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## EFFECT OF CERTAIN TYPES OF FERTILIZERS FOR PHYTOTOXICITY OF ORDINARY CHERNOZEM SOIL UNDER FLOWER PLANTS

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The studies under plants – *Echinacea purpurea* (*Echinacea purpurea* Moench.), *Cheiranthus cheiri* and *Tagetes patula* L. on ordinary chernozem soil, it was found that under the plants *Echinacea* third year of soil phytotoxicity embodiment, except for “Pocon” decreased 2,5–3,8 fold. In the version with “Pocon” soil toxicity on the contrary increased by 2 times. Under *Erysimum cheiri* plant (*Cheiranthus cheiri* L.) in ordinary chernozem soil was found that the phytotoxicity of the soil on the above embodiments with fertilizers studied than in controls, but is reduced after two months is 1,4–1,5 times. Under *Tagetes patula* L. fertilizer “Belogor” and “Pocon” reduced toxicity of ordinary chernozem soil at 1,1–1,5 times, compared to the control during the entire growing season. Most greatly reduces the toxicity of the soil fertilizer “Pocon”.

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**Keywords:** ordinary chernozem, fitotoxicity, plants, *Echinacea purpurea* Moench., *Cheiranthus cheiri* и *Tagetes patula* L.

The introduction of soil cover many cultivated areas exposed to various influences: mechanical, chemical in making fertilizers and pesticides, pathogens are affected, etc. As a result of the disturbance, the soil becomes toxic for growing crops and requires the use of methods of improvement. Currently, for pollution control components of the environment, including soil and uses a number of tools biological assays. Biological methods to more objectively reflect the ecological status of the system, in particular, the self-cleaning capacity of the soil, its response to a particular stimulus. The biological method is highly effective in determining the total soil phytotoxicity, simple to perform, allows you to quickly assess the overall ecological condition of the soil. The principle of the method of bioindication based on establishing the relationship between soil toxicity and the effect of his actions on the test object. The main requirement to the test object is a high sensitivity [2].

At the present level of economic development of the pollution of the biosphere as a whole, and the soil in particular, waste management, emissions and wastewater of all kinds of industrial production, agriculture, public utilities, cities have become global and serious concern in connection with the sharp deterioration of the ecological and geochemical condition of soils – the main component of the natural environment and the negative impact on human health [5]. Improving and maintaining soil fertility – is one of the most important and difficult tasks of practical and theoretical activity of the person. Crop yields and intensity of microbiological processes in the soil, are

directly dependent, therefore become important ways to increase microbiological processes in it. One of these ways is to fertilization [4; 6].

Soil fertility is also largely determined by the state phytosanitary agrophytocenosis. Phytotoxicity soil caused by the accumulation of physiologically active substances, among which there are phenolic compounds, organic acids, aldehydes, alcohols and others.

**The purpose of this study** – to identify the impact of different types of fertilizers on phytotoxicity of ordinary chernozem soil.

In this regard, the objectives of the study included a comparative study of the effect of organic and microbial fertilizers on phytotoxicity of ordinary chernozem soil.

### Materials and methods of research

The studies were conducted on the territory of the Southern Federal University Botanical Garden, from may to september 2012–2014 years for plants – *Echinacea purpurea* (*Echinacea purpurea* Moench.), *Cheiranthus cheiri* and *Tagetes patula* L. – on ordinary chernozem soil.

We studied 2 types of fertilizer – microbiological fertilizer (concentrate of microorganisms) “Belogor” produced by “Scientific and technological center of biological technologies in agriculture” (Shebekino Belgorod region), and “Pocon” liquid fertilizer with microelements Holland production.

Concentrate microorganisms “Belogor” series KM-104 complex contains lactic acid, propionic acid bacteria, yeast and culture microorganisms and *Bacillus* genera *Pseudomonas*, as well as products of bacterial metabolism, macro- and microelements, necessary for the activity of microorganisms and useful for plant growth. Its composition includes components: total nitrogen – 1,4%, total phosphorus – 0,9%, total potassium – 1,5%, Zn – 55 mg/kg, Mn – 31 mg/kg, Mg – 9,6 mg/kg, Fe – 5,7 mg/kg, Cu – 7,1 mg/kg, Se – 1,0 mg/kg, B – 6,0 mg/kg, Mo – 2,7 mg/kg.

Composition "Pocon": N = 7% (2,9% – nitrate, 1,8% – ammonium form; 2,3% – in the form of urea),  $P_2O_5$  soluble – 3%,  $K_2O$  soluble – 7%, B – 0,02%, Cu – 0,004%, Fe – 0,04%, Mn – 0,02%, Mo – 0,002%, Zn – 0,004%.

The study of the efficiency of fertilizers were carried out under the following scheme, including the options: 1 – control, 2 – concentrate microorganisms "Belogor", 3 – liquid fertilizer "Pocon" with trace elements. Repeated options – 3 fold. Fertilizers were added 2 times in may. Watering was carried out over a plant fertilizer solution (100 ml/10 liters of water) at the rate of 400 l/ha (dose recommended fertilizer producers). Plants were watered reference plot with the same amount of water.

Soil samples (0–25 cm) were taken by variants of the experiment after 1 and 3 months after fertilizer application. Phytotoxicity was determined by soil bioassay using radish seeds [1, 4]. Data on the activity of seed germination were converted into conventional units uke (coulmarin conditional units).

### Results of research and their discussion

Soil fertility is largely determined by the phytosanitary condition of the soil, ie soil clean of weeds, pests, pathogens started, as well as toxic substances emitted by plants, rhizosphere microflora and decomposition products. Phytotoxicity soil caused by the accumulation of physiologically active substances, among which there are phenolic compounds, organic acids, aldehydes, alcohols and others. The combination of these substances called colin, composition and concentration of which depends on temperature and soil moisture by microorganisms and plants. At low concentrations in soil phytotoxic substances detected stimulatory effect, but with increasing content of strong inhibition occurs the growth of plants or germination of seeds.

Source of education and income of toxic substances in the soil – root exudates of plants, post-harvest crop residues and microbial metabolism products. The most intensively phytotoxic substances accumulate in the cultivation in the same place or close in homogeneous cultures and biology to create anaerobic conditions in soil. Adding of mineral and organic particularly (microbiologi-

cal) reduces the fertilizer in the soil microbial population toxic [2].

Echinacea is characterized by the presence of compounds with high biological activity: phenolic compounds, organic acids, saponins, essential oils, etc. These substances may accumulate in the aerial parts, roots and rhizosphere soil and released to the environment, determining the level of soil toxicity. Studying the toxicity of soils under culture Echinacea is important in its introduction in order to create highly productive crops.

After 1 month after the application of fertilizers on soil toxicity variant with fertilizer "Belogor" decreased by 1,8 times, compared to the control. When using the mineral fertilizers "Pocono" soil toxicity increases in the 3 times (Table 1).

In September – 3 months after the application of fertilizers – in the control of soil toxicity has not changed. On versions with "Lignohumate" and mineral fertilizer "Pocono" a reduction in soil toxicity 3 times. In the version with "Belogor", on the contrary, soil toxicity increases 5 times. The level of soil toxicity on all variants can be assessed as medium.

It was found that the phytotoxicity of chernozem ordinary under Echinacea purpurea plants of different ages is not the same: with increasing age decreases the toxicity of the soil. In 2010, under the plants Echinacea third year of soil phytotoxicity embodiment, except for "Pocon" fell in 1,2 times. In the version with "Pocon" soil toxicity on the contrary increased by 2 times.

Fertilizing of culture Echinacea purpurea positive impact on the development of plants. The most effective action on the growth of Echinacea purpurea concentrate has "Belogor" microorganisms [3], due to increased mineralization of humus. Number of batteries in the soil increases, respectively, improves root nutrition of plants and increased crop yields [7; 8].

**Table 1**  
Phytotoxicity of ordinary chernozem soil under Echinacea purpurea at fertilization (0–25 cm) (average 2009–2010 years)

Options	July 2009		September 2009		September 2010	
	The number of germinated seeds, pcs.	YKE	The number of germinated seeds, pcs.	YKE	The number of germinated seeds, pcs.	YKE
Control	63	43	62	47	80	19
"Belogor"	74	24	34	135	68	35
"Pocono"	38	130	61	48	43	100

Table 2

Phytotoxicity of ordinary chernozem soil at fertilization under *Erysimum cheiri* (*Cheiranthus cheiri*) (2014)

Options	The number of germinated seeds, pcs.	YKE
After 1 month after the application of fertilizers		
Control	77	22
“Belogor”	58	50
“Pocono”	42	105
After 3 months after the application of fertilizers		
Control	79	20
“Belogor”	67	35
“Pocono”	51	70

As a result of research at the Botanical Garden SFU, from May to September 2014 under *Erysimum cheiri* (*Cheiranthus cheiri* L.) plants on ordinary chernozem soil it was found that the phytotoxicity of the soil on the above embodiments with fertilizers studied than in control, but two months later she was reduced by 1,4–1,5 times. Under the control of soil toxicity practically remained unchanged (Table 2).

However, it was found that, despite the increased phytotoxicity of ordinary chernozem soil under *Cheiranthus cheiri* on microbiological fertilizer variants “Belogor” mineral and “Pocono” plants had more optimal morphological parameters compared to the control (Table 2) [10].

morphological indicators that allows us to speak about the prospects of the use of these fertilizers [3; 6; 7; 8; 9; 10].

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Table 3

Phytotoxicity of ordinary chernozem soil at fertilization by *Tagetes patula* L. (average data 2012–2014)

Options	July	September
	YKE	YKE
Control	51	50
“Belogor”	48	48
“Pocon”	35	34

When fertilization under *Tagetes patula* L. was found that fertilizer “Belogor” and “Pocon” reduced toxicity of ordinary chernozem soil at 1,1–1,5 times, compared to the control during the entire growing season. Most greatly reduces the toxicity of the soil fertilizer “Pocon” (Table 3) [9].

### Conclusions

Adding microbial and mineral fertilizers had a positive impact on the reduction of phytotoxicity of ordinary chernozem soil in comparison with control, and as a result of plant

## INTERMOLECULAR INTERACTION OF PROTEINS AND SMALL MOLECULES

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This review presents the modern data on biomolecules involved in the formation of internal structures of cell, organ and organism as a whole. Almost every process occurring in the cell involves proteins and shows multifunctionality due to their ability to change the conformation of molecules in the interaction with ligands. Intermolecular interactions are crucial virtually in all fundamental biological processes, such as cellular regulation, pathways of biosynthesis and degradation, signal transmission, initiation of DNA replication, transcription and translation, the formation of oligomers and multimolecular complexes, the packing of the virus and the immune response. These interactions form the basis of any interactome of a living cell. Low-molecules act as ligands and are located in the cytoplasm of cells in the free state and form a pool of intermediate metabolites. Many of them are precursors of macromolecular synthesis and can regulate the activity of individual enzymes and entire enzyme cascades.

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**Keywords:** small molecules, metabolites, intermolecular interaction, interactome

Millions of different molecules participate in the internal structures of cell building, as well as organs and an organism as a whole. Each molecule contains a characteristic set of chemical elements, has a specific structure and is capable of selective and specific binding with other molecules. Many biological molecules represent macromolecules, i.e. polymers with a molecular weight more than 5000. Thousands of different small and medium organic molecules that have a molecular weight from 50 to 500 dissolved in the cytoplasm of cells. All these molecules are water-soluble, polar or charged. A single set of small molecules in living cells is a manifestation of the universality and the evolutionary conservatism of metabolic processes [1].

Intermolecular interactions play a significant role in the implementation of vital cell functions, the organ and the organism as a whole. Universal carriers of interactions in living systems are biological molecules having different chemical structure and molecular weight. Protein-protein interactions are crucial in virtually all fundamental biological processes, such as cellular regulation, pathways of biosynthesis and degradation, signal transmission, initiation of DNA replication, transcription and translation, the formation of oligomers and multi molecular complexes, the packing of the virus and the immune response.

A natural process of metabolism is the coordinated activity of cells, in which the combination of all chemical reactions catalyzed by enzymes. Metabolism provides with many enzymatic reactions. It is known that the sequence of enzymatic reactions is called a metabolic pathway. Many metabolic pathways in the cell work simultaneously. In each reaction,

which is also called the stage of the metabolic pathway, the specific change in the chemical composition is taken place. As a rule, these reactions consist of moving, adding or removing one atom or functional group; at the end of the reaction the intermediate products are formed, which are called metabolites. A central metabolic pathway performs the synthesis, breakdown or interconversion of the most important metabolites, and the accumulation of energy that allows us to grow, reproduce, maintain structures and respond to the environment. These metabolic pathways are remarkably similar for all living forms [2]. The understanding of these processes was the basis of metabolic maps creation. Metabolic maps allow us to get a full understanding of the specific metabolic pathway formed of intermediates and end products, the enzymes catalyzing the biochemical reactions of a given path, and can also serve as a reference to determine the location of known molecules in metabolism [3]. There is a huge number of works devoted to the study of the interaction of molecules with each other, in order to reflect all the interaction of the metabolome of a given organism [4].

The traditional approach to the compilation of the metabolic maps suggests the compartmentalization of metabolism in accordance with the main classes of compounds – metabolism of carbohydrates, metabolism of amino acids and proteins, lipid metabolism, nucleic acids metabolism, etc. In 2004, A.G. Malygin proposed a non-trivial approach to making the metabolic maps based on the symmetry found in the structure of the network of reactions in metabolism [5]. The number of carbon atoms and the number of COOH-groups in the skeleton of the chemical compound are displayed



in a two-dimensional coordinate system. All metabolites and their reactions are treated as full-fledged participants in the metabolism. Metabolic maps can be used as a key to databases associated with metabolic information, can help understand the metabolic processes in the conditions of norm and pathology, to identify reactions, inhibited or activated by various modulators. Currently, the main metabolites are already known; the list of intermediate of low molecular weight compounds and signaling molecules regulating metabolic fluxes is being updated actively.

Almost every process occurring in the cell, involves proteins, showing the inexhaustible variety of functions. Proteins are multi-functional due to their ability to change the conformation of molecules in the interaction with ligands. Proteins can interact with almost all types of molecules, from small organic compounds, metals, sugars, fatty acids, phospholipids of cell membranes to macromolecular proteins and nucleic acids [6]. The systematic analysis of binary interactions of proteins was begun in the 1990s; it showed us some complex interactions in large macromolecular protein complexes such as DNA polymerase, and a simple interaction, for example, in complex enzyme-inhibitor, enzyme-substrate [7]. Protein-ligand interactions can be classified as fixed or stable, for example, cytochrome oxidase forming protein aggregates of the 13 proteins or ATP-synthase is temporary or reversible that is a characteristic of most proteins involved in biochemical cascades [8]. Numerous studies of protein-ligand interactions allowed us to identify hundreds of thousands contacts, information about which was collected in specialized databases, which can be divided into two groups. The first group includes the primary database, where the existence of protein-ligand interactions was established experimentally. For example, Biomolecular Interaction Network Database (BIND), Biological General Repository for Interaction Datasets (BioGRID), Human Protein Reference Database (HPRD), IntAct Molecular Interaction Database, Molecular Interactions Database (MINT) (Ceol, 2009). The second group includes databases of forecasting, which consists of mainly predicted protein-ligand interaction obtained with the use of computer and computer-based methods; they are sometimes supplemented by experimental data. For example: Online Predicted Human Interaction Database (OPHID), Known and Predicted Protein-Protein Interactions (STRING) and Unified Human Interactome (UniHI). In the UniHI database contains

information about 350.000 molecular interactions of more than 30,000 human proteins [9]. For better understanding the interactions of proteins with ligands, you can use software visualization in three dimensions, such as RasMol, Jmol and Protein Explorer First Glance.

The main processes in living cells are largely controlled by macromolecular interactions and among them protein-protein interactions play a crucial role. Violation of interactions between proteins is the basis of many diseases [10, 11]. Many key cell functions such as DNA replication, signal transmission, immune response are regulated by the complexation of proteins. Functioning, activity and specificity of such complexes depend on the nature of protein-protein interactions. In addition, in the genomic era, the study of protein networks provides an insight look into molecular evolution, the reaction of cells to external and internal stimuli and the elucidation of protein functions [12]. The combination of protein-protein interactions for the given organism is called interactome. The term "interactome" was proposed by a group of French scientists headed by B. Jacques in 1999 [13]. It is established that the size of the interactome of *S. Cerevisiae*, varied from 10–17 thousands to 25–35 thousands protein-protein interactions according to the different studies [14]. It is assumed that the size of the human interactome can be formed about 650 thousands of protein interactions [15]. About 39 thousand protein interactions were recognized in human cells [16]. Thus, the number of interacting pairs of human proteins is 10 times more than *Drosophila melanogaster*.

These data help us to make the assumption that the size of the interactome depends on the level of complexity of the organism. Determination of interacting pairs of proteins was a step to make an interactome card. Such maps are graphs consisting of nodes showing the binary contacts. Creation of maps are useful for understanding the functioning of proteins to determine the role and interaction of individual proteins in causing pathological conditions of an organism, their diagnostics, and also possible targets for the action of different modulators [17, 18]. Currently, a large number of studies devoted to the analysis and clarification of data interaction of proteins, using various experimental and computer methods are already available. Thus, for example, according to Janin et al. (2008) detailed structural analysis of the sites responsible for the interaction between proteins (interface) at constant heterodimeric complexes shows in

average 204 atoms belonging to 57 amino acids (mainly glycine, asparagine and lysine, to a lesser extent, methionine, phenylalanine, tyrosine and tryptophan) [19].

In homodimer protein interface there are twice or more hydrophobic because it contains more aromatic and aliphatic amino acid residues. Analysis of the interfaces may be conducted in the group of proteins involved in specific disease. It was found that the interfaces of protein-protein complexes in cancer were smaller and more densely packed [20]. It is important to estimate the number of possible types of protein interaction which is, according to some sources, about 4000 [21]. In the literature, there are data on similar interfaces and templates in interactome's interaction [22]. Some researchers try to define classes of protein-protein interactions to connect low-molecular ligands easily. Here we wonder if small molecules can contact multiple protein complexes. It is assumed, that the binding site of the protein with low molecular weight ligands must be small and narrow [23]. The most important target among protein molecules – enzymes, receptors and ion channels, usually have a concave binding site with small molecule as a pocket [22]. Some researchers noted the marked differences between the interfaces that determine the nature of protein-protein interactions and protein-ligand interactions. The binding sites with small ligands typically have from 3 to 5 amino acid residues and are found in proteins that bind to components on the surface of the cell membrane [25]. Such binding sites are called the “anchor” [26]. Separate interfaces can dynamically adapt to the upcoming sequestration and have transition states that may occur the binding with the ligand [27].

Based on the literature information, we would like to mention the necessity of studying the nature of interaction between small molecules and large biomolecules or their complexes, accompanied by a conformational change of the latest. The ability to enter into parameterizes interaction defines a wide range of biological effects of small molecules, low molecular weight intermediates, the specific mechanisms which require detailed study [28].

The number of studies of interactions of protein – small molecule (metabolite) increased significantly. However, the study of these interactions according to Wiley Online Library in 2011, the number of publications lags far behind research into other types of interactions [29].

From the biochemical point of view, the majority of biological systems work through

the implementation of their proteins of diverse functions. Due to the revolutionary progress in the study of genomics and proteomics a more accurate idea of the amount of proteins synthesized in the body has developed currently, but there is little understanding about how much of the metabolites are formed in the body and what kind of proteins interact with them. To decipher the mechanisms of protein binding and various types of molecules metabolic networks of molecular interactions were constructed. As a model organism, the yeast is very convenient for constructing a metabolic network having a simple genome and evolutionary preserved the basic biological mechanisms [30]. It should be noted, that the use of model organisms based on the fact that all living organisms have a common origin and retain key mechanisms of storage and realization of genetic information. The number of protein-ligand interactions in yeast cells, according to the project, Model Organism ENCYclopedia Of DNA Elements (modENCODE Consortium, 2011) can range from 3,5 to 43,7 million, it is the sum of the maximum theoretical protein-DNA, protein-RNA, protein-protein and protein-small molecule (metabolite) interactions involved in various biological processes. Information was obtained from the database of a yeast genome and databases of metabolites [31]. We can assume, that much more is theoretically possible protein-ligand interactions in higher organisms with more complex structure. Given that the second largest group is theoretically possible protein-small molecule interactions, it becomes clear the relative scarcity of relevant studies.

Metabolic pipeline contains compounds having a wide range of types and targets of influence, depending on the needs of the cell and the external environment. Special role is played by molecules with a molecular weight of from 100 to 1000. Low-molecular compounds are found in the cytoplasm of the cell in the free state and form a pool of intermediate metabolites. Many of them are precursors for macromolecular synthesis and can regulate the activity of certain enzymes and enzymatic cascades. Small molecules are very dynamic, computer databases contain now information about more than 90,000 known interactions of small molecules [32]. This diversity is determined by the ability of small molecules quickly and easily diffuse through the cell membrane. Currently, significant research efforts directed to the discovery of small and middle molecules, that specifically bind to specific proteins or proteins that have

distinctive functional properties, which determine the cellular phenotype [33].

In the literature, considerable attention is paid to proteins responsible for transport of endogenous and exogenous metabolites. For example, human serum albumin due to the numerous binding sites and conformational lability, has a large number of ligands [34]. Studying the interactions of albumin with endogenous metabolites, it was found that fatty acids significantly inhibit the binding of the albumin-metabolite, which is required for its operation. Fatty stearic and myristic acids have the greatest influence on the binding of albumin lactate, significantly reduce binding to phenylalanine and pyruvate, and do not affect the binding with citrate [35]. For most metabolites, competition for binding to albumin is absent due to the large number of binding sites [36]. In another experiment using the method of mass spectrometry integrated with equilibrium dialysis (MIDAS), it was determined that palmitic acid binds with glucokinase and glycogen phosphorylase, suppressing the activity of both enzymes, thereby providing a mechanism of reservation of carbohydrates in the body [37].

Metabolic pathways are extremely dynamic and intertwined, which is convenient for their regulation [38]. Endogenous metabolites are the numerical majority of the cellular molecules and protein-metabolite interactions is a widespread phenomenon in the cell [39]. Metabolites can act as not only substrates and products of enzymatic reactions but also serve as regulators of signaling pathways and modulators functioning [40]. Medium and small-molecule metabolites act quickly and their contact is reversible, which allows a high degree of modulating the function of biomolecules [41]. This is the classic example of such regulation in bacteria: lactose binds with the protein-repressor stop the transcription process and the modulation of the activity of pyruvate kinase with different concentrations of the metabolites, ribose-5-phosphate, glucose-6-phosphate, AMP, ATP [42]. The tricarboxylic acid cycle is the central intersection of many metabolic pathways in the body, an important source of precursor molecules, from which in the course of other biochemical reactions that synthesize these important metabolic compounds such as amino acids, carbohydrates, fatty acids. The intermediate metabolite TCA,  $\alpha$  - Ketoglutarate identifies as a new ligand-binding  $\beta$ -subunit of ATP synthase, also known as complex V of the mitochondrial chain of electron transfer. The respiratory chain is high-

ly conservative, generating energy in the cell. In the experiments of M. Randall et.al. (2014) found that  $\alpha$ -Ketoglutarate inhibit the activity of ATP-synthase, which leads to a reduction of ATP content [43]. Partial suppression of the activity of ATP synthase increases the lifespan of *Caenorhabditis elegans* [44]. This inhibition is also easy to detect in living mammalian cells, for example,  $\alpha$ -Ketoglutarate inhibits the activity of ATP synthase of mitochondria bovine heart. Physiological increase in the level of metabolite was registered in yeast, bacteria and birds during fasting, and a man – after exercise [45, 46]. It can be assumed that the biochemical basis of the increase in the level of  $\alpha$ -Ketoglutarate is the activation of glucose synthesis in the gluconeogenesis process. The identification of a new protein target for  $\alpha$ -Ketoglutarate, showed that key metabolites is mediated by regulating cell energy metabolism and metabolic networks is arranged in a much more difficult way. Moderation of ATP synthesis probably is an evolutionary mechanism to ensure the efficiency of the body in response to the presence or absence of nutrients.

Central part of the regulation of metabolism of carbohydrates is pyruvic acid because it is the end product of glycolysis and the main substrate of the citric acid cycle in the mitochondria. It has been suggested that diffusion of pyruvic acid across the mitochondrial membrane is the transport-mediated [47]. In studies of D.K. Bricker et al. in 2012 identified two protein mitochondrial pyruvate carrier 1 and mitochondrial pyruvate carrier 2, required for the transport of pyruvate into mitochondria of yeast, *Drosophila* and mammals. Proteins function as a single heterodimer complex (150 Mm Kd) in the inner membrane of mitochondria [48]. Inhibiting effect on the transport function of mitochondrial pyruvate carriers  $\alpha$ -cyanocinnamate – derived acetic acid shows. Identification of the mitochondrial pyruvate carrier, understanding the mechanism of regulation of their functions, provides the basis for understanding a new level of metabolic control of catabolic and anabolic processes, the key point of which is pyruvate [49, 50].

