysis.

Movement is a characteristic of both smoke and flame, therefore the algorithm considers it as a common feature for their detection. Extracting of moving pixels is performed on the basis of adaptive background subtraction.

The background image B_t at time *t* is estimated recursively using a frame I_{t-1} and a background image B_{t-1} as follows [4]:

$$B_t(x,y) = \begin{cases} \alpha B_{t-1}(x,y) + (1-\alpha) I_{t-1}(x), \; if \;\; (x,y) \in moving\ region \\ B_{t-1}(x,y), otherwise \end{cases},$$

where (x, y) – frame pixel and α is adaptation parameter on interval (0; 1).

The mixing parameter (called alpha-channel) was introduced by Porter and Duff to control the mix of background and foreground images [5]. Mathematically, frame I_{t+1} is a linear combination of foreground F_{t+1} and background B_t components:

$$I_{t+1}(x,y) = \beta F_{t+1}(x,y) + (1-\beta) B_t(x,y),$$

where β – blending parameter.

Further combining of pixels in connected areas is performed with the help of morphological operations and contour analysis. A distinctive feature of this algorithm that enables us to reduce the possibility of false detection is random movement estimation in revealed areas in terms of movement vectors, which are specified by the Lucas–Kanade method of optical flow calculation. The algorithm estimates whether the vectors of the object's movement are codirectional or not. The Lucas–Kanade method assumes that the displacement of the image contents between two nearby instants (frames) is small and approximately constant within a

neighbourhood of point *p* under consideration. Thus the optical flow equation can be assumed to hold for all pixels within a window centred at *p*. Namely, the local image flow (velocity) vector (V_x, V_y) must satisfy

$$\begin{aligned} I_x(q_1)V_x + I_y(q_1)V_y &= -I_t(q_1) \\ I_x(q_2)V_x + I_y(q_2)V_y &= -I_t(q_2) \\ &\vdots \\ I_x(q_n)V_x + I_y(q_n)V_y &= -I_t(q_n) \end{aligned}$$

where $q_1, q_2, \ldots, q_n$ are the pixels inside the window, and $I_x(q_i), I_x(q_y), I_t(q_i),$ are the partial derivatives of the image *I* with respect to position *x, y* and time *t,* evaluated at the point q_i and at the current time.

These equations can be written in a matrix form $Av = b$, where

$$A = \begin{bmatrix} I_x(q_1) & I_x(q_1) \\ I_x(q_2) & I_x(q_2) \\ \vdots & \vdots \\ I_x(q_n) & I_x(q_n) \end{bmatrix}, \quad v = \begin{bmatrix} V_x \\ X_y \end{bmatrix}, \quad \text{and} \quad b = \begin{bmatrix} -I_t(q_1) \\ -I_t(q_2) \\ \vdots \\ -I_t(q_n) \end{bmatrix},$$

This system has more equations than unknowns and thus it is usually over-determined. The Lucas–Kanade method obtains a compromise solution by the least squares principle. Namely, it solves the 2×2 system

$$\begin{aligned} A^T Av &= A^T b \\ v &= (A^T A)^{-1} A^T b, \end{aligned}$$

where A^T is the transpose of matrix A. That is, it computes

$$\begin{bmatrix} V_x \\ V_y \end{bmatrix} = \begin{bmatrix} \sum_i I_x(q_i)^2 & \sum_i I_x(q_i) I_y(q_i) \\ \sum_i I_y(q_i) I_x(q_i) & \sum_i I_y(q_i)^2 \end{bmatrix}^{-1} \begin{bmatrix} -\sum_i I_x(q_i) I_t(q_i) \\ -\sum_i I_y(q_i) I_t(q_i) \end{bmatrix}$$

with the sums running from *i*=1 to *n*.

The matrix $A^T A$ is often called the structure tensor of the image at point *p*.

Then, colour segmentation and smoke contrast analysis is applied with taking into account a distinction of bright and colour properties of fire features. Flame segmentation is performed in the YCbCr area of colour considering a global frame analysis and an analysis of a local candidate-region. A distinctive feature of the algorithm is employment of spatial and temporal wavelet analysis for both flame and smoke on the stage of classification. Smoke and flame is semi-transparent, so the edges of image frames can lose their sharpness and this leads to a decrease in the high frequency content of an image. To identify smoke or flame in a scene, the background was estimated and any decrease in high-frequency energy was monitored using a spatial wavelet transform of the current and background image. Following the 2-D spatial wavelet transform, the whole image is separated into four regions: horizontal low-band vertical low-band (LL), horizontal low-band vertical high-band (LH), horizontal high-band vertical low-band (HL), and horizontal high-band vertical high-band (HH). The wavelet sub-images LH, HL and HH contain horizontal, vertical, and diagonal high-frequency information from the original image, respectively. If smoke or flame covers one of the edges of the original image, then the edge initially becomes less visible and it may disappear from the scene after some time as the smoke thickens. The spatial energy is evaluated block-wise by dividing the image into regular blocks of a fixed size and summing the squared contribution from each coefficient image, as shown on the following formula [6]:

$$E(B_k, i_t) = \sum_{m,n \in B_k} \left[LH(m,n)^2 + HL(m,n)^2 + HH(m,n)^2 \right],$$

where B_k is the *k*ht block of the scene and I_t is the input image at time *t*.

The energy value of a specific block varies significantly over time in the presence of smoke. This energy drop can be further emphasized by computing the ratio α between the image energy of the current input frame I_t and that of the background model BG_t. The energy ratio has the advantage of normalizing the energy values and it allows a fair comparison between different scenes when the block energy can itself vary significantly. The ratio of the block B_k is given by

$$\alpha(B_k, i_t, BG_t) = \frac{E(B_k, I_t)}{E(B_k, BG_t)}.$$

The application of the united methods of dynamic images processing for detecting smoke and free flame simplifies the algorithm structure, simplifies its realization and allows us to lower computational costs.

The algorithm is implemented in C++ in Microsoft Visual Studio 2010 development environment using a computer vision Open CV 2.2 library. Experiments were carried out on video successions received in real conditions using a Panasonic SDR-S50 video camera, which are also loaded on http://signal.ee.bilkent.edu.tr/VisiFire/Demo/SampleClips.html, http://www.openvisor.org, http://cvpr.kmu.ac.kr. The examples of detection are presented on fig. 1. The time costs for frame size 320x240 pixels are shown in table 1. The results of the research show that the algorithm allows a stable smoke, flame or their complex detection, including one on complicated dynamic background with moving objects, or objects with alike bright and color properties. The low speed of calculations is explained by single-thread computing.

Fig.1. Examples of smoke and flame detection with a hybrid algorithm

Table 1 – Time costs for frame analysis

Stage	**Time cost (ms)**
Preprocessing	4
Interframe difference calculation	11
Countour analysis	51
Optical flow calculation	23
Weber contrast calculation	6
Spatial and temporal analysis	22
Flame color segmentation	12
Total	129

Multithreaded programming with task parallelization is supposed to be applied on the further stages of the development. Preparatory frame processing tasks in video succession, segmentation of moving areas, morphological operations and random movement estimation can be hardly parallelized. In this case, parallel fulfillment of relatively low amount of computation is practical. Nevertheless after this stage a possibility of parallel fulfillment of two independent branches of the algorithm appears: smoke detection and free flame detection. Thus the time of frame processing reduces in a nonlinear way because it is not necessary to carry out all the steps when smoke or flame is detected, and the possibility of reducing a number of candidate-regions on initial stages of analysis rises. Hereby, the suggested approach allows reducing the frame processing time by 45% on average as compared to the fulfillment of the whole cycle of frame analysis in one thread, and it lets us increase a number of frames in processing in unit time, that means to increase the quality or quantity of input information.

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NONLINEAR JUNCTION LOCATOR WITH THE POSSIBILITY OF IDENTIFYING NONLINEAR OBJECTS

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It is concept of nonlinear radar with the ability to identify nonlinear object using DSB-signal in the role of the probe. The block diagram developed nonlinear junction radar. Here formalized tasks that are necessary for the efficient operation of the nonlinear radar, which helps to raise the accuracy of the identification of objects that include elements with nonlinear current-voltage characteristics.

Currently nonlinear locators are used to search for artificial man-made objects, containing nonlinear electrical contacts. It is principle of operation of nonlinear junction radar: the frequency signal is converted to higher harmonic due to the nonlinear properties of the above elements with their subsequent re-emission in air during irradiation high-sounding call objects that contain non-linear electrical contacts [1].

Almost complete absence of non-linear properties of the electromagnetic natural background (soil, water, vegetation) can effectivelyuse nonlinear radar for finding various artificial objects, including small-sized and fixed use, which is practically impossible to carry out by means of traditional radar.

Nonlinear junction radars can be used to detect eavesdropping devices, regardless of whether they are turned on or off, the radio-controlled devices, such as remote detonators; wreckage of planes and helicopters, small arms. Also used in nonlinear radar remote marking, for example, underground objects, "black boxes" of aircraft and certain terrain. There used for this the so-called non-linear markers (usually – semiconductor diodes loaded on antenna reflectors) [2].

It is known that the spectrum of the non-linear feedback element is different from the spectrum of the acting signal. It is enriched in components of higher harmonics acting a signal. Static IVC any nonlinear element can be represented as a power series.

$$i = i_0 + a_1 U + a_2 U^2 + a_3 U^3 + \dots , \tag{1}$$

here i_0 – quiescent current operating point; a_1 – IVC slope at the operating point; a_2 – the first derivative of the slope; a_3 – the second derivative of the slope and etc.

When exposed to the non-linear element DSB-signal:

$$u(t) = U_0 + U_{m1}\cos(\omega_0 + \Delta\omega)t + U_{m2}\cos(\omega_0 + \Delta\omega)t , \tag{2}$$

here: $\omega_0 + \Delta\omega$ – the band centrum of the upper sideband spectrum;

$\omega_0 - \Delta\omega$ – the band centrum of the lower sideband spectrum;

ω_0 – suppressed carrier,

$\Delta\omega$ – suppressed subcarrier.

feedback of the nonlinear element represented by the expression:

$$\begin{aligned} i(u) &= a_0 + a_1 U_{m1}\cos(\omega_0 + \Delta\omega)t + a_1 U_{m2}\cos(\omega_0 - \Delta\omega)t + \frac{a_2}{2}(U_{m1}^2 + U_{m2}^2) + \\ &+ \frac{a_2}{2}U_{m1}^2\cos(2\omega_0 + 2\Delta\omega)t + \frac{a_2}{2}U_{m2}^2\cos(2\omega_0 - 2\Delta\omega)t + \\ &+ a_2 U_{m1}U_{m2}\cos(2\omega_0)t + a_2 U_{m1}U_{m2}\cos(2\Delta\omega)t + \left(\frac{3a_3U_{m1}^3}{4} + \frac{3a_3U_{m1}U_{m2}^2}{2}\right)\cos(\omega_0 + \Delta\omega)t + \\ &+ \left(\frac{3a_3U_{m2}^3}{4} + \frac{3a_3U_{m2}U_{m1}^2}{2}\right)\cos(\omega_0 - \Delta\omega)t + \frac{a_3U_{m1}^3}{4}\cos(3\omega_0 + 3\Delta\omega)t + \frac{a_3U_{m2}^3}{4}\cos(3\omega_0 - 3\Delta\omega)t + \\ &+ \frac{3a_3U_{m2}U_{m1}^2}{4}\cos(3\omega_0 + \Delta\omega)t + \frac{3a_3U_{m2}U_{m1}^2}{4}\cos(\omega_0 + 3\Delta\omega)t + \\ &+ \frac{3a_3U_{m1}U_{m2}^2}{4}\cos(3\omega_0 - \Delta\omega)t + \frac{3a_3U_{m1}U_{m2}^2}{4}\cos(\omega_0 - 3\Delta\omega)t. \end{aligned} \tag{3}$$

Fig. 1 shows the principle of conversion form, and therefore the spectrum of the input signal by a nonlinear element (a semiconductor diode).

In practice, most IVC real objects can be with sufficient accuracy approximated by finite power series, because harmonics generated by such objects are small amplitude. Degree approximating polynomial determines the number of the highest harmonic in the spectrum of the response of the nonlinear element.

Among the nonlinear properties of real objects expressed most strongly in semiconductor junctions and pinch the metal contacts. IVCs are most semiconductor junctions included in all elements of modern electronic equipment, close to quadratic. CVCs dissimilar metals, and metal-oxide-metal corrosion occurring as a result, are approximated by a polynomial of the third degree. When irradiated with nonlinear radar semiconductor junctions harmonic signal at the second harmonic feedback is much stronger (about 20 dB) than the third. For metallic contacts the picture is opposite (Fig. 2) [3].

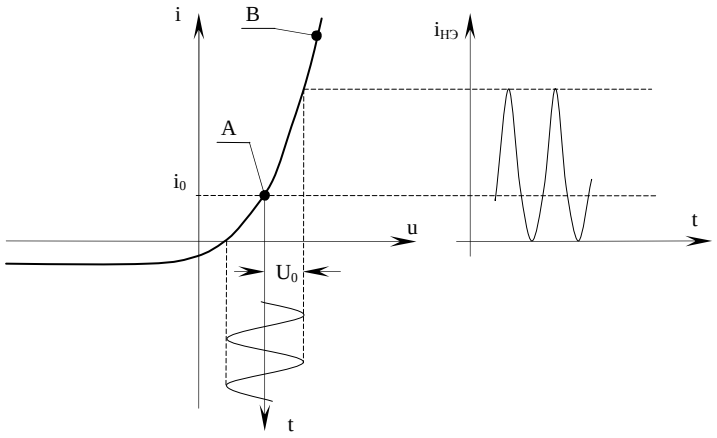

Fig. 1. It is Converting harmonic signal on the nonlinear element:
A – operating point in IVC, approximated by a polynomial of the second degree; B – operating point in IVC, approximated by a polynomial of degree greater than two

Analysis of the available publications on nonlinear junction radar shows that in matters of accuracy and speed of the object localization are by various authors united. This indicator is caused by the characteristics of antennas and receiver, recording the reflected signals. Question of identification of objects at the moment is more in the stage of theoretical debates and depends solely on the experience and skills of personnel using nonlinear junction locator.

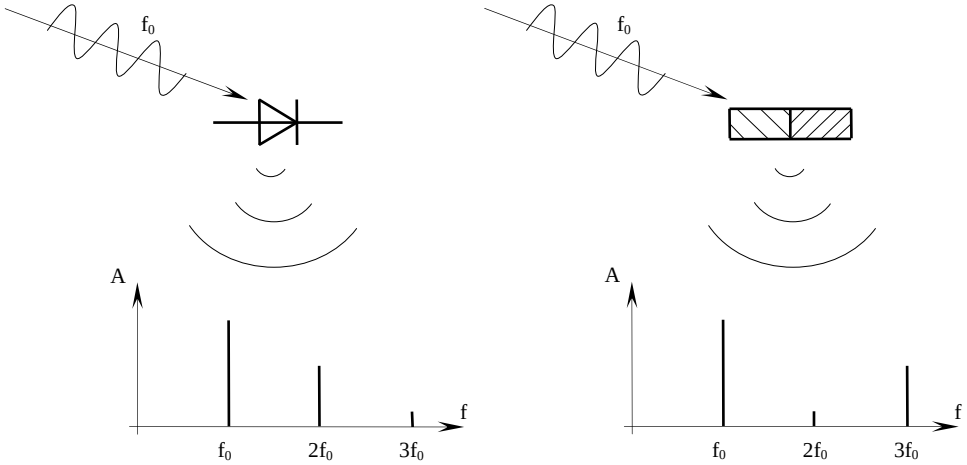

Fig. 2. It is nonlinear transformation of the harmonic signal with frequency f0 semiconductor devices (left) and objects formed by contact of metal parts (right)

From Figure 2 it is obvious that it is theoretically possible to distinguish objects containing electronic components, metal structures, or combinations thereof, to an object of the re-spectrum signal. However, in practice this approach is accompanied by a number of difficulties. Difficult problems, for example, are the right

choice of power and frequency of the signal. Low power (amplitude) of the probing signal does not allow force to produce a nonlinear harmonic. Too high power probing signal shifts the operating point of the nonlinear element beyond his typical IVC (quadratic area for semiconductor junctions), see Fig. 1, point B. As a result, the spectrum of the response element varies. Additionally, it is necessary to consider that power of the probing signal determines the detection range of the radar objects nonlinear. Moreover high power radiation may result, for example, to actuation the electronic detonators. Regard to the selection frequency sensing real objects is a complex set of dipoles of different geometry, loaded on nonlinear elements. Obviously, these objects will have a different response to different frequencies (different nonlinear effective dispersion surface). Type of response is characteristic of a particular type of object. To increase the range of detection of objects, it is desirable to use the frequency at which feedback is maximal goals, determine the frequency of such advance either extremely difficult or impossible.

To solve these problems, modern nonlinear junction radar can use different modes of signal emission (pulsed or continuous) and power control algorithms radiation [4, 5]. It should also be noted that according to the technical characteristics of the existing nonlinear junction radars frequencies use they radiation in the range from 400 to 1000 MHz (receive frequency from 800 MHz to 3000 MHz respectively). Interesting solutions to improve the characteristics of nonlinear junction radars as proposed in [2, 6, 7, 8]. American authors suggest the use of several harmonic probing signals to increase the range of nonlinear junction radar.