We can notice a growing number of studies dedicated to the problem of understanding the protein-protein interactions. Many of the reported interactions were “unexpected” and had a profound influence on the understanding of cell signaling. Now the molecular mechanisms of action and biochemical targets of low weight molecules as well as their physiological effects are on the foreground of the scientific interest.

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## RESEARCH APPLICATIONS OF REMOTE SENSING AND GIS IN DETERMINATION THE VOLATILE AND FORECAST CHANGES IN THE CHAIN OVERLAY MARKOV CHAIN IN Y YEN DISTRICT – NAM DINH PROVINCE – VIETNAM

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Land's natural resource invaluable for each country, the conditions for the existence and development of human beings and other creatures on earth. In recent years, the impact of the economic orientation – society should demand increasing land use, including special-use land as residential land, transport, irrigation land, land for construction structural building infrastructure... tends to rise sharply to agricultural land, continues to shrink. Consequently, the allocation and efficient use of land is a matter of primary concern must be to enable sustainable development, environmental protection and ecology. Therefore researchers identified fluctuations and determine trends change surface coating is a major problem today. And to carry out this study the authors used remote sensing technology, GIS, Markov Chain chains combined in order to determine volatility and forecasting changes overlay in Y Yen district – Nam Dinh province – Viet Nam country. This will create a rationale help managers to grasp the situation in local land use management.

**Keywords:** In Nam Dinh Yen, remote sensing, GIS, Markov Chain

Determination of fluctuations and changing trends of surface coating is an urgent issue in the process of development in our country. Currently information technology is growing strongly, allowing simplification of work to solve complex problems of the economy – society of the country in general and land management sectors in particular. Specifically, remote sensing technology with resources that satellite imagery has a resolution higher and higher, large number of spectral channels, short iteration cycles, cover large spaces and faithfully reflect the earth's surface at the time of shooting. Simultaneously associated with processing capabilities and data analysis of GIS technology has created a useful tool in

Research on fluctuation and management of land resources. Addition with the assistance of Markov Chain chain gives basic assumptions about trends in coatings. This is a new method, modern, a lot more advanced countries in the world to adopt and bring better efficiency compared to traditional methods, which we can manage and update revised land information quickly and timely.

Y Yen district, Nam Dinh province, with total area of natural land is 24,129.74 ha (2013). In recent years, the impact of the economic orientation – the society makes the demand for increasingly high land, specialized land tends to increased sharply, agricultural land continues to shrink. Therefore, the allocation and efficient use

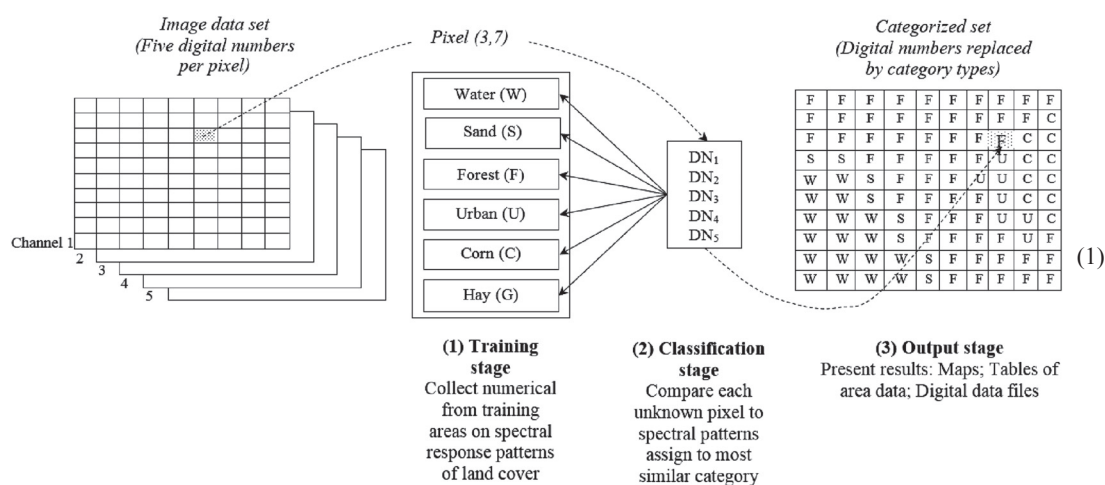


Fig. 1. Classification method with accreditation

of land is a matter to be top concern. Stemming from the practical needs as well as the urgency of identifying changes and trends change overlays Y Yen district – Nam Dinh Province – Viet Nam country the author conducted “*Research Applications of Remote Sensing and GIS in determination the volatility and forecast changes in the chain overlay Markov Chain in Y Yen district – Nam Dinh province – Viet Nam country*”.

## Materials and methods of research

### 1. Method classification inspection

This is a form of classification. The classification criteria are established based on the sample area and enforce decisions based on appropriate algorithms to label each pixel corresponding to a specific service area. Based on data collected on a sample area each sample area, the statistical parameters are determined. From that, the classification criteria used in the process of appointing the pixel belongs to each particular category.

In this research, method chosen to categorize the image classification method has expertise according to the maximum likelihood algorithm.

$$g_i(x) = \ln p(\omega_i) - \frac{1}{2} \ln |\Sigma_i| - \frac{1}{2} (x - m_i)^T \Sigma_i^{-1} (x - m_i).$$

Inside  $i$  – Object classification;  $x$  – The number of spectral channels;  $p(\omega_i)$  – Value probability occurs when the object like other objects  $\omega_i$ ;  $|\Sigma_i|$  – Covariance matrix of the object  $\omega_i$ ;  $\Sigma_i^{-1}$  – The inverse of the object  $\omega_i$ ;  $m_i$  – Spectrum values change vector.

Classification by maximum likelihood method that is considered the statistics of each class of each transmission channel is dispersed in a conventional way and this method takes into account the possibility of a pixel belonging to a certain class. If not choose a probability threshold, it must classify all pixels. Each pixel is assigned to a class with the highest probability. According to this method the spectral distribution channels and the pixel standards will be classified in the class that has the highest probability. This method of classification accuracy, but take time and depend calculate the standard distribution of data. Includes the following steps:

– *Identify the types*: Landsat Data As always reflect honesty, objectivity soil surface at the time of imaging, should map built after deciphering the map vegetation

cover. To cater to the construction of image interpretation course, first need to determine the type of land use for the purposes in the research area.

– *Selection of Features*: The characteristics include spectral characteristics and structural features. The selection has important significance, it allows separate object classes together.

– *Choose the form*: The selection of sample areas are critical to the classification results. To ensure accuracy in choosing the right form noting the following requirements:

+ The number of sample areas to suit each object: The number of sample areas too little will not ensure the accuracy. The number of sample areas too little will not ensure the accuracy, whereas if too much will increase the volume of calculations a lot, sometimes disturbing results of calculations;

+ The area of the sample is large enough, and the form is not located near the boundary between the object class;

+ The sample was selected to characterize the object classification and evenly distributed across the research area;

+ Calculation of the sample statistical indicators: After sampling conducted statistical indicators calculation sample area and the difference between the sample.

– *Assessing precision sample file*: Each sample classification will be calculated to compare the difference with the remaining samples.

– *Assessment of image classification accuracy*: The accuracy of the image classification does not depend on the accuracy of the sample but also depends on the density and the distribution of plots. To assess the nature of the errors committed in the course of classifying people based on the index Kappa ( $\kappa$ ), the index is within the range from 0 to 1 and indicates the proportional reduction in error is performed by one factor completely random classification.

$$\kappa = \frac{N \sum_{i=1}^r x_{ii} - \sum_{i=1}^r (x_{i+} \cdot x_{+i})}{N^2 - \sum_{i=1}^r (x_{i+} \cdot x_{+i})} \quad (2)$$

Inside  $N$  – total number of sampling points;  $r$  – The object class classification;  $x_{ii}$  – Points right field in the 1st class;  $x_{i+}$  – The field point of the  $i$ th layer of the sample;  $x_{+i}$  – Total points of class  $i$ th field after sorting.

### 2. Methods of determining volatility in comparative overlays after sorting

The essence of this approach is that the resulting image classification at two different times we established status map overlays at two moments. Then overlay the two maps to overlays mapping volatility (Fig. 2). The status map may take the form of raster or vector maps.

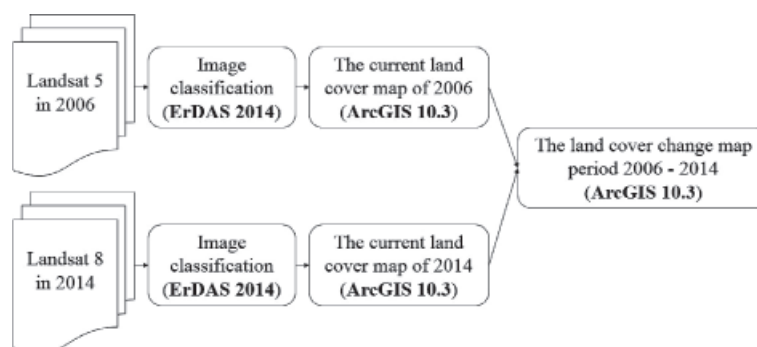


Fig. 2. Comparison method after sorting

Comparison method after classification is the most widely used, simple, easy to understand and easy to implement. After 2 satellite imagery geometrically corrected to conduct independent classification to form two maps. Two maps were compared by comparing pixel matrix forming volatile.

According to J. Jensen, the advantage of this method is that the change from what kind of land into what type of soil; Disadvantages of this method is to classify independent of remote sensing to precision depends on the accuracy of each taxonomy and high precision often because of errors in the classification of each photo remain in the map changes.

### 3. Method of determining the trend change in the chain overlay Markov Chain

Using Markov Chain chain forecasts trend to change land use in a certain period. Markov Chain chain model is used to determine the ability to change the land use based on evolution of land use and the factors affecting the change.

### 4. The process of identifying and forecasting volatility change overlays

#### Results of research and their discussion

##### 1. Introduce Landsat satellite system

Landsat satellite is experimental aerospace agency NASA (National Aeronautics and Space Administration). It is a system very close orbit satellites (orbital plane angle than the equatorial plane is  $98,2^\circ$ ), originally named ERST (Earth Remote Sensing Satellite), after 2 years since launch ERST – renamed Landsat 1, then the Landsat – TM and Landsat – ETM.

The first Landsat satellite was launched into orbit dated 23.07.1972 and retired on 01.06.1978 date named Landsat 1. At present there are 8 Landsat generation. Landsat research applications in many fields of research

$$\left( \begin{matrix} \text{The proportion} \\ \text{of land use in} \\ \text{the first time} \end{matrix} \right) \times \left( \begin{matrix} \text{Matrix change of} \\ \text{land use between the} \\ \text{first and second times} \end{matrix} \right) = \left( \begin{matrix} \text{The proportion} \\ \text{of land use types in} \\ \text{the second time} \end{matrix} \right). \quad (3)$$

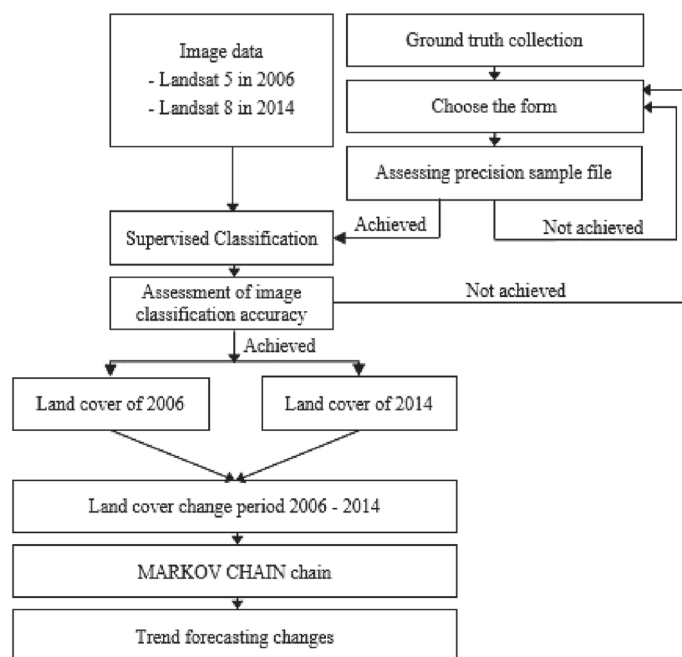


Fig. 3. The process of identifying and forecasting volatility change overlays

Can be rewritten as a generalization of the matrix:

$$[V1, V2, V3]_1 \times \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix} = [V1, V2, V3]_2.$$

Inside:  $\gamma_{ij}$  is probable change is determined from the overlay map land use at different times. To predict the distribution of land use in the next moment can be applied to this model.

from the status quo to monitor fluctuations and most commonly used, at low cost.

##### 2. Research Documentation

– Satellite images used for research are downloaded directly from the site (<http://earthexplorer.usgs.gov/>) of the US Geological Survey (United States Geological Survey – USGS) to area Y Yen District, Nam Dinh province include:

**Table 1**

The Landsat satellite system

Satellite	Launch	Decommissioned	Remote
Landsat 1	23.07.1972	06.01.1978	MSS – TM
Landsat 2	22.01.1975	25.02.1982	MSS – TM
Landsat 3	05.03.1978	31.03.1983	MSS – TM
Landsat 4	16.07.1982	15.06.2001	MSS – TM
Landsat 5	01.03.1984	08.1995	MSS – TM
Landsat 6	05.03.1993	Failure lunch	TM/ETM
Landsat 7	15.04.1999	Active	ETM +
Landsat 8	11.02.2013	Active	OLI – TIRS

+ Landsat satellite 5 data with 30 m resolution for spectral channels 1, 2, 3, 4, 5, 7 and 60 meters for secondary channels 6 were included in the day 06/11/2006, the path is 126 and the row is 46.

+ Landsat satellite 8 data with 30 m resolution for spectral channels 1, 2, 3, 4, 5, 6, 7, 9; 15 m for 8-channel Universal and Universal Channel 100m for 10, 11 were enrolled in day 10/11/2014, the path is 126 and the row is 46.

### 3. Results and Discussion

#### 3.1. Establishing image interpretation course

To establish an image interpretation course, it is a need to identify land types under land

use purposes in the research area. Basing on the current situation of land use, the features of landsat data and image resolution, the author has set out 4 land cover types as shown in the classification table of land use types (Table 4). Thereby, the establishment of the landsat image interpretation course is performed by carrying out field research with the support of handheld GPS (Table 5).

#### 3.2. Development of template file and assessment of template file accuracy

Basing on the field survey data, the current land use map, four types of land cover have been highlighted directly onto the image that needs classifying. (Fig. 4).

**Table 2**

Data collected satellite

Satellite	Data name	File date	Path/Row
Landsat 5	LT51260462006310BJC00	06.11.2006	126/ 46
Landsat 8	LC81260462014284LGN00	11.10.2014	126/46

**Table 3**

Comparison of images characteristic spectral channels Landsat satellite 5 and Landsat satellite 8

Landsat 5 TM			Landsat 8 OLI and TIRS		
			30 m Coastal/Aerosol	0,435–0,451 $\mu\text{m}$	Band 1
Band 1	30 m Blue	0,441–0,514 $\mu\text{m}$	30 m Blue	0,452–0,512 $\mu\text{m}$	Band 2
Band 2	30 m Green	0,519–0,601 $\mu\text{m}$	30 m Green	0,533–0,590 $\mu\text{m}$	Band 3
Band 3	30 m Red	0,631–0,692 $\mu\text{m}$	30 m Red	0,636–0,673 $\mu\text{m}$	Band 4
Band 4	30 m NIR	0,772–0,898 $\mu\text{m}$	30 m NIR	0,851–0,879 $\mu\text{m}$	Band 5
Band 5	30 m SWIR-1	1,547–1,749 $\mu\text{m}$	30 m SWIR-1	1,566–1,651 $\mu\text{m}$	Band 6
Band 6	60 m TIR	10,31–12,36 $\mu\text{m}$	100 m TIR-1	10,60–11,19 $\mu\text{m}$	Band 10
			100 m TIR-2	11,50–12,51 $\mu\text{m}$	Band 11
Band 7	30 m SWIR-2	2,064–2,345 $\mu\text{m}$	30 m SWIR-2	2,107–2,294 $\mu\text{m}$	Band 7
			15 m Pan	0,503–0,676 $\mu\text{m}$	Band 8
			30 m Cirrus	1,363–1,384 $\mu\text{m}$	Band 9










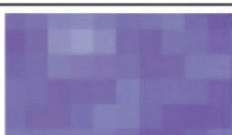




Table 4

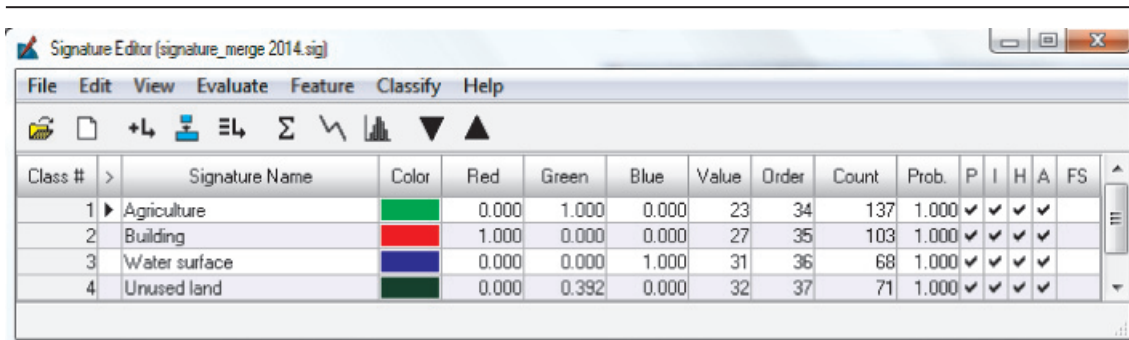
Classification of land use types in Y Yen district

Land cover type	Description
Agriculture	Paddy rice; Annual crops, Pedestrian crops; ...
Building	Residential land; Land used for transportation; Land in industrial zones; Land used as ground for construction of production and business premises; Land for construction of offices, public service delivery institutions; Land with communal houses, temples; Land for cemeteries, graveyards; ...
Water surface	Land with rivers, streams, canals, and specialised water surface.
Unused land	Unused land.

Table 5

Image interpretation sources Landsat 5 – 2006 and Landsat 8 – 2014

Land cover type	Image 2006	Image 2014	Field image
Agriculture			
Building			
Water surface			
Unused land			







Class #	Signature Name	Color	Red	Green	Blue	Value	Order	Count	Prob.	P	I	H	A	FS
1	Agriculture		0.000	1.000	0.000	23	34	137	1.000	✓	✓	✓	✓	
2	Building		1.000	0.000	0.000	27	35	103	1.000	✓	✓	✓	✓	
3	Water surface		0.000	0.000	1.000	31	36	68	1.000	✓	✓	✓	✓	
4	Unused land		0.000	0.392	0.000	32	37	71	1.000	✓	✓	✓	✓	

Fig. 4. Template file of Landsat 8 – 2014

Basing on the features of spectral reflectance energy of the selected objects in the template file, to conduct the calculation of the difference between templates, and the selected evaluation method is Feature Space Layers

(spectral space), it can be seen that the less the spectral range of intersecting layers is, the higher the accuracy is. Thereby, it can be found that the accuracy of the selected template file on both images is good (Fig. 5).

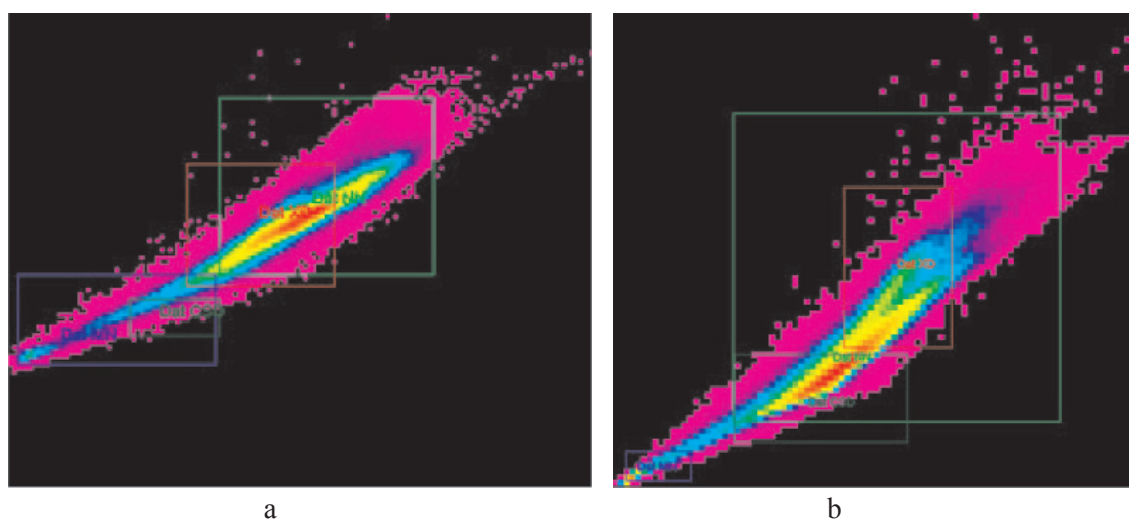


Fig. 5. Evaluation result of the template file accuracy  
Landsat image 5 – 2006 (a) and Landsat image 8 – 2014 (b)

### 3.3. Image classification and evaluation of the accuracy of classifying result

With the tested classification method under Maximum likelihood, the results obtained are classification image in 2006 in 2014 (Fig. 6), simultaneously apply Majority Analysis against the obtained classification results to combine scattered pixels or the pixels classified in classes into the class containing it.

To evaluate the accuracy of image classification results, for the image classification in

2014, handheld GPS shall be used to compare to the field research with GPS 100 points; as for image classification in 2006, to evaluate the accuracy, the author has combined field surveys and current land use map in 2005 with 103 points. The evaluation process has been automatically performed on ERDAS 2014 and achieved good results.

– The accuracy of the classification result of Landsat image 5 – 2006 is 97,00% and Kappa statistic is 0.9575. (Fig. 7, a).

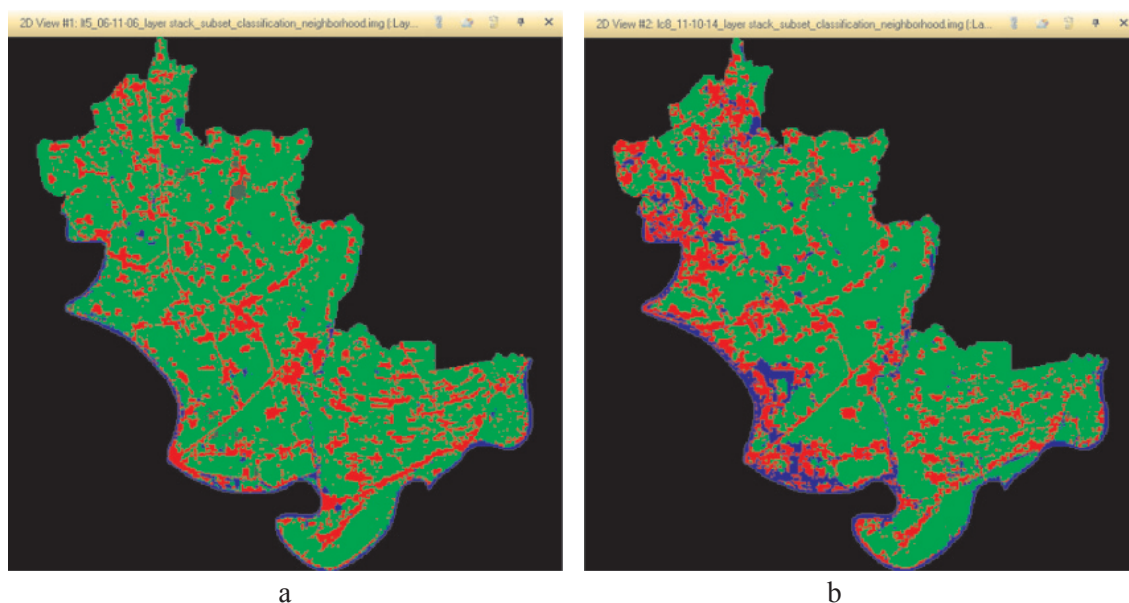


Fig. 6. Image classification results  
Landsat image 5 – 2006 (a) and Landsat image 8 – 2014 (b)

CLASSIFICATION ACCURACY ASSESSMENT REPORT						
ERROR MATRIX						
Classified Data	Dat NN	Reference Data			Row Total	
		Dat XD	Dat MN	Dat CSD		
Dat NN	34	0	2	1	37	
Dat XD	0	35	0	0	35	
Dat MN	0	0	17	0	17	
Dat CSD	0	0	0	11	11	
Column Total	34	35	19	12	100	
----- End of Error Matrix -----						
ACCURACY TOTALS						
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	
Dat NN	34	37	24	100.00%	91.89%	
Dat XD	35	35	35	100.00%	100.00%	
Dat MN	19	17	17	89.47%	100.00%	
Dat CSD	12	11	11	91.67%	100.00%	
Totals	100	100	97			
Overall Classification Accuracy = 97.00%						
----- End of Accuracy Totals -----						
KAPPA (K <sup>2</sup> ) STATISTICS						
Overall Kappa Statistics = 0.9575						
Conditional Kappa for each Category.						
Class Name	Kappa					
Dat NN	0.8771					
Dat XD	1.0000					
Dat MN	1.0000					
Dat CSD	1.0000					
----- End of Kappa Statistics -----						

Landsat image 5 – 2006 (a)

CLASSIFICATION ACCURACY ASSESSMENT REPORT					
ERROR MATRIX					
Classified Data	Reference Data				Row Total
	Dat NN	Dat XD	Dat MN	Dat CSD	
Dat NN	32	3	3	1	39
Dat XD	2	33	4	2	41
Dat Mn	0	0	14	0	14
Dat CSD	0	0	0	9	9
Column Total	34	36	21	12	103
----- End of Error Matrix -----					
ACCURACY TOTALS					
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Dat NN	34	39	32	94.12%	82.05%
Dat XD	36	41	33	91.67%	80.49%
Dat Mn	21	14	14	66.67%	100.00%
Dat CSD	12	9	9	75.00%	100.00%
Totals	103	103	88		
Overall Classification Accuracy =			85.44%		
----- End of Accuracy Totals -----					
KAPPA (K <sup>2</sup> ) STATISTICS					
Overall Kappa Statistics = 0.7914					
Conditional Kappa for each Category.					
Class Name	Kappa				
Dat NN	0.7321				
Dat XD	0.7000				
Dat Mn	1.0000				
Dat CSD	1.0000				
----- End of Kappa Statistics -----					

and Landsat image 8 – 2014 (b)

Fig. 7. Accuracy evaluation result of classified

– The accuracy of the classification result of Landsat image 8 – 2014 is 85,44 % and Kappa statistic is 0.7914. (Fig. 7, b).

### 3.4. Convert the classified image into vector

In order to form a current land cover map basing on remote sensing and GIS, the last manipulation to create the current land cover map for users is to convert images from raster to vector (Fig. 8). This is the main mission of the integration of remote sensing and GIS.

### 3.5. Determination of land cover change

Analyzing land cover change should be based on table of interchange of land cover types, especially the Land for construction. Using Union to identify the area change of land cover types by stacking two land cover maps of 2006 and 2014 to find out the changing area (Fig. 9), using Tabulate Area to build the table of interchange of land cover types (Table 7), the change is clearly shown in the chart of Fig. 10.



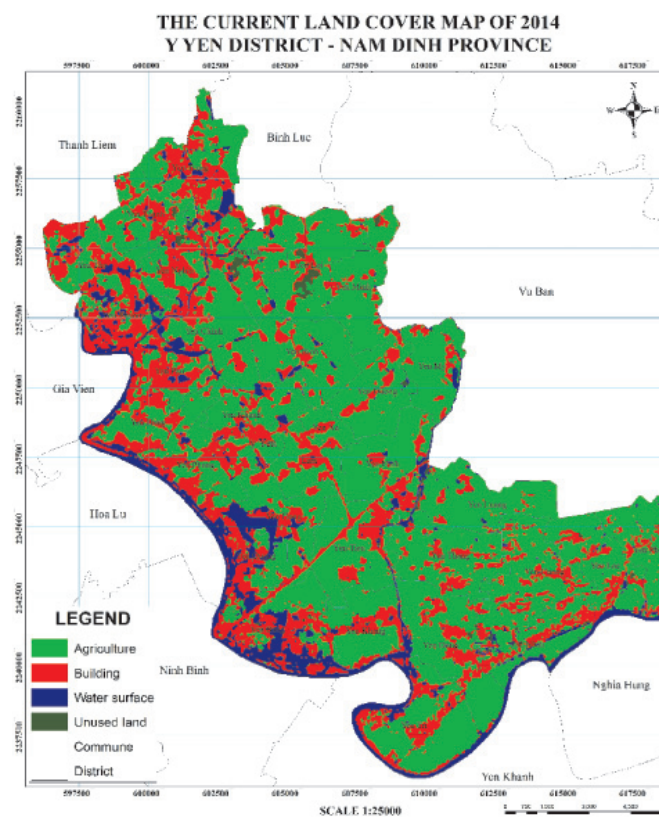
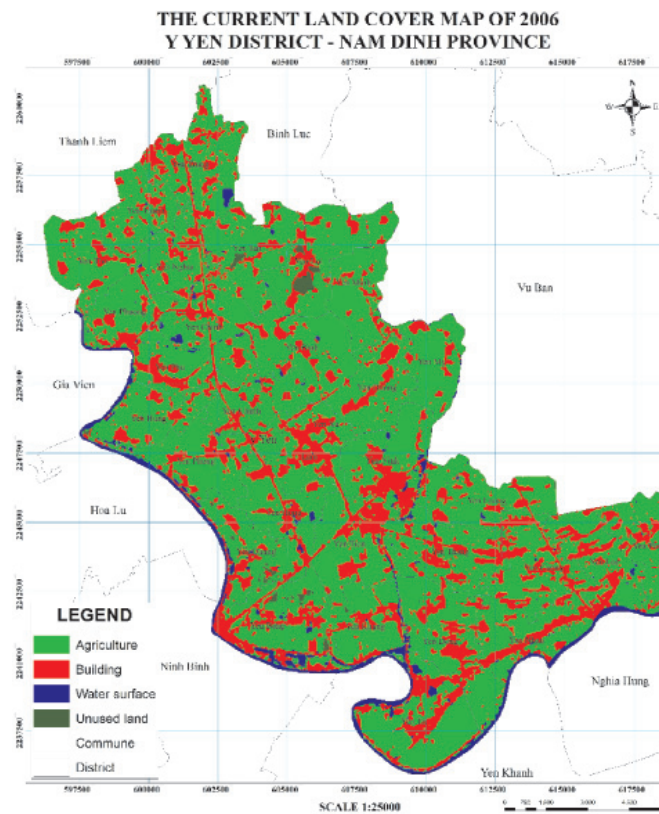


Fig. 8. The current land cover map of 2006 (a) and the current land cover map of 2014 (b)

Table 6

Statistics of the area of land cover types

Land cover type	Year 2006		Year 2014		Increase (+) Reduced (–)
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	
Agriculture	16 516,39	68,45	15 970,68	66,19	–545,71
Building	4 921,43	20,40	5 755,79	23,85	+834,36
Water surface	2 471,74	10,24	2 190,34	9,08	–281,40
Unused land	219,05	0,91	211,80	0,88	–7,25
<b>Total</b>	<b>24 128,61</b>	<b>100</b>	<b>24 128,61</b>	<b>100</b>	

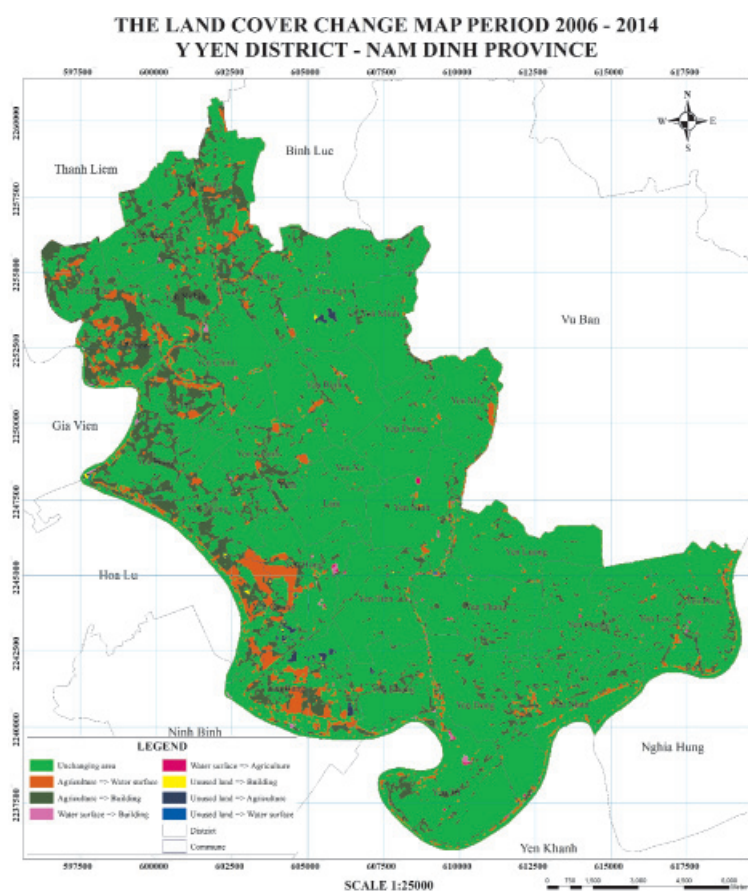


Fig. 9. The land cover change maps period 2006–2014

Table 7

Chart of land cover change period 2006–2014

Land cover type	Agriculture	Building	Water surface	Unused land	Total – 2014
Agriculture	<b>15 816,39</b>	0	153,00	1,29	15 970,68
Building	501,65	<b>4 921,43</b>	329,65	3,06	5 755,79
Water surface	198,35	0	<b>1 989,09</b>	2,90	2 190,34
Unused land	0	0	0	<b>211,80</b>	211,80
Total – 2006	16 516,39	4 921,43	2 471,74	219,05	<b>24 128,61</b>
Increase	154,29	834,36	201,25	0	1 189,90
Reduced	700,00	0	482,65	7,25	1 189,90
<b>Land cover change</b>	<b>–545,71</b>	<b>+834,36</b>	<b>–281,4</b>	<b>–7,25</b>	

Table 8

Matrix of change rate Period 2006–2014

Land cover type	Agriculture	Building	Water surface	Unused land
Agriculture	0,96	0,03	0,01	0
Building	0	1	0	0
Water surface	0,06	0,13	0,81	0
Unused land	0,01	0,02	0,01	0,97

$$\begin{bmatrix} 0,96 & 0,03 & 0,01 & 0,00 \\ 0,00 & 1,00 & 0,00 & 0,00 \\ 0,06 & 0,13 & 0,81 & 0,00 \\ 0,01 & 0,02 & 0,01 & 0,97 \end{bmatrix} \times \begin{bmatrix} \text{Current land in 2014} \\ \hline \text{Agriculture} & \text{Building} & \text{Water surface} & \text{Unused land} \\ \hline 15,970,68 & 5,755,79 & 2,190,34 & 211,80 \end{bmatrix} = \begin{bmatrix} \text{Current land in 2022} \\ \hline \text{Agriculture} & \text{Building} & \text{Water surface} & \text{Unused land} \\ \hline 15,430,64 & 6,535,94 & 1,957,24 & 204,79 \end{bmatrix}$$

### 3.6. Forecasting of land cover change

The forecasting of land cover change shall base on the proportion of urban land changes due to the transformation of other land use types. Basing on the change of land cover types in Table 7, the author has identified rate of transformation as shown in Table 8.

To predict the land cover changes in the future by MARKOV CHAIN, we multiply two matrices together including the matrix of current land in 2014 and the matrix of change rate period 2006–2014 (Table 8).

Similarly, if we want to predict the land cover change of the following year, we shall multiply the matrix of current land cover of the following year by the matrix of change rate.

From the chart in Fig. 10, it is shown that from 2006 to 2014, land for construction got the highest increase up to 834,36 hectares, agricultural land reduced to 545,71 hectares, water surface land reduced to 281,4 hectares, unused land reduced to 7,25 ha. By 2022, the land for construction will reach 6 535,94 hectares, agricultural land will reach 15 430,64 hectares,

Table 9

Forecasting of land cover change by 2030 (Unit: Hectare)

Year	Agriculture	Building	Watersurface	Unusedland
2006	16 516,39	4 921,43	2 471,74	219,05
2014	15 970,68	5 755,79	2 190,34	211,80
2022	15 430,64	6 535,94	1 957,24	204,79
2030	14 899,02	7 268,51	1 763,08	198,01

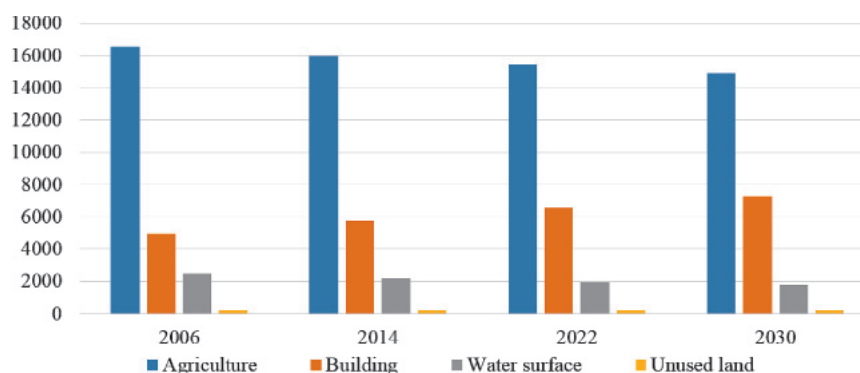


Fig. 10. Chart of Forecasting of land cover change by 2030

the water surface land will reach 1 957,24 hectares, and the unused land will reduce to 204,79 hectares. By 2030, land for construction will reach 7 268,51 hectares, agricultural land will be 14 899,02 hectares, water surface land will be 1 724,87 hectares and the unused land will reduce to 198,01 ha (Table 9 and Fig. 10).

### Conclusion

Basing on the Landsat image 5 in 2006 and Landsat image 8 in 2014 of Y Yen district, an interpretation course of four land use types including agricultural land, land for construction, water surface land and unused land has been built as the basis for interpretation of remote sensing image.

The interpretation results shown that in period 2006–2014, the total area of non-agricultural land increased by 834,36 hectares, accounting for 3,46% of the total natural area of the district, of which the agricultural land area transferred to non-agricultural land is 545,71 hectares, accounting for

2,26%, the water surface land transferred into non-agricultural land is 281,4 hectares, accounting for 1,17%, that of the unused land is 7,25 hectares, accounting for 0,03%. This change shows that the pace of development of the district and people are more and more improved.

In combination with MARKOV CHAIN in forecasting of land cover change by 2030, this forecast shall only be exact without any change regarding land use policy in the applicable year. And vice versa, if there is any change regarding land use policy, this forecast shall not work effectively.

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## ABOUT POSSIBILITY THE IMPACT OF EXPLOITATION OF SMALL HYDROPOWER PLANTS ON THE DEGREE OF POLLUTION OF RIVER WATER BY HEAVY METALS

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The territory of Armenia is characterized by the domination of dry lands and many mountain rivers. To obtain and investigate the expensive and ecologically clean hydropower, a cascade of mountain rivers is used. Investigations have shown the difference in the chemical composition of the river water according to the content of heavy metals (HMs) in the upper and lower sections of the river. In that context, a quantitative determination of ions of some HM in a plant-indicator has been developed, allowing determining the spreading zones of the elements off the river bank. The concentration of the given HMs obviously decreases when moving far from the river bank. The analysis and comparison of these results show that the soil pollution has a protracted character.

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**Keywords:** Small hydroelectric power station, Mountain river, Ecosystem, Heavy metals, Plant-indicator, River bank

The development of hydropower often leads to considerable changes in the management of natural regimes of water problems for the majority of rivers. It is well-known that hydropower plants strongly destroy the dynamic development of the ecosystem along the river flow [1]. At the same time, the change in the water quality [2, 3], sediment and flow at constructing dams has been mentioned [4].

The presence of a hydropower plant cascade introduces spatial and cumulative effects against the natural process of ecological recovery, however it leads to more damage in the ecological characteristics [5], and it can lead to the succession of the whole damage of the ecosystem.

At present, it is not possible to completely abandon the use of the river flow for power purposes, especially in a geographic region where rough mountain rivers dominate. Armenia is distinguished by a network of mountain rivers. The necessity of using alternative power sources is of a social and industrial interest. This facilitates the rapid development of small hydropower plants (HPP) constructed on the mountain rivers. The HPPs allow to produce low-cost electricity of water flows by using hydraulic turbines, generators and transformers, and deliver it to the by high-voltage wires. Such a power source is completely renewable. Despite the high cost of constructing such power plants, they fully compensate the expenses for a short period of time. It is particularly important to use the energy of water masses in the channel streams and the tidal movements as a power source.

That is why, hydropower plants are usually built on the rivers by erecting dams and reservoirs. For the efficient production of electricity at hydropower plants in Armenia, the factor of having a rather wide net-

work structure of mountain rivers with great slopes plays an important. They are built immediately on the water source or near it, using the flow of water as an energy source [6]. The production efficiency of HPPs depends on the uninterrupted water supply throughout the year, the slope of the river, as well as the type of the relief.

The energy of small rivers has rather an important role in the reserves and scales of application. The reason for this is the high energy density of the water flow and the relative temporal stability of the flow regime of most rivers [7].

But the impact of small HPPs on the environment is unavoidable. Among the factors, contributing to the environmentally irreversible processes should particularly be mentioned the influence of small HPPs on the geochemical changes in the environment.

The quality and quantity of the water consumed changes for the worse. The surface water is used by people both globally for the irrigation of agricultural crops and for everyday needs [8]. Therefore the issue on building water facilities on the mountain rivers is very urgent and perspective now. In fact, technically, the contaminated water comes to the general consumer – the human, along a chain. The whole volume of the public consumption of water in small HPPs leads to restriction in the surface water in the national economy.

Maintenance of small HPP is accompanied not only by a change in the chemical composition of surface waters, but also violates the volume and direction of the rivers. It is shown that the construction of a hydropower plant changes the direction of the river, leading to a break in the natural dynamic balance [9]. It is obvious that hydrochemical



factors play a decisive role in the proper formation of the overall environmental situation at developing hydroenergetics. A special attention should be paid to the quality of the used constituents and parts of the HPPs. They can significantly change the chemical composition of the water used, too [10].

It is well-known that the rivers in different regions have their own key elements due to their special background conditions. In the present work, the problem of estimating the possibility of ecological consequences, leading to the destruction of the river ecosystem and the change of typical ecological characteristics is investigated. Our goal has been to investigate the changes in the chem-

ical composition of the river water caused by the operation of hydropower plants. That is why, in our investigations, the rate of some heavy metals (HM), existing to the river water in the river bank soil with their further accumulation in the plants-indicators has been assessed.

### Materials and methods of research

#### *The geographic description of location of the River Voghji*

As an object for monitoring, the River near the town of Kapan, Armenia has been selected (Fig. 1). The River Voghji is the left tributary of the River Araks. The river length on the territory of Armenia is 48 km and the water catchment area – 933 km<sup>2</sup>, with 0,038% of average inclination and 2200 m of average catchment area elevation.



Fig. 1. The location of the River Voghji with points in which the sampling of water (points 1, 2, 3, 4), and the study of migration of heavy metals by bank of the river (point 3) have taken place

The River Voghji is a mountain river with typical seasonal water regime, depending on the spring snow melting and rain floods. The latter change was very slowly due to the prolonged melting of the snow and glaciers in Meghri and Zangezour, lasting from April to July. The soil cover is diverse, but it mainly consists of dark brown soils. The forest covers 18% of the River Voghji basin [11].

#### Sampling and database collection

As an indicator plant – *Urtica Dioica L.*, growing on the banks of the river and further into the depths along the normal has been used. The length of the ground is 300 m, the width of the section (normal to the waterfront) – 30 m. The gathering point of the nettle leaves were gridded  $(5 \pm 0,5) \times (50 \pm 1)$  m oriented along the bank of the river. At a distance  $\geq 500$  m from the bank, additional 5 points of the gathering *Urtica Dioica* to determine the “background concentrations” of heavy metals in the leaves of the plant were randomly selected. The gathering of the plant was carried out in May before the blossoming period.

#### Determination of the HM concentration

Environmental monitoring of the river water condition by some heavy metals was carried out. The choice of these HMs was dictated by their participation in the process of adaptation of plants at the anthropogenic stress [12]. HMs were measured by the atomic absorption flame spectroscopy. The concentration of ions of molybdenum, manganese, nickel and cobalt in the solution was determined on the AAS “Analyst – 800”, and then calculated on the dry material. [13].

#### Statistical analysis

For all the biochemical measurements, a Student t-criteria: a minimum of all measured values for this removal ( $f=4$ ;  $P=0,95$ ); “background” values (when the number of degrees of freedom  $f=13$  and the probability level  $P=0,95$ ) have been determined. The data are presented as means of four biological replicates  $\pm$  standard error (SE). The effects were considered significant at  $p < 0,05$ .

### Results of research and their discussion

To understand the mechanism of possible changes in the composition of the river water caused by the work of a number of small HPPs on the River Voghji, it is necessary to choose the place for biological estimation of the cumulative capacity of the plant. The river water is used to a full extent for various needs of the town. That is why, the chemical condition of the water after using small HPPs was assessed

before entering the town of Kapan. Our goal was to evaluate the water before it was used for different purposes.

According to the obtained results, we can assume that the operation of the small HPPs has probably caused a change in the chemical composition of the water. This fact may be related to both the direct operation of the small HPPs and the wear of its constituent parts. That is why, first, the major physical and chemical parameters of water sampling in the period of 2008–2013 were analyzed. Based on a great number of samples, the concentration changes of some HMs were measured. These metals were nickel, cobalt, manganese, and molybdenum which take an active part in the metabolism of the plants and regulate the physiological processes of growth and adaptation [12]. According to the results shown in Fig. 1, the tendency of the contents of these HMs is maintained for 6 years.

The first two points are almost at the water intake source of Voghji and here, there are a rather limited number of small HPPs. Therefore, the results of the total concentration of HMs are not very different in their values, with a slight increase in the value in the second point of water sampling. Further, along the river, small HPPs are located. The third point of water sampling is almost in a suburb of the town of Kapan. The possible migration of these HMs from the water into the soil and subsequently their accumulation in the plant was studied in this very place. The change in the chemical composition of the river water directly affects the physiological characteristics of the plant, growing directly near the rivers. The results of comparison of quantitative changes in the content of the investigated transition of metals in water and plants are presented in Table.

The heavy metal content in the leaves of the plant based on the dry substance, depending on the distance along the normal from the bank

Name of metal	Concentration of metal in water [ $\mu\text{g/g}$ ] (**)	Concentration of metal in plant removing by normal from the bank [ $\mu\text{g/g}$ ]	
		30 m (*)	500 m (**)
Nickel	$1,350 \pm 0,068$	$0,136 \pm 0,004$	$0,062 \pm 0,001$
Cobalt	$0,442 \pm 0,022$	$0,146 \pm 0,003$	$0,044 \pm 0,002$
Manganese	$19,156 \pm 0,957$	$0,328 \pm 0,006$	$0,107 \pm 0,003$
Molybdenum	$12,149 \pm 0,607$	$0,420 \pm 0,010$	$0,116 \pm 0,005$

Notes:

(\*) – the minimum of all the measured values for this removal ( $f=4$ ;  $P=0,95$ );

(\*\*) – “background” values (when the number of degrees of freedom  $f=13$  and the probability level  $P=0,95$ ).

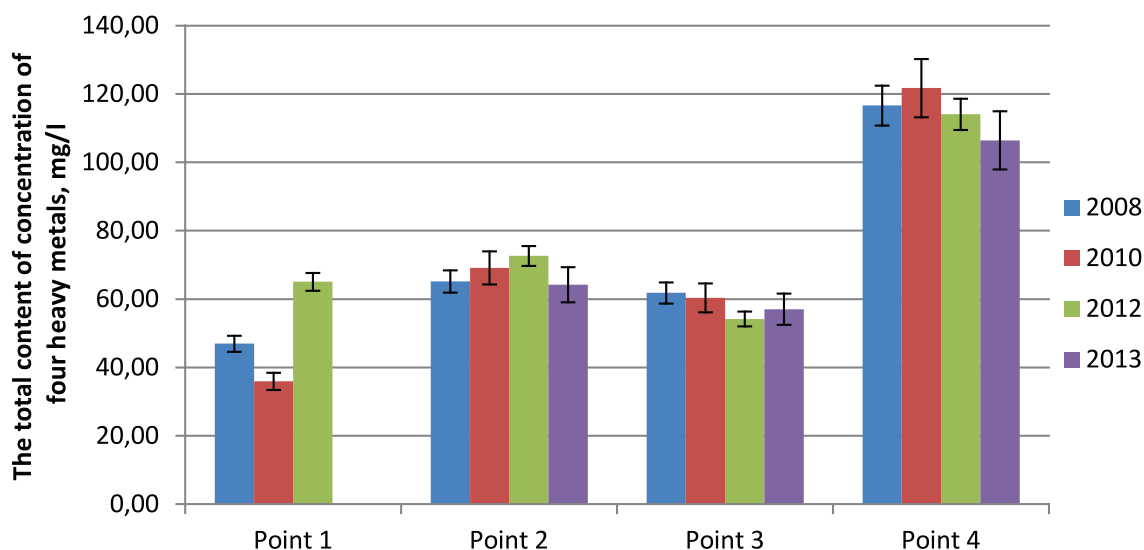


Fig. 2. A change in the total content of some heavy metals (Ni, Co, Mn, Mo) in points where sampling of water in the period 2008–2013 was carried out

It is known that soil is a natural filter at migration of chemical elements through it. That is why, in order to monitor the chemical composition of water, the method of phyto-indication was used. Plants are sensitive to the content of HMs and react to their toxicity. The latter depends on the dose and type of the ion during the whole period of time. HMs, in the period of the plant growth, participates in various metabolic processes to form various complexes of a low molecular weight.