The authors of this article suggest the idea to develop a sensing using DSB-signal, programmable power control radiation. Such an approach can increase the reliability of the identification of objects by reflected signal, as well as increasing the range of the radar. Nonlinear object emits modified probe signal, when irradiated nonlinear object DSB-signal. You can get information about the nonlinear effective scattering surface of the object at a given frequency and it is highly likely to restore IVC nonlinear element in appearance and character reflected signal. (fig. 3).

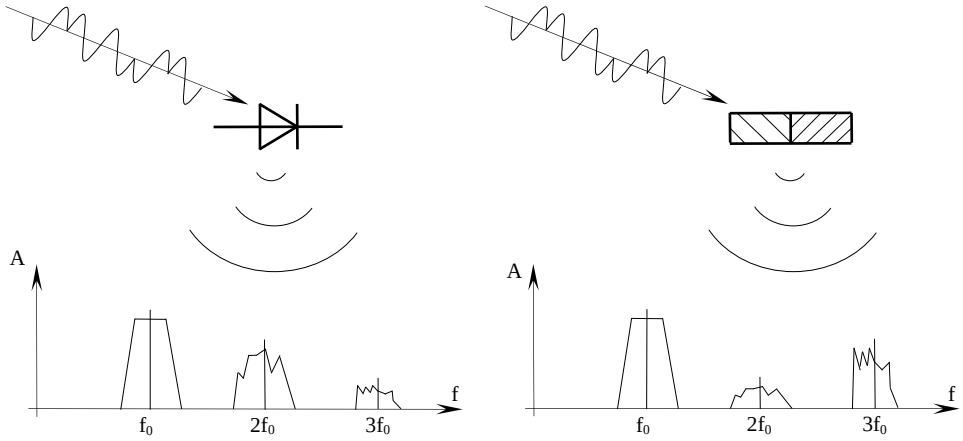

Fig. 3. It is nonlinear transformation of the spectrum noise-like signal (PSK signal, the center frequency f0) semiconductor devices (left) and objects contacts containing metal parts (right).

Fig. 4 shows a block diagram of the nonlinear radar. Function of the main block does not require explanation. It should be noted that additionally includes a fast digital-to-analog converter. It is controlled by Matlab program that is installed on the PC (personal computer) and it provides her with the data for visualization. DSB-signal generator generating a probe signal and run the program MATLAB, which he changes the power output. In this case it is possible to more effectively explore the object for its characteristic frequencies increase radar range, improve the accuracy of identification of nonlinear objects.

In conclusion, we pose questions that are critical to the effective nonlinear junction radar that uses noise-like signals. Firstly, it is necessary to simulate the process of re DSB-signal array of dipoles of different geometry, loaded by linear loads, in order to determine how the signal spectrum will vary for different objects. It would be interesting to conduct field trials.

Secondly, you need to define the characteristics of DSB-signal (center frequency, amplitude and form of the side lobes of the spectrum), which will ensure optimal tactical and technical characteristics of the device in terms of accuracy, range, stealth, etc.

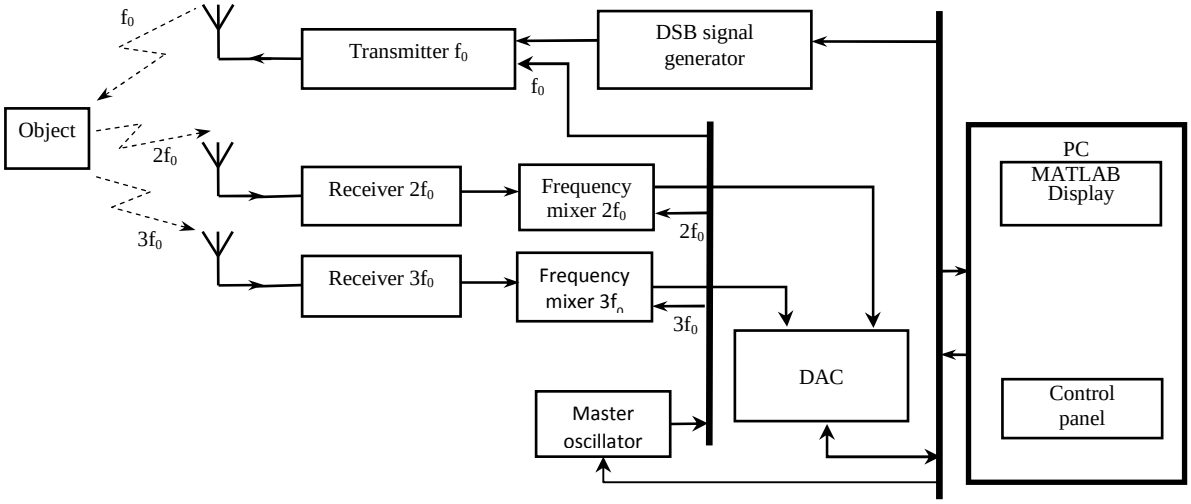

Fig. 4. It is block diagram of the proposed nonlinear junction radar using DSB-signal

Interesting technical challenges for future research could be the development of decision-making algorithms for the identification of various objects on the basis of information extracted from the spectrum of re-signals, as well as adjust the emission power of the nonlinear radar.

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UDC 519.681.3/004.41

THE BASIC PRIMITIVES OF DIGITAL CIRCUIT OBFUSCATION

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Features of obfuscation as applied to specifications in VHDL language are considered. Brief survey of obfuscation types is given and their drawbacks are investigated. Circuit obfuscation methods are considered. Basic primitives of circuit obfuscation are proposed and ways of their usage are explored.

Hardware piracy assisted by modern equipment turned into a threatening problem during past decade. Today the financial loss from illegal manufacturing and usage of digital devices is estimated in more than 1 billion dollars a day [1]. Piracy is not the only danger. Other threats are evolved and improved, new threats are

developed. Successful attacks on hardware implementations of secure cryptographic algorithms (side-channel attacks) take place more often. Examples of such side channels are leakages of power during computations [2], electromagnetic emanation [2], timing imperfections [2], even acoustic emanations from power supply chains are already exploited [3]. Side channels allow deducing secret key values. Another threat is hardware Trojan injection. Hardware Trojan is malicious modification in circuit. Trojans can negatively affect functionality of circuit, leak secret information, switch off and even destroy circuit. Trojans pose the greatest danger to critical applications: power stations, medical equipment and military systems. High difficulty in detecting of such malicious alterations makes situation even worse. In this context the development of hardware protection methods turns into the most urgent and important objective. Obfuscation is one of the possible ways. Obfuscation is intended to make structure and function of circuit difficult to perceive and comprehend in order to prevent reverse engineering or substantially increase its time and cost [4]. Also obfuscation is often used to hide author's watermarks and user's fingerprints [5].

There are two types of obfuscation methods in HDL's case: *lexical* and *functional (circuit)* [6]. *Lexical* obfuscation affects only source code level. And here is rooted its main disadvantage: synthesis results (circuits) before and after obfuscation are identical [6], i.e. circuit remains unchanged. This observation reveals the simplest method of attack which is logical (RTL) synthesis [6]. Many different approaches of lexical obfuscation have been developed for general purpose programming languages. Comprehensive taxonomy is presented here [7]. These approaches are suitable for protection of HDL sources as well.

Formally lexical obfuscation can be described as shown below:

$$V; V^* = obf(V); O(V) < O(V^*); Sch = DD(V) = DD(V^*),$$

here V – HDL source, V^* – lexically obfuscated source, *obf* – obfuscation, O – complexity, *DD* – synthesis procedure, *Sch* – circuit.

Considering lexical obfuscation for HDL description we should note that synthesis can help to create lexical transformations. *Collapsing signals introduction* inserts combinations of interweaved signals into design. These combinations are distributed across source code; also they are parts of expression, which computes constant. Synthesizer always detects and removes such combinations, so they don't affect resultant circuit. But in order to remove them manually reverse engineer forced to locate all of them, put together and compute full expression. Using previous notation this transformation and several others (identifiers scrambling, comments removing, layout destroying) can be described as follows:

$$V^* = V \pm V_r; Sch = DD(V); Sch^* = DD(V^*) = DD(V \pm V_r) = DD(V) \pm DD(V_r) = Sch \pm \varnothing = Sch,$$

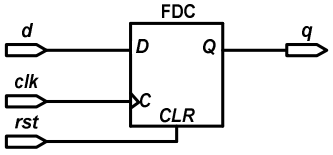
here V_r – HDL description of nonsynthesizable (empty) circuit.

Lexical obfuscation example is presented in fig. 1. Following obfuscation transformations are used in (*a*): identifiers scrambling, comments removing, collapsing signals introduction, layout destroying. Elements (*c*) and (*d*) clearly illustrate main drawback of lexical obfuscation.

```
a)process (o0o1o0ioo,oi1oo0i0o,oi1oo0io0) begin o0o1o0ioo<=(oi1oo0i0o) OR oi1oo0io0; end process ; process (oo0oo0ioo,oi1oooi0o,oi1oo0loo)
  begin oo0oo0ioo<=(oi1oooi0o) AND oi1oo0loo; end process ; process ( oi1oo0io0,oi1oooi0o,oi1oo0loo) begin oi1oo0io0<=(oi1oooi0o) AND  not
    oi1oo0loo; end process ;process (o00100l10,o00100llo,oi1oo0i0o, oi1oooi0o,oi1oo0loo) begin if (oo0100ll0 = '1') then oooi00ll0 <='0'
  ; elsif (rising_edge (o00100llo)) then oooi00ll0 <= o00100l10; end if;o00100ll0<=oooi00ll0;oi1oo0i0o<=(not oi1oooi0o)AND not oi1oo0loo;
  end process; process (o00l00ioo,o01oo0ioo,oo0oo0ioo) begin o00l00ioo<=(o01oo0ioo) OR oo0oo0ioo; end process; process (o0010o0ioo
  ,o0o1o0ioo,o00l00ioo) begin o001o0ioo<=(o0o1o0ioo)OR o00l00ioo; end process ; process (o01oo0ioo,oi1oooi0o, oi1oo0loo)
  begin o01oo0ioo<=( not oi1oooi0o) AND oi1oo0loo; end process ;
```

```
b)process(d, clk)
  begin
    if (rst = '1') then
      qx <= '0';
    elsif
  (rising_edge(clk))then
      qx <= d;
    end if;
    q <= qx;
  end process;
```

c)



d)

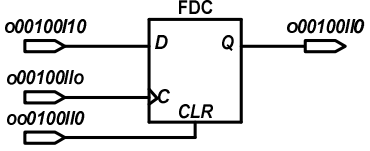


Fig. 1. Example of lexical obfuscation: (*a*) obfuscated snippet; (*b*) target code before obfuscation; (*c*), (*d*) synthesis results before and after obfuscation respectively

The essence of *circuit* obfuscation is creating more sophisticated and unintelligible circuit which functionality (externally observed behaviour) is equivalent to the original one [6]:

$$V; V^* = obf(V); Sch = DD(V); Sch^* = DD(V^*); Sch \neq Sch^*; func(Sch) \equiv func(Sch^*);$$
$$O(V^*) > O(V); O(Sch^*) > O(Sch);$$

here *func* – functionality of circuit.

There are several approaches to circuit obfuscation. "*Stuttering ciruits*" method is based on transformation of circuit in a way that when the wrong key is passed the circuit performance degrades significantly but it is still functioning [8]. Another method is insertion of "*time bombs*" by designer. "*Time bomb*" is logic which disables device functioning after expiring of evaluation period (several number of power-ons) until the correct key is entered [9]. The next method is based on FSM state space expanding. Device begins its work at random state. In order to reach the start a state user has to pass the correct key. If the key is wrong then ciruit goes into "*black-hole-state*" where it loops until reset [10].

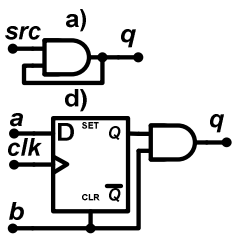
Constant generators insertion is one of the basic methods of circuit obfuscation. Constant generator is a form of *opaque predicate*, which value is known at obfuscation time but has to be deduced by adversary during analysis [7]. The method implies substitution of "0" and "1" pins by circuits (primitives), which generate appropriate logical values permanently:

$$V_{\{0,1\}}; DD(V_{\{0,1\}}) = Sch_{0,1} \notin \{V_{DD}, GND\}; func\{Sch_{0,1}\} \equiv func\{V_{DD}, GND\},$$

here $V_{\{0,1\}}$ – HDL-description of the primitive; V_{DD}, *GND* – sources of logical "1" and "0" respectively.

Complexity of opaque predicate will be determined by analysis difficulty of the primitive.

Fig. 2 illustrates examples of proposed constant generators.



b)
```
x <= x and src;
q <= x;
```

e)
```
process(a, clk, b)
begin
  if (b = '1') then
    val <= '0';
    elsif (rising_edge(clk))
    then val <= a; end if;
end process;
q <= val and b;
```

c)
```
o0ooilool <=o0ooilool
and oo0oilooi;oo0oilool
<= o0ooilool ;
```

f)
```
process (oi1l0li1o,oi1l0l11o,oi1l0l1l0
) begin if (oi1l0l1l0= '1' )then o00l0l110
<='0'; elsif (rising_edge(oi1l0l11o)
) then o00l0l110 <= oi1l0li1o;end if; end
process;oo1l0l110 <= o00l0l110 and oi1l0l1l0;
```

Fig. 2. Generators of constants (*a*), (*d*); original HDL-sources (*b*), (*e*); lexically obfuscated sources (*c*), (*f*)

It is critical to make generator circuit unrecognized and not minimized by synthesis tool. Different circuits which were made using only combinational logic weren't sufficient. Sequential circuits and sequential-combinational circuits are more promising and effective from hardware resources utilization point of view. Considering further tricks, we should mention usage of signals with well-defined semantics (such as system reset, clock) on the inputs of generators.

Generators from fig. 2 were synthesized using XST I.24 Release 8.1i. Synthesizer wasn't able to recognize constants and minimize such circuits. Circuit (*a*) has two flaws: synthesizer throws warning about combination loop, which itself gives good clue for adversary; if input *src* has "1" during power-on then until it will be changed it's possible for output to return "1". Countermeasure against second flaw is to connect generator's input to system reset. Circuit (*b*) is free from such flaws, but it utilizes more hardware resources and can produce glitches.

Basic primitives pave the way for many other circuit obfuscation transformations. With help of basic primitives we can build compound primitives for more complex functions. For example, having "0"-generating basic primitive we can implement logical *and* using 2-input multiplexor. It is illustrated in fig. 3(*a*). We can build logical *or* in similar way, it is shown in fig. 3(b).

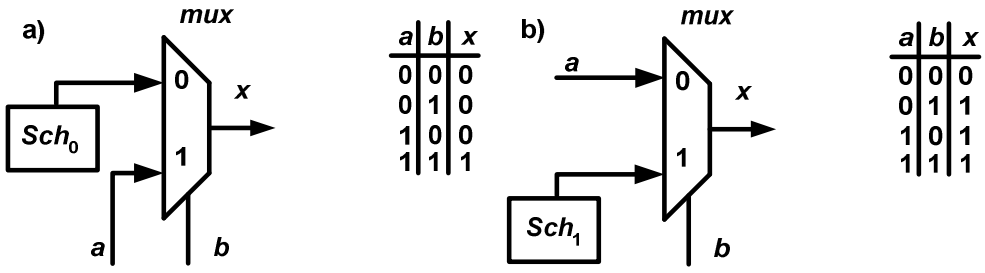


Fig. 3. Obfuscated and gate and its truth table (a); obfuscated or gate and its truth table (*b*)

Synthesizer doesn't recognize these compound primitives, so reverse engineer is forced to completely analyze such circuits.

Main advantage of circuit obfuscation is complicating of comprehension not only of HDL description but also of synthesis result. Mentioned examples illustrate problems of circuit obfuscation which are increase in hardware utilization and regress in performance in some cases.

Primitive's insertion process takes place on HDL level. In order to increase complexity it's possible to create primitives which are depended from key. If key is wrong then they generate random signals, breaking specification and correctness of device's functioning.

Software metrics are usually used for complexity measurement of source codes. Complexity metrics indicate quality of source code. Also these metrics are very useful to measure efficiency of obfuscation transformations against human-reader. The main difference is that in case of obfuscation the goal is not to minimize but to maximize their values [7]. Such metrics have their problems in case of circuit obfuscation. First, they don't indicate hardware overheads and time penalty which is incurred by circuit obfuscation. Second, they don't take into account complexity of the resultant circuit. The solution to the first problem was proposed in [11], where the method for obfuscation transformation quality estimation is described. This method considers area and time overheads and allows flexible metrics tuning. The second problem is still open. The possible solution may be to borrow logical circuits complexity measurement approaches such as the total number of gates or the number of gates on the critical path [12]. The obvious flaw of such approaches is their inapplicability for sequential circuits; also they don't take into account the number of interconnections between blocks or connection lines.

The lexical obfuscation of HDL-sources alone is not sufficient for the protection of circuits because the result of such transformations doesn't survive synthesis. The solution to the problem is circuit obfuscation, which changes not only HDL-sources but also circuit. Different approaches exist to circuit obfuscation. Their main drawback is additional area and time overheads which they impose on design. *Constant generators insertion* allows hiding of constants which are valuable clues for reverse engineer. Necessity to explore interdependencies between primitive's inputs and source circuit's signals further increases time and analysis complexity of obfuscated circuit. It makes sense to use different types of obfuscation complementary in order to increase protection on all levels of abstraction. For example, HDL obfuscation makes source code unintelligible. Circuit obfuscation makes circuit functionality and structure unclear. Processor's commands obfuscation makes understanding of processor actions difficult. Data obfuscation makes data transfer protocol between digital device and memory unclear. It can be accomplished, for example by introducing function which maps source address to destination. It's obvious that every mentioned obfuscation type has its own application therefore their composition allows creating of more secure systems.

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APPLICATION OF FUZZY LOGIC IN PROBLEMS OF RISK ASSESSMENT

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The paperdiscusses the use of fuzzy logic in the problems of risk assessment in economics and IT. Based on fuzzy logic method of occupational risk assessment considers.

The basics of fuzzy logic were formula tedby famous American mathematician Lotfi A. Zadeh attheend of 1960s. The paper "Fuzzy Sets"waspublishedin1965 inthe "Information and Control". It laid the foundations for modeling human intellectual activity and became the reference point for the development of new mathematical theory [1]. Zadeh gave the name for the new field of science – "fuzzy logic" (fuzzy – vague, uncertain). However, this theory was not put to use until the mid-1970s, when Ibrahim Mamdanidesigned of fuzzy controller for a steam engine [1]. Since then, fuzzy logic is widely use in control problems. Especially widespread fuzzy logic typical for Japan, where the world's leading companies are exploring and using fuzzy logic to design more commonsense instruments, devices and systems management.

Fuzzy logic manipulates such vague concepts as «cold», «close», «fast», etc., inherent in human thinking. The notion of fuzziness refers to classes in which there are different scales of toiletries, intermediate between full membership and belonging to this class of objects [2]. In other words, a fuzzy set is a class of objects in which there is no sharp boundary between those objects that are in this class, and those that it does not include.

On the basis of fuzzy inference were obtained solving a large number of problems of analysis and control of power systems [3], and process plants: chemical reactors, electric motors, welding processes, installations for water purification, cooling units, fans and air conditioners, heaters, rechargeable units, communication systems [4], transport.

Based on its instruments fuzzy logic has received its application in expert systems, including control problems and risk assessment. In the early 1990s a health management system applied for large firms in Japan. The fuzzy system diagnoses the health of patients and draw up personalized plans to help them prevent disease and stay fit.

The use of the theory of fuzzy sets expandsto problems of management and risk assessment, decision support. Widespread fuzzy set theory gets in the economic sphere. For example, in [5] provides a comparison of methods and models for risk analysis of bankruptcy. According to the results of the comparative analysis the most highly accurate prediction of bankruptcy of enterprises Mamdani (90%) and Tsukamoto (88%)models showed, followed by fuzzy multiple Nedosekin's method (80%) and finally, the worst performance prediction accuracy has a classic method Altman'sdiscriminant analysis (73%). In a paper [6] also conducted a comprehensive evaluation of the risk of bankruptcy corporations based on fuzzy descriptions.

Paper [7] devoted to the application of fuzzy set theory to analysis of investments in the securities market. The questions assess the risk of bankruptcy of the issuer, the project risk of direct investment, the risk of investments in stocks, bonds, options, and combinations thereof. The paper presents a technique for assessing the investment attractiveness of the shares. Suggested by the author an independent theory of risk assessment using fuzzy sets formed the basis of a number of software products developed by Russian companies. In [8] the use of fuzzy logic in assessing investment risks.

A new approach to the description of information risk based on fuzzy sets and fuzzy semantic networks presents in paper [9]. Application of this method was the basis of a software decision support system that performs some of the functions of the expert in the field of information security.

The theory of fuzzy sets is actively used to assess risks in the economy, information technology, and existing studies demonstrate the effectiveness of such methods. On the other hand, there are many different approachesin the assessment of occupational risks, which are not very flexible and are often very difficult to use. Fuzzy set theory provides convenient tools for applications in which an important role have expert knowledge. Because of these reasons, it is possible to use fuzzy set theory to evaluate occupational risks.

Currently, assessment of occupational risks is an important task, which is a quality solution with one of the key areas in order to reduce accidents and occupational diseases in the enterprise. Determining the level of occupational risk allows developing risk management measures to prevent exposure of occupational hazards to the health of employees. That is, at the moment this method is regarded as a much more effective alternative to incident response.

The level of occupational exposure is influenced by such factors as the state of injury, occupational diseases and conditions in the workplace, which are expressed in quantitative and qualitative form. Depending on the level of risk in the workplace, there are certain requirements to respond. The level of risk is expressed in a qualitative way, such as "acceptable risk". That is, input data are quantitative or qualitative data, and output data risk assessment methods should be qualitative determination of the level of risk at the workplace. These qualitative variables operates fuzzy set theory, which confirms the possibility of its application in this case.

Currently, there are several algorithms for fuzzy inference, the most famous of which are the algorithms Mamdani Tsukamoto, Sugeno and Larsen [10]. The most common is Mamdani fuzzy inference algorithm. This algorithminclude following steps: forming the base of fuzzy inference rules, fuzzification of the input parameters, aggregation, intensification sub-conditions in fuzzy production rules, defuzzification. More often than not fuzzy systems glean their rules from experts. Expert determines linguistic variables and sets the membership function for each linguistic variable term. Aggregation is a definition the degree of truth conditions for each of the fuzzy inference system rules. Next is determination degree of truth each of the conclusions of fuzzy rules. Finally, defuzzification is performed using the method of the center of gravity.

Occupational risk assessment methodology using the specified fuzzy inference was presented in [11]. This methodology has been implemented as a software application "Calculator occupational hazards". The application determines the impact of occupational risk occupational hazard, occupational hazard and occupational risk of the combined impact of harmful factors. Imprint application were compared with the results of model -based environment fuzzy TECH identical sets of input data. In general, the results were similar in values.

Obviously, the most difficult step is the formation of the rule base and the determination of membership functions for linguistic variables, as at this stage, the determining factor is the knowledge expert who performs these actions. That is the quality of the entire model is largely dependent on the professional level expert.

Based on the application of fuzzy set theory to the assessment of risks in the economy and information technology was determined the possibility of applying this theory to the evaluation of occupational hazards which are caused by health and safety hazards at work place. On the basis of methodology for assessing the level of occupational risk was developed application "Calculator occupational hazards", the realization of which is not a difficult task. Such an application can be used in the enterprise as a result of its work to assess the level of occupational risk. It can be concluded that the application of fuzzy sets theory is a promising direction to improve methodology for assessing occupational hazards.

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UDC 621

AN APPROXIMATE METHOD OF DETERMINING THE COEFFICIENT OF VOLTAGE HARMONIC DISTORTION

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This article is devoted to investigations of different methods of determining the coefficient of voltage harmonic distortion. The paper contains approximate expression for the calculation of the coefficient of harmonic distortion of the voltage according to the testimony of voltmeters and tasks for its further metrological studies and checking.

One of the important tasks of modern electric power is to control and maintain the quality of electricity (SCE) in accordance with GOST 13109 - 97[1], as mismatch SCE established requirements leads to a significant economic loss[2].

For an objective quality evaluation of electricity SCE should be measured instrumentally, using the appropriate measuring instruments. SCE measurement is possible in part by a general-purpose instrumentation [3] or using special measuring instruments for measuring the SCE [4].

Of course, special measuring instruments of SCE are favorable because they are universal, measured practically the entire spectrum of the SCE, are complying with the requirements of GOST metrological characteristics, able to record and store information about the measured SCE etc. Meanwhile, this equipment is complex, expensive, often intended for stationary installation and not always mobile. Therefore, if necessary, and in the absence of special instruments for measuring SCE GOST allow the measurement of certain SCE using a general-purpose instruments. [1]

Really, measuring instruments of SCE are devices that actually measure voltage, i.e. to its original purpose are voltmeters. However, not all SCE can be measured with a voltmeter. In addition, measurement of the SCE frequency counters and spectrum analyzers are necessary [4].

Such SCE as steady voltage deviation δU_s , the depth of the voltage dip δU_d , voltage asymmetry on the reverse sequence K2U and zero sequence K0U can be measured with a voltmeter [5] . Information about measuring the coefficient of harmonic distortion using a voltmeter cannot be found in the technical literature.

Harmonic distortion of the voltage according to [1] estimated coefficient voltage harmonic distortion K_{Ui} and coefficient of n-th harmonic voltage component. Of these coefficients using voltmeters can try to determine only the coefficient of voltage harmonic distortion K_{Ui} .

Harmonic distortion coefficient voltage K_{Ui} according to [1] is defined as:

$$K_{Ui} = \frac{\sqrt{\sum_{k=2}^{40} U_k^2}}{U_1} \cdot 100\% \quad (1)$$

where U_k – active value of the higher harmonics;

U_1 – active value of the first harmonic

For simplification, we introduce a replacement:

$$U_{vg} = \sqrt{\sum_{k=2}^{40} U_k^2} \quad (2)$$

For the ideal sinusoidal voltage the relation between the amplitude and the current value in the form is typical [6]:

$$\frac{U_{1m}}{U_1} = \sqrt{2} \quad (3)$$

Estimate of the coefficient of voltage harmonic distortion to build on the default logical expression (3), where:

$$\frac{U_{Dm}}{U_D} \neq \sqrt{2} \quad (4)$$

where U_{Dm} – measured maximum voltage;

U_D – RMS measurement of distorted sine wave.

Rms value of the distorted sine wave can be expressed as [6]:

$$U_D = \sqrt{U_1^2 + \sum_{k=2}^{40} U_k^2} \quad (5)$$

Considering (2):

$$U_D = \sqrt{U_1^2 + {U_{vg}}^2} \quad (6)$$

Distorted voltage amplitude is equal to the algebraic sum of the amplitudes of harmonics with phase shifts, and therefore $U_{Dm} \neq U_{1m}$.

Rms value of the voltage distortion U_D can associate an ideal sinusoidal voltage with an amplitude $U_E = \sqrt{2} \cdot U_D$, and the current value $U_E = U_D$.

Then the difference between the amplitude of the equivalent sinusoidal voltage and voltage distortion will be proportional to the total current value of the higher harmonics U_{vg}:

$$Uvg = \frac{U_{Em} - U_{Dm}}{\sqrt{2}} = U_D - \frac{U_{Dm}}{\sqrt{2}}$$

Then, on the basis of the above mentioned, with (1) may provide an approximation formula rated voltage harmonic distortion factor as:

$$K_{U_1} = \left|1 - \frac{U_{Dm}}{\sqrt{2} \cdot U_D}\right| \cdot 100\% \quad (7)$$

To determine the suitability of this formula it is necessary first to explore its systematic error in the determination of the coefficient of voltage harmonic distortion, and secondly – in which ranges of values of this coefficient can be used. Furthermore, we should analyze influence of instrumental errors voltmeters accuracy of determination of the desired coefficient.

For these investigations as a test of the distorted sine wave AC voltage should be taken with a known harmonic structure, and known in advance the exact value of coefficient voltage harmonic distortion. According to the research may require correction of the expression (7).

Effect of instrumental errors voltmeters with the rms value of the distorted sinusoidal voltage U_D and U_{Dm} amplitude value can be estimated by standard methods. All research can be done by numerical modeling in any convenient software environment.

For an approximate factor measurement voltage harmonic distortion can be measured with a voltmeter the rms value of the distorted sinusoidal voltage and its amplitude values. Previously an approximate expression for calculating this coefficient has been obtained as:

$$K_{U_1} = \left|1 - \frac{U_{Dm}}{\sqrt{2} \cdot U_D}\right| \cdot 100\% \quad (8)$$

where U_{Dm} – measured maximum voltage;

U_D – RMS measurement of distorted sine wave.

To estimate the systematic error of expression coefficient of voltage harmonic distortion in the form (8) as a test of the distorted voltage use voltage harmonic composition known in advance, the current value of the voltage, its amplitude value and the known exact value of the coefficient of harmonic distortion. We take as a distorted test trapezoidal alternating voltage with a voltage amplitude U_{Tm} and a changing function of a trapezoidal angle α in the range from 40° to 60°.In favor of this choice is possible to carry that this form is closest to the sinusoidal and has a coefficient of harmonic distortion close to real conditions.

Assessment of systematic error of expression (8) will hold a numerical method in Mathcad software environment and the provision of information in graphical form.

Therefore distorted function alternating voltage is [7]:

$$u = \frac{4 \cdot U_{Tm}}{\pi \cdot \alpha} \left[\sin\alpha \cdot \sin\omega \cdot t + \frac{1}{3^2}(\sin 3\alpha \cdot \sin 3\omega \cdot t) + \frac{1}{5^2}(\sin 5\alpha \cdot \sin 5\omega \cdot t) + \cdots\right] \quad (9)$$

where U_{Tm}- amplitude value of voltage;

α - angle of fracture trapezoidal function.

Rms value of the trapezoidal voltage equal to:

$$U_T = U_{Tm}\sqrt{1-\frac{4\cdot\alpha}{3\cdot\pi}} \quad (10)$$

First harmonic amplitude trapezoidal voltage is [7]:

$$U_{1m} = \frac{4\cdot U_{Tm}\cdot\sin\alpha}{\pi\cdot\alpha} \quad (11)$$

The total rms value of the higher harmonics find as:

$$U_{vg} = \sqrt{U_T - U_1} \quad (12)$$

The exact value of the coefficient of distortion of trapezoidal voltage:

$$K_{U_T} = \frac{U_{vg}}{U_T}\cdot 100\% \quad (13)$$

The approximate value of the coefficient of harmonic distortion trapezoidal voltage according to (8):

$$K_{U_A} = \left|1-\frac{U_{Tm}}{\sqrt{2}\cdot U_T}\right|\cdot 100\% \quad (14)$$

Let U_{Tm}= 100 V., and α varies from 40° ($\frac{4\pi}{18}$) to 60° ($\frac{\pi}{3}$) with step 1° ($\frac{\pi}{180}$). With the help of Mathcad receive the results of the calculation of exact values of the coefficient (13), and the approximate coefficient (14) in the form of graphs, which are shown on Fig.1.

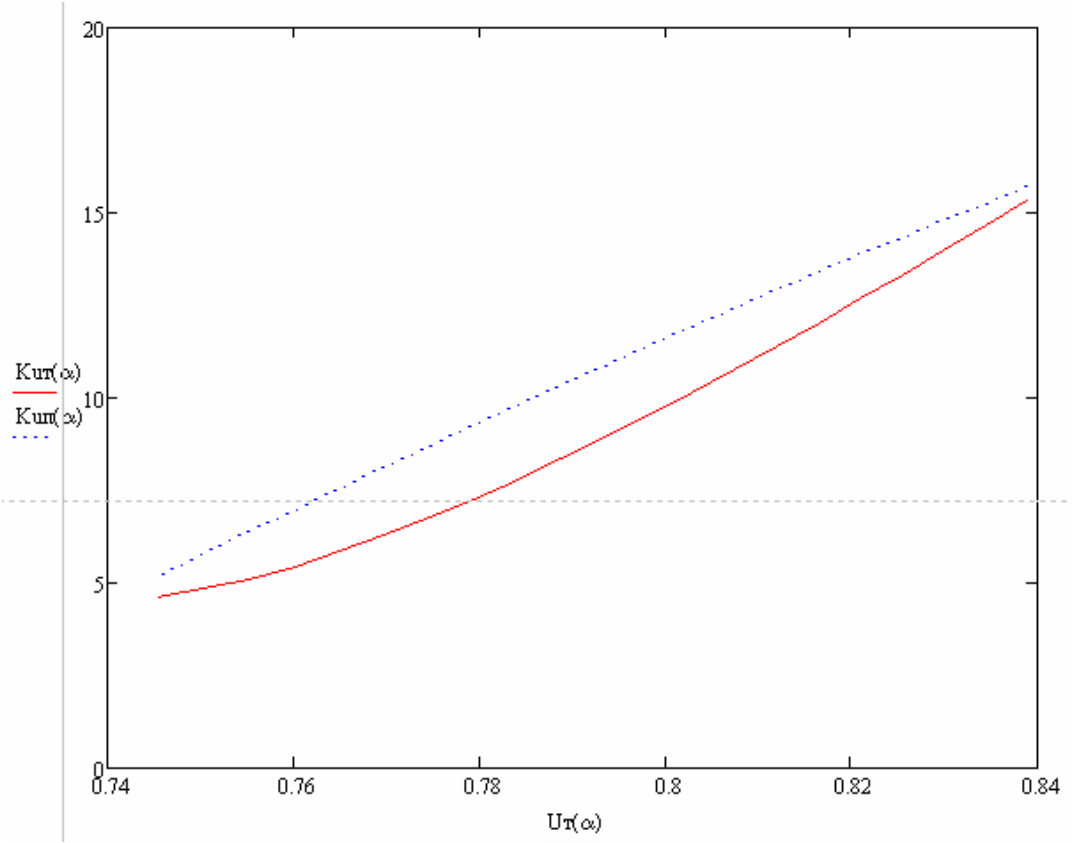

Fig.1

Dependence of the difference of exact and approximate values of the coefficient of harmonic distortion for trapezoidal voltage by changing the angle α in the same range is shown in Figure 2.