To estimate the accumulation of rate HMs by plants, of the plant material – namely *Urtica Dioica* was performed twice. At a distance from the bank, along the normal of 30 m, the HM concentrations of the test decreased by almost one orders, except for the case with cobalt. In this case, the decrease in the concentration of the chemical element was 33 %. There were significant changes in the concentration of manganese and molybdenum.

Then we carried out selection of the plant at a distance of 500 m from the bank line along the normal. In this case, the concentration of heavy metals decreased almost three times.

Further, along the river, the main small HPPs are located before the entering Kapan. It

is here, that the change in the chemical composition of a small watercourse can be due to the increasing intensification of the anthropogenic influence [14, 15].

It especially increases the water amount of those rivers that flow near the settlements. So here, sampling of the river water was carried out. Our assumptions were confirmed. In point number four the highest concentration of all the HMs (Fig. 2) can be found.

### Conclusion

The distance from the bank has been determined at which the changes in the concentration of HMs has been established. It is 500 meters from the bank where there is an obvious low concentration of HM content, allowing using the bank soils safely for various needs. By using a special plant-indicator, it is possible to limit the migration of HMs, using plants which absorb and accumulate the specific chemical elements. It immediately reduces the rate of migration of HMs and allows using the bank soil for the agricultural purposes during the operation of small HPPs.

*Conflict of interests.* The authors declare that there is no conflict of interests regarding the publication of this paper.



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## NERVOUS COMPONENT OF ARTERIAL HYPERTENSION

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World Health Organization experts believe that 95% of the causes of primary arterial hypertension are unknown. We analyse the causes and mechanisms of arterial hypertension and study the influence of gymnastics and massage on the development of primary arterial hypertension. Compression of the sympathetic renal nerves resulted in disruption of the control of liquid transport through kidneys. Metasympathetic nervous system of kidneys increased the level of blood pressure regulation, which led to hypertension. The initial stage of hypertension is most likely caused by violation of the sympathetic innervation of the kidneys. Rehabilitation measures aiming to eliminate spastic states in the intervertebral muscles, and to recover the renal sympathetic innervation can prevent the development of primary hypertension.

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**Keywords:** hypertension, arterial hypertension, non-drug treatments, rehabilitation, spine, muscles, kidneys, the sympathetic nervous system, physical training, gymnastics

World Health Organization (WHO) experts believe that 85 % of the causes of arterial hypertension (AH) are unknown, while 5 % are caused by a kidney disease. Prevention of hypertension development includes weight control, reduce intake of alcohol, increasing physical activity, restriction of salt intake, stopping smoking, restriction of fat consumption. A meta-analysis of randomized controlled trials shows that aerobic exercise endurance decreases SBP and DBP at rest on 3,0/2,4 mm Hg. The influence of exercises on hypertension remains little studied. In the treatment of hypertension WHO experts recommend only drug therapy.

There is an alternative approach to the problem of hypertension. The first person who said that hypertension is not a disease but a reversible functional impairment in the regulation of vascular tonus was Russian doctor G.F. Lang [3], who considered arterial hypertension as “vascular neurosis”. He believed that the cause of the disease is stress. If it is possible to remove the “vascular neurosis” at the initial stage of the disease development, the disease will not develop.

Nowadays, medicine believes that hypertension is incurable and a patient for life needs to take medications. However, there is a way out of this impasse. We must return to the principles of normal physiology, i.e., identify and eliminate the nervous component of hypertension. Currently, primary hypertension is of special importance. We believe that addressing the causes of primary hypertension can prevent the development of the disease.

Analysis of the mechanisms of control of the tone of blood vessels shows that all of these mechanisms are of short duration.

Vascular baroreceptors and neurons of vasoconstrictor nerve center are being adapted to increased pressure within 1 hour and thus are not responsible for hypertension. Hormonal mechanisms operate for several days. Renin-angiotensin system plays an important role in normalization of blood circulation at pathological decrease in blood pressure as well as at blood loss due to trauma. This mechanism is also not related to hypertension. The only mechanism for the regulation of blood pressure that remains is the relation between intravascular blood volume and capacity of vessels. It is shown that a low (2–3 %) permanent increase in the volume of liquid in the circulatory system at shutdown of neural regulation leads to an increase in blood pressure by almost 50 % [1, 2]. Thus, the main mechanism responsible for the long-term increase in blood pressure is kidney control system of volume of fluid in the circulatory system.

### The aims of investigation:

1. Analysis of the causes of primary hypertension.
2. Study of the effect of physical exercises on the development of primary hypertension.

### **Results of research and their discussion**

Within 3 months we were able to observe the development of hypertension from the very beginning and use the experimental non-drug exposure to normalize blood pressure. Our 60-year-old patient (weight 74 kg, height 174 cm, the absence of chronic kidney diseases or any other chronic diseases for more than 20 years) was engaged in running during 20 years and, until recently, had stable pressure 125/80. After a prolonged stress, our patient

first suffered a sympathetic-adrenal crisis – the pressure was 193/90 and the pulse 57–60. After the end of the sympathetic-adrenal crisis the state of resistant hypertension occurred – the upper pressure of 160–180, the lower pressure of 110–120, with the pulse of 100–110 at rest. Taking drugs to lower blood pressure had no effect. The blood pressure remained at this level during more than two weeks before the patient sensed pain in the lower back in the 8–12 thoracic vertebrae and the 1–2 lumbar vertebrae. The patient has received massage of the muscular system of the spine. During an hour after the massage the pressure decreased from the level of 150/103 to 137/86, and after 2 hours stabilized at 130/83, which is a normal level for our patient. However, the patient continued suffering from chronic stress, and 2 weeks after the first massage session the pressure rose again and reached the level of 160/100. Later two massage sessions were held with a blood pressure control. In the first case, there was a decrease of pressure from 176/97 to 136/83 after the massage. In the second case, there was a decrease of pressure from 160/97 to 137/88 after the massage. By the end of the day the pressure increased slightly, but did not reach the initial high level.

The patient participated in three series of experiments:

- 1) 8 days of Tibetan gymnastics on the shores of the warm sea;

- 2) 7 experimental rounds of running, each consisted of 3 stages, 1650 meters each stage, at a speed of 10 kilometers per hour, and gymnastic exercises for the spine after each stage;

- 3) 10 experimental runs, 5 kilometers a day, at a speed of 10 kilometers per hour and Tibetan gymnastics exercises for the spine after jogging.

The execution of each series of experiments resulted in normalization of blood pressure.

1. Performing daily Tibetan exercises “Five Tibetan pearls” gradually led to normalization of pressure. We give the results of daily monitoring: 160/100 – 100; 154/104 – 96; 158/90 – 94; 150/90 – 93; 152/91 – 93; 144/90 – 73; 134/82 – 75; 133/81 – 65. The measurements were carried out at the same time and under the same conditions.

2. 3 stages of running, 1650 meters each stage, at a speed of 10 km per hour, and gymnastic exercises for the spine after each stage resulted in an average reduction of the upper pressure level from 150 to 135 mm Hg and raising the lower pressure level from 88 to 91 mm Hg.

3. Especially significant are the results of combination of running and Tibetan gymnastics that lasted for 10 days. The average val-

ue of blood pressure at the beginning of the day for the first three days of the experiment was 141/89 mm Hg, and at the end of the day 123/86 mm Hg. Over the past three days, the mean value of blood pressure at the beginning of the day was 126/83 mm Hg, and at the end of the day was 129/81 mm Hg.

Examination of the patient showed that the stress had caused spasms of the muscles of the spine in the lower thoracic spine. The state of the spine muscular corset affects the regulation of blood pressure. Hypertonicity and spasms of the intervertebral muscles in the lower thoracic spine leads to a persistent increase in blood pressure. Probable mechanism of this influence is the compression of the sympathetic nerves that control the transport of water through the kidneys. Removal of spastic condition and of hypertonia of intervertebral muscles with the help of gymnastics for the spine regularly led to normalization of blood pressure. Thus, the long-term primary hypertension has a direct connection with the violation of the state of the sympathetic nerves that control the transport of water through the kidneys.

#### Analysis of the causes of hypertension

**Water transport through the circulatory system.** Every day up to 10 liters of fluid is being absorbed into and withdrawn from the blood system, which is almost 2 times greater than the volume of blood in the circulatory system. Up to 3 liters of water is consumed with food, up to 7 liters of digestive juices are produced: 2,5 L in the stomach, 2 L in the pancreas and 2,5 L in the proximal small intestine (the first half of the small intestine). These 10 liters are absorbed back into the circulatory system in the distal small intestine and along the entire length of the colon. The liquid passes through the liver and is thrown back into the circulatory system. With all this going on, the level of blood pressure remains stable. In fact, this is a “third circulation” – the circulation of fluid through the blood circulatory system. For any value of blood pressure, for any tonus of blood vessels, the pumps in small and large intestine absorb 10 liters of fluid and direct it into the circulatory system. The circulatory system transports the liquid back into the digestive tract and removes it through the kidneys. The question arises: what kind of system maintains a balance in moving 10 liters per day (200% of the volume) through the circulatory system? It is quite obvious that this is controlled by the hypothalamus via metasympathetic nervous system of the kidneys.

With increasing pressure by 1 mm Hg the water excretion by the kidneys is increased by 100%. The volume of water that is removed by the kidneys increases by 8 times even when the blood pressure increases only by 10 mm. Hg. This is the mechanism of stabilization of blood pressure under control of the hypothalamus. For denervated kidneys, the characteristic “pressure – the rate of water transport” is decreased in 6–8 times.

From the course of anatomy it is known that the kidneys are innervated and controlled by sympathetic division of nervous system along the neural pathways: baroreceptors – hypothalamus – neural pathways in the spinal column coming out of the spine in the 9–11 thoracic vertebrae – the nerve center – metasympathetic part of the autonomic nervous system located in the walls of the kidneys. The compression of nerves passing between the intervertebral muscles evokes a violation of the transmission of nerve impulses to the kidneys and, therefore, a violation of hypothalamus-controlled fluid transport. In such a case regulation of the fluid transport falls exclusively on metasympathetic nervous system (MSNS) of kidneys. The effectiveness of MSNS is 3–4 times lower than management by the sympathetic nervous system. Consequently, the most likely explanation of the occurrence of hypertension is that the blood pressure increases as a result of violation of evacuation of fluid from the circulatory system. Renal “valve”, discharging fluid from the circulatory system into the bladder, is “installed” to a higher pressure level. In the absence of signals from the hypothalamus, the renal blood pressure regulator continues to maintain a stable blood pressure, but on a much higher level. In fact, we are dealing with a functional partial denervation of the kidney. In our opinion, this is the main cause of hypertension.

Observation of our patient with initial stage of hypertension caused by neurosis fully confirms the conclusions drawn on the basis of our analysis. Pathological chain of hypertension development for our patient is as follows. Long neurosis caused hypertonus, and then spasms of the muscles in the lower thoracic intervertebral department of the spine. The patient felt pain in the spine at this place. Manual therapist discovered the presence of hard and painful intervertebral muscles in this area. Muscle spasm caused compression of the renal sympathetic nerves emanating from the spine in that region. Compression of the renal nerves resulted in disruption of the control of liquid transport through kidneys. Metasympathetic nervous system of kidneys increased the level of blood pressure regulation, which led to hypertension.

Massage of spinal muscular corset has eliminated spasms of the muscles, and within an hour

the pressure returned to normal. However, neurosis continued to maintain hypertonicity of intervertebral muscles in the area of exit of sympathetic nerves innervating the kidneys. The remaining muscle hypertonicity can be removed with the help of gymnastic exercises for the spine. The same thing happened after the removal of neurosis while relaxing in the warm sea. Thus, the case of our patient is not “vascular neurosis” described by Lang, but “renal neurosis”.

To summarize, the rapid rise of pressure (during less than an hour) under stress is due to the vascular response. Transient pressure rise, from an hour to several days, may be caused by the direct effects of stress on the center of regulation of water transport in the hypothalamus. Long-term stable hypertension, lasting for years, is caused by conduction abnormalities of the renal sympathetic nerves exiting the spine as part of the spinal nerves.

Rehabilitation measures to restore the sympathetic innervation of the kidneys (massage, exercises for the spine and complete rest) can prevent the development of hypertension at its initial stage. At later stages of hypertension, it is very likely that degenerative processes arise in the sympathetic innervation and in metasympathetic nervous system of kidneys, which does not allow a quick victory over hypertension. However, this does not mean that rehabilitation measures will be useless. To normalize the blood pressure for a long time, it is necessary to do a series of massage of a spinal muscular corset and to perform regularly, preferably every day, exercises for the spine.

### Conclusions

1. The initial stage of hypertension is most likely caused by violation of the sympathetic innervation of the kidneys.

2. Rehabilitation measures aiming to eliminate spastic states in the intervertebral muscles, and to recover the renal sympathetic innervation (massage, exercises for the spine and complete rest) can prevent the development of hypertension at its initial stage.

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## A NEW METHOD TO EVALUATE THE EFFECTIVENESS OF SEAWEED WRAPPING GEL ON HANDS SKIN

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This work describes the usage of a new acoustic instrument for express method of evaluation of cosmetic product effectiveness on hands skin based on changes of mechanical properties of the skin. A cosmetic product, seaweed body wrap gel "Gorgeous skin", is manufactured by NPO Summa Technology, Russia and is used for SPA treatments. Seaweed wrapping gel is recommended for hands treatment to provide deep hydration and prevent dryness. The mask is homogenized jelly substance from brown seaweed *Laminaria Japonica* valuable for high concentration of micro and macro elements, vitamins and amino acids. Quickly penetrated the mask intensively moisturizes and deeply nourishes, preventing dry and itchy skin.

**Keywords:** acoustic method, speed of propagation of audible frequency surface waves, the effectiveness of seaweed wrapping gel on hands skin

For the purpose of confirmation of the above characteristics of the cosmetic product – seaweed body wrap gel «Gorgeous skin» – we made experimental investigation of the changes of skin mechanical properties. We developed a scheme for hands acoustic scanning in three areas which differ in their properties and in their exposure to environmental influence. We offered the method of evaluation of skin mechanical properties changes. As an objective criterion we offered the parameter equal to the difference in propagation speed of audible frequency surface waves measured before and after 30 minutes of the product application. The measured results show that the speed decreases after the seaweed mask application in 91 % thus confirming moisturizing effect as the proven fact is that skin hydration causes the decrease in speed. The cosmetic product can be highly recommended to people with dry hand skin.

Nowadays we can see a lot of new technologies, directions, numerous cosmetic products and a number of treatments including SPA procedures for handskin texture improvement. It's difficult to evaluate their efficiency taking information just from advertising and directions for use. Usually the benefits of the products are evaluated subjectively: visual examination, palpation, patient's perception. We do need objective, multiply repeated methods of control. One of such methods can be acoustic scanning.

**Purpose of the work:** to prove high informative possibilities of acoustic medical diagnostic instrument (AMDI) in evaluation of effectiveness of seaweed wrapping gel and to confirm declared product benefits.

### Materials and methods of research

**Objectives:** to develop the method of examination and experimental measurement of acoustic mechanical skin properties during mask application.

**Study object:** hand skin (11 women of different age: from 20 to 60 years old), which seaweed body wrap gel «Gorgeous skin» was applied to, was investigated. The mask was evenly applied to both hands (5 grams to each hand).

Speed (V) measurements were made in specific areas according to written above scheme of scanning in the mutually perpendicular directions.

**Study method:** Study was performed by using anacoustic medical diagnostic instrument (AMDI) [1, 2], widely used for examination of skin and soft tissues [8–9], which is capable to determine the propagation speed of surface wave  $V$ . The measurement of speed was made in the mentioned areas in mutually perpendicular directions:  $Y$  axis coincides with natural vertical hand axis;  $X$  axis is perpendicular to  $Y$  axis. Such measurement method allows to get more experimental parameters for each area.

The speed measurements were performed during 3–5 seconds (express method). The speed difference was calculated as

$$\Delta V = V_{\text{before}} - V_{\text{after}} \text{ (30 minutes after mask application).}$$

### Results of research and their discussion

Hands skin acoustic scanning scheme was developed. It included three areas which differ in their properties and in their exposure to environmental influence.

The first area (point 1) – inner part of the hand near the thumb (there are no sebaceous glands).

The second area (point 2) – middle outer part of the hand (always in contact with environment). The third area (point 3) – outer side of the arm (lower part), which is often covered with clothes.

**Table 1**Speed parameters  $V_y$  and  $V_x$  before and after application in point 1 – thumb area (Patient 6)

Right						Left					
$V_y$			$V_x$			$V_y$			$V_x$		
11,25	11,25	12,37	10,41	10,50	10,50	12,37	12,13	12,19	11,26	11,16	11,31
9,32	9,60	9,65	9,12	9,22	9,12	8,22	8,15	8,19	8,47	8,47	8,53
1,93	1,65	2,72	1,29	1,28	1,38	4,15	3,98	4,00	2,79	2,69	2,78

 $\Delta V$ 

Average parameters											
Right						Left					
$V_y$			$V_x$			$V_y$			$V_x$		
11,62			10,47			12,23			11,24		
9,52			9,15			8,19			8,49		
2,10			1,32			4,04			2,75		

 $\Delta V$ **Table 2**Speed parameters  $V_y$  and  $V_x$  before and after application in point 2 – outer hand area (Patient 6)

Right						Left					
$V_y$			$V_x$			$V_y$			$V_x$		
8,44	8,44	8,44	8,86	9,19	8,96	8,85	8,86	8,89	8,63	8,83	8,59
7,53	7,78	7,53	8,50	8,47	8,50	8,77	8,60	8,65	8,41	8,33	8,50
0,91	0,66	0,91	0,36	0,72	0,46	0,08	0,26	0,24	0,22	0,50	0,09

 $\Delta V$ 

Average parameters											
Right						Left					
$V_y$			$V_x$			$V_y$			$V_x$		
8,44			9,00			8,87			8,68		
7,61			8,49			8,67			8,41		
0,83			0,51			0,19			0,27		

 $\Delta V$ **Table 3**Speed parameters  $V_y$  and  $V_x$  before and after application in point 3 – lower arm area (Patient 6)

Right						Left					
$V_y$			$V_x$			$V_y$			$V_x$		
8,33	8,33	8,36	8,47	8,54	8,56	8,63	8,69	8,72	8,62	8,72	8,80
8,09	8,19	8,14	8,30	8,30	8,47	8,53	8,36	8,41	8,53	8,47	8,41
0,24	0,14	0,22	0,17	0,24	0,09	0,10	0,33	0,31	0,09	0,25	0,39

 $\Delta V$ 

Average parameters											
Right						Left					
$V_y$			$V_x$			$V_y$			$V_x$		
8,34			8,52			8,68			8,71		
8,14			8,36			8,43			8,47		
0,20			0,17			0,25			0,24		

 $\Delta V$

All the patients were in a sitting position during measurements, the arm was laying on the table without any tension.

The measurements were made three times in each scanning point before and after 30 minutes of the mask application. Individual parameters (patient 6) of speed  $V_y$  and  $V_x$  are given in Table 1 – for the thumb area, Table 2 – for the

outer part of the hand, Table 3 – for the lower part of the arm.

Graphic illustrations of the Tables for Patient 6 in corresponding points are represented in Fig. 1, 2, 3 (measurements for axis  $X$  – blue color, for axis  $Y$  – red color).

The summary of the results for all patients in each area is represented in Table 4.

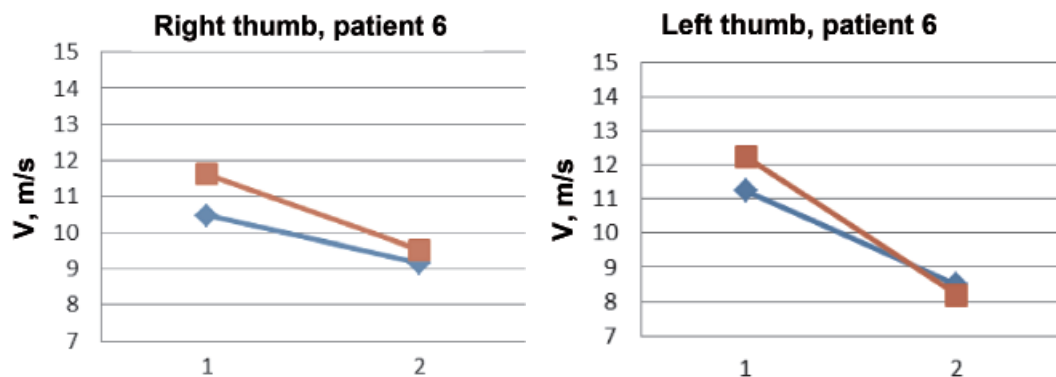


Fig. 1. Speed change after the product application in point 1

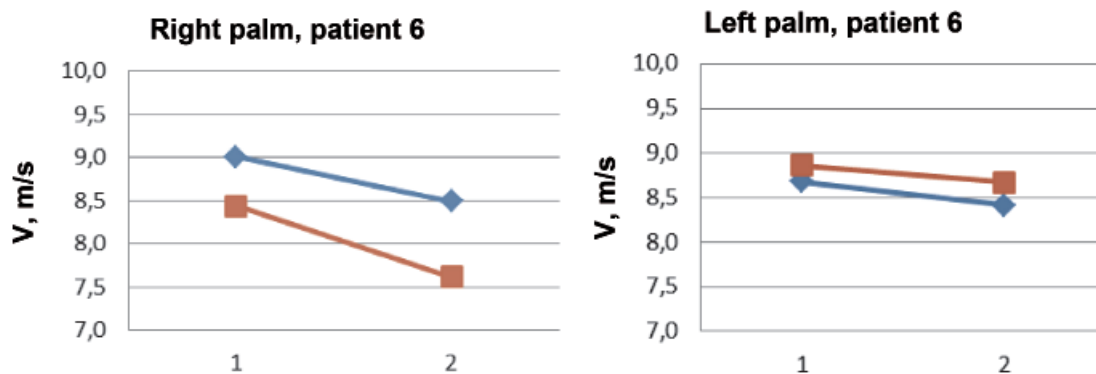


Fig. 2. Speed change after the product application in point 2

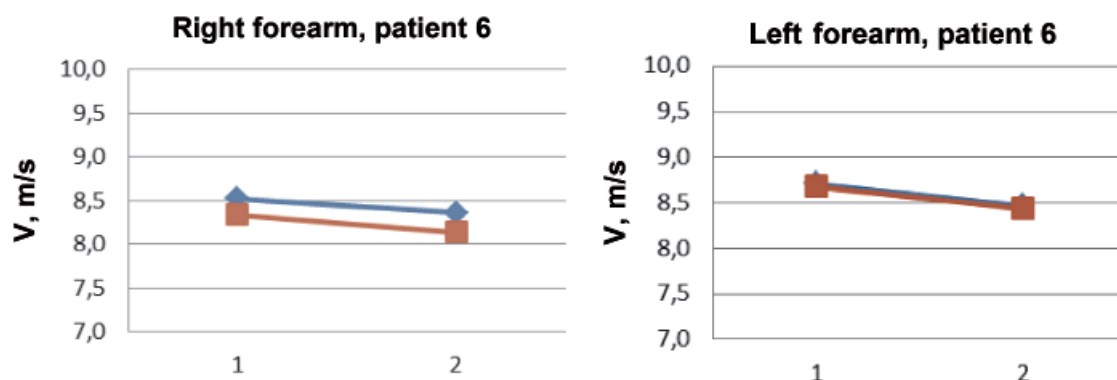


Fig. 3. Speed change after the product application in point 3

Table 4

The comparison of speed change  $\Delta V_y$  and  $\Delta V_x$  after the product application in different areas

Patient	Thumb area (Point 1)				Outer hand area (Point 2)				Lower arm area (Point 3)			
	Right		Left		Right		Left		Right		Left	
	$\Delta V_y$	$\Delta V_x$	$\Delta V_y$	$\Delta V_x$	$\Delta V_y$	$\Delta V_x$	$\Delta V_y$	$\Delta V_x$	$\Delta V_y$	$\Delta V_x$	$\Delta V_y$	$\Delta V_x$
1	0,36	1,09	0,20	0,16	0,25	0,22	0,18	0,23	0,22	0,24	0,16	0,15
2	<b>0,53</b>	<b>0,86</b>	<b>0,88</b>	<b>0,65</b>	<b>0,34</b>	<b>0,52</b>	<b>0,53</b>	<b>0,80</b>	<b>0,57</b>	<b>0,26</b>	<b>0,33</b>	<b>0,37</b>
3	0,17	0,78	0,39	0,42	0,41	0,17	0,36	0,81	0,62	0,39	0,16	0,62
4	0,12	0,27	0,18	0,23	0,15	0,13	0,24	0,13	0,34	0,66	0,78	0,27
5	0,19	0,83	0,46	0,24	0,28	0,18	0,50	0,33	0,21	0,12	0,10	0,33
6	<b>2,10</b>	<b>1,32</b>	<b>4,04</b>	<b>2,75</b>	<b>0,83</b>	<b>0,51</b>	<b>0,20</b>	<b>0,27</b>	<b>0,20</b>	<b>0,16</b>	<b>0,25</b>	<b>0,24</b>
7	<b>0,74</b>	<b>0,93</b>	<b>0,49</b>	<b>0,68</b>	<b>0,57</b>	<b>0,29</b>	<b>0,41</b>	<b>0,39</b>	<b>0,44</b>	<b>0,56</b>	<b>0,28</b>	<b>0,34</b>
8	0,17	0,34	0,30	0,54	0,16	0,63	0,18	0,29	0,38	0,27	0,21	0,19
9	<b>3,54</b>	<b>1,07</b>	<b>1,68</b>	<b>1,19</b>	<b>1,27</b>	<b>0,30</b>	<b>1,25</b>	<b>0,28</b>	<b>0,53</b>	<b>0,17</b>	<b>0,51</b>	<b>0,55</b>
10	0,28	0,48	-0,07	0,23	-0,55	-0,50	-0,58	0,01	0,30	0,39	0,60	-0,16
11	0,34	0,67	0,17	0,17	0,48	0,74	0,15	0,35	0,38	0,68	1,56	1,29

Based on the results of this work one can conclude the following:

1. Speed parameters after the product application decreased in each area in both directions among 10 patients (91 %).

2. Only one patient (10) experienced an increase in surface waves speed as well as a decrease.

3. The most significant speed decrease is measured in thumb area of the inner side of the hand.

4. The product effectiveness was more pronounced in thumb area of the patients with dry skin (Patients 2, 6, 7, 9). These women themselves confirmed the greater benefits of the product and are willing to use it more often.