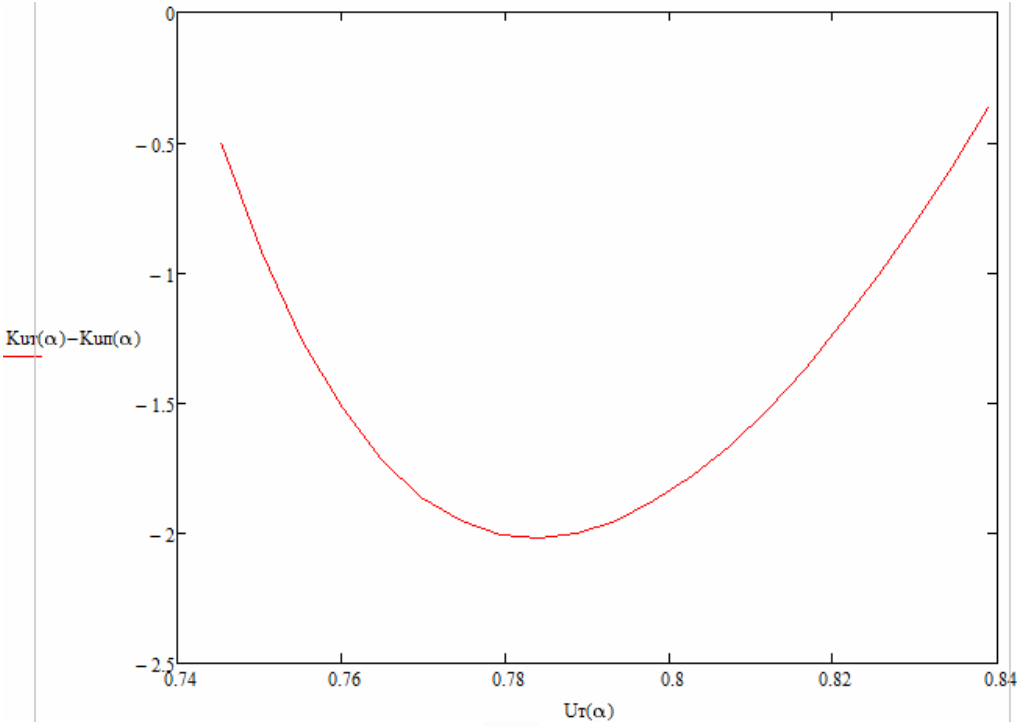

Fig.2

The obtained dependence represents the absolute methodological error of calculation of the required coefficient of harmonic distortion voltage for the expression (8).

To reduce this error in expression (8) it is advisable to introduce the offset and the average magnitude of this error. Then, in accordance with Fig. 2 a revised formula to calculate the coefficient harmonic distortion of the voltage can be represented as:

$$K_{U_1} = \left|1 - \frac{U_{0m}}{\sqrt{2}\cdot U_0}\right| \cdot 100\% - 1.3 \qquad (15)$$

Dependence of the difference of exact and approximate values of proximate coefficient harmonic distortion (15) for the trapezoidal voltage by changing the angle α in the same limits is shown in Figure 3.

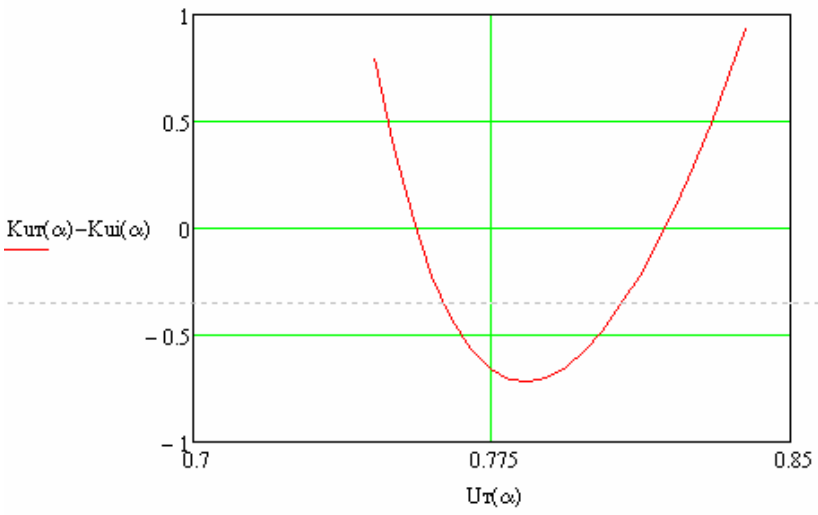

Fig.3

From the analysis of the graph (Figure 3) it should be said that when the angle α trapezoidal functions ranging from 40^0 ($\frac{4\pi}{18}$) to 60^0 ($\frac{\pi}{3}$) with step 1^0 ($\frac{\pi}{180}$) the methodical error of determining the coefficient of harmonic distortion of no more than 1.3%.

Thus, if the sum of simultaneously acting amplitudes of harmonics A3 + A5 + A9 + A7 + A11 is equal to or less than 8% of the amplitude of the first harmonic, the coefficient harmonic distortion of voltage does not exceed 7%, and the absolute error of its determination the formula (15) is not more 1.3%.

With a coefficient of the voltage harmonic distortion up to 7% of the proposed formula for determining the coefficient work and allows us to estimate nonsinusoidal voltage with an absolute error less than 1.3%.

This is verified and the trapezoidal waveform voltage in the range of angle changes from 40 degrees to 60 degrees, and at a voltage in the form of an arbitrary mixture of harmonics up to k = 11 inclusive.

In this article an attempt is made to approximate determination of the coefficient harmonic distortion voltage indications of the voltmeter, measure the rms value of the distorted sinusoidal voltage U_D and peak value U_{Dm} the same voltage.

We received approximate expression (7) for the calculation of the coefficient of harmonic distortion of the voltage according to the testimony of voltmeters.

The formulated tasks for the metrological studies obtained expression to determine the possibility of practical application of the obtained formulas for calculation of the coefficient of the harmonic distortion of the voltage according to the testimony of voltmeters.

The expression (8) can be used for approximate assessment of nonsinusoidal periodic voltage via the measured RMS voltage and of its peak value in a limited range of coefficient for voltage harmonic distortion up to 7% with an absolute error no more than 1,3%.

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DETERMINATION OF THE FINE STRUCTURE INFORMATION SIGNS OF THE SPEECH SIGNAL

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The paper presents the research results of methods to assess primary features of the speech signal: the frequency of the mail tone and formants. Deviation of the calculated values of the main tone investigated by means of these methods was ± 1,37%. The most resistant to noise method for estimating the frequency of the man tone is the autocorrelation method. The paper also presents the research results of methods for determining the basic phonemes of Russian formants. According to the research the first phoneme of Russian formant "a" is the most resistant to noise.

The determination of primary features of the speech signal, such as the period (or frequency) of the main tone (MT) F_0 , is a necessary criterion for determining the presence of speech in high level noise. The determination of the formants $F_1, F_2, \ldots, F_n$ is the source of additional, but not less important information, not only about the speech signal, but also about the individual signs of the speaker. The analysis of works by L.R. Rabiner, R.V. Shafer, J. Markel, A.H. Gray, I.O. Arkhipova, V.B. Gitlin, V.G. Mikhailov, L.I. Zlatoustova, A.N. Golubinsky, S.I. Rasskazova [1-6] and others shows that existing methods for determining the frequency of the main tone and formants of speech were tested in normal conditions and practically were not studied in terms of influencing factors. Therefore, the evaluation of primary features of elements of the speech signal such as the frequency of the main tone and formants in terms of influencing factors, is one of the most important tasks of the design and control of communication equipment and systems for the protection of speech information from losses by technical channels [7].

In order to identify the best methodologies for assessment of the frequency of the main tone we studied Russian language phonemes without influencing factors. The deviation of the calculated values of the MT frequency was ± 1,37%. Based on studies of eight methods for assessing MT frequency from their noise immunity and sensitivity, as well as the analysis and processing of the results we chose the following three methods: amplitude, cepstral and autocorrelation. Further, these methods have been studied in terms of influencing factors. Influencing factors were white Gaussian noise with the distribution of amplitude and chaotic pulse sequence noise. For additional signal distortion different kinds of clipping have been used.

Studies were performed on the basis of Russian vowel phonemes *а, о, у, э, и, ы* pronounced by male and female voices, with an average duration of 0.3 s. Evaluation of the main tone frequency was performed at various signal/noise ratio. The frequency of the main tone and the intelligibility of phonemes at different levels were estimated and the thresholds of cutoff signal clipping were specified.

Studies based on the method of amplitude selection using cueing points in the maximum values of quasi-periodic signal portions showed that, despite the fact that this method is simple to implement and requires few computational resources, its evaluation results are of very low precision and stability even at low noise levels. When clipping is high, the chance of missing the maximum and incorrect definition of the main tone is frequent. When the cutoff threshold is higher than 30-40%, this calculation is not possible.

Cepstral analysis method was developed by R.V. Schafer and L.R. Rabiner [1]. This method is based on the calculation and analysis of the cepstrum – an inverse Fourier transform of the logarithm of the power spectrum of the signal. This method is the best to assess vocal sounds. One of the features of this method is an increasing influence of a low-frequency noise component due to the operation logarithm spectrum. Work was in the unreal-time, and to improve the precision in estimating the time window, the smoothing operation should be applied. Therefore, the cepstral method has not been widely used to determine the main tone because it has low resistance to noise and computational complexity.

On the basis of experimental data, the autocorrelation method is the best to estimate the periodicity of the signal depending on the delay. A short-term autocorrelation function (ACF) is used for the analysis of the speech signal. For the vocal phonemes ACF has a clear maximum in the delay, equal to the period of the main tone. This method allows us to determine the frequency of the main tone of the spoken phonemes exactly and allows us to detect a voice signal, despite the background of strong noise and different types of clipping. It has been found that the central cutoff at high levels of threshold changes the frequencies of the main tone. This leads to a change in voice and a significant decrease in intelligibility. When determining the main tone frequency from vowels spoken by a female voice, sounds *у, и* are subject to change significantly, while sounds *а, э* are not. In the study of a male voice we observed noticeable changes in sounds *у, и, ы*. Sounds *а, э, о* are less susceptible to changes.

There are several properties of the cepstrum: it fully preserves information about the spectrum amplitude of the original signal, and decreases the contrast of the frequency components. These properties make it resistant to the formant structure of signals. Therefore cepstral analysis method was chosen out of the investigated methods of discrete Fourier transform, linear predictive coding and wavelet transform.

The criteria for evaluation were deviations of phoneme formants allocated for various influencing factors from phoneme formants isolated in the absence of any influences. Analysis of the data evaluation formant frequencies from the literature does not allow us to make a conclusion about the use of different methods and conditions for assessing the formants. The results of our experiments match the results obtained by M.A. Sapozhkov for vowel phonemes [8].

Under applicable in phonetics vowel quadrangle described by E. Skuchik [9] or so-called triangle (trapezoid) vowels described by L.V. Scherba, was built some curve, establishing spread dependencies second formant frequency F_2 of the first formant F_1 for investigated phonemes (fig. 1).

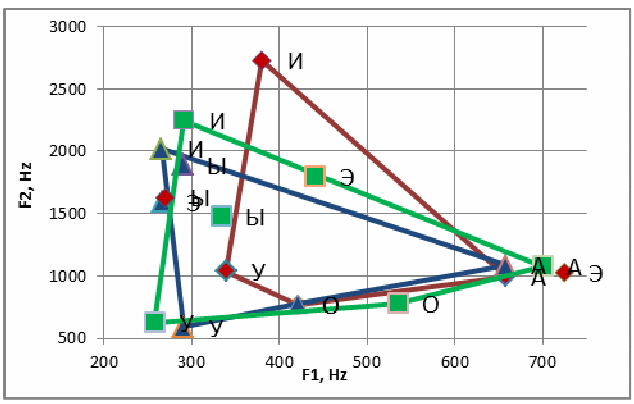

Fig. 1. Formants triangles

The vertices of the quadrilateral are sounds *а*, *о*, *у*, *и*, but sounds *э*, *ы* are located in the neighborhood of the resulting figure. We obtained figures based on the analysis of female and male voices, which show that with a decreasing voice (male) the quadrangle shifted to the origin and with an increasing voice (female) – away from the origin. However, the relative position of the sounds does not change. If the voice is hoarse, the location of the quadrilateral changes, but the relative position of the phonemes does not change. Quads vowels with different ratios of signal/noise were built. Figure 2 shows the change in the dependence of formants F_1 and F_2 for phonemes spoken by a female voice.

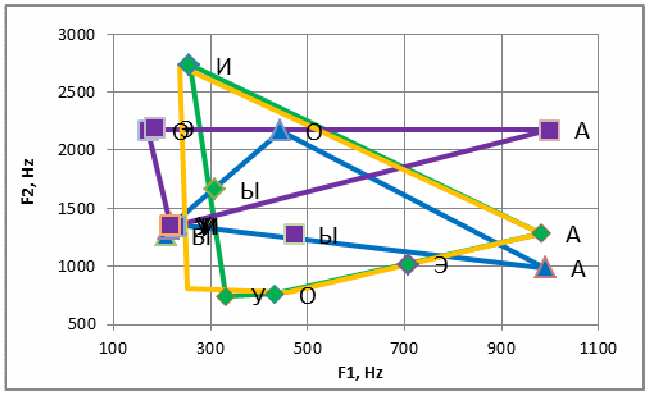

Fig. 2. The change of the location of phonemes under the influence of noise

According to the research it can be concluded that formant F_1 for phoneme *а* is most resistant to noise. And as the relative position of the sound remains, we recognize the voice. Thus, by changing the location of the formants and relative displacement of the vertices we can assess the magnitude of the distortion of the speech signal. And a shift of formants F_1 allows us to assess the intelligibility of a particular phoneme. Figure 3 also shows the stability of formants phonemes to interference.

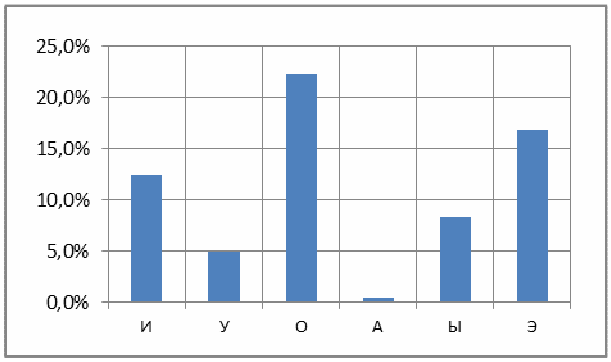

Fig. 3. Noise immunity of phonemes

As a result, the research proposed to use a combination of methods to assess primary features of the speech signal: AFC for frequency of the main tone and cepstral for the determination of the main formants (just the first two formants). This approach will allow determining the presence of speech in noise and assessing the magnitude of the distortion of the signal.

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VARIANTS OPTIMIZATION ALGORITHMS FOR SOLVING SYSTEMS OF LINEAR EQUATIONS

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This article describes options for increasing the rate of convergence of algorithms for solving systems of linear equations and considers the relaxation method for solving systems of linear equations

The subject of my report intersects with my master's thesis "Optimization algorithm for calculating the stationary gas networks". At this point a calculation algorithm based on the method of simple iteration, which is applied to the numerical methods and can be called the method of successive approximations, is developed in our university.

The idea of the simple iteration method is that the equation $f(x) = 0$ results in an equivalent equation $x = \varphi(x)$ so that the mapping $\varphi(x)$ was contracting. If it succeeds, then the sequence of iterates $x_{i+1} = \varphi(x_i)$ converges. This conversion can be done in different ways. In particular, the roots of the equation are retained in the form $x = x - \lambda(x) f(x)$, if $\lambda(x) \neq 0$ on the investigated interval.

The iteration method is the easiest to implement, however, this method is not very effective, due to the slow convergence.

Let us consider some ways to optimize the algorithms:

1) reducing the accuracy of the calculations;
2) the distribution of computing power;
3) the replacement of the basic algorithm for solving linear equations.

The first and third methods refer to software, and the second - to hardware. Let's dwell on each of them closely.

Reducing the precision of calculations is quite an effective way to increase the performance of algorithms for solving linear equations, as it reduces the required number of iterations to achieve the final result by several times, but if the algorithm is used in industry, this process is irrelevant as it usually requires less accuracy and is not specified in the condition. Therefore, this method can't be used in the context of the topic of my dissertation.

This hardware method implies partial transfer calculations to other computers or hardware of the local computer, which is not currently engaged in calculations. For example, we have two independent systems of equations, which ultimately influence the final decision. Having two computers, we can parallelize the solutions of these systems, and then put the final data together. The method is quite effective, but entails additional risks:

1) incorrect data transmission;
2) incorrect receive in processed data;
3) failure of network hardware;
4) inability to local use.

In this case, a replacement of the basic algorithm means changing the program used for solving systems of linear equations. Replacement of the basic algorithm, in our case, complicates the implementation, but at the same time, increases the efficiency of the algorithm as a simple iteration method has the slow speed of convergence. The methods for solving systems of linear equations are direct and iterative. Well-known iterative methods are:

1) Jacobi method (simple iteration);
2) Gauss – Seidel method;
3) The method of relaxation;
4) Multigrid method;
5) MethodMontante;
6) Abramov method;

7) The method of generalized minimal residual;
8) The biconjugate gradient method;
9) The stabilized biconjugate gradient method;
10) The quadratic biconjugate gradient method;
11) The method of quasi-minimal residual.

To optimize the existing algorithm I'm going to use a method of relaxation. Let's consider the method in details.

System of linear equations:

$$\begin{cases} a_{11}x_1 + \ldots + a_{1n}x_n = b_1 \\ a_{21}x_1 + \ldots + a_{2n}x_n = b_2 \\ \ldots \\ a_{n1}x_1 + \ldots + a_{nn}x_n = b_n \end{cases}$$

is reduced to the form:

$$\begin{cases} b_{11}x_1 + b_{12}x_2 + \ldots + b_{1n}x_n + c_1 = 0 \\ \ldots \\ b_{n1}x_1 + b_{n2}x_2 + \ldots + b_{nn}x_n + c_n = 0 \end{cases}$$

where

$$b_{ij} = -\frac{a_{ij}}{a_{ii}}, \; c_i = \frac{b_i}{a_{ii}}$$

we find residual: R_j:

$$\begin{cases} R_1^{(0)} = c_1 - x_1^{(0)} + \sum\limits_{j=2}^{n} b_{1j}x_j^{(0)} \\ R_2^{(0)} = c_2 - x_2^{(0)} + \sum\limits_{j=1, j\neq 2}^{n} b_{2j}x_j^{(0)} \\ \ldots \\ R_n^{(0)} = c_n - x_n^{(0)} + \sum\limits_{j=1}^{n-1} b_{nj}x_j^{(0)} \end{cases}$$

Is chosen initial approximation: $X^{(0)} = 0$.

At each step, we must bring the maximum discrepancy to zero:

$$R_s^{(k)} = \delta x_s^{(k)} \Rightarrow R_s^{(k+1)} = 0, R_i^{(k-1)} = R_i^{(k)} + b_{is}\delta x_s^{(k)}.$$

Stopping condition:

$$|R_j^{(k)}| < \varepsilon, \forall j = \overline{1,n}.$$

The answer:

$$x_i \approx x_i^{(0)} + \sum_j \delta x_i^{(j)}$$

According to the preliminary calculations the relaxation method will increase the speed of convergence of the system of equations by two times.

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METHOD OF THE CONSECUTIVE ANALYSIS OF OPTIONS IN A PROBLEM OF DRAWING UP THE SCHEDULE

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On the basis of the theory of consecutive decisions and dynamic programming the general scheme of the consecutive analysis of options was developed. The technique of consecutive development, analysis and elimination of options consists of development of options and creation of analysis operators which allow eliminating unpromising initial parts of options before their full construction. On the basis of the general scheme a number of algorithms of the consecutive analysis of options were developed. They received broad application in practice.

The branch of science, which received the name of the «theory of schedules», originated from Henry Gantt's well-known work of 1903 [1] which introduced what today we call Gantt's charts referred to in many works on the theory of schedules [2, 3].

The first works in the field of automated scheduling appeared in the 50s-60s of the XXth century when of automated control production systems were introduced [4].

At the turn of XXth and XXIst centuries the creation of automated education systems management [5] became an actual problem. The reasons were the following: to strengthen quality requirements of training, to develop new forms of education including distance learning, to increase economic efficiency of training, etc.

There is a set of methods aiming at drawing up the study schedule: a local and evolutionary method, a multiagent approach, a method of replacements, a method of the consecutive analysis of options, a genetic algorithm, a method of coloring the vertices of a graph, an intellectual method, etc.

In this article we consider how a method of the consecutive analysis of options can be applied to drawing up the study schedule.

On the basis of the theory of consecutive decisions and dynamic programming the general scheme of the consecutive analysis of options was developed. From the point of view of formal logic, the scheme of the consecutive analysis of options is consolidated to the following sequence of repeated procedures:

1. to split a set of versions of the task solution into some subsets, each of which possesses specific properties;
2. to use these properties to search for logical contradictions in the description of separate subsets;
3. to except further consideration of the subsets of versions which have logical contradictions.

Thus the technique of consecutive development, analysis and elimination of options consists of the development of options and creation of analysis operators which eliminate unpromising initial parts of options before their full construction. This technique also reduces computing expenses.

On the basis of this general scheme a number of algorithms of the consecutive analysis of options were developed. Many of them received broad application in practice

Approximate methods can be divided into the following groups: methods of local optimization, modification of exact methods, heuristic methods, methods of casual search, and methods combining local optimization with casual search.

We will note that many approximate algorithms allow solving problems of discrete optimization in a dialogue mode. Depending on allocated resources (time, memories of the computer, etc.) these algorithms optimize the task solution by changing of all or some of the basic data.

The considerable part of approximate algorithms of discrete optimization is based on computing schemes of exact methods, such as a method of branches and borders, the consecutive analysis of options and others.

One of the most developed approximate methods is the method of the local optimization, searching for locally optimum decisions. At certain stages of the task solution these methods are often combined with methods of casual search and heuristic methods which reduce a set of options and consider the specifics of a task.

It should be noted that algorithms in which various ideas are combined appear to be the most effective. By means of these methods numerous challenges object classification, placements, planning and design were

solved. The main advantage of these methods is the simplicity of realization, and the main shortcoming is that they can't adapt to conditions of a task. Much more flexible are methods in which the probabilistic law depends on outcomes of the previous tests and changes from iteration to iteration. These are methods of casual search.

Methods of casual search are used for the approximate solution of multidimensional tasks on a rank, and problems of linear Boolean programming of big dimension.

The specification of the scheme of the consecutive analysis of options is in several directions. In connection with the solution of tasks of linear or treelike structure the generalized principle of optimality for monotonously recursive functionalities on the basis of which it is possible to build the scheme of decisions, free from some restrictions inherent in initial procedures of dynamic programming was created.

For treelike structures, the questions connected with order of viewing of branches were investigated, and ways of minimization of the number of information arrays necessary for the realization of procedures of the consecutive analysis of options were found.

The method of the consecutive analysis of options was used for planning and design (calculation of transport networks, problems of placement on a treelike network, design of distributive electric networks, a choice of optimum parameters of the main gas pipelines, etc.).

Further on the basis of the algorithmic scheme of the consecutive analysis of options, effective methods of designing, analysis and elimination of options were developed to solve scheduling problems. Based on the theory of scheduling the exact methods of the solution of different classes of problems of small dimension were proved, necessary and sufficient conditions of a pre-solution for problems of scheduling with the same equipment were proved, effective ways which use rules of domination were developed.

Decomposition algorithms based on schemes of the consecutive analysis and elimination of options were developed to solve problems of big dimension of discrete separable and linear integer programming.

Thus the narrowing of an initial set of options was carried out by eliminating components that gave the chance to consolidate the solution of an initial problem of big dimension to the solution of set of subtasks of small dimension.

The method of the consecutive analysis of options is based on the elimination of unpromising elements, both on restrictions, and on criterion function.

The method of the consecutive analysis of options which can be used to draw up the study schedule is considered. The method is effective for problems of small dimension as at big dimension of the solution task time significantly increases. Decomposition algorithms which are based on the schemes of the consecutive analysis and elimination of options were developed to solve the problems of big dimension of discrete separable and linear integer programming.

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THE NOTION OF THE "COMMON FIXED POINT" AS ONE OF THE FACTORS OF THE LOCAL EVOLUTIONAL SEARCH EFFICIENCY

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This article is devoted to the efficiency evaluation of the local evolutional algorithms. Efficiency evaluation is one of the most important aspects in creating of the new optimization approaches.

The problem that discrete optimization deals with is to find an extremum of function on a discrete set of points. If the function domain comprises a finite number of points the problem of discrete optimization can be solved basically always by trying out the whole set. However, being finite the set can be too large so the enumerative techniques prove to be inefficient. [1] the overwhelming majority of such problems have a distinct application character and it is very topical for modern science as well as for manufacturing to find a qualitative solution for them. "Classic" methods such as genetic algorithms, annealing simulation algorithms, neural networks etc. have common traits: all of them are adaptive iterative and stochastic algorithms. Their every step deals with the value of a qualitative function and every single one of them can prove its convergence to the absolute optimum.

One of the more reliable methods is a heuristic search method. The heuristic search is a kind of state space search that utilizes the knowledge of the problem to find a more effective solution. It is usually easy to make heuristic algorithms that quickly find a solution, but it is impossible to prove that the heuristic algorithm always finds the solution that is close to the optimal one. [2] Moreover one of the major drawbacks of such methods is the absence of a predictable procedure.

The local evolutional approach is based on the synthesis of the heuristic and the evolutional approaches. The heuristic approach contributed the use of local heuristics (i.e. local rules of solution search). The evolutional one contributed the parallel development of many search processes (the population) and the selection model.

The peculiarity of the local evolutional approach is the ability to conduct the search in a strongly bounded solution space. This peculiarity allows to substantially reduce time costs compared to traditional methods and to increase the quality of the solution.

Additional compression of the search space becomes possible when using heuristics of a special kind, particularly, the recursive ones. One of the most topical problems while developing solution algorithms based on the recursive heuristics is the evaluation of their work efficiency and estimation of the moment when the search space reduction stops and further work of the heuristic algorithm becomes a waste of time and computing power.

We will introduce several definitions.

Definition 1. *Heuristics fi* is a functional image $S \to S$. Heuristics allows to move in the solution search space S in the direction of the evaluation function $\varphi(s) \geq \varphi(fi(s))$ (1) lack of growth where $\varphi(s) : S \to R$.

Definition 2. Recursive heuristics is the heuristics that results in a fixed point (FP) – $fi(s) = fi^2(s)$.

If we set any point of the initial search space after implementing the first heuristics we will inevitably come down to the reduced space and never exceed its bounds. That is why the search space compression should be considered a result of the approach to the solution search and not a workaround.

It is easy to prove the term character of the recursive heuristic calculation. Unfortunately, it is impossible to prove generally the convergence of the recursive heuristic calculation, because in our case the halt condition will be $\forall fi(s) : fi(s)=s$ (3), and this situation depends on the heuristic system applied and can be unrelated to reaching optimum.

A stable (and efficient) work of heuristics is usually mentioned as the main factor influencing the heuristic search efficiency.

The first point worth paying attention to is the search space compression effect when using recursive heuristics. In this case the search space power equals |S*|.

Definition 3. We will express the fact of the search space compression with the *ratio of reduction* $r=|S|/|S^*|$. This ratio characterizes the heuristics system as a whole and is connected with efficiency.

Definition 4. We will express the fact of the search space compression due to the work of separate heuristics with the ratio $r_i=|S|/|S_i|$ which we will call the heuristic power. It is calculated as an average power of the S/α_i partition classes.

Another factor connected with efficiency is the fact that heuristics have "common fixed points" (CFP). The fact of this possession indicates the search efficiency loss in these points up to a halt. In other words, such points make the calculations "thrash".

Definition 6. We will define the search efficiency loss record coefficient in CFPs as $p = \frac{\sum|S_i|}{|S^*|} = \frac{\sum|S_i|}{|S^*|} \cdot \frac{|S|}{|S|} = r \cdot \sum \frac{1}{r_i}$. It equals the average number of "malfunctioning" heuristics at any given moment of calculations.

We will introduce time cost estimation as $t = p \cdot \frac{|S|}{r}$ i.e. we suppose that the bigger the reduced space is and the bigger the losses because of inefficient calculations in CFPs, the longer the calculations will take. This estimation characterizes the time cost expressed through conventional units. However, it neglects both time complexity of the heuristics and their work character.

Thus it is easy to see that the main merits of the local evolutional approach is a relatively short time for the search for a quasi-optimal solution, it depends directly on the losses due to the inefficient work of the heuristics in CFPs. That is why with regard to the heuristic work character it is usually possible to suggest heuristic management strategy for the time of calculations. The aim of such strategy is to minimize the presence in CFPs thus reducing time loss due to inefficient calculations.

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CONTRIBUTION OF THE AMENDMENT OF THE FIFTH ORDER IN THE ASYMPTOTICS OF FUNCTION OF DISTRIBUTION COORDINATE OF THE ELEMENTARY ACT OF SORPTION

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The problem of dynamics of sorption is the cornerstone of many chemical and nature protection technologies connected with the cleaning of harmful emissions. To model this process we use the equations of mathematical physics. Thus let's solve the system of the differential equations in the private derivatives describing kinetics of sorption and balance of absorbed impurity. For linear isotherms and standard regional conditions such a system (see [1]) is reduced to the equation

$$-\omega'_\xi = e^{-\tau}\left(e^{-\xi} + \int_0^\tau e^{\tau} d_\tau \omega\right), \quad (1)$$

where ω – the given concentration of absorbed substance, ξ and τ – the respectively dimensionless coordinate and time [2].

It is obvious that the elementary act of sorption – a casual event. The respectively dimensionless concentration $\omega(\xi,\tau)$ can be interpreted as statistical probability of penetration of particles of impurity in absorbing layer on depth ξ. Respectively $1-\omega(\xi,\tau)$ – probability of absorption of a molecule such layer of a sorbent, and

$$f(\xi,\tau) = \frac{\partial(1-\omega(\xi,\tau))}{\partial\xi} = -\omega'_\xi(\xi,\tau) \quad (2)$$

– density of probability of the elementary act of sorption.

Using (1), it is possible to find the initial moments of a random variable without solving the equation (see [3])

$$\nu_n(\tau) = n!\sum_{k=0}^{n}(-1)^k\frac{\tau^k}{k!}\sum_{l=0}^{k}C_{n+1}^{l}(-1)^l\,,\quad (n=0,1,2,...) \tag{3}$$

where C_{n+1}^{l} – the numbers of combinations. Knowing the initial moments $\nu_n(\tau)$, it is easy to find the corresponding central moments

$$\mu_n(\tau) = \sum_{i=0}^{n}(-1)^i C_n^{n-i}\cdot\nu_{n-i}(\tau)\cdot\nu_1^i(\tau)\,. \tag{4}$$

The knowledge of all moments of a random variable is equivalent to the knowledge of its function of distribution. On the basis of this fact in [3] we receive that under $\tau \geq 18$ the random variable is distributed under the law close to the normal

$$f(\xi,\tau)\xrightarrow[\tau\to\infty]{} f_N(\xi,\tau) = \frac{1}{\sqrt{2\pi}\sigma(\tau)}e^{-\frac{(\xi-m(\tau))^2}{2\sigma(\tau)^2}}\,, \tag{5}$$

dependence on time of its parameters

$$m(\tau) = \tau+1\,,\qquad \sigma(\tau) = \sqrt{2\tau+1}\,. \tag{6}$$

We will define a deviation of asymptotic expression (5) from differential function of distribution at final times

$$f(\xi,\tau) = f_N(\xi,\tau)\cdot\big(1+\varphi(\xi,\tau)\big)\,, \tag{7}$$

where $\varphi(\xi,\tau)$ – the relative error arising at replacement $f(\xi,\tau)$ with the normal law.

The amendments $\varphi(\xi,\tau)$ caused by asymmetry and an excess are in [3]

$$\varphi(\xi,\tau) = \sum_{n=1}^{\infty}\frac{\varphi_n(x(\xi,\tau))}{\sigma^n(\tau)}\,, \tag{8}$$

where $\varphi_n(x)$ – some functions which are subject to definition.