5. Seaweed body wrap gel "Gorgeous skin" demonstrated its high effectiveness, proving its moisturizing properties.

The results of the work confirmed that one can develop a method allowing individual selection of cosmetic products for each person using the changes in mechanical properties of

the skin after a single application. The mask can be highly recommended for woman with dry hands.

In conclusion, acoustic method proved to provide objective express evaluation of the effectiveness of seaweed wrapping gel to hand skin.

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## THE CHARACTERISTICS OF FUNCTIONAL CONDITION OF PATIENTS WITH CLOSED HUMERAL AND LEG FRACTURES TREATED ACCORDING TO ILIZAROV

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The authors performed a comparative examination of the rigidity of bone fragment fixation and the regenerated bone blood supply in two groups of adult patients with closed humeral bone fractures ( $n = 35$ ) and leg fractures ( $n = 35$ ) under treatment according to Ilizarov. They found that in case of humeral injuries the tolerated functional load of the limb is considerably lower, and the strain-gauge registered micromobility of bone fragments is 3-fold higher for graduated load of limb segment. In case of humeral fractures circulation rate in the regenerated bone vessels increases and normalizes faster.

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**Keywords:** humeral fractures, leg bone fractures, transosseous osteosynthesis, blood supply of regenerated bone

An opinion about the absence of the principal differences in regeneration of human upper and lower limb fractured bones formed a priori on the basis of the data about regeneration of the fore and hind limb fractured bones in experimental animals. Ilizarov when treating patients with closed fractures of both humerus and leg bones recommended to adhere to the same optimal periods of fixation – 54 days [1]. In this case it was not taken into account that the lower limbs unlike the upper ones perform a weight-bearing function.

The working ability descent while maintaining locomotor activity is a characteristic of functional condition of patients during humeral fracture treatment. Both the proximity of the humeral proximal part to the trunk and the need to maintain movements in the elbow make it impossible to use the typical set of the Ilizarov fixator supports used for treatment of patients with leg bone fractures when treating a humeral fracture [2]. The characteristics of bone blood supply which is more intense in the humerus are of great importance for achieving bone fracture union [3, 4, 5].

The purpose of this study was to compare the ability to static functional loading of humerus and leg, as well as the rigidity of bone fragment fixation and regenerated bone blood supply when treating closed shaft bone fractures of these limb segments according to Ilizarov.

### Scope and Methods of the Study

Two groups of patients were examined. Group 1 included 35 patients with closed humeral shaft fractures under the conditions of treating by Ilizarov method. The patients' age was from 26 to 66 years ( $40 \pm 3$ ), there

were 10 women among the patients, the period of fixation at the time of examination was from 3 to 94 days ( $22 \pm 6$ ). Group 2 included 35 mature patients with closed leg bone shaft fractures under treatment according to the Ilizarov method.

When graduated, stepwise increasing (by 5 kg) axial loading of the appropriate limb the micromobility of humeral or tibial bone fragments revealed in all the patients [7]. In this case, using a tensostation and B7-73/1 voltmeter a signal registered which during re-registration allowed to reveal a change in the distance between the wires extending from the bone above and below the zone of fracture.

Moreover, using a sensor with the carrier frequency of 8 MHz of *Angiodin-2KM* computed diagnostic complex by BIOSS (Russia) Production Association the circulation rate in the zone of fracture was registered along the tibial anterior-internal surface or the humeral external surface when stepwise increasing functional loading of the leg or humerus (Fig. 1).

Statistical processing was made using Microsoft EXCEL-2010 data analysis package. Student *t*-test was used to assess the reliability of result differences. Correlation and regression analysis methods were used as well.

### Results of the Study

The most significant differences in the parameters of the patients from two groups revealed when limb functional loading assessed. While the most of patients with leg bone fractures were able to transfer their body mass to the injured limb, maximum load in patients with humeral fractures was  $15,9 \pm 1,3$  kg, and it was accompanied by pain.

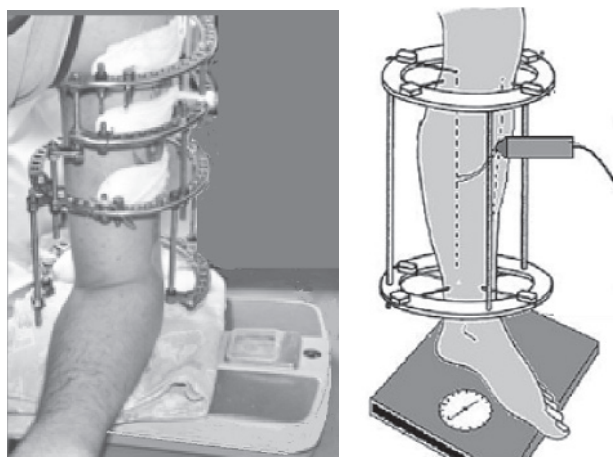


Fig. 1. The definition of the functional load on the shoulder and lower leg in the treatment of fractures by Ilizarov

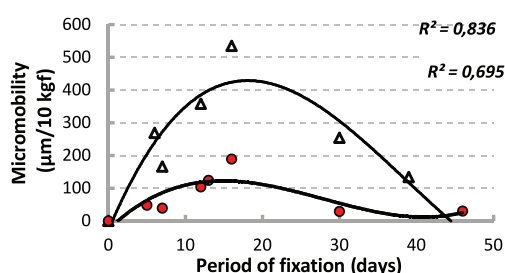


Fig. 2. Dynamics of bone fragment micromobility during treatment of patients with humeral and tibial fractures

The micromobility of bone fragments in the period of fixation in the patients of Group 1 and Group 2 changed identically increasing in the first two weeks after osteosynthesis due to resorption of bone fragments. In the first two weeks it amounted to  $219 \pm 39 \mu\text{m}/10 \text{ kgf}$  for humeral fractures, and  $71 \pm 18 \mu\text{m}/10 \text{ kg}$  – for tibial fractures. Subsequently during treatment the micromobility of bone fragments in both groups steadily decreased due to regenerated bone compactization (Fig. 2).

The features of the Ilizarov fixator design in treating humeral injuries (not rings but half-rings used in the upper and lower third of humerus) could be one of the reasons for the differences in regenerated bone rheological properties of patients in the early period of fixation. Nevertheless, such significant differences in the parameters suggest that the properties of humeral regenerated bone differ from those of tibial regenerated bone.

Some differences also revealed in the values of circulation rate in the vessels of humeral and leg regenerated bone. Circulation rate in the humeral regenerated bone was  $32,4 \pm 3,4 \text{ cm/s}$ , that in the leg one –  $26,6 \pm 3,2 \text{ cm/s}$ . Circulation rate in the humeral vessels was the highest in the first days after injury, and it decreased during the first month of fixation period (Fig. 3). Circulation rate in the leg vessels increased throughout the first week of treatment and decreased throughout the period of fixation.

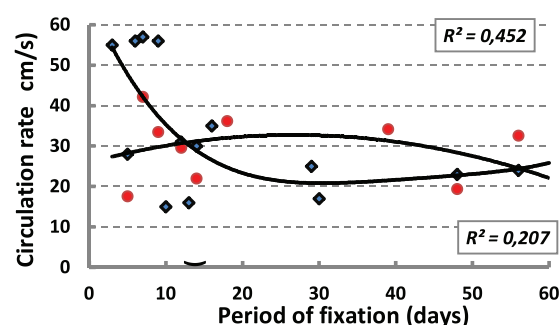


Fig. 3. Dynamics of circulation rate in the vessels of humeral and tibial regenerated bone

The rate of regenerated bone blood supply depended significantly on the rigidity of bone fragment fixation. As far as fragmental micromobility increased to  $180 \mu\text{m}/10 \text{ kg}$ , circulation rate increased both in Group 1 patients and in Group 2 ones with leg bone fractures. Lower values of local blood flow intensity observed for larger values of micromobility.

When making the test with increasing axial loading of the humerus the rate of blood arterial flow began decreasing. When 15 kg load achieved, a temporary increase in the value observed that associated with the decrease in intramural pressure in the arterial wall and with decreased vascular resistance (Fig. 4). Further pressure increase led to a rapid decrease in circulation rate due to mechanical overlapping of the vascular bed and pain occurrence.

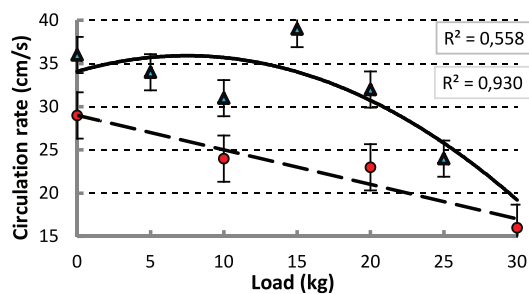


Fig. 4. Dynamics of circulation rate in humeral regenerated bone when increasing the functional static load of the limb

The same dynamics of the change in circulation rate also observed for increasing the leg load. Higher intravascular pressure (the effect of additional hydrostatic pressure the value of which exceeds 70 mm Hg) is known to be characteristic of the leg vessels in standing position. When the patients examined in standing position the rate decrease observed as far as the limb functional load increased. The value relative increase revealed through the steady decrease in circulation rate when 20 kg load achieved. This suggests that the vessels of the leg regenerated bone are better protected

against the exposure of the load from outside. This protection is determined by the higher values of hydrostatic pressure and, apparently, by morphological characteristics of the regenerated bone.

Thus, the existing difference in functional mission of the upper and lower limbs in humans leaves its mark on their condition in the period of bone fracture treatment. Even under the Ilizarov method using the humerus ability to endure the functional load is 2–3-fold less comparing with the leg. The regenerated bone pliability during humerus treatment is significantly more when testing functional load. Circulation rate after humeral fracture increases in the first days after injury, and it increases during the first week after tibial injury. In the patients from Group 1 the protection of circulatory bed against the applied axially oriented load in Group 1 patients is less efficient.

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*Materials of Conferences***HEALTH EFFECTS  
OF MICROWAVE RADIATION**

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Electromagnetic waves come in a very wide range of wavelengths: there are radio, microwave, infrared (heat), visible light, ultraviolet, X-ray, and gamma-ray waves. All are used in medicine in one way or another. Microwave radiation is used in certain kinds of heat treatment, where the heat is generated in the target tissue (as in a microwave oven). Microwaves are a form of electromagnetic radiation with wavelengths ranging from one meter to one millimeter; with frequencies between 300 MHz (100 cm) and 300 GHz (0,1 cm). They are classified as non-ionizing radiation – radiation which can change the position of atoms but it is not strong enough to alter their structure, composition, or properties.

At the present time, there is substantial scientific fact that establishes negative health effects associated with the direct exposure to microwave radiation. Microwave radiation penetrates the body, the exposed molecules move about and collide with one another causing friction and, thus, heat. This is known as the thermal effect. If the radiation is powerful enough, the tissue or skin will be heated or burned. The scientific literature indicates a relationship between exposure to microwave radiation and birth defects, such as mongolism (Down's Syndrome) and central nervous system damage. It has been demonstrated that microwave radiation may cause eye and testicular damage due to their high vulnerability to radiation damage because they contain few blood vessels. As for the effects on the eye, several scientific investigations have shown that cataracts among humans and laboratory animals have occurred as a result of the intense heating of high frequency microwave radiation.

As noted, microwave radiation may also cause damage to the male testes/reproductive organs. Specifically, scientists have demonstrated that exposure to microwave radiation may result in partial or permanent sterility. In addition, some scientific evidence suggests similar effects associated with microwave exposure and female reproductive problems.

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**STUDY OF THE POSSIBILITY  
FOR APPLYING OF POROUS SILICON  
NANOPOWDERS AS A SYSTEM  
FOR THE TARGETED DRUG DELIVERY  
OF "VINPOCETINE"**Polkovnikova Yu.A., Prokhorova A.V.,  
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Nowadays diagnostics and treatment of disorder of the cognitive functions is one of the most intensively studied areas of the modern neurology. Vinpocetine is one of the widely used medicinal preparations for the treatment of such kind of diseases [1]. Presently vinpocetine is produced in the form of pellets containing 5 and 10 mg of the drug. Such drug dosage form proves to be rather efficient but it does not provide the desired prolonged effect [2]. Moreover, chemical structure of vinpocetine can be the reason of instability of this drug dosage form.

Therefore, now an actual problem is the elaboration of stable and biocompatible drug dosage forms with the delayed release of vinpocetine.

One of the prospective ways for solution of this problem is the development of systems for the targeted drug delivery based on silicon nanoparticles including those ones obtained from porous silicon. It is well known that these systems are biocompatible and biodegradable [3]. Now quite successful attempts in the use of porous silicon nanopowders in the systems of the targeted drug delivery are presented in scientific community [4].

The purpose of this work is the elaboration of vinpocetine delivery system on the basis of porous silicon and the study of efficiency of the processes concerned with adsorption and desorption of the medicinal preparation in this system.

**Materials and methods of research.** Porous silicon nanopowder was obtained according to a standard procedure using electrochemical etching of silicon in the alcoholic solution of fluoric acid [5], followed by ultrasonic grinding. Specific surface area of the porous silicon nanopowder was of ~ 60 m<sup>2</sup>/g. Some features in morphology and composition of the particles used in the work are presented in [6].

The obtained nanopowder was submerged into 5%-solution of vinpocetine (ND 42-9175-03) for 20 and 60 minutes. Adsorption of the drug onto porous silicon was controlled by IR-spectroscopy method with the use of VERTEX 70 Bruker spectrometer. Kinetics of vinpocetine release from the nanoparticles into 0,1 M solution of hydrochloric acid was determined at the temperature of



$37 \pm 0,5^{\circ}\text{C}$ . The volume of dissolution medium was of 100 ml. Dialysate tests (5 ml) were sampled after strictly determined intervals of time (15, 30, 45, 60, 90, 120 minutes). Required amount of medium was supplied with the same solvent. In order to determine vinpocetine content spectrophotometric method in the UV-spectral range ( $314 \pm 2\text{ nm}$ ) was applied. Concentration of the analyzed substance was determined by the calibration plot. Producing of vinpocetine microcapsules with the shells made of gelatin, ethylcellulose and sodium alginate as well as the procedure of biopharmaceutical investigations for these drug forms can be found in [7].

#### Results of research and their discussion.

Comparative analysis of IR-transmission spectra for nanopowders of porous silicon in the range of  $400\text{--}4000\text{ cm}^{-1}$  after deposition of the drug with those ones of the primary powder of porous silicon and vinpocetine substance demonstrated the presence of the bands characteristic of the medicinal preparation in the samples (absorption bands at  $1720$ ,  $1680$  and  $1607\text{ cm}^{-1}$ ). Note that composition of the porous silicon particles according to IR-spectroscopy data did not considerably change [8].

Our investigations demonstrated that the release of vinpocetine from Si nanoparticles was of 60% for 6 hours of the experiment that is comparable with the degree of vinpocetine release from microcapsulated forms (70 and 94% from microcapsules with the shells of ethylcellulose and gelatin, respectively).

#### Conclusion

The performed study showed a possibility of using porous silicon as an agent of prolonged vinpocetine delivery and significance of the further pharmacologic investigations of this system.

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#### IDENTIFICATION OF PHENIBUT IN MICROCAPSULES BY SPECTROSCOPIC TECHNIQUE IN IR- AND UV-RANGES

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Vascular encephalopathy takes the second place in the structure of mortality as a result of circulatory system diseases. Annual death rate from the stroke is one of the highest in the world. It should be noted an important physiological role of gamma aminobutyric acid (GABA) in the regulation of the functional activity of central nervous system for these kinds of diseases.

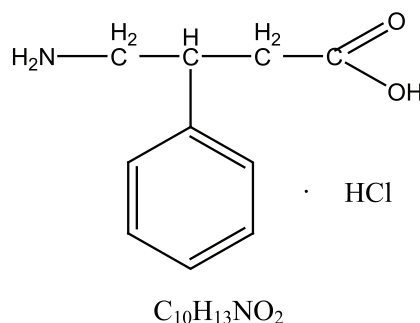
At present, the establishment of the new drug formulations for such derivative of GABA as phenibut characterized by a prolonged action is quite actual [1].

In order to obtain a prolonged action microcapsules seem to be rather perspective formulation [2, 3, 4]. Microcapsules of phenibut were obtained by extrusion technique.

**Object of the research work** was to perform a qualitative estimation of the components compatibility comprising a composition of the established drug formulation, namely, microcapsules.

#### Experimental technique

In the experimental investigations while preparing microcapsules a substance of phenibut was used as an active pharmaceutical substance corresponding to the requirements of ND 42-00380051-00 (Fig. 1), and additives allowed for the medicinal application and corresponding to the requirements of the normative documents.



$\gamma$ -amino- $\beta$ -phenylbutyric acid hydrochloride

Fig. 1. Structural formula of phenibut

IR-spectra were surveyed with Vertex 70 spectrometer (Bruker Optik GmbH, Germany), in the middle part of IR-region in the range of  $4000\text{--}400\text{ cm}^{-1}$  applying ATR technique (attenuated total reflectance method), using ZnSe attachment with the diamond window; as a result, IR-absorption spectra were obtained for phenibut substance, placebo-microcapsules and microcapsules with phenibut.



In addition, in order to identify phenibut in the microcapsules spectrophotometry technique was also applied in the UV-region of spectra at the wavelength of  $257 \pm 2$  nm with spectrophotometer Hitachi U-1900. Identification technique was as follows: an accurately weighted sample of phenibut microcapsules of 0,3 g in mass was placed in volumetric flask of 50 ml capacity, then added 0,1 M of hydrochloric solution and stirred for 45 minutes in the agitator, then developed the volume of solution with the same solvent up to a specified label, and filtrated solution through a paper filter. 5 ml of the obtained filtrate were transferred to the volumetric flask with a capacity of 25 ml, and then developed the volume of 0,1 M solution of hydrochloric acid up to a specified label. 0,1 M solution of hydrochloric acid was applied as a reference one.

#### Results of investigations and their discussion

Results of IR-spectroscopy study for a substance of phenibut, microcapsules-placebo and microcapsules with phenibut are presented in Fig. 2.

Comparison of IR-spectra made it possible to identify phenibut substance in the microcapsules. IR-spectra of the substance and microcapsules with phenibut within the range of  $4000\text{--}400\text{ cm}^{-1}$  show absorption bands at  $3050\text{--}2800\text{ cm}^{-1}$ , meaning the presence of the primary aliphatic aminogroup in the samples; while the bands at 1712, 1656, 1668, 1620 indicate at the presence of carboxylic group in the same samples and thus allowing to state that chemical interaction between the chosen components of the mixture is absent.

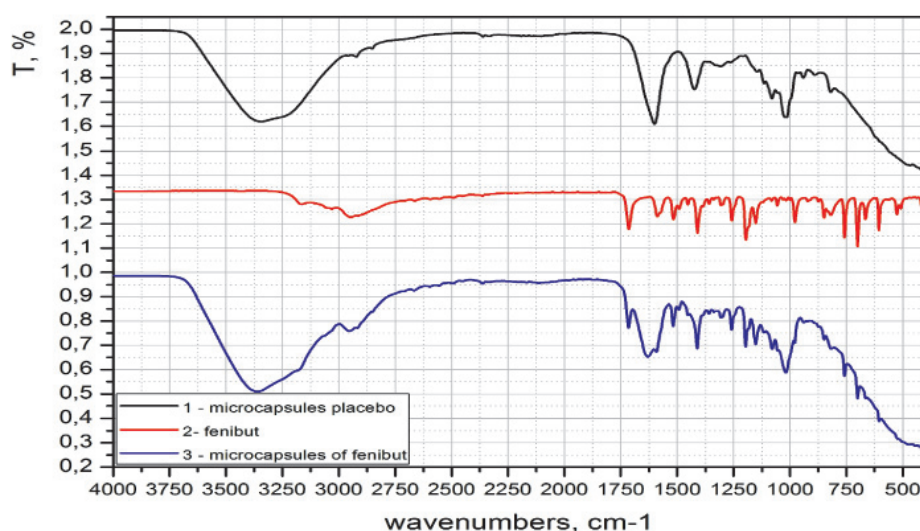


Fig. 2. IR-transmission spectra of phenibut substance, microcapsules-placebo and microcapsules with phenibut

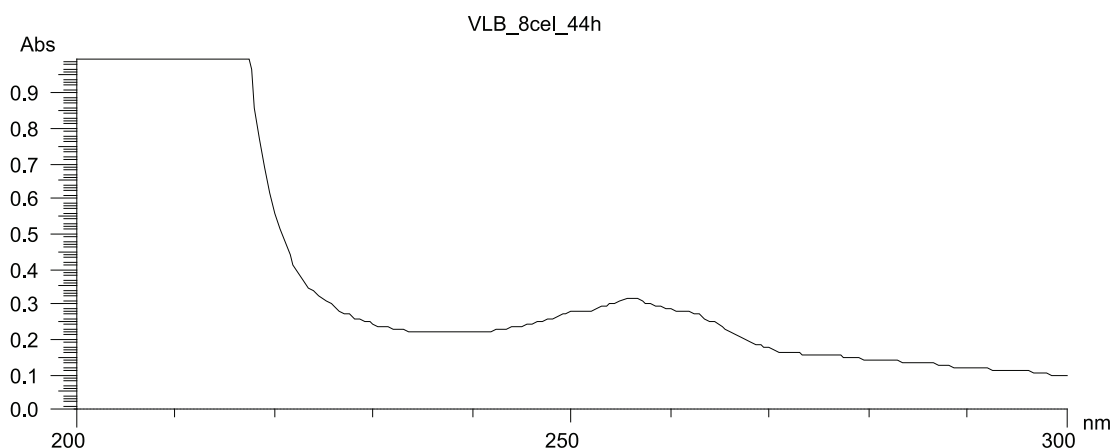


Fig. 3. Absorption spectrum of the tested solution of phenibut

UV-spectrum of phenibut within the range of 200–400 nm shows an absorption peak at 257 nm (Fig. 3).

#### Conclusions

It is recommended the use of spectroscopy technique in IR- and UV-ranges for the verification of identity of the phenibut substance in microcapsules.

The research was performed under financial support of RFBR in the framework of scientific project № 16-34-50140 mol\_nr.

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## Short Reports

PERSPECTIVES OF MONITORING  
FOR NEWCASTLE DISEASE

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Wild birds are considered to be the natural reservoir of the Newcastle disease virus (NDV; avian paramyxovirus-1) causing Newcastle disease, and are often suspected to be involved in outbreaks in domesticated birds. To evaluation the epidemiologic status of nucleic acids of environmental samples were sequenced by shotgun technology. It is shown simultaneous circulation of lentogenic, mesogenic and velogenic virus variants it provides a basis for new insights into monitoring system for Newcastle disease. Metagenomics can become an essential tool for the characterization of the epizootic situation in wild birds or poultry to develop the options and reduce the possibility of Newcastle disease outbreaks in poultry industry.