Functions $\varphi_n(x)$ are the polynoms which senior degree is multipled to three [3]

$$\varphi_n(x) = \sum_{k=0}^{3n}c_{nk}x^k\,, \tag{9}$$

where c_{nk} – unknown numerical coefficients. Polynoms $\varphi_{2n-1}(x)$ contain only odd degrees x and give a contribution to asymmetry $f(\xi,\tau)$. Similar to $\varphi_{2n}(x)$ – are even functions x and provide an excess $f(\xi,\tau)$

$$\varphi_{2n-1}(x) = \sum_{k=0}^{3n-2}c_{2n-1\,2k+1}x^{2k+1}\,;\qquad \varphi_{2n}(x) = \sum_{k=0}^{3n}c_{2n\,2k}x^{2k}\,. \tag{10}$$

Developing probability-theoretic approach to modeling of dynamic sorption activity, we will show that $\varphi_n(x)$ with any number decide on the help of the central moments of a random variable of coordinate of the elementary act of sorption ξ (see 4). It is convenient to pass into the system of coordinates connected with working layer of a sorbent and as the characteristic size to use a mean square deviation

$$x(\xi,\tau) = (\xi - m(\tau))/\sigma(\tau)\,. \tag{11}$$

From (9) we will pick up coefficients c_{nk} so that identities were carried out

$$\frac{\mu_i(\tau)}{\sigma(\tau)^i} \equiv \int_0^{\infty}\left(\frac{\xi-m(\tau)}{\sigma(\tau)}\right)^i f(\xi,\tau)d\xi,\ (i=0,1,2,3,...)\,. \tag{12}$$

Having substituted (5), (7), (8) in (12) and having executed variable replacement, we will receive

$$\frac{\mu_i(\tau)}{\sigma(\tau)^i} \equiv \int\limits_{-\frac{m(\tau)}{\sigma(\tau)}}^{\infty} x^i \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \left(1+\sum_{n=1}^{\infty}\frac{\varphi_n(x)}{\sigma^n(\tau)}\right)dx. \qquad (13)$$

On the bottom limit of identity (13) arises -∞, as the population mean $m(\tau)$ grows over time quicker than a mean square deviation $\sigma(\tau)$ (see(6)). Taking into account this circumstance (13) we will receive

$$\frac{\mu_i(\tau)}{\sigma(\tau)^i} \equiv \int\limits_{-\infty}^{\infty} x^i \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \left(1+\sum_{n=1}^{\infty}\frac{\varphi_n(x)}{\sigma^n(\tau)}\right)dx. \qquad (14)$$

Equating coefficients at identical degrees $\sigma(\tau)$ in the left and right parts (14) for even i we will receive on one equation concerning all $\varphi_n(x)$ with even numbers, and at odd i – on one equation concerning all $\varphi_n(x)$ with odd numbers. The ratio (14) allows us to calculate $\varphi_n(x)$ with any number. For example, passing $\varphi_1(x), \varphi_2(x), \varphi_3(x)$ evaluation and $\varphi_4(x)$, we will find at once $\varphi_5(x)$ (see (10))

$$\varphi_5(x) = c_{51}x + c_{53}x^3 + c_{55}x^5 + c_{57}x^7 + c_{59}x^9 + c_{5,11}x^{11} + c_{5,13}x^{13} + c_{5,15}x^{15}. \qquad (15)$$

Integrals in the right part (14) at coefficients of c_{5k} will be other than zero for odd i. Taking into account a type of the right part (15), we will need eight linearly independent equations (14) with odd numbers (i=1,3,5,7,9,11,13,15). Thus in the left part (14) it is convenient to mark out obvious dependence of the central moments from $\sigma(\tau)$.

$$\begin{aligned}
&\frac{\mu_1(\tau)}{\sigma(\tau)^1} = 0, \quad \frac{\mu_3(\tau)}{\sigma(\tau)^3} = \frac{3}{\sigma(\tau)} - \frac{1}{\sigma(\tau)^3}, \quad \frac{\mu_5(\tau)}{\sigma(\tau)^5} = \frac{30}{\sigma(\tau)} + \frac{50}{\sigma(\tau)^3} - \frac{36}{\sigma(\tau)^5},\\
&\frac{\mu_7(\tau)}{\sigma(\tau)^7} = \frac{315}{\sigma(\tau)} + \frac{2415}{\sigma(\tau)^3} + \frac{714}{\sigma(\tau)^5} - \frac{1590}{\sigma(\tau)^7}, \quad \frac{\mu_9(\tau)}{\sigma(\tau)^9} = \frac{3780}{\sigma(\tau)} + \frac{74340}{\sigma(\tau)^3} + \frac{213192}{\sigma(\tau)^5} - \frac{63792}{\sigma(\tau)^7} - \frac{94024}{\sigma(\tau)^9},\\
&\frac{\mu_{11}(\tau)}{\sigma(\tau)^{11}} = \frac{51975}{\sigma(\tau)} + \frac{2061675}{\sigma(\tau)^3} + \frac{15758820}{\sigma(\tau)^5} + \frac{21516660}{\sigma(\tau)^7} - \frac{18051220}{\sigma(\tau)^9} - \frac{6653340}{\sigma(\tau)^{11}},\\
&\frac{\mu_{13}(\tau)}{\sigma(\tau)^{13}} = \frac{810810}{\sigma(\tau)} + \frac{56486430}{\sigma(\tau)^3} + \frac{859999140}{\sigma(\tau)^5} + \frac{3622853520}{\sigma(\tau)^7} + \frac{2150285280}{\sigma(\tau)^9} - \frac{4006270632}{\sigma(\tau)^{11}} - \frac{393371616}{\sigma(\tau)^{13}},\\
&\frac{\mu_{15}(\tau)}{\sigma(\tau)^{15}} = \frac{14189175}{\sigma(\tau)} + \frac{1584457875}{\sigma(\tau)^3} + \frac{41528877390}{\sigma(\tau)^5} + \frac{356114508750}{\sigma(\tau)^7} + \frac{935959124100}{\sigma(\tau)^9} + \frac{58146919740}{\sigma(\tau)^{11}} -\\
&-\frac{957880837200}{\sigma(\tau)^{13}} + \frac{45599275904}{\sigma(\tau)^{15}}.
\end{aligned} \qquad (16)$$

We will equate in these eight equations coefficients at $\sigma(\tau)^{-5}$ on the left and on the right, we will receive

$$\left.\begin{aligned}
&\frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^1 e^{-\frac{x^2}{2}} \varphi_5(x)dx = 0, \qquad \frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^9 e^{-\frac{x^2}{2}} \varphi_5(x)dx = 213192,\\
&\frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^3 e^{-\frac{x^2}{2}} \varphi_5(x)dx = 0, \qquad \frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^{11} e^{-\frac{x^2}{2}} \varphi_5(x)dx = 15758820,\\
&\frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^5 e^{-\frac{x^2}{2}} \varphi_5(x)dx = -36, \qquad \frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^{13} e^{-\frac{x^2}{2}} \varphi_5(x)dx = 859999140,\\
&\frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^7 e^{-\frac{x^2}{2}} \varphi_5(x)dx = 714, \qquad \frac{1}{\sqrt{2\pi}}\int\limits_{-\infty}^{\infty} x^{15} e^{-\frac{x^2}{2}} \varphi_5(x)dx = 41528877390.
\end{aligned}\right\} \qquad (17)$$

Having substituted in (17) decomposition (15) and having executed integration on x, we will receive the system of the linear algebraic equations of rather unknown coefficients written down in a matrix form $c_{5\ 2k+1}$, k=0,1,…,7

$$\hat{A}^{(8)} \cdot \begin{pmatrix} c_{51} \\ c_{53} \\ c_{55} \\ c_{57} \\ c_{59} \\ c_{5,11} \\ c_{5,13} \\ c_{5,15} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ -36 \\ 714 \\ 213192 \\ 15758820 \\ 859999140 \\ 41528877390 \end{pmatrix}, \qquad (18)$$

where $\hat{A}^{(n)} = \begin{pmatrix} I_1 & . & . & I_n \\ I_2 & . & . & I_{n+1} \\ . & . & . & . \\ I_n & . & . & I_{2n-1} \end{pmatrix}$, a $I_m = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} x^{2m} e^{-\frac{x^2}{2}} dx = 1 \cdot 3 \cdot 5 \cdot \ldots \cdot (2m-1),\ m = 1, 2, 3, \ldots.$

The only decision (18) is the set of numbers

$$c_{51} = -\frac{487}{256}, \quad c_{53} = \frac{630}{53}, \quad c_{55} = -\frac{3964}{173}, \quad c_{57} = \frac{1360}{93},$$
$$c_{59} = -\frac{508}{141}, \quad c_{5,11} = \frac{97}{256}, \quad c_{5,13} = -\frac{13}{768}, \quad c_{5,15} = \frac{1}{3840}. \qquad (19)$$

We will emphasize that the system for their receiving was certain and thus we in any way didn't use information about $\varphi_1(x), \varphi_2(x), \varphi_3(x), \varphi_4(x)$.

The fifth amendment defined by formulas (15), (19) adequately approaches a deviation of the $\Delta_5 = f - f_N(1 + \varphi_1 + \varphi_2 + \varphi_3 + \varphi_4)$ fourth approach from distribution function $f(\xi, \tau)$ (fig. 1).

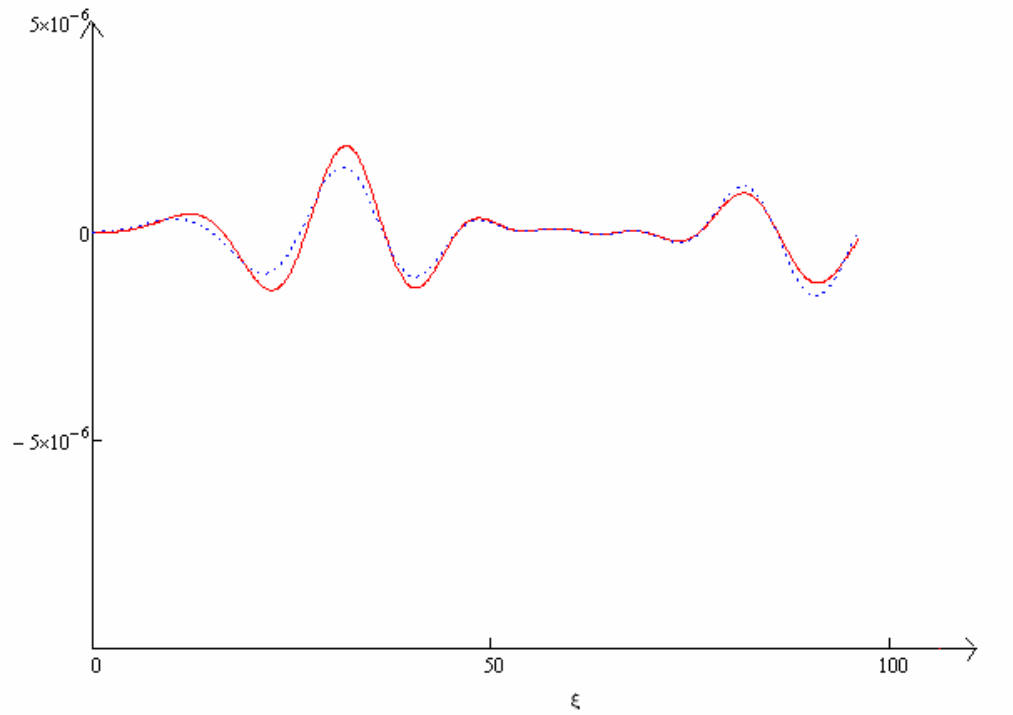

Fig. 1 –Function deviation $f(\xi,60)$ from the fourth approach (a continuous curve) and a contribution of the amendment to its fifth order on σ^{-5} (a dotted line)

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MATHEMATICAL MODEL OF THE FIXED OXYGEN BREATHING APPARATUS WITH A CIRCULAR AIRWAY SCHEME

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The research deals with the influence of the CO_2 breakthrough on the dynamic sorption activity of the regenerative cartridge of fixed oxygen breathing apparatus with a circular airway scheme. It is illustrated that the breakthrough return during breath at the later stages of the apparatus operation is essential and depending on the apparatus model or its operating regime noticeably (up to 10%) reduces its protection term.

The atmosphere in the fixed oxygen breathing apparatus regenerates in the process of the exhaled air filtration through the regenerative cartridge with porous granules of potassium superoxide-based oxygen-containing product. As a result of the CO_2 chemisorption in the proportion close to ideal the oxygen necessary for breathing is produced

$$4KO_2 + 2CO_2 = 2K_2CO_3 + 3O_2 + 360 \text{ kJ}, \quad (1)$$

Regenerating process modeling is a classical task of sorption dynamics (see [1-3]) that traces the evolution of admixture break through the absorber layer. It is usually solved by using mathematical physics methods if there are stationary boundary conditions upon entering the filter [4]. However, the apparatus with a circular airway scheme, besides the invariable component set by the apparatus operation regime, adds the CO_2 breakthrough that steadily increases as the regenerative cartridge resources exhausts. In other words, a variable absorber concentration upon entering the absorber layer takes place. The research [5] suggests an appropriate formalism that analytically describes the dynamic sorption activity with a variable absorber concentration upon entering the filter and comes to the following equation system:

$$-\omega_{\xi}'(\xi,\tau) = e^{-\tau}\left[e^{-\xi}\omega_0(0) + \int_0^{\tau} e^{\tau} d_{\tau}\,\omega(\xi,\tau)\right], \qquad \tau > 0, \quad (2)$$

$$u(\xi,\tau) = e^{-\tau}\int_0^{\tau} e^{\tau}\omega(\xi,\tau)d\tau, \qquad \tau > 0, \quad (3)$$

where τ and ξ are dimensionless time and coordinate (the penetration depth in the absorber layer) respectively, $\omega(\xi,\tau)$ – reduced concentration CO_2, $\omega_0(0)$ – its initial value upon entering the filter, $u(\xi,\tau)$ – waste product ratio;

The solution (2) can be presented as a series

$$\omega(\xi,\tau) = e^{-\xi-\tau}\sum_{n=0}^{\infty}\frac{f_n(\tau)}{n!}\xi^n, \quad (4)$$

with its coefficients connected by the recurrent correlation

$$f_{n+1}(\tau) = \int_0^{\tau} f_n(\tau)\,d\tau, \quad (5)$$

and knowing that

$$f_0(\tau) = e^{\tau}\omega_0(\tau) \quad (6)$$

allows to calculate any $f_n(\tau)$ up to any number. The formula (6) for $f_0(\tau)$ follows from the series (4) and the boundary condition

$$\omega(0,\tau) = \omega_0(\tau)\,. \tag{7}$$

Using computer calculations the correlations (2) – (7) allow to describe the CO_2 chemisorption in the regenerative cartridges of the breathing apparatus with a circular airway scheme[1]. To do so $\omega_0(\tau)$ in (7) in accordance with the described above should be replaced[2] with

$$\omega_0(\tau) = 1 + \omega(\eta,\tau)\,, \tag{8}$$

where η is a dimensionless cartridge length. As a result a self-consistent problem of defining the required function $\omega(\xi,\tau)$ appears. In order to solve it an iterative procedure with a small parameter $\omega(\eta,\tau)$ is used.

In order to get a null approximation in (8) the breakthrough $\omega(\eta,\tau) = 0$ should be considered completely negligible. This leads back to the stationary boundary condition $\omega(0,\tau) = 1$, with its solution for the recurrent correlation (6) written analytically

$$f_n(\tau) = e^{\tau} - \sum_{k=0}^{n-1} \frac{\tau^k}{k!} \qquad (n = 1,\ 2,\ \ldots)\,. \tag{9}$$

Having substituted (9) into (4) we get the known result (e.g. (10) in [6])

$$\omega 0(\xi,\tau) = e^{-\xi}\left[1 + \sum_{n=1}^{\infty} \frac{\xi^n}{n!}\left(1 - e^{-\tau}\sum_{k=0}^{n-1}\frac{\tau^k}{k!}\right)\right]. \tag{10}$$

The next step of the iterative procedure corresponding to the first approximation $\omega 1(\xi,\tau)$ is the substitution of (10) into (8) and a numerical implementation of the recurrent procedure (5). To do so a special program was written in the MathCAD package environment with its main fragments illustrated in fig. 1.

The breakthrough-time diagram drawn using this program (fig. 2) is predictable and allows reasonable interpretation. In the beginning when the CO_2 breakthrough is small, the graphs drawn for the open (curve 1) and the circular (curve 2) schemes of the airway are practically identical. But as the cartridge resource exhausts the breakthrough in the circular scheme grows at a greater rate, which is natural since the CO_2 molecules that avoided chemisorption return during breath increasing the CO_2 amount in the exhaled air. As it develops the process moves farther away from the one which takes place in the open scheme. As a result the critical CO_2 breakthrough time $\tau_{кр}$ is reduced by 11.6%. It equals in the order of values to the value received in [7] using approximate approach, based on the hourglass principle according to which the apparatus operation term is determined by the amount of the entered CO_2 molecules [8].

The second iteration (corresponding to the approximation $\omega 2(\xi,\tau)$) deals with the substitution of $\omega 2(\xi,\tau)$ into (8) instead of $\omega(\eta,\tau)$. The result of the subsequent implementation of the recurrent procedure (5) is also graphically represented in fig.2 (curve 3). The critical CO_2 breakthrough time has reduced by 0.9% which is hardly distinguished by eye. However, it raises a question of the convergence of the applied iterative procedure within the current breakthrough change range.

[1] In terms of application the fact that the equation (2) was received without considering the steady increase of $\omega_0(t)$ is also important. It means that the correlations (2) – (6) can also describe the admixture desorption with its dilution upon entering the filter.

[2] The way the amount of in the breathed air influences the gas exchange in the organism and, correspondingly, the amount of CO_2 in the exhaled air is a complicated issue. That is why the concentration additivity is an idealization as it is and can only be accurately implemented in a breathing simulator.