Infection of birds with virulent strains of Newcastle disease virus (NDV) causes one of the most important infectious diseases of poultry, 123 countries reported ND in domestic species to the World Organization for Animal Health (OIE). In 2016 there were about 35 such countries ([http://www.oie.int/wahis\\_2/public/wahid.php/Diseaseinformation/WI](http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/WI)) and many countries have endemic NDV, with outbreaks occurring year after year [1]. Although all NDV strains belong to a single serotype, they are nevertheless genetically highly diverse. Based on the complete fusion gene sequences, NDV strains are divided into two classes, I and II. In the latter, at least 18 genotypes and multiple subgenotypes have been defined [2–4], but the diversity continues to increase as surveillance improves. NDV has a spacious diapason of host, including approximately 241 species of 27 orders, of the known 50 orders of birds [1]. More commonly species include chickens, turkeys, ducks, pigeons, guinea fowl, Japanese quail and many wild birds of all ages [5]. The most susceptible avian species to this disease are chickens and also some mammals like humans, cats and dogs [6]. The disease transmits through droppings and secretions from the nose, mouth and eyes of infected birds. The disease spreads by contaminated water, feed and transport. Airborne transmission of the virus is also an important route of transmission for ND [7]. Mechanical transfer of infected faeces occurs by rodents, insects, dogs, fleas, or scavenging animals [7]. Infection takes place by virus inhalation, ingestion or by contact with conjunctiva.

The disease is characterized by respiratory, nervous system impairment, gastrointestinal and reproductive problems. ND causes huge economic losses to the commercial poultry farmers round the world [2]. Wild aquatic birds are considered as reservoir hosts for NDVs and may act as vectors for transferring these viruses to poultry, causing outbreaks of disease. However Newcastle disease

in wild birds occurs without clinical signs, which makes it difficult to diagnose the disease. The isolation of virus strains is possible in a small number of investigated samples. The number of positive samples does not exceed 10 %. This feature of the diagnosis and the possibility of simultaneous circulation of the various genetic types of the disease make it difficult to restrictive actions against the outbreak.

Therefore the aim of the our investigation was to use the NGS for detection of NDV at environmental samples. Nucleic acids of environmental samples were sequenced by a shotgun technologies (HiSeq, Illumina). Paired-end sequence reads generated from the Illumina HiSeq were assembled into contigs using standalone Edena software, freely available under the General Public License (GPLv3) at [www.genomic.ch/edena.php](http://www.genomic.ch/edena.php). This tool is all publicly available, and currently often used to assemble short reads generated by next-generation sequencing platforms, such as Illumina Genome Analyzer (read length = 35–150 bp). As a source of benchmark sequences (viral genomes) we used a standalone version of the NCBI nucleotide database, comprising 6079 complete genomes of viruses. It was found that environmental samples contain sequences of several genetic lines of the Newcastle disease virus. It is shown simultaneous circulation of lentogenic, mesogenic and velogenic virus variants and it provides a basis for new insights into monitoring system for Newcastle disease. This fact requires to carry out a vaccination program based on the possibility of circulation different viruses. Metagenomics could become an essential tool for the characterization of the epizootic situation in wild birds or poultry to develop the options and reduce the possibility of Newcastle disease outbreaks in poultry industry.

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## THE PHENOMENON OF SILYBUM MARIANUM

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The article presents the results of study of composition, properties, biological activity Silybum marianum. It is shown that the unique components of the plant possess wide range of biological effects. On the basis of the conducted researches we developed drugs Natursil and Silystrong, biologically active supplements to food, with well-expressed membrane-protective, antioxidant, reparative, immunomodulatory, cardiogenic, choleric, hepato-protective properties. This leads to the use of drugs in different branches of medicine: gastroenterology, surgery, obstetrics and gynecology, pulmonology, cardiology, otolaryngology, dentistry. With the use of experimental models at different levels of structural-functional organization, the molecular mechanisms of action and biologically active substances of milk thistle were studied. We installed their activating effect on enzymes of glycolysis, including revitalizing effect under conditions of oxidative stress, studied neuron activating properties of drugs. The ability of silystrong to affect protein-protein interaction allows the use of the drug as a metabolic probe. Shows the different responses of group-specific antigens of the system ABO to the introduction of Silystrong, demonstrating the specificity of individual response to the action of biologically active substances, drugs, xenobiotics, toxicants, due to the peculiarities interprotein relationships. The obtained results allow to recommend drugs from Silybum marianum as tools for targeted correction of metabolism, ecoprotection with broad spectrum.

**Keywords:** Silybum marianum, biologically active substances, ecoprotector, natursil, silystrong, metabolic processes, glycolytic enzymes, protein-protein interaction, the ABO blood group antigens

Public health has been the most important biosocial problem for years. Human existence in a technologically transformed environment leads inevitably to environmentally induced changes, which are the metabolic substrates for the multifactorial diseases. In the current situation, the maintenance of the dynamic constancy of the environment and the balance of interspecies relationships are essential as a foundation for successful interactions in the global ecosystem. This approach considers the objects of animate and inanimate nature as carriers of biologically active substances accumulated in various species. The optimal source of these compounds are plants, as they are capable for self-reliance, preservation of species, synthesis of biopolymers, aliphatic and polycyclic substances with complex structure and different regulatory properties [1, 2, 3, 4]. These natural compounds are similar to the human being, as they ingested to the organism historically via food chains and participated in metabolism.

We studied milk thistle (*Silybum marianum*), planted in Samara region as a carrier of biologically active substances. The idea of our study was preceded with a large research of exchange processes in norm and pathology by professor F. N. Gilmiyarova. For the first time from human and animal tissues glycolytic enzymes were isolated, purified to a homogeneous state, and their structural and functional

properties were studied in physiological conditions, atherosclerosis, alcohol intoxication. We installed the molecular level of alteration under these pathological conditions and revealed the specific parts of pathogenesis [5–14]. Enzyme drugs of fructose-bisphosphate aldolase (EC 4.1.2.13), glyceraldehyde-3-phosphate dehydrogenase (EC 1.2.1.12), glycerol-3-phosphate dehydrogenase (EC 1.1.1.8) were obtained by F.N. Gilmiyarova, V.M. Radomskaya, L.N. Vinogradova using the original technology, normalized and proposed for performing analytical studies and enzyme diagnostics. Isolation and purification enzyme methods are protected by copyright certificates and patents [15–17].

We also studied the influence of exogenous dehydrogenases on the integral metabolism. Malate dehydrogenase (EC 1.1.1.37) and lactate dehydrogenase (EC 1.1.1.27), marked with tritium were used as molecular probes. For the first time penetration into the brain, the liver, the heart, kidneys and other organs were discovered by analyzing the distribution of enzymes in the organs and tissues, evaluation of the dynamics of distribution and excretion. All of these opens up a lot of prospects for the development of new enzyme therapy areas [18–20].

Quite a large branch of research focused on valeological direction. We studied the state of metabolism in ecologically unfavorable regions and elucidated the biochemical deterioration mechanisms of public health. Furthermore, we

identified targets for target metabolism correction [21–29]. Searching the essential factors with curative properties had become one of the scientific biochemistry school branches in Samara.

Milk thistle (*Silybum marianum*, *cardus marianus*) is an annual or biennial plant of the Asteraceae family, achenes are used as a medical raw. The author's collective studied chemical composition of achenes in detailed. Due to variety of methods, such as gas-liquid chromatography, high-performance liquid chromatography, emission analysis, ultraviolet and infrared spectroscopy, spectrophotometry, NMR we determined the composition of milk thistle seeds: proteins (17–18%), lipids (10–11%), including saturated and unsaturated fatty acids, tocopherols (17–18 mg%), carotenoids (1,6 mg%), flavolignans (2–3% of dry weight), carbohydrates (2,0%), trace minerals [30]. The lipophilic fractions composition of the *Silybum marianum* fruits (milk Thistle oil) is diverse, it contains a complex of biologically active substances [31] (Table 1).

Unique composition of studied fruits are allowed to presume that the fraction remaining after the primary processing of raw materials may contain substances with remarkable biological properties. Using this non-waste technology, we obtained Natursil drug (thistle oil) from the fruit by pressing and Silistrong drug

(water-alcoholic extract) from the grist; both of them are food supplements.

Mass production of drugs was preceded by the series of experimental studies based at Samara State Medical University, as well as in cooperation with Russian leading specialized research centers: the laboratory of drug toxicology, institute of experimental cardiology of Russian cardiological center, research institute of nutrition (Russian Academy of Sciences), research institute of Emergency care named after N.V. Sklifosovsky, institute of surgery named after A.V. Vishnevsky, interregional center of thermal injuries and plastic surgery, Samara Military Medical Institute, chair of biochemistry of Bashkir state medical University.

During the preclinical phase general and specific pharmacological activity, pharmacokinetics, acute and chronic toxicity, local irritating, immune, allergenic action, the possibility of carcinogenic, mutagenic properties were defined. Laboratory experiments on various species showed that milk thistle drugs did not possess local irritant, skin-resorbing, sensitizing effects. Toxicity study revealed the low drugs toxicity even at the maximum possible doses (200–250 times greater than recommended for human highest daily therapeutic dose). The absence of the studied drugs mutagenic

Table 1

Physical and chemical composition of milk thistle oil

Category	Charasteristics
Color	From light yellow to yellowish brown
Physical condition	Oily liquid
Density	0,910–0,930
The refractive index	1,457–1,480
Acid number	≤ 5,0
Saponification value	180–205
Iodine number	65–90
The fatty acid composition, %	
Saturated:	
– palmitic (16:0)	10,8 ± 2,3
– stearic (18:0)	3,61 ± 0,84
Unsaturated:	
– oleic (18:1)	22,1 ± 5,37
– linoleic (18:2)	60,8 ± 9,16
– linolenic (18:3)	1,32 ± 0,38
Tocopherols, mg %:	
– α-Tocopherols	35,4
β- and γ-Tocopherols	16,8
Carotenoids, mg % (lutein and zeaxanthin)	4,9
Flavolignans (silymarin), mg %	≥ 25



and DNA-damaging effects, potential carcinogenic risk was discovered. In addition, milk thistle preparations had no negative effects on the reproductive function, no embryo toxicity and teratogenicity were found.

Completing this block of studies, we moved to clinical trials. Initially Natursil was declared as anti-ulcer agent (patent № 2051686 from 10.01.1996). Its ability to accelerate epithelialization, reparation and regeneration of skin defects of different origin was established during the pre-clinical stage. However, in clinical studies it was shown that milk thistle drugs had not only anti-inflammatory and wound-healing effect, but also membrane-protective, immunomodulatory, cardiotonic, choleretic, antioxidant, hepatoprotective properties, they increased tolerance to physical and mental stress. Based on these results we registered drugs Silistrong (Pharmacopoeia article 42-

0211-0703-01) and Natursil (Pharmacopoeia article 42-3889-99). They were included in the State register of medicines of the Russian Federation. We obtained 14 patents for invention, for 24 PhDs and 14 doctorates of science it was the basis of their researches.

The result of the scientific research was the creation of scientific and methodological basis for the nutritional supplements Natursil and Silistrong production. Technological complex in the ecologically clean region of Ulyanovsk was built on the basis of Sengileevskiy grain enterprises for growing plants, raw materials processing and obtaining biologically active substances from milk thistle. These nutritional supplements are available in pharmacies and can be used not only for ecological protection. The milk thistle clinical effects variety determined a wide scope for using it in different branches of medicine (Table 2).

Table 2

The fields of medicine and main clinical effects of Natursil

Field of medicine	Clinical effect	Way of use
Gastroenterology (Peptic and duodenal ulcer; acute and chronic liver diseases)	Recovering time reduction of mucous membrane natural morphological structure at the site of the ulcer, reduction of dyspepsia [33]	Per os (peptic ulcer), using endoscope (duodenal ulcer)
Surgery (Burn wounds different severity and localization)	Accelerated necrotic tissue rejection and epithelialization, formation of elastic scar tissue, healing of skin flap, epithelium activation in autological dermal transplantant, reduction of microbial contamination in burn surface [30, 34]	Application to the burnt surface
Obstetrics and gynecology: (Cervical erosion, post-natal complication)	Time reduction of inflammation with subsequent epithelialization of surface erosion, allows to avoid surgical treatment if recurrent and sluggish processes; metabolism normalization during gestation [30, 35]	Application, intravaginal tampons  Per os 1/2 tea spoon 3 times per day from 32 to 34 gestation weeks
Pulmonology (Chronic bronchitis in acute stage)	Immunostimulating effect, enhancing antibacterial effect [36], reducing the time of inflammatory process resolution in the lungs [37]	Per os 1 tea spoon 2 times per day for 2 weeks
Cardiology (Cardiac ischemia)	Plastic process improvement in the cardiac muscle, antioxidant and membrane stabilizing effect in ischemia conditions [38, 39]	Per os 1 tea spoon 3 times per day for 2 weeks
Otorhinolaryngology (Inflammatory diseases of the upper respiratory tract)	Anti-inflammatory effect on the mouth and nose mucous membranes [30]	Application
Stomatology (Inflammatory diseases of the oral cavity)	Anti-inflammatory, analgetic, regenerative effects in chronic generalized periodontitis, chronic apical periodontitis in the postoperative period [40–42]	Turunda into periodontal pockets, application
Dermatology and cosmetology	The improvement of the face skin, manifested by a decrease in dryness of the skin, fat normalization, decreasing the depth of wrinkles [43, 34, 44]	Application, masks

The desire to provide citizens of the ecologically unfavorable regions available methods of metabolic correction, which can be used routinely, prompted the authors to create the biologically active food supplements. Methods of administration milk thistle supplements in the composition of bakery and confectionery products, drinking water, soft drinks were developed:

- “Additive of ground seeds of milk Thistle”, patent № 2053598 from 26.01.1996;
- “The composition of ingredients for the production of bread and bakery products”, patent № 2099949 from 27.12.1997;
- “Mix butter biscuit”, patent № 2099950 from 27.12.1997;
- “Composition for the preparation of aerated confectionery products with anabolic properties”, patent № 2099960 from 27.12.1997;
- “Composition ingredients “Samaritan woman” for making non-alcoholic drinks”, patent № 2113808 from 27.06.1998.

This approach allowed us to make food of average citizens more healthy adding antioxidant properties [45–47]. All supplements of milk thistle was registered in the Federal register of biologically active additives to food.

The success of using milk thistle drugs and food supplements for the prevention and treatment of various diseases, as well as the variety of clinical effects observed in different organs and systems, determined the further course of our research. We tried to study molecular mechanisms of action of the components of milk thistle at various levels of structural-functional organization by experiments *in vitro*, *in vivo*, *ex vivo*, *in silico*.

As we mentioned before, there was a large group (12 compounds) of flavolignans in the composition of milk thistle among substances with valuable biological properties. Flavolignans were up to 70–90 % of the total flavonoids amount presented with silybin and its isomers – isosilybin, dehydrosilybin, silychristin, silychristin, digidroergochristin, silidianin [48–50]. Considering the effects of milk thistle and possible mechanisms of their realization at the molecular level, we applied to the basic postulate of A.M. Butlerov theory: the properties of substances are determined by their chemical structure. This problem was solved by using computer aided Prediction of Activity Spectra for Substances (PASS C&T) and “Pharma Expert”, developed by the staff of the structural and functional drugs design Laboratory of the research Institute of Biomedical chemistry named after V.N. Orechovich – full member of the Russian Academy of medical Sciences

Professor V.V. Poroikov, PhD A. Filimonov. Prediction of pharmacological activity, biological effects of substances and possible mechanisms of their realization are based on the analysis of their chemical structure. Spectrum of biological activity is described qualitatively: estimated probability of presence (Pa) and the lack of each type of activity (Pi) having values from 0 to 1. Since in our case we investigated molecules with known structure, the optimal value of the presence activities probability was considered more than 0,5. The use of the computer program allowed us to identify 154 the possible effects of milk thistle flavolignans, including a number of new properties along with established in the experimental studies [52]. The probability to possess antitoxic, hepatoprotective, antiviral, antioxidant, antineoplastic, anti-apoptotic, fibrinolytic effects and to regulate the metabolism of lipids and nucleotides were shown.

We found meaningful to compare the spectra of biological activity of each isomer of silybin. Different isomers had different spectre of activity which is probably due to the peculiarities of the chemical structure. Hence, silybin and isosilybin, being identical in chemical structure, differing only slightly in the spatial configuration of remnant of conifery alcohol, have identical effects and numerical values of the effects presence probabilities. These isomers have antioxidant (Pa 0,688), fibrinolytic (Pa 0,666), antiherpetic (Pa 0,655) activity, as well as the ability to inhibit lipid peroxidation (Pa 0,586). Dehydrosilybin involved in the strengthening of vascular walls (0,629 Pa), moreover, it is an agonist of apoptosis (Pa 0,792) and regulator of the nucleotides metabolism (Pa 0,535).

Silychristin, being the most reactive object, shows the highest ability to stabilize the cell membranes (Pa 0,952), has antitoxic and hepatoprotective effects (Pa 0,904 and 0,816). Isosilybin (silychristin isomer) acts as a “free radicals trap” (Pa 0,762). Silydianin has the strong antitumor effect (Pa 0,782). It is highly noteworthy, that no mutagenicity, teratogenicity, carcinogenicity, cardiotoxicity was revealed during our study.

Paying attention to the wide range of possible milk thistle lignan flavonoids biological effects, we may conclude that the mechanisms of their realization is regulation of the cell metabolism key enzymes activity. We used polisubstrate multienzyme system of muscle tissue homogenate and lysate of erythrocytes as an experimental model. Studying the influence

of silystrong, as well as silymarin and ethanol on the activity of glyceraldehyde 3-phosphate dehydrogenase (EC 1.2.1.12), glycerol phosphate dehydrogenase (EC 1.1.1.8) and lactate dehydrogenase (EC 1.1.1.27) we discovered that, silystrong caused significant rate changes in the studied enzyme reactions; silymarin and ethanol showed less biological effects [51–53]. The activity of lactate dehydrogenase increased from  $0,321 \pm 0,006$  to  $0,623 \pm 0,007$  E/mg (+94,1%,  $p < 0,001$ ), glyceraldehyde 3-phosphate dehydrogenase (+86,5%,  $p < 0,001$ ). The most important changes were observed in the reaction with glyceraldehyde-3-phosphate dehydrogenase. The rate of reaction catalyzed by this enzyme increased in 2 times (+110%,  $p < 0,001$ ). Adding erythrocytes in the lysate of the silymarin solution revealed no significant changes: the activity of glyceraldehyde 3-phosphate dehydrogenase increased (+8,9%,  $p > 0,05$ ), the reaction rate with lactate dehydrogenase stayed unchanged. However, the rate of the glycerol phosphate dehydrogenase reaction increased (+57,1%,  $p < 0,01$ ) compared to baseline. Incubation with ethanol resulted in an increasing activity of glyceraldehyde-3-phosphate dehydrogenase from  $0,251 \pm 0,003$  to  $0,440 \pm 0,002$  U/mg (+75,3%,  $p < 0,001$ ), glycerol phosphate dehydrogenase (+27,1%,  $p < 0,05$ ). The rate of the final stage of glycolysis increased in 1,6 times (+63,1%,  $p < 0,01$ ).

We noticed similar patterns in the reactions with homogenate of muscle tissue (Table 3). The significant changes were observed in the reactions with the glyceraldehyde-

3-phosphate dehydrogenase, the activity after the incubation with silystrong, silymarin and ethanol increased to 487,4; 190,4; 346,2%, respectively ( $p < 0,001$ ).

Considering high antioxidant activity of lignan flavonoids, we studied their effects on the glycolytic enzymes activity under the conditions of oxidative stress. In vitro experiments established the modifying effect of hydrogen peroxide on the studied dehydrogenases: complete disappearance of the of glyceraldehyde-3-phosphate dehydrogenase activity, inhibition of the lactate dehydrogenase (–53,5%,  $p < 0,01$ ) and glycerol phosphate dehydrogenase (–48,2%,  $p < 0,01$ ). Incubation of enzymes with silystrong observed the recovery of lactate dehydrogenase activity to 90,4% ( $p < 0,01$ ), glycerol phosphate dehydrogenase activity to 75,5% ( $p < 0,01$ ), glyceraldehyde-3-phosphate dehydrogenase to 12,0% ( $p < 0,05$ ). Pre-incubation with silystrong provided the protective effect, helped to enhance and maintain the activity of dehydrogenases. Thus, thistle flavolignans have a revitalizing effect on glycolytic enzymes that covers them from the damaging effects of oxidants. This is one of the mechanisms of the silystrong activity [51–54].

The results of biological effects computer prediction and literature analysis showed that flavolignans possessed the neurotropic activity [55–58]. However, the specific mechanisms of this effect were not discovered during the study and deserves special attention, as it allows studying the effect of lignan flavonoids on the tissue and organ-specific level.

Table 3

The activity of glycolytic enzymes (U/mg) from the homogenate of muscle tissue after incubation with silystrong, silymarin and ethanol

	Control	Silystrong	Silymarin	Ethanol
Glyceraldehyde 3-phosphate				
Initial value	$0,506 \pm 0,049$	$0,492 \pm 0,061$	$0,509 \pm 0,038$	$0,511 \pm 0,023$
Incubation with drugs		$2,89 \pm 0,24^{***}$	$1,48 \pm 0,27^{***}$	$2,28 \pm 0,31^{***}$
Deviation, %		+ 487,4	+ 190,8	+ 346,2
Glycerol phosphate dehydrogenase				
Initial value	$0,305 \pm 0,026$	$0,311 \pm 0,034$	$0,296 \pm 0,026$	$0,298 \pm 0,022$
Incubation with drugs		$0,521 \pm 0,056$	$0,411 \pm 0,033^{**}$	$0,278 \pm 0,022^*$
Deviation, %		+67,5	+38,8	–6,7
Lactate dehydrogenase				
Initial value	$2,44 \pm 0,26$	$2,32 \pm 0,21$	$2,46 \pm 0,28$	$2,39 \pm 0,23$
Incubation with drugs		$3,28 \pm 0,31^{***}$	$3,07 \pm 0,22^{**}$	$2,69 \pm 0,29^*$
Deviation, %		+41,4	+24,8	+12,6

Notes: \*  $p > 0,5$ ; \*\*  $p < 0,01$ ; \*\*\*  $p < 0,001$ .

We studied the silystrong effects on the brain cells apoptosis and neurons pacemaker activity in the experiment with animals. The TUNEL-positive cells level was less than 2% in the control group of animals. We registered 4 times increasing cells level in the group of animals with acute ischemia. The percentage of apoptotic cells to the total number increased from  $3,4 \pm 0,46\%$  after 24 hours after the start of the experiment to  $8,1 \pm 0,73\%$  on the 7th days after surgery. We registered the lower level of apoptosis in the group of animals with ischemia giving the silystrong to the animals. The number of TUNEL-positive cells remained stable, not exceeding the limit throughout the experiment (Table 4) [20, 59].

In our opinion, flavolignans may act as a source of protons, which are essential for the normal functioning of the mitochondria respiratory chain and the processes of energy saving. Hence, these allow them to maintain the apoptosis at the physiological level.

The results of the study indicated the possibility of silystrong to influence various bio-

ties and the ability to regulate the permeability of cell membranes.

This researches revealed the mechanisms of silystrong neurotropic action, which may explain the effectiveness in asthenic syndrome [61], it can be used as a reserved drug on the practice of disaster medicine and emergency situations (patent № 56880 from 05.04.2011 "lifeline").

It should be noted that we used as a standard experimental model at each stage of the study, we have developed the methodology of the experiments that allowed us to assess the biological effects of the studied compounds. The success in proteomics, metabolomics, genomics, and progress in high-tech methods provided us a detailed study of the proteins structural organization. The key elements in the implementation of the functions of the body are protein-protein interactions, their alteration can lead to the chain of pathological conditions [62–66]. For the first time as a model for studying protein-protein interactions, assessment of the dynamics in intact conditions and

**Table 4**

The percentage of TUNEL-positive cells in brain tissue of rats under the condition of acute ischemia with the introduction of silystrong (for 100% accepted the total number of cells in the tissue sample)

Animal groups	After 24 hours	After 48 hours	After 168 hours
Control	$2,0 \pm 0,087$	$1,9 \pm 0,056$	$2,0 \pm 0,088$
Without silystrong	$3,4 \pm 0,46^*$	$6,5 \pm 0,51^*$	$8,1 \pm 0,73^*$
With silystrong	$2,0 \pm 0,053$	$1,0 \pm 0,034$	$2,6 \pm 0,081$

Note: \*  $P < 0,01$ .

chemical and physiological processes, into the nerve cell in particular. Next, we tried to discover the mechanisms of silystrong effect on the group neurons activity and to clarify the role of the drug in the electrophysiological processes of interaction. The task was solved with simulation of neuronal centers activities in vitro. We investigated spontaneous electrical activity with pontobulbospinal and bulbospinal preparations of newborn rats perfused with artificial CSF with the addition of silystrong. It was established that the introduction of milk thistle hydroalcoholic to the bulbospinal preparation caused the increasing pacemaker activity of the respiratory center [60]. Silystrong obviously affects the changes in action potential of the membrane receptors activating respiratory pacemaker due to the membranotropic proper-

under the influence of biologically active substances we used the antigens and antibodies of the AB0 blood group system and the drug silystrong as abiological probe. This approach was chosen to detect group-specific features of intermolecular interactions of glycoproteins and erythrocytes, differing in chemical structure [67, 68], with natural and monoclonal antibodies. This determined not only the group AB0 blood group, but also the differences of individual response to various stimules.