$\eta := 4 \qquad \xi := 0, 0.1 .. \eta \qquad N := 30 \qquad \beta := 1 \qquad \tau := 0, 0.05 .. \eta + 5$

$$\omega 0(\xi,\tau) := e^{-\xi}\cdot\left[1 + \sum_{n=1}^{N}\left[\frac{\xi^n}{n!}\cdot\left(1 - e^{-\tau}\cdot\sum_{k=0}^{n-1}\frac{\tau^k}{k!}\right)\right]\right]$$

$f0(\tau) := (1 + \omega 0(\eta,\tau))\cdot e^{\beta\cdot\tau} \qquad N1 := 80 \qquad k := 0 .. N1 \qquad x_k := 0.05\cdot k$

$$y1_k := \beta\cdot\int_0^{x_k} f0(\tau)\,d\tau \qquad S1 := cspline(x, y1) \qquad f1(\tau) := interp(S1, x, y1, \tau)$$

$$y2_k := \beta\cdot\int_0^{x_k} f1(\tau)\,d\tau \qquad S2 := cspline(x, y2) \qquad f2(\tau) := interp(S2, x, y2, \tau)$$

$$y3_k := \beta\cdot\int_0^{x_k} f2(\tau)\,d\tau \qquad S3 := cspline(x, y3) \qquad f3(\tau) := interp(S3, x, y3, \tau)$$

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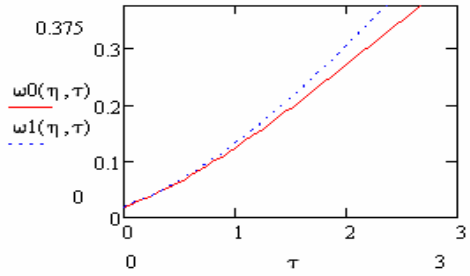
$$y35_k := \beta\cdot\int_0^{x_k} f34(\tau)\,d\tau \qquad S35 := cspline(x, y35) \qquad f35(\tau) := interp(S35, x, y35, \tau)$$

$$\omega 1(\xi,\tau) := e^{-\beta\cdot(\xi+\tau)}\cdot\left[f0(\tau) + f1(\tau)\cdot\beta\cdot\xi + f2(\tau)\cdot\frac{(\beta\cdot\xi)^2}{2!} + f3(\tau)\cdot\frac{(\beta\cdot\xi)^3}{3!} + \ldots + f35(\tau)\cdot\frac{(\beta\cdot\xi)^{35}}{35!}\right]$$



$\tau := \eta \qquad \tau(\eta) := root(\omega 0(\eta,\tau) - 0.375, \tau)$

$\tau 1 := \eta \qquad \tau 1(\eta) := root(\omega 1(\eta,\tau 1) - 0.375, \tau 1)$

$\tau(\eta) = 2.666$

$\tau 1(\eta) = 2.358$

$$\frac{\tau 1(\eta)}{\tau(\eta)} = 0.884$$

Fig. 1. The program to calculate the evolution of the CO_2 break through the regenerative cartridge of the fixed oxygen breathing apparatus with a circular airway scheme

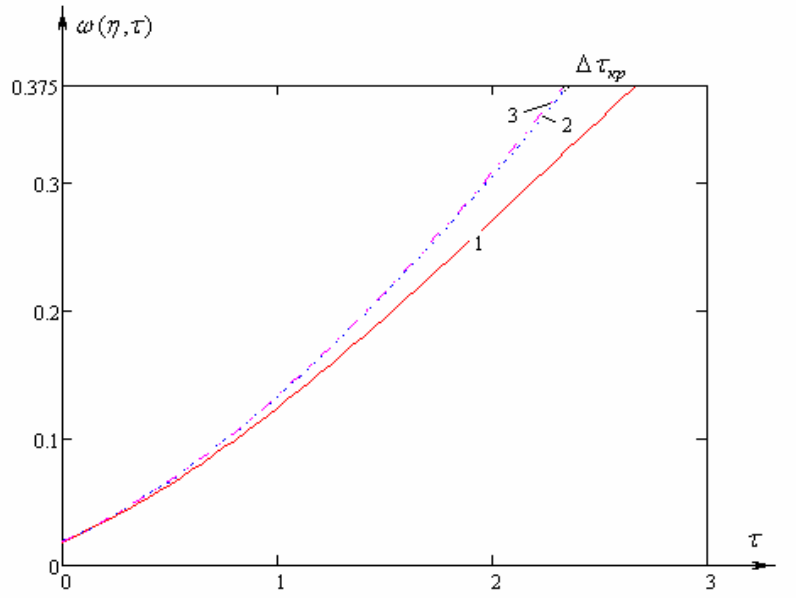


Fig. 2. The evolution of the CO_2 break through the regenerative cartridge of the fixed oxygen breathing apparatus connected via: 1 – the open scheme; 2 – the circular scheme (the first approximation), 3 – the circular scheme (the second approximation)

Due to the breathing physiology the carbon dioxide poisoning starts when its amount in the inhaled air reaches 1.5%. Normally, a person exhales air with a 4% amount of the carbon dioxide, i.e. the condition for the critical CO_2 breakthrough is

$$\omega(\eta, \tau_{кр}) = 1,5/4 = 0,375 . \quad (11)$$

It means that if $\tau \le \tau_{кр}$ then the adjustments to $\omega_0(\tau)$ (see (8)) appearing during the iterative procedure can be evenly estimated by the members of a descending geometric sequence with the denominator q = 0.375 which converges if q<1.

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EVALUATION OF THE RESOURCE USAGE EFFICIENCY INCREASE OF THE FIXED OXYGEN BREATHING APPARATUS

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The research shows that the CO_2 critical breakthrough time when using a heterogeneously fitted regenerative cartridge connected via the open scheme provides an understated breathing apparatus protection increase evaluation. It is better to employ the average oxygen-containing product usage along the full length of the cartridge by the time of the CO_2 critical breakthrough, because the breakthrough decrease due to the dependence of the product granules diameter on the granules occurrence depth evolves in time by itself. It is shown that the suggested evaluation in terms of quantity equals the one determined by the protection term for the circular airway scheme where the CO_2 breakthrough returns during breath.

The current fixed oxygen breathing apparatus have a substantial reserve for protection resource usage efficiency increase of the regenerative cartridge. For instance, a 2-litre cylinder for P12 respirator designed for a 4-year protection term is filled with 550g of compressed oxygen. The PX-4 apparatus is designed for the same term. Its regenerative cartridge contains 3.7kg of oxygen-containing product 90% of which is potassium superoxide. Taking into account the formula KO_2 of the chemical compound and the molecular weight of its elements we get 0,9.3,7.32/71=1,5kg of oxygen. If we apply the stoichiometry of the reaction

$$4KO2 + 2CO2 = 2K2CO3 + 3O2 + 360\ kJ , \quad (1)$$

$1.5 \cdot 3/4 = 1.13$ kg is produced in free form which is more than twice the amount in the cylinder. It means that by the end of the apparatus protection term only half of the cartridge resource is used. The performance of the apparatus with a shorter protection term is even worse.

The main reasons for the inefficient resource usage is a dead layer of the sorbent which is not used by the CO_2 critical breakthrough time and granule sintering of the oxygen-containing product affected by unevenly distributed exothermal heat sources [1].

When the dynamic sorption activity is mathematically modeled, dimensionless variables related to time t and coordinate x as

$$\tau = \beta\gamma t \in \left[0, \tau_{kp}\right], \qquad \xi = \beta x / v \in [0, \eta] \tag{2}$$

where v is the filtration speed, τ_{kp} – the CO_2 critical breakthrough time, η – dimensionless length of the cartridge, β and γ – phenomenological constants that characterize the speed and resource of the reaction (1). The intervals of changing ξ and τ characterize in a general way not only the regenerative cartridge itself, but its operation regime.

Attempts are made to increase the cartridge resource usage efficiency by means of influencing v [2, 3] altering the apparatus structure in order to accelerate the filtered air flow in the frontal layers of the oxygen-containing product, and to slow it down in the closing. It allows to broaden the product working layer i.e. to engage a greater amount of product with a larger heat dissipation surface in the process of heat removal at the beginning of the cartridge. As a result the cartridge temperature conditions soften and the chance of the product sintering lowers. On the other hand the contact time of its reagents increases at the end of the cartridge i.e. the dead layer of the chemisorbent gets thinner. The both factors increase the cartridge dynamic sorption activity i.e. increase the cartridge resource usage efficiency. However, introducing additional elements to the apparatus construction results in additional weight, dimension, physiological cost of wearing and reduces reliability etc.

The alternative way to increase the cartridge efficiency is suggested in [4, 5] and based on controlling the granulometric composition of the oxygen-containing product. The point is that the sorption speed is determined by CO_2 molecule diffusion inside the oxygen-containing product granules and it is inversely proportional to their square diameter [6]. Since it is the β value that is influenced by the granule diameter we will introduce a correction factor α:

$$\beta \to \alpha\beta, \tag{4}$$

which possesses the value of α_1 and α_2 in the first and the second parts of the cartridge respectively.

Now we will evaluate efficiency increase of the regenerative cartridge available resource due to the granule diameter reduction towards the filtration of the exhaled air. In order to do so we will apply the formalism developed in [4].

$$\omega(\xi,\tau) = \omega_1(\xi,\tau)\theta(\zeta-\xi) + \omega_2(\xi-\zeta,\tau)\theta(\xi-\zeta), \tag{3}$$

$$u(\xi,\tau) = u_1(\xi,\tau)\theta(\zeta-\xi) + u_2(\xi-\zeta,\tau)\theta(\xi-\zeta), \tag{4}$$

$$\omega_1(\xi,\tau) = e^{-\alpha_1\xi}\left[1 + \sum_{n=1}^{\infty}\frac{(\alpha_1\xi)^n}{n!}\left(1 - e^{-\alpha_1\tau}\sum_{k=0}^{n-1}\frac{(\alpha_1\tau)^k}{k!}\right)\right], \tag{5}$$

$$u_1(\xi,\tau) = 1 - e^{-\alpha_1\tau}\left(1 - e^{-\alpha_1\xi}\sum_{n=1}^{\infty}\frac{(\alpha_1\xi)^n}{n!}\sum_{k=1}^{n}\frac{(\alpha_1\tau)^k}{k!}\right), \tag{6}$$

$$u_2(\xi,\tau) = e^{-\alpha_2\tau}\alpha_2\int_0^{\tau} e^{\alpha_2\tau}\omega_2(\xi,\tau)d\tau, \tag{7}$$

$$\omega_2(\xi,\tau) = e^{-\alpha_2(\xi+\tau)}\sum_{n=0}^{\infty}\frac{f_n(\tau)}{n!}(\alpha_2\xi)^n, \tag{8}$$

$$f_{n+1}(\tau) = \alpha_2\int_0^{\tau} f_n(\tau)\,d\tau, \tag{9}$$

$$f_0(\tau) = e^{\alpha_2\tau}\omega_1(\zeta,\tau), \tag{10}$$

where $\omega(\xi,\tau)$ is a modified CO_2 concentration in the filtered airstream, $u(\xi,\tau)$ is a modified concentration of fixed carbon, ζ is a dimensionless coordinate of the point of the granule diameter leap and $\theta(\xi)$ is the Heaviside function.

The correlations (3), (10) allow any precision of calculation of the breakthrough and determination of the waste product share (see pic. 1, 2 curves 2) in the cartridge with granule diameter leap. The calculations are done for $\eta = 4,426$, $\zeta = 0,91$, $\alpha_1 = 0,64$, $\alpha_1 = 1,78$

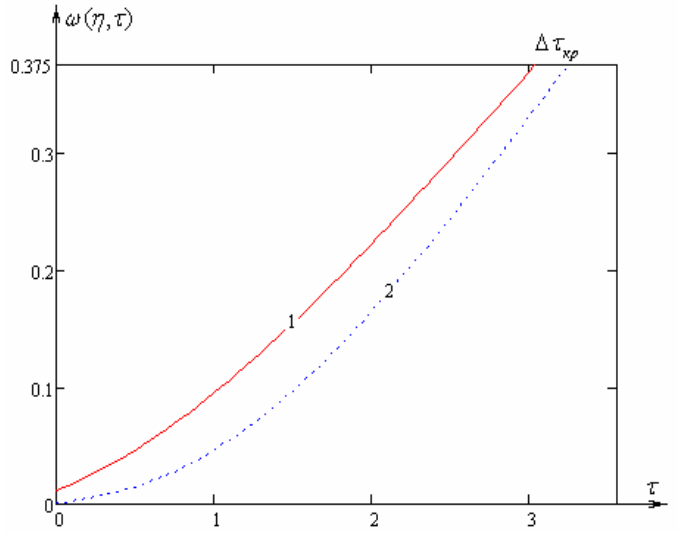

Fig. 1. CO_2 break through the regenerative cartridge:1 – homogeneously fitted; 2 – with a granule diameter leap

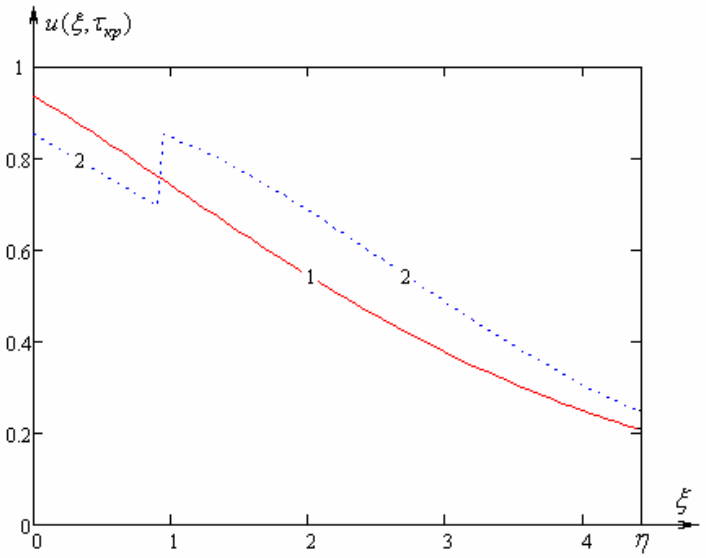

Fig. 2. Oxygen-containing product wear: 1 – in a homogeneously fitted cartridge; 2 – with a granule diameter leap

The curves 1 introduced for comparison in both figures correspond to a homogeneous cartridge are constructed with the help of formulas (5) and (6) respectively with $\alpha_1 = 1$

$$\omega_o(\xi,\tau) = e^{-\xi}\left[1+\sum_{n=1}^{\infty}\frac{\xi^n}{n!}\left(1-e^{-\tau}\sum_{k=0}^{n-1}\frac{\tau^k}{k!}\right)\right], \tag{11}$$

$$u_o(\xi,\tau) = 1-e^{-\tau}\left(1-e^{-\xi}\sum_{n=1}^{\infty}\frac{\xi^n}{n!}\sum_{k=1}^{n}\frac{\tau^k}{k!}\right), \tag{12}$$

The CO_2 critical breakthrough time was established on condition that

$$\omega(\eta, \tau_{кр}) = 0.375 . \quad (13)$$

It increased by 6.9% in a heterogeneously fitted cartridge (fig. 1). The fixed carbon distribution (as well as the exothermal heat sources) has become more even and the average regenerative cartridge performance increased by 12.9%

Now we will find out which of the last two values we should use to evaluate the breathing apparatus protection resource usage efficiency increase. We must take into account that the apparatus is insulating i.e. the breakthrough remains inside the airway. It mixes with the air that comes for a breath inside the breathing bag. This leads to the increase of the CO_2 amount exhaled. It means that the boundary condition for the sorption dynamics problem stops being stationary. Such situation is simulated in [7] for a homogeneous cartridge. Using the iterative method, breakthrough addition to the constant constituent (conditioned by the apparatus operation regime) shows the substantial reduction of the protection term. The effect must be less noticeable in an apparatus with a chemisorbent granule diameter leap because of a slower breakthrough growth (see fig.1). In order to perform a quantitative assessment expression (5) must be neglected when describing the breakthrough in the first part of the cartridge and formulas (8) and (9) must be applied having substituted α_2 for α_1:

$$\omega_{11}(\xi, \tau) = e^{-\alpha_1(\xi+\tau)} \sum_{n=0}^{\infty} \frac{f_n(\tau)}{n!} (\alpha_1 \xi)^n , \quad (14)$$

$$f_{n+1}(\tau) = \alpha_1 \int_0^{\tau} f_n(\tau)\, d\tau . \quad (15)$$

The first index in the left part of (14) numbers the regenerative cartridge part under study and the second one – the steps of the iterative procedure (for more details see [7]). According to the mentioned above for $f_0(\tau)$ instead of (10) we should write

$$f_0(\tau) = e^{\alpha_1 \tau}(1 + \omega(\eta, \tau)), \quad (16)$$

where $\omega(\eta, \tau)$ must be calculated using (3), (8) – (10). The resulting function $\omega_{11}(\zeta, \tau)$ must be substituted into (10) as a modified boundary condition in order to get (using (8) and (9)) the breakthrough in the second part of the cartridge $\omega_{21}(\eta, \tau)$:

$$\omega_{21}(\xi, \tau) = e^{-\alpha_2(\xi+\tau)} \sum_{n=0}^{\infty} \frac{f_n(\tau)}{n!} (\alpha_2 \xi)^n , \quad (17)$$

$$f_{n+1}(\tau) = \alpha_2 \int_0^{\tau} f_n(\tau)\, d\tau , \quad (18)$$

$$f_0(\tau) = e^{\alpha_2 \tau} \omega_{11}(\zeta, \tau) , \quad (19)$$

Remember that the first index of the reduced concentration ω numbers the parts of the regenerative cartridge and the second one – the steps of the iterative procedure. By combining the functions (14) and (17) in the first approximation we determine the evolution of the CO_2 modified concentration of the regenerated airstream in a heterogeneous cartridge of an apparatus with a circular scheme of the airway

$$\omega^{(1)}(\xi, \tau) = \omega_{11}(\xi, \tau)\theta(\zeta - \xi) + \omega_{21}(\xi - \zeta, \tau)\theta(\xi - \zeta) , \quad (20)$$