It was shown that the primary target for silystrong was a glycoprotein A. The drug slowed down the recognition and interaction of the antigen with the antibody, prolonged the time of agglutination occurrence on 75,0%. This effect was not revealed for the glycoprotein

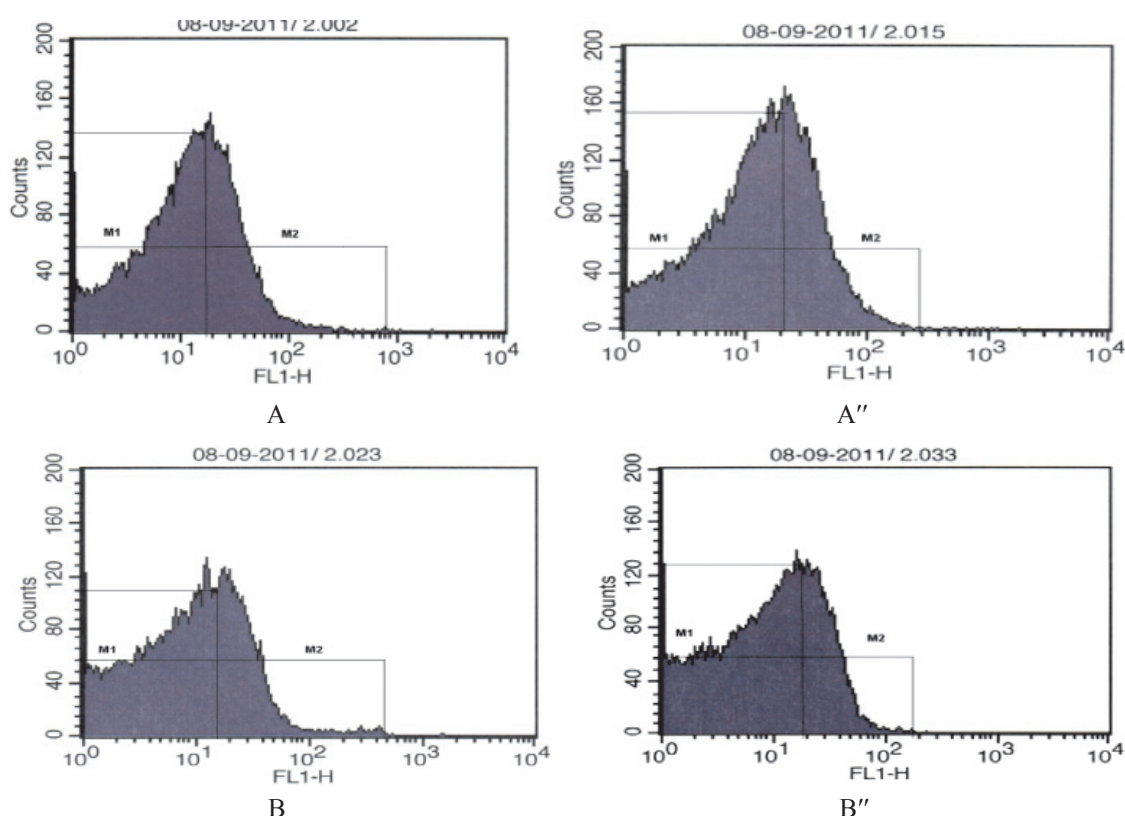


B. Monoclonal anti-A and anti-B antibodies were modified by silystrong, which increased the protein-protein interaction with the respective antigens. In the experiment with natural antibodies revealed a reduced capacity for agglutination anti-B antibodies in 70%, indicating a high sensitivity of the antigen-antibody system for A(II) blood group. The agglutinating capacity of anti-A-antibodies decreased by 16,0%, indicating a smaller reaction to external stimulates the antigen-antibody system of B (III) blood group. The results revealed the molecular basis of interaction with various pathogens, toxicants, leading to high morbidity for A(II) blood groups in comparison with B(III) blood group [69–71].

Visualization of antigen-antibody complexes using flow-cytometry and confocal laser scanning microscopy with labelled monoclonal antibodies discovered the differences in A and B antigens. Silystrong caused increasing the number of antigen-antibody complexes formed by glycoprotein and A monoclonal an-

ti-A-antibody, the number of antigen-antibody complexes with the glycoprotein B remained stable (Figure).

The obtained results allowed to highlight both theoretical and practical importance in various areas of scientific research. Firstly, silystrong can modify protein-protein interactions, hence, it can be a metabolic probe for studying these interactions. Secondly, we developed the molecular model of antigen-antibody interaction which can be used in testing a wide range of substances with biological and pharmacological activity ("Way of effect assessing of biologically active substances on antigen-antibody interaction" [72]. Thirdly, the differences in reactions with glycoproteins A and B to external stimulates revealed a necessity of population screening for the blood group affiliation, focusing on the people with A (II) blood group, as they form high-risk groups and are needed to perform personalized prevention. We developed the model rendered a qualitative and



Visualization of the antigen-antibody interaction using flow-cytometry:

Glycoprotein A – antibody complex (control); A'. Glycoprotein

A – antibody Complex (silystrong incubation); B. Glycoprotein B – antibody complex (control);

B' – Glycoprotein B – antibody complex (silystrong incubation)



quantitative assessment of protein-protein interaction, it is a target for the intermolecular interaction, determining the characteristics of the individual response to the action of biologically active substances, drugs, various xenobiotics, toxicants.

Thus, as a result of this research studying the composition and properties of milk thistle carried out by our team, as well as experimental and clinical substantiation of drugs using created on its basis and the molecular mechanisms of the biological activity implementation of Natursil and Silystrom components in various levels of structural and functional organization, we can recommended them as drugs for targeted metabolic correction and as ecoprotectors with wide spectrum of activities, maintaining a good quality health level.

P.S. Looking through this article, turning back 20 years ago, when the idea and the ways of its realization only arose, when we were making the first steps to understanding the phenomenon of milk thistle – only now you feel how much has been done and how much still can be done. The desire to reveal the pages of the secrets of nature, carefully planned experiments, daily painstaking work of scientists allowed to touch the truth, to keep the accumulated time of knowledge, to see the unknown, to understand the essence. All the amazing is very close, all the interesting is ahead...

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## INSPECTION STOPPING RULES FOR CONVENTIONAL INSPECTION AND INSPECTION WITH MEMORY

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We have found the expected number of inspected items, before the inspection is stopped, for such inspection stopping rules as “out of the last  $r$  items,  $k$  items are defective” for both conventional inspection procedures and inspection with memory. Also, we have found the expected number of inspected items, before the inspection is stopped, for such an inspection stopping rule as “out of the last  $r_1$  items, 2 items are defective, or out of the last  $r_2$  items,  $k_2$  items are defective” for conventional inspection.

**Keywords:** continuous inspection, inspection plan, probabilistic characteristics, recurrent events

The continuous inspection plan [1, 2, 3] is defined as a set of control rules and actions aimed at detecting the deterioration of product quality and at taking measures to normalize the production process. Those plans use such stopping rules as “out of the last  $r$  items,  $k$  items are defective” ( $r, k$  are integers,  $r \geq 2, 2 \leq k \leq r$ ). The application of such plans, when the inspection is stopped, implies that after the equipment is changed over or replaced, the inspection is recommenced without recording the results of the previous inspection.

This can be interpreted in the following way. Every produced item meets the standards with probability close to 1. Long-term production may lead to equipment failure, causing product quality deterioration. Once product quality deterioration is detected, inspection is stopped, the equipment is changed over or replaced to achieve product quality recovery and the inspection is recommenced without recording the results of the previous inspection.

Equipment changeover is impossible in human health risk management. In this case, when inspection is stopped, health risk reduction measures are taken. However, such measures cannot produce an immediate effect as they have a longer term impact. Taking this into account [4, 5] has proposed a new approach – continuous statistical inspection with memory. In contrast to the conventional inspection plan, continuous inspection with memory memorizes the last result after stopping of the inspection procedure and the next inspection does not

start from “point zero” but recommences taking into account the previous inspection data.

### Inspection stopping rules as recurrent events

It has been shown [4, 5] that an inspection stopping rule can be interpreted as an event  $E$ , which a finite set of conditions  $A_1, A_2, \dots, A_N$  correspond to, and the expected number of the inspected items until the occurrence of the event  $E$  is:

$$\mu(E) = \frac{\sum_{j=0}^{l-1} c_j}{P(E)}, \quad (1)$$

where  $A_1, A_2, \dots, A_N$  are conditions corresponding to the event  $E$ ;  $l = \max_{1 \leq i \leq N} L(A_i)$  is the maximum length of a condition corresponding to the event  $E$ ;  $c_h$  is the probability of transition from conditions  $A_1, A_2, \dots, A_N$ , corresponding to the event  $E$ , into the same conditions by  $h$  steps.

### Main results

Inspection stopping rules  $\Pi_l$  are used for the plans of continuous inspection by attributes. The probability of each item to be non-defective and defective is  $p$  and  $q = 1 - p$ , respectively. A non-defective item will be hereinafter designated as “0”, and a defective item as “1”.

Let us consider a classical case of inspection, i.e. the case where the previous inspection data are not recorded. We list all the conditions, which cause the stopping of inspection, for the stopping rules “out of the last  $r$  items,  $k$  items are defective” with  $k \geq 2, r \geq k$ . These conditions are:

$$\begin{aligned} & \left\langle \underbrace{1, 1, \dots, 1}_k \right\rangle, \left\langle \underbrace{1, 0, 1, \dots, 1}_{k+1} \right\rangle, \left\langle \underbrace{1, 1, 0, 1, \dots, 1}_{k+1} \right\rangle, \dots; \\ & \left\langle \underbrace{1, \dots, 1, 0, 1}_{k+1} \right\rangle, \left\langle \underbrace{1, 0, 0, 1, \dots, 1}_{k+2} \right\rangle, \dots, \left\langle \underbrace{1, \dots, 1, 0, 0, 1}_{k+2} \right\rangle, \dots; \\ & \left\langle \underbrace{1, 0, \dots, 0, 1, \dots, 1}_{r-k} \right\rangle, \dots, \left\langle \underbrace{1, \dots, 1, 0, \dots, 0, 1}_{r-k} \right\rangle. \end{aligned}$$

It is not difficult to see that the conditions, which have the length (the number of noughts and ones in a condition) of  $k$  are  $C_{k-2}^{k-2}$  conditions (i.e. only one condition), those, which have the length of  $(k+1)$ , are  $C_{(k+1)-2}^{k-2}$  conditions. Using the same line of reasoning, we obtain that the conditions, which have the length of  $r$  are  $C_{r-2}^{k-2}$  conditions. Therefore, the probability of the event  $E_1$ , which denotes the stopping of inspection according to the rule “out of the last  $r$  items,  $k$  items are defective”, is equal to

$$P(E_1) = q^k \sum_{i=k}^r p^{i-k} C_{i-2}^{k-2}$$

or

$$P(E_1) = q^k \sum_{j=0}^{r-k} p^j C_{j+k-2}^j.$$

Let  $l$  be the maximum length of the conditions corresponding to the event  $E_1$ ,  $l$  equals  $r$ . Note that  $c_0 = 1$  and let us find  $c_h$ , the probability of transition from the conditions, corresponding to the event  $E_1$ , into the same conditions ( $h$  varies from 1 to  $l-1$ ).

We shall use the following line of reasoning. During  $h$  steps, there can be  $i$  defective items ( $i$  varies from 1 to  $k-1$ ). The number of  $h$  steps should not be fewer than the number of defective items, but should not exceed the number, which equals  $(l-k+i)$ . Moreover, the number of variants of transition from the conditions, corresponding to the event  $E_1$ , into the same conditions is  $C_{h-1}^{i-1}$ . Therefore,

$$\sum_{j=1}^{l-1} c_j = \sum_{i=1}^{k-1} \sum_{h=i}^{l-(k-i)} C_{h-1}^{i-1} q^i p^{h-i}$$

or

$$\sum_{j=1}^{l-1} c_j = \sum_{i=1}^{k-1} \sum_{h=i}^{r-(k-i)} C_{h-1}^{i-1} q^i p^{h-i}.$$

Then

$$\sum_{j=0}^{l-1} c_j = 1 + \sum_{i=1}^{k-1} \sum_{h=i}^{r-(k-i)} C_{h-1}^{i-1} q^i p^{h-i}.$$

According to formula (1), we obtain the following equation for the expected number of the inspected items, before the inspection is stopped by the rule “out of the last  $r$  items,  $k$  items are defective” at  $k \geq 2$ ,  $r \geq k$ , when each item has probability  $p$  of being non-defective, and probability  $q = 1 - p$  of being defective:

$$\mu(E_1) = \frac{\sum_{j=0}^{l-1} c_j}{P(E_1)} = \frac{1 + \sum_{i=1}^{k-1} \sum_{j=i}^{r-k+i} q^i p^{j-i} C_{j-1}^{i-1}}{q^k \sum_{j=0}^{r-k} p^j C_{j+k-2}^j}. \quad (2)$$

In fact, we have proved the following theorem.

**Theorem 1.** The expected number of the inspected items, before the inspection is stopped in conventional inspection by the rule “out of the last  $r$  items,  $k$  items are defective”, with  $q$  denoting the probability of defectiveness of each item and  $p = 1 - q$  the probability of non-defectiveness of each item is equal to (2).

Let us consider inspection with memory, i.e. the case, where the data on the last inspected item is memorized when the inspection is stopped. Suppose that a defective item has been observed before the inspection is commenced. Let us list all the conditions (series), which lead to the stopping of the inspection, for such inspection stopping rules as “out of the last  $r$  items,  $k$  items are defective” at  $k \geq 2$ ,  $r \geq k$ . These are the following conditions:

$$\begin{aligned} & \left\langle \underbrace{1, 1, \dots, 1}_{k-1} \right\rangle, \left\langle \underbrace{0, 1, \dots, 1}_k \right\rangle, \left\langle \underbrace{1, 0, 1, \dots, 1}_k \right\rangle, \dots; \\ & \left\langle \underbrace{1, \dots, 1, 0, 1}_k \right\rangle, \left\langle \underbrace{1, 0, 0, 1, \dots, 1}_{k+1} \right\rangle, \dots, \left\langle \underbrace{1, \dots, 1, 0, 0, 1}_{k+1} \right\rangle, \dots; \\ & \left\langle \underbrace{1, 0, \dots, 0, 1, \dots, 1}_{r-k} \right\rangle, \dots, \left\langle \underbrace{1, \dots, 1, 0, \dots, 0, 1}_{r-k} \right\rangle; \end{aligned}$$



$$\begin{aligned}
& \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, 1, \dots, 1}_k \right\rangle, \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, 0, 1, \dots, 1}_{k+1} \right\rangle, \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, 1, 0, 1, \dots, 1}_{k+1} \right\rangle, \dots, \\
& \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, \dots, 1, 0, 1}_{k+1} \right\rangle, \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, 0, 0, 1, \dots, 1}_{k+2} \right\rangle, \dots, \\
& \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, \dots, 1, 0, 0, 1}_{k+2} \right\rangle, \dots, \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, 0, \dots, 0, 1, \dots, 1}_r \right\rangle, \dots, \left\langle \underbrace{0, \dots, 0}_{r-k+1}, \underbrace{1, \dots, 1, 0, \dots, 0, 1}_r \right\rangle.
\end{aligned}$$

It is not difficult to see that the conditions, which have the length of  $k-1$  and the length of  $(r-k+1) + (k)$  are  $C_{(k)-2}^{k-2}$  conditions, those, which have the length of  $k$  and the length of  $(r-k+1) + (k+1)$  are  $C_{(k+1)-2}^{k-2}$  conditions. Using the same line of reasoning, we obtain that the conditions, which have the length of  $r-1$  and the length of  $(r-k+1) + (r)$ , are  $C_{(r)-2}^{k-2}$  conditions. Therefore, the probability of the event  $E_1^P$ , which denotes the stopping of inspection according to the rule “out of the last  $r$  items,  $k$  items are defective”, in inspection with memory is equal to

$$P(E_1^P) = q^{k-1} \sum_{i=k}^r p^{i-k} C_{(i)-2}^{k-2} + q^k \sum_{i=k}^r p^{(r-k+1)+(i-k)} C_{(i)-2}^{k-2}$$

or

$$P(E_1^P) = q^{k-1} \sum_{j=0}^{r-k} p^j C_{(j)+k-2}^j + q^k \sum_{j=0}^{r-k} p^{(r-k+1)+j} C_{(j)+k-2}^j.$$

Next, let us assume that  $l^P$  is the maximum length of the conditions, corresponding to the

event  $E_1^P$ ,  $l^P$  equals  $2r-k+1$ . Note that  $c_0 = 1$  and let us find  $c_h$ , the probability of transition from the conditions, corresponding to the event  $E_1^P$ , into the same conditions ( $h$  varies from 1 to  $l^P-1$ ). We reason by analogy with the previous case. Let us schematically present, for the sake of illustration, the structure of steps for the number of inspection steps, which vary from 1 to  $r-1$ :

$$\left\langle \underbrace{X, X, X, X, X, X}_{\text{idefective items}}, [1] \right\rangle,$$

$h$  steps from 1 to  $r-1$

$$\left\langle \underbrace{0, 0, \dots, 0}_{r-k+1}, \underbrace{X, X, X, X, X}_{k \text{ defective items} + \text{nondefective items}}, [1] \right\rangle,$$

$h$  steps from  $r+1$  to  $2r-k+1$

where “1” is a defective item, “0” is a non-defective item and “X” is either a defective item or a non-defective one. Then

$$\sum_{j=1}^{l^P-1} c_j = \sum_{i=1}^{k-1} \sum_{h=i}^{r-(k-i)} C_{h-1}^{i-1} q^i p^{h-i} + \sum_{j=0}^{r-k} C_{j+k-2}^j q^k p^{(r-k+1)+j}.$$

Therefore,

$$\sum_{j=0}^{l^P-1} c_j = 1 + \sum_{i=1}^{k-1} \sum_{h=i}^{r-(k-i)} C_{h-1}^{i-1} q^i p^{h-i} + \sum_{j=0}^{r-k} C_{j+k-2}^j q^k p^{(r-k+1)+j}.$$

Plugging the obtained values of the probability of the event and the sum of the probabilities of transition of the conditions, corresponding to this event, into the same conditions, into formula (1), we obtain:

$$\mu(E_1^P) = \frac{1 + \sum_{i=1}^{k-1} \sum_{j=i}^{r-(k-i)} C_{j-1}^{i-1} q^i p^{j-i} + \sum_{j=0}^{r-k} C_{j+k-2}^j q^k p^{(r-k+1)+j}}{q^{k-1} \sum_{j=0}^{r-k} p^j C_{(j)+k-2}^j + q^k \sum_{j=0}^{r-k} p^{r-k+1+j} C_{(j)+k-2}^j}. \quad (3)$$



Let us develop a theorem based on the proposition, that was proven above.

**Theorem 2.** The expected number of the inspected items, before the inspection is stopped, in inspection with memory by the rule “out of the last  $r$  items,  $k$  items are defective”, with  $q$  denoting the probability of defectiveness of each item and  $p = 1 - q$  the probability of non-defectiveness of each item is equal to (3).

Evidently, for any fixed set of  $r$ ,  $k$  and  $q$ , the following inequality is true:

$$\mu(E_1^p) < \mu(E_1). \quad (4)$$

#### An additional result

It is clear that we can similarly consider inspection stopping rules  $P_2$ , which are employed for the plans of conventional continuous inspection by attributes. The probability of each item to be non-defective and defective is sup-

posed to be  $p$  and  $q = 1 - p$ , respectively. The inspection stopping rule  $P_2$  is “out of the last  $r_1$  items,  $k_1$  items are defective, or out of the last  $r_2$  items,  $k_2$  items are defective”, where  $r_2 > r_1$ ,  $k_2 > k_1$  and  $k_1 > 1$ .

Let us consider a conventional inspection case, i.e. the case where the inspection data is not recorded when the inspection is stopped. For inspection stopping rules  $P_2$ , assume that  $k_2/(k_1 - 1)$  is an integer (note that at  $k_1 = 2$  the number is always an integer) and let us describe all the conditions corresponding to the occurrence of the event  $E_{r_1, r_2, k_1, k_2}$ , i.e. the inspection stopping rule “out of the last  $r_1$  items,  $k_1$  items are defective, or out of the last  $r_2$  items,  $k_2$  items are defective”.

Let us first list those conditions, which correspond to the occurrence of the event “out of the last  $r_1$  items,  $k_1$  items are defective”. The conditions are:

$$\langle \underbrace{1, \dots, 1}_{k_1} \rangle, \langle 1, 0, \underbrace{1, \dots, 1}_{k_1+1} \rangle, \dots, \langle \underbrace{1, \dots, 1}_{k_1+1}, 0, 1 \rangle, \dots, \langle \underbrace{1, 0, \dots, 0}_{r_1-k_1}, \underbrace{1, \dots, 1}_{r_1} \rangle, \dots, \langle \underbrace{1, \dots, 1}_{r_1}, \underbrace{0, \dots, 0}_{r_1-k_1}, 1 \rangle.$$

Then, we list the conditions, which correspond to the occurrence of the event “out of  $r_2$  ( $r_2 > r_1$ ) last items,  $k_2$  ( $k_2 > k_1$ ) items are defective”. Note that until the occurrence of such an event, the condition, corresponding to this event, may have no more than  $(k_1 - 1)$  successive defective items. Otherwise, the event “out of the last  $r_1$  items,  $k_1$  items are defective” would occur earlier. Moreover, between the neighboring groups consisting of  $i$  and  $j$  defective items, if  $i + j \geq k_1$ , there should be a group consisting of no fewer than  $(k_1 - t)$  non-defective items, where  $t = \max(i, j)$ . Now, taking into account that  $k_2/(k_1 - 1)$  is an integer, we assume that it equals  $k_0$ . Thus, the minimum length, which is equal to

$$n_0 = k_2 + (k_0 - 1)(r_1 - k_1 + 1) = k_2 + \left( \frac{k_2}{k_1 - 1} - 1 \right) (r_1 - k_1 + 1),$$

belongs to the following condition

$$\langle \underbrace{1, \dots, 1}_{k_1-1}, \underbrace{0, \dots, 0}_{r_1-k_1+1}, \underbrace{1, \dots, 1}_{k_1-1}, \dots, \underbrace{1, \dots, 1}_{k_1-1} \rangle$$

where  $k_0$  groups consisting of  $(k_1 - 1)$  defective items and  $(k_0 - 1)$  group consisting of  $(r_1 - k_1 + 1)$  non-defective items. It is clear that the length, which is equal to

$$k_2 + \left( \frac{k_2}{k_1 - 1} - 1 \right) (r_1 - k_1 + 1) + 1,$$

belongs to the following conditions:

$$\langle \underbrace{1, 0, \dots, 1}_{k_1}, \underbrace{0, \dots, 0}_{r_1-k_1+1}, \underbrace{1, \dots, 1}_{k_1-1}, \dots, \underbrace{1, \dots, 1}_{k_1-1} \rangle, \langle \underbrace{1, 0, 1, \dots, 1}_{k_1}, \underbrace{0, \dots, 0}_{r_1-k_1+1}, \underbrace{1, \dots, 1}_{k_1-1}, \dots, \underbrace{1, \dots, 1}_{k_1-1} \rangle, \dots, \langle \underbrace{1, \dots, 1}_{k_1-1}, \underbrace{0, \dots, 0}_{r_1-k_1+1}, \underbrace{1, \dots, 1}_{k_1-1}, \dots, \underbrace{1, \dots, 1}_{k_1-1}, 0, 1 \rangle.$$

Using the same line of reasoning, we find that the maximum length, which is equal to  $r_2$ , belongs to such conditions as

$$\langle \underbrace{1, 0, \dots, 0}_{r_2-n_0}, \underbrace{1, \dots, 1}_{k_1-2}, \underbrace{0, \dots, 0}_{r_1-k_1+1}, \underbrace{1, \dots, 1}_{k_1-1}, \dots, \underbrace{1, \dots, 1}_{k_1-1} \rangle, \dots, \langle \underbrace{1, \dots, 1}_{k_1-1}, \underbrace{0, \dots, 0}_{r_1-k_1+1}, \underbrace{1, \dots, 1}_{k_1-1}, \dots, \underbrace{1, \dots, 1}_{k_1-2}, \underbrace{0, \dots, 0}_{r_2-n_0} \rangle.$$

Then, the probability of the occurrence of the event  $E_{r_1, r_2, k_1, k_2}$  equals the sum of probabilities of the conditions, which are described above:

$$P(E_{r_1, r_2, k_1, k_2}) = q^{k_1} \sum_{i=0}^{r_1-k_1} p^i C_{i+k_1-2}^i + q^{k_2} p^{(k_0-1)(r_1-k_1+1)} \sum_{i=0}^{r_2-(k_0-1)(r_1-k_1+1)-k_2} p^i C_{i+k_2-2}^i. \quad (5)$$

Let us fix  $k_1 = 2$  ( $k_0$  is an integer) and find  $P(E_{r_1, r_2, 2, k_2})$ , i.e. the probability of the occurrence of the event  $E_{r_1, r_2, 2, k_2}$ :

$$P(E_{r_1, r_2, 2, k_2}) = q^2 \sum_{i=0}^{r_1-2} p^i + q^{k_2} p^{(k_2-1)(r_1-1)} \sum_{i=0}^{r_2-r_1(k_2-1)-1} p^i C_{i+k_2-2}^i. \quad (6)$$

Now we find  $\sum_{j=0}^{l-1} c_j$ . To do this, let us note that base "1" is included into any condition, corresponding to the event  $E_{r_1, r_2, 2, k_2}$  and  $c_0 = 1$ . Then, it is easy to see that

$$\sum_{j=0}^{l-1} c_j = 1 + q \sum_{i=0}^{r_1-2} p^i + q^{k_2-1} p^{(k_2-1)(r_1-1)} \sum_{i=0}^{r_2-r_1(k_2-1)-1} p^i C_{i+k_2-2}^i + \sum_{j=1}^{k_2-2} q^j p^{j(r_1-1)} \sum_{i=0}^{r_2-r_1(k_2-1)-1} p^i C_{i+j-1}^i. \quad (7)$$

Indeed, the first summand reflects the fact that  $c_0 = 1$ , the second and the third summand reflects the probability of transition into the conditions, corresponding to  $E_{r_1, r_2, 2, k_2}$  from base "1". The forth summand is the sum of the probabilities of transition into the conditions, corresponding to the event  $E_{r_1, r_2, 2, k_2}$  from bases, which are different from base "1".