As the null approximation we should use expression (3) that describes the CO_2 break through a heterogeneously fitted cartridge connected via the open scheme $\omega^{(0)}(\xi, \tau) = \omega(\xi, \tau)$. The results of the calculations done with the MathCAD package are illustrated in fig.3

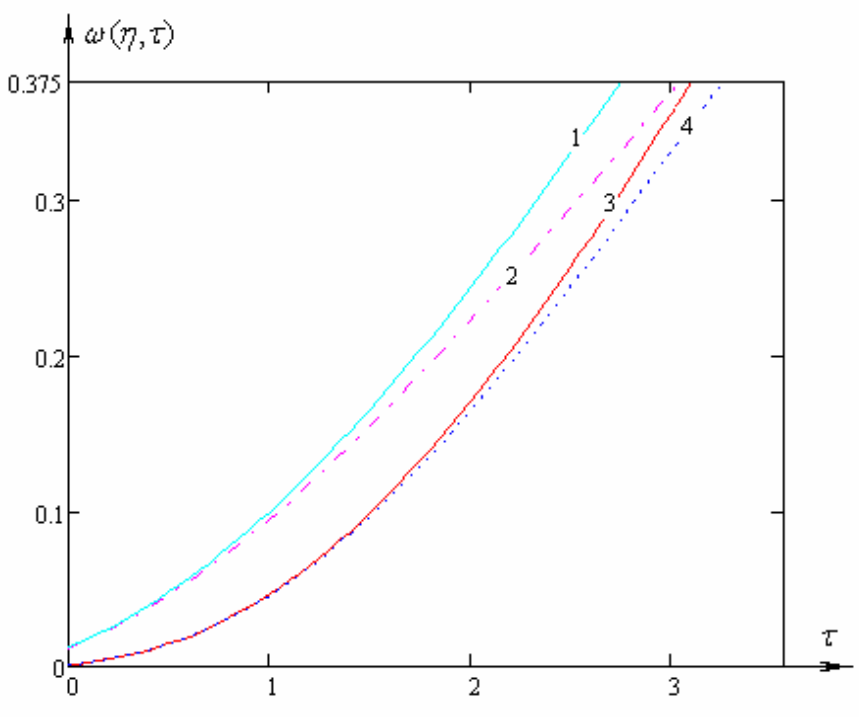

Fig. 3. CO_2 break through the regenerative cartridge: homogeneously fitted with the circular (1) and open (2) connection schemes; with a granule diameter leap in the circular (3) and open (4) schemes

The curves 2, 3 and 4 are built using formulas (11), (20) and (3) respectively. And the curve 1 – with the procedure described in [7]. Apparently, the influence of the closed character of the airway is less evident in a cartridge with a granule diameter leap. It increases the critical breakthrough time growth from 6.9% to 12.9% which equals the value calculated on the average pollution of the cartridge connected via the open scheme by the time of the CO_2 critical breakthrough time. This is probably not a random coincidence and it is a result of the carbon dioxide molecules conservation law. Indeed, with a specified filtration speed the CO_2 critical breakthrough time is determined by the number of molecules that went into the filter which equals the number produced in the process of human's vital activity minus those absorbed by the cartridge.

Thus there is no need to build the circular airway scheme in order to evaluate the protection increase of a heterogeneously fitted apparatus. One is only to calculate the average pollution growth of the cartridge with an open connection scheme.

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ABOUT ONE LEGAL ROUTE IN THE SPACE OF THE SQUARE MATRIXES

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The task of the construction of one legal route in the space of the square matrixes of the n-th order is considered in the article. This route connects an identity matrix with a certain matrix the last column of which is a preassigned n-dimensional vector-column codirectional with the last column of the identity matrix.

Let's consider Euclidean n-dimensional space R^n. Let's denote the vectors of the canonical orthonormalized basis of this space by means of e_i, $i=\overline{1,n}$. We take up the space M_n along with the vectorial space R^n. The space M_n is the space of the square real-valued matrixes of an order n with the spectral (operator) norm [1, c.355], i.e. the norm, which is induced on M_n by Euclidean norm in the space R^n. We give the following definition.

Let $\xi_1,\ldots,\xi_2$ be the sequence of vectors from the space R^n, where ρ is a certain positive number. The sequence of matrix $P_0,\ldots,P_l \in M_n$ is called ρ - *legal route (concerning the sequence of vectors ξ_i), which connects points P_0 and P_l*, if the unequality is in progress $\det P_i \geq \rho$, $i=\overline{0,l}$ and vectors $u_i \in R^n$, $i=\overline{1,l}$ are found, and in every $i=\overline{1,l}$ the following correlations take place

$$P_i - P_{i-1} = \xi_i \cdot u_i^T.$$

A natural number l is called the length of the legal route [2].

The legal route is an auxiliary instrument when we solve tasks of the global controllability of different asymptotical invariants [2–6] of the linear non-stationary control systems of the ordinary differential equations of the following type

$$\dot{x} = A(t)x + B(t)u, \qquad x \in R^n, \quad u \in R^m, \quad t \geq 0. \tag{1}$$

So, for example, with the help of the appropriately constructed legal route [2] we got the proofs of the global controllability of Lyapunov`s exponents *n*-dimensional linear systems (2) with the sectionally evenly continued factors, as well as of two-dimensional [3] and three-dimensional [4, 5] linear systems (1) with local integrable and integrally bounded matrixes of the factors A and B; we set the global controllability of the complete summation of Lyapunov`s invariants [6; 7, c. 281-325] of the two-dimensional linear systems (1) with a continuous and bounded matrix A and with a bounded piecewise uniformly continuous matrix B.
In our research we drew on the method of the construction of the legal route for the square matrixes of the second order [3] and found the legal route in the space M_n of the square matrixes of the n-th order. This route connects an identity matrix with a certain matrix the last column of which is a preassigned n-dimensional vector-column codirectional with the last column of the identity matrix.

The main result of the paper (theorem 2) is based on lemmas 1,2, theorem 1 and its corollary.

Lemma1. *If we have any numbers $0 < \delta, \beta \leq 1$ and arbitrary identity vectors $\xi_i \in R^n$, $i=\overline{1,n}$ with the estimation $|\det[\xi_1,\ldots,\xi_n]| \geq \delta$ among vectors $\nu_i \in R^n$, $\|\nu_i\|=1$, $i=\overline{1,n}$ which meet $|\det[\nu_1,\ldots,\nu_n]| \geq \beta$, for every $l \in \{1,\ldots,n\}$, there can be found at least one vector v, at which the following correlation is correct*

$$|\det[\xi_1,\ldots,\xi_{l-1},v,\xi_{l+1},\ldots,\xi_n]| \geq \delta\beta / n.$$

Let's denote normalized bases formed from vectors $\nu_i(j) \in R^n$, $i=\overline{1,n}$ for every $j=\overline{1,n}$ through $\mathfrak{B}_j$ i.e. a set of vectors

$$\mathfrak{B}_j = \left\{\nu_1(j), \nu_2(j), \ldots, \nu_n(j) : \|\nu_i(j)\| = 1,\ \nu_i(j) \in R^n,\ i=\overline{1,n}\right\}.$$

The volume of a system of the vectors (basis) $\mathfrak{B} = \{\nu_1, \nu_2, \ldots, \nu_n\} \subset R^n$ [8, c.260-261] is a non-negative number, which is equal to $|\det \mathfrak{B}| = |\det[\nu_1, \nu_2, \ldots, \nu_n]|$.

Geometrically lemma 1 means that for every two bases $\mathfrak{B}_1$ и $\mathfrak{B}_2$ from the space of R^n, which have a sufficiently large volume, and for every vector $\nu_1 \in \mathfrak{B}_1$ there can always be found at least one vector $\nu_2 \in \mathfrak{B}_2$, so that if we replace ν_1 by ν_2, we get a system of vectors from $\mathfrak{B}_1$, which will be a normalized basis in the R^n This system of vectors has a sufficiently large volume (it depends on the volumes of bases $\mathfrak{B}_1$ и $\mathfrak{B}_2$).

T h e o r e m 1. *We have a canonical basis* e_i, $i = \overline{1,n}$ *of the space* R^n. *For random numbers* $\beta \in (0,1]$ *in every* n *the set of the identity vectors* $\nu_1^{(i)},\nu_2^{(i)},\ldots\nu_n^{(i)} \in R^n$, $i = \overline{1,n}$ *with* $\det[\nu_1^{(i)},\nu_2^{(i)},\ldots\nu_n^{(i)}] \geq \beta$, *ther can be found at least one vector* $w^{(i)}$. *This vector belongs to the* i*-th set and at which the following inequality is correct*

$$|\det[w^{(1)},e_2,e_3,\ldots,e_n]| \geq (\beta/n)^n =: \delta_n, \quad |\det[w^{(1)},w^{(2)},e_3,\ldots,e_n]| \geq \delta_n, \quad \ldots,$$
$$|\det[w^{(1)},w^{(2)},w^{(3)},\ldots,w^{(n)}]| \geq \delta_n.$$

Geometrically theorem 1 means that for the canonical basis of the n-dimensional vectorial space $e_1,e_2,...,e_n \in R^n$ and an ordered sequence of n normalized bases $\mathfrak{B}_i$, $i = \overline{1,n}$ of sufficiently large volumes in every of them there can be found at least one vector $\nu_{j_i}^{(i)} \in \mathfrak{B}_i$, $j_i \in \{1,...,n\}$, . If we coherently replace every vector e_i for $\nu_{j_i}^{(i)} \in \mathfrak{B}_i$, we get a system of the vectors from the canonical basis

$$\mathfrak{B}_i^{'} = \{\nu_{j1}^{(1)},\nu_{j2}^{(2)},...,\nu_{jk}^{(k)},e_{k+1},...,e_n\},\ j_k \in \{1,...,n\}, \quad k = \overline{1,n}$$

This system of the vectors will be normalized bases in the R^n of a sufficiently large volume (however, this system of the vectors will possibly have the direction opposite to that of the canonical basis).

O b s e r v a t i o n. If for vectors $w^{(i)}$, $i = \overline{1,n}$, described in the theorem 1, we put

$$\nu_i := \operatorname{sign}(\det[\nu_1,\nu_2,\ldots,\nu_{i-1},w^{(i)},e_{i+1},\ldots,e_n])w^{(i)}, \quad i = \overline{1,n},$$

we`ll get inequalities

$$\det[\nu_1,e_2,e_3,\ldots,e_n] \geq \delta_n, \quad \det[\nu_1,\nu_2,e_3,\ldots,e_n] \geq \delta_n, \quad \ldots, \quad \det[\nu_1,\nu_2,\nu_3,\ldots,\nu_n] \geq \delta_n.$$

C o r o l l a r y t o t h e o r e m 1. *Matrixes*

$$P_0 := E,\ P_1 := [\nu_1,e_2,\ldots,e_n],\ P_2 := [\nu_1,\nu_2,e_3,\ldots,e_n],\ \ldots,\ P_n := [\nu_1,\nu_2,\ldots,\nu_n],$$

in which vectors ν_i, $i = \overline{1,n}$ *are determined by theorem 1 and observation, conform in the space* $n \times n$*-matrixes* δ_n*-legal route relative to the sequence of vectors* e_i, $i = \overline{1,n}$, *connecting points* E *u* P_n.

L e m m a 2. *For any numbers* $0 < \delta \leq 1$ *and* $0 < \varphi < \delta/2$ *and arbitrary identity vectors* $\xi_i \in R^n$, $i = \overline{1,n}$ *with the estimation* $|\det[\xi_1,\xi_2,...,\xi_n]| \geq \delta$, *if for the identity vector* $\xi_k' \in R^n$ *the inequality* $\measuredangle(\xi_k',\xi_k) \leq \varphi$ *is completed with* $k \in \{1,...,n\}$, *the correlation* $|\det[\xi_1,\xi_2,...,\xi_{k-1},\xi_k',\xi_{k+1},...,\xi_n]| \geq \delta/2$ *is correct.*

Geometrically lemma 2 means that if we have «the departure» of one of the vectors of the normalized basis by a sufficiently little angle measure (i.e. if we replace one of the vectors of the normalized basis for an identity vector situated together with a removable vector in a cone and the cone has a sufficiently little angle measure), the system of vectors which we get will be also the basis. Its volume can change insignificantly.

When we make the legal route and work with vectors of different normalized bases of the space R^n, we`ll reckon that the following operations with these vectors are executable:

1) expansion (shrinkage) of every vectors (i.e. multiplication of the vector by the real number);

2) substitution of every vector from every basis for such two identity vectors of the space R^n which are «deflected» from the replaceable vector by a sufficiently littlle angle measure (i.e. situated together with a replaceable vector in the cone of a sufficient little angle measure) and a certain linear combination of which gives a replaceable vector.

The relevancy of the introduction and feasibility of the given operations on vectors of normalized bases of the space R^n follow from the possibility of their introduction and justification when we solve the main problem – the problem of the global management of Lyapunov`s exponents [3].

T h e o r e m 2. *Suppose that for a random number* $\delta \in (0,1]$ *we get the identity vectors* $\nu_1, \nu_2, ..., \nu_n \in \mathbb{R}^n$ *and* $\det P_0 := \det[\nu_1, \nu_2, \ldots, \nu_n] \geq \delta_0$ *takes place. Then for any non-zero vectors* $h \in R^n$, *which is codirectional with the vector* ν_n, *and every* $i = \overline{1,n}$ there can be *found a vector* w_i^0, *which belongs to the i-th set of the random identity vectors* $w_j(i) \in \mathbb{R}^n$, $j = \overline{1,n}$, *that meets the inequality* $\left|\det[w_1(i), w_2(i), \ldots, w_n(i)]\right| \geq \beta \in (0,1]$, *and the sequences of the numbers* $\alpha_i' \in \mathbb{R}$ *bounded on the module* $|\alpha_i'| \leq (2n/\beta)^n (\| h \| + 1) =: \gamma$, $i = \overline{1,n}$, *and* $\sigma_i \in \{1,2\}$, *that if the correlations are correct*

$$\alpha = 2^{3n+2} n (\| h \| + 1)(n/\beta)^{2n} \quad \text{and} \quad \varphi \leq \arcsin(1/\alpha),$$

then for every $i = \overline{1,n}$ *and for the vectors* $w_i, w_i' \in R^n$, *the conditions are correct*

$$\| w_i \| = \| w_i' \| = 1, \quad \measuredangle(w_i^0, w_i) \leq \varphi, \quad \measuredangle(w_i^0, w_i') \leq \varphi, \quad i = \overline{1,n},$$

and a certain linear combination forms vector w_i^0, *the following equality takes place*

$$h - \nu_n = \alpha_1' w_1' + \alpha_2' w_2' + \ldots + \alpha_n' w_n'$$

and the following estimations take place

$$\det P_1 := \det[\nu_1 + (-1)^{\sigma_1} \alpha w_1, \nu_2, \ldots, \nu_{n-1}, \nu_n] \geq \delta,$$

$$\det P_2 := \det[\nu_1 + (-1)^{\sigma_1} \alpha w_1, \nu_2, \ldots, \nu_{n-1}, \nu_n + \alpha_1' w_1'] \geq \delta,$$

$$\det P_3 := \det[\nu_1 + (-1)^{\sigma_1} \alpha w_1, \nu_2 + (-1)^{\sigma_2} \alpha w_2, \ldots, \nu_{n-1}, \nu_n + \alpha_1' w_1'] \geq \delta,$$

$$\det P_4 := \det[\nu_1 + (-1)^{\sigma_1} \alpha w_1, \nu_2 + (-1)^{\sigma_2} \alpha w_2, \ldots, \nu_{n-1}, \nu_n + \alpha_1' w_1' + \alpha_2' w_2'] \geq \delta, \quad \ldots,$$

$$\det P_{2n-1} := \det[\nu_1 + (-1)^{\sigma_1} \alpha w_1, \nu_2 + (-1)^{\sigma_2} \alpha w_2, \ldots, \nu_{n-1} + (-1)^{\sigma_{n-1}} \alpha w_{n-1}, \nu_n + \sum_{i=1}^{n} \alpha_i' w_i'] =$$

$$= \det[\nu_1 + (-1)^{\sigma_1} \alpha w_1, \nu_2 + (-1)^{\sigma_2} \alpha w_2, \ldots, \nu_{n-1} + (-1)^{\sigma_{n-1}} \alpha w_{n-1}, h] \geq \delta.$$

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