Thus, we obtain the expected number of the inspected items, before the inspection is stopped, by such inspection stopping rule as "out of the last  $r_1$  items, 2 items are defective, or out of the last  $r_2$  items,  $k_2$  items are defective":

$$\mu(E_{r_1, r_2, 2, k_2}) = \frac{1 + q \sum_{i=0}^{r_1-2} p^i + q^{k_2-1} p^{(k_2-1)(r_1-1)} \sum_{i=0}^{r_2-r_1(k_2-1)-1} p^i C_{i+k_2-2}^i + \sum_{j=1}^{k_2-2} q^j p^{j(r_1-1)} \sum_{i=0}^{r_2-r_1(k_2-1)-1} p^i C_{i+j-1}^i}{q^2 \sum_{i=0}^{r_1-2} p^i + q^{k_2} p^{(k_2-1)(r_1-1)} \sum_{i=0}^{r_2-r_1(k_2-1)-1} p^i C_{i+k_2-2}^i}. \quad (8)$$

In fact, we have proved the following theorem.

**Theorem 3.** The expected number of the inspected items, before the inspection is stopped in conventional inspection by the rule "out of the last  $r_1$  items, 2 items are defective, or out of the last  $r_2$  items,  $k_2$  items are defective", with  $q$  denoting the probability of defectiveness of each item and  $p = 1 - q$  the probability of non-defectiveness of each item, is expressed by formula (8).

### Conclusion

Inspection stopping rules play a significant role in a continuous inspection plan, in which they are included.

In practice, using any inspection stopping rules, the following measures are tak-

en. If the really inspected number of items, before the inspection is stopped, is fewer than the expected number of the inspected items for fixed  $p$  (the probability of item's non-defectiveness, i.e. for the normal production of items), then measures are taken to normalize the production process. These may be the producing equipment changeover or replacement in flow-line production or preventive measures in human health management. If the really inspected number of items, before the inspection is stopped, is greater than or equal to the expected number of the inspected items for fixed  $p$ , then inspection is continued without taking any measures.

This can be interpreted in the following way: what happened, happened. In this

case, in conventional inspection statistical data is not recorded while inspection with memory memorizes the last inspection step. It is the distinction between inspection with memory and conventional inspection.

In this work, we demonstrate that the number of inspected items, before the inspection is stopped, for any fixed set  $r, k, q$  and for a fixed inspection stopping rule in inspection with memory is fewer than that in conventional inspection, which follows from relation (4). In [5] a table for inspection stopping rule “out of the last  $r$  items, 2 items are defective” was presented as an example.

The main results obtained in this work for the inspection stopping rule “out of the last  $r$  items,  $k$  items are defective” at  $k \geq 2$ ,  $r \geq k$  for conventional inspection as well as for inspection with memory and for the rule

“out of the last  $r_1$  items, 2 items are defective, or out of the last  $r_2$  items,  $k_2$  items are defective” for conventional inspection, are formulated in theorems.

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# STUDY OF NAVIER – STOKES EQUATION SOLUTION I. THE GENERAL SOLUTION OF NONLINEAR ORDINARY DIFFERENTIAL EQUATION

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Values of large dimensionless unknown functions (for example, a large Reynolds number) can be found out as solutions of non-linear partial differential equation. In this case these equations can be brought to some number of non-linear ordinary differential equations. Turbulent solutions corresponding to large values of unknown function are complex. Transition from real solution to complex turbulent solution is realized through infinity of the right parts of ordinary differential equation system to which Navier – Stokes equations are brought. Thus, real solution of Navier – Stokes equation for turbulent mode yields function going to infinity. At the same time, complex solution for the turbulent mode is finite. Fluid flow resistance coefficient is calculated for round pipeline with different pipeline walls roughness.

**Keyword:** large dimensionless unknown functions, solutions of non-linear partial differential equation, Navier – Stokes equation, turbulent function, fluid flow resistance coefficient, round pipeline

## Problem Formulation

Let us consider Navier – Stokes problem and continuity equation for incompressible fluid. They are as following

$$\frac{\partial \mathbf{V}_k(t, \mathbf{r})}{\partial t} + \sum_{l=1}^3 \mathbf{V}_l(t, \mathbf{r}) \frac{\partial \mathbf{V}_k(t, \mathbf{r})}{\partial x_l} = - \frac{\partial P(t, \mathbf{r})}{\rho \partial x_k} + \nu \Delta \mathbf{V}_k(t, \mathbf{r}), \quad k = 1, \dots, 3.$$

$$(\nabla, \mathbf{V}) = 0$$

Boundary conditions on the body boundary adjoining to fluid are  $\mathbf{V}(t, \mathbf{r}) = 0$ ,  $\mathbf{r} \in S$  where  $S$  is a body boundary. We will seek a solution in the form of series using Galerkin method (hereinafter  $N \rightarrow \infty$ )

$$\mathbf{V}_l(t, \mathbf{r}) = \sum_{n=1}^N \mathbf{x}_{nl}(t) \varphi_{nl}(\mathbf{r}), P(t, \mathbf{r}) = \sum_{n=1}^N y_n(t) \psi_n(\mathbf{r}) + \psi_0(\mathbf{r});$$

$$\mathbf{r} \in S \rightarrow \varphi_n(\mathbf{r}) = 0, \varphi_n(\mathbf{r}), \psi_n(\mathbf{r}) \in C^2,$$

where space  $C^2$  is twice continuously differentiable function,  $\psi_0(\mathbf{r})$  is a defined external action which, in case of pipeline, is equal to

$$\psi_0(\mathbf{r}) = \frac{-(P - P_0)z}{L} + P,$$

where  $z$  – direction of the pipeline longitudinal;  $P, P_0$  – pressure at the beginning and the end of the pipeline;  $L$  – pipeline length.

Now we substitute these functions into the differential equation, multiply by  $\psi_m(\mathbf{r})$  and integrate over the volume, then we obtain following differential equations system:

$$\frac{dx_m(t)}{dt} = \sum_{p,q=1}^{3N} F_{mpq} x_p(t) x_q(t) + \sum_{p=1}^{4N} G_{mp} x_p(t) + H_m, \quad m = 1, \dots, 3N;$$

$$\sum_{p=1}^{3N} P_{mp} x_p(t) = 0, \quad m = 1, \dots, N. \quad (\text{A.1})$$

After we resolved the second equation (A.1), substituted

$$x_{n+2N}(t) = \sum_{m=1}^{2N} c_{nm} x_m(t), \quad n = 1, \dots, N$$

from the second equation (A.1) to the first one, we have

$$\frac{dx_m(t)}{dt} = \sum_{p,q=1}^{2N} F_{mpq}^1 x_p(t) x_q(t) + \left( \sum_{p=1}^{2N} + \sum_{p=3N+1}^{4N} \right) G_{mp}^1 x_p(t) + H_m, \quad m = 1, \dots, 2N;$$

$$\sum_{p,1=q}^{2N} F_{mpq}^1 x_p(t) x_q(t) + \left( \sum_{p=1}^{2N} + \sum_{p=3N+1}^{4N} \right) G_{mp}^1 x_p(t) + H_m = 0, \quad m = 2N+1, \dots, 3N. \quad (\text{A.2})$$

Defining  $x_{n+3N}(t)$ ,  $n = 1, \dots, N$  corresponding to pressure change, from the second equation (A.2) and substituting found out value into the first equation (A.2), we have equations system

$$\frac{dx_m(t)}{dt} = \sum_{p,q=1}^{2N} F_{mpq}^2 x_p(t) x_q(t) + \sum_{p=1}^{2N} G_{mp}^2 x_p(t) + H_m^1, \quad m = 1, \dots, 2N. \quad (\text{A.3})$$

At that

$$x_{n+2N}(t) = \sum_{m=1}^{2N} c_{nm} x_m(t); \quad x_{n+3N}(t) = \sum_{m=1}^N c_{nm} H_m + \sum_{m=1}^{2N} b_{nm} x_m(t) + \sum_{p,q=1}^{2N} F_{mpq}^1 x_p(t) x_q(t), \quad n = 1, \dots, N.$$

Where values

$$x_{nl}(t) = x_{n+N(l-1)}(t), \quad l = 1, \dots, 3; \quad y_n(t) = x_{n+3N}(t), \quad n = 1, \dots, N.$$

are known and coefficients  $F_{mpq}$ ,  $G_{mp}$ ,  $H_m$ ,  $F_{mpq}^1$ ,  $G_{mp}^1$ ,  $H_m^1$ ,  $F_{mpq}^2$ ,  $G_{mp}^2$ ,  $H_m^2$ ,  $c_{nm}$ ,  $b_{nm}$  are constants. This system of non-linear ordinary differential autonomous equations (A.3) is to be solved. Solution convergence issues will be discussed below in the text.

### Finding of Solution of Ordinary Differential Equations in Complex Plane

Let us consider system of non-linear differential autonomous equations

$$\frac{dc_l}{dt} = Q_l(c_1, \dots, c_N), \quad l = 1, \dots, N. \quad (1)$$

Navier – Stokes equation system and continuity equation can be brought to system of non-linear differential equations:

$$\frac{dc_m(t)}{dt} = \sum_{p,q=1}^N F_{mpq} c_p(t) c_q(t) + \sum_{p=1}^N G_{mp} c_p(t) + H_m = Q(c_1, \dots, c_N), \quad m = 1, \dots, N, \quad (2)$$

where three-dimensional velocity is defined by

$$|A_{kl}(b_1^s, \dots, b_N^s)| = 0.$$

formula  $V(t, x_1, x_2, x_3) = \sum_{n=1}^N c_n(t) \varphi_n(x_1, x_2, x_3)$ .

At that, function  $\varphi_n(x_1, x_2, x_3)$  is given in the form of sine or cosine. Then coefficients  $c_n(t)$  for continuous function decrease not more rapidly than  $1/n^2$  when index increases and series reduction is possible, i.e. instead of infinite number of terms, finite terms number is used. At the same time, the infinite number of terms forms convergent series.

It was found out that a set of  $N+1$  coordinates for the system balance position exists (2). Indeed, let us assume that we have found several balance positions with coordinates  $b_l^0$ ,  $l = 1, \dots, N$ . Let us seek the solution in the form  $b_l = b_l^0 + b_l^s$ . For that we will substitute the solution into the right part of the differential equation (2) and will equate it to zero, then following equations system is obtained

$$\sum_{l=1}^N A_{kl}(b_1^s, \dots, b_N^s) b_l^s = 0.$$

For existence of non-zero solution of this differential equation, it is necessary that determinant is equal to zero:

Given zero determinant, coefficients  $b_l^s$  from linear equation will be defined up to a multiplier. This multiplier will be defined from equality to zero of determinant of non-linear equation system. Thus, we have  $N$  unknown multipliers, which will be defined from determinant equality to zero. I.e. set of  $N+1$  coordinates of the system balance position exists.

Differential equation system (2) for non-multiple balance positions can be expressed

by means of  $c_l = \sum_{k=1}^N g_{lk} x_k$  substitution. At that,

the system (2) balance positions  $b_l^s$ ,  $l = 1, \dots, N$ ,  $s = 1, \dots, S$  will be transformed into balance positions  $a_l^s$ ,  $l = 1, \dots, N$ ,  $s = 1, \dots, S$  and eigen values and eigen vectors of the linearized system (2) will be defined as.

$$\left[ \frac{\partial Q_k}{\partial c_m}(b_1^s, \dots, b_N^s) - \Lambda_\alpha^s \delta_{km} \right] g_{m\alpha}^s = 0;$$

$$\left| \frac{\partial Q_k}{\partial c_m}(b_1^s, \dots, b_N^s) - \Lambda_\alpha^s \delta_{km} \right| = 0.$$



Equation system (2) will be

$$\frac{dx_n}{dt} = \Lambda_n^s (x_n - a_n^s) + \sum_{k=1}^N (x_n - a_n^k)^2 P_n^k(x_1, \dots, x_N) = F_n(x_1, \dots, x_N). \quad (3a)$$

Values  $a_l^s$  satisfy condition  $F_k(a_1^s, \dots, a_N^s) = 0, k = 1, \dots, N, s = 1, \dots, S$ .

Equation system (3a) can be written as

$$\frac{dx_l}{dt} = \exp[G_l(x_1, \dots, x_N)] \prod_{s=1}^S (x_l - a_l^s), \quad (3b)$$

where multiplier which can never be equal to 0 is used  $-\exp[G_l(x_1, \dots, x_N)]$ , and this multiplier is equal to

$$\exp[G_l(x_1, \dots, x_N)] = \frac{F_l(x_1, \dots, x_N)}{\prod_{s=1}^S (x_l - a_l^s)}.$$

After this multiplier is substituted to (3b) we obtain (3a). Now we will demonstrate that this multiplier can never be equal to 0. When  $x_l \rightarrow a_l^\alpha, l = 1, \dots, N$  the limit of

$$\begin{aligned} \exp[G_l(a_1^\alpha, \dots, a_N^\alpha)] &= \frac{\partial F_l(a_1^\alpha, \dots, a_N^\alpha)}{\partial x_l} \bigg/ [(a_l^\alpha - a_l^1) \dots (a_l^\alpha - a_l^{\alpha-1})(a_l^\alpha - a_l^{\alpha+1}) \dots (a_l^\alpha - a_l^S)] = \\ &= \frac{\Lambda_l^\alpha}{(a_l^\alpha - a_l^1) \dots (a_l^\alpha - a_l^{\alpha-1})(a_l^\alpha - a_l^{\alpha+1}) \dots (a_l^\alpha - a_l^S)} \end{aligned}$$

is finite.

Here we canceled out a multiplier  $x_l - a_l^\alpha$ , as we consider only not coincident roots being coordinates of balance position. So we showed that this multiplier does not equal to zero after infinite time.

Thus, the differential equation can be written as

$$\frac{dx_l}{dH_l(t, t_0)} = \prod_{s=1}^S (x_l - a_l^s); \quad \frac{dH_l(t, t_0)}{dt} = \exp\{G_l[x_1(H_l), \dots, x_N(H_l)]\}, \quad l = 1, \dots, N, \quad (4)$$

where  $H_l(t, t_0)$  – function which tends to infinity when coordinates tend to balance position. For real solutions, this function is monotonic. That is, we have obtained dependence of the solution on value  $H_l(t, t_0)$ , which is monotonic time-dependent function.

**Lemma 1.** Necessary and sufficient criterion for unknown function to tend to steady balance position coordinates is  $H_l(t, t_0) \rightarrow \infty$  when  $t \rightarrow \infty$ . At the same time, balance position coordinates have to have a real part.

So, we have

$$\begin{aligned} \exp[G_l(x_1, \dots, x_N)] &\rightarrow \exp[G_l(a_1^s, \dots, a_N^s)] = \\ &= \frac{\Lambda_l^s}{(a_l^s - a_l^1) \dots (a_l^s - a_l^{\alpha-1})(a_l^s - a_l^{\alpha+1}) \dots (a_l^s - a_l^S)}; \end{aligned} \quad (5)$$

at  $t \rightarrow \infty$  and hence  $H_l(t, t_0) \rightarrow \infty, l = 1, \dots, N$  as integral of constant. Inverse theorem is also valid, on condition  $H_l(t, t_0) \rightarrow \infty, l = 1, \dots, N$ , one of steady balance positions is realized. This is a consequence of solution type; on condition  $H_l(t, t_0) \rightarrow \infty, l = 1, \dots, N$ , according to Lemma 3, negative real part of value  $\lambda_l^s$  exists in formula (6) and solution tends to balance position coordinate  $a_l^s$  in formula (4). If balance position coordinates have real parts, values  $\lambda_l^s$  have real part. At that  $t \rightarrow \infty$ .

**Lemma 2.** Solution of differential equation (1) is function  $x_l(t)$  which satisfies to equation (6).

To obtain (6), let us divide equation (4) by product of multipliers  $x_l - a_l^s$  and multiply (4) by  $dH_l(t, t_0)$ . Then we will decompose obtained fraction into sum of simple fractions and perform integration. The following equation is obtained

$$\sum_{s=1}^S \lambda_l^s \left[ \ln(x_l - a_l^s) + 2\pi i n_s \right] \bigg|_{t_0}^t = H_l(t, t_0),$$

$$l = 1, \dots, 2N.$$

Here for the case of sound energy emission in interval  $[t_0, t]$  different branches of logarithm are obtained.

After the expression exponentiated, we have (6)

$$\frac{\prod_{s=1}^S (x_l - a_l^s)^{\lambda_l^s} \exp(2\pi i \lambda_l^s \Delta n_s)}{\prod_{s=1}^S (x_l^0 - a_l^s)^{\lambda_l^s}} = \exp[H_l(t, t_0)];$$

$$\lambda_l^s = \frac{1}{(a_l^s - a_l^1) \dots (a_l^s - a_l^{s-1})(a_l^s - a_l^{s+1}) \dots (a_l^s - a_l^S)}, \quad (6)$$

where all values of balance position coordinates are not multiple and are not dependent on radiation process occurring in an interval  $[t_0, t]$ . In case of laminar real solution, radiation will not appear, and in case of turbulent solution, followed by radiation, there will be energy transition. Really, presence of radiation yields the complex solution which describes turbulent pulsing mode. At that, at solution transformation, turbulent mode is followed by sound noise. Exponential multiplier does not affect balance position coordinates which define stationary solution. Existence of multiplier  $\exp(2\pi i \lambda_l^s \Delta n_s)$  changes calculated main branch of solution for coordinate  $x_p$ , but will not affect balance position coordinate.

**Lemma 3.** Sum of coefficients  $\lambda_l^s$  by index  $s$  is equal to zero, i.e.  $\sum_{s=1}^S \lambda_l^s = 0$ .

In case if following fraction decomposed.

$$P(y) = \frac{Q_{S-1}(y)}{(y - a_l^1) \dots (y - a_l^{s-1})(y - a_l^{s+1}) \dots (y - a_l^S)}.$$

where  $Q_{S-1}(y)$  is  $S - 1$ -ordered polynomial. Equation  $\sum_{s=1}^S \lambda_l^s = 0$  will remain satisfied,

$$\lambda_l^s = \frac{Q_{S-1}(a_l^s)}{(a_l^s - a_l^1) \dots (a_l^s - a_l^{s-1})(a_l^s - a_l^{s+1}) \dots (a_l^s - a_l^S)}.$$

Let us prove this. For this let us consider a sum

$$P(y) = \sum_{s=1}^S \frac{Q_{S-1}(a_l^s)(y - a_l^1) \dots (y - a_l^{s-1})(y - a_l^{s+1}) \dots (y - a_l^S)}{(a_l^s - a_l^1) \dots (a_l^s - a_l^{s-1})(a_l^s - a_l^{s+1}) \dots (a_l^s - a_l^S)}.$$

This sum is equal to  $P(y) = Q_{S-1}(y)$ . We write formula for polynomial equal to  $Q_{S-1}(y)$ , dividing the equation by product  $(y - a_l^1) \dots (y - a_l^S)$  we obtain

$$\sum_{s=1}^S \frac{Q_{S-1}(a_l^s)}{(a_l^s - a_l^1) \dots (a_l^s - a_l^{s-1})(a_l^s - a_l^{s+1}) \dots (a_l^s - a_l^S)(a_l^s - y)} + \frac{Q_{S-1}(y)}{(y - a_l^1) \dots (y - a_l^{s-1})(y - a_l^s)(y - a_l^{s+1}) \dots (y - a_l^S)} = 0.$$

If suppose that  $y = a_l^{s+1}$ , equality  $\sum_{s=1}^{S+1} \lambda_l^s = 0$  is satisfied when  $s + 1$  balance position exists.

But to realize the solution, it is necessary to know balance positions of this non-linear equations system. Besides, balance positions can be multiple that changes the solution finding process, it becomes random or chaotic, but we are not going to consider this case. Nevertheless, it is possible to prove the following important theorem.

**Theorem 1.** Cauchy task is considered under arbitrary real initial conditions for system

of orthogonal non-linear ordinary differential equations (1). If system (1) has complex conjugate balance positions with real parts then, for finite real argument  $t$ , Cauchy problem solution for the system (1), for real initial conditions, tends to infinity. Then this solution becomes a complex one, tending to balance position in case when complex balance position coordinates have real part. Here the right part of (1) is considered as being a regular function, real for real arguments. This function has finite number of non-multiple balance positions.

### Proving

If the system (2) is resolved at non-multiple balance positions then, according to Lemma 2, we have

$$\left\{ -2\lambda_{iml}^s \arctan \left[ \frac{(x_l - a_l^s)}{b_l^s} \right] + \lambda_{rel}^s \ln \left[ (x_l - a_l^s)^2 + (b_l^s)^2 \right] \right\} \Big|_{t_0}^t + \sum_k \lambda_l^k \ln(x_l - c_l^k) \Big|_{t_0}^t = H_l(t, t_0), \quad (7)$$

where  $a_l^s + ib_l^s$  selected complex balance position,  $c_l^k$  other balance positions. Coefficients  $\lambda_l^s$  satisfy condition  $\sum_s \lambda_l^s = 0$ , according to Lemma 3. At that, in sum  $\sum_{s=1}^S \lambda_l^s$  real part value  $\lambda_{rel}^s$  in case of complex solution  $\lambda_l^s$  presents twice as all values  $\lambda_l^s$  satisfy condition  $\sum_s \lambda_l^s = 0$ , so we have formula

$$2\lambda_{rel}^s + \sum_k \lambda_l^k = 0.$$

Let us substantiate solution (7). For that we will modify two complex conjugate terms of the solution (for expression simplicity, index  $l$  is omitted)

$$\frac{\lambda_{re}^s + i\lambda_{im}^s}{x - a^s - ib^s} + \frac{\lambda_{re}^s - i\lambda_{im}^s}{x - a^s + ib^s} = \frac{2(x - a^s)\lambda_{re}^s - 2b^s\lambda_{im}^s}{(x - a^s)^2 + (b^s)^2}. \quad (8)$$

where  $\lambda^s = \lambda_{re}^s + i\lambda_{im}^s$ . After integration (8) over argument  $x$ , we obtain formula (7)

$$\lambda_{re}^s \ln[(x - a^s)^2 + (b^s)^2] - 2\lambda_{im}^s \arctan \frac{x - a^s}{b^s}.$$

The solution is  $x_l(t) = a_l^s + b_l^s \tan D_l(t)$ , where

$$\begin{aligned} D_l(t) &= \left\{ \sum_k \lambda_l^k \ln(x_l - c_l^k) \Big|_{t_0}^t + \lambda_{rel}^s \ln[(x_l - a_l^s)^2 + (b_l^s)^2] \Big|_{t_0}^t - H_l(t, t_0) \right\} / 2\lambda_{iml}^s = \\ &= \left\{ \sum_k \lambda_l^k + 2\lambda_{rel}^s + \sum_k \lambda_l^k \ln \left( 1 - \frac{c_l^k}{x_l} \right) + \lambda_{rel}^s \ln \left[ \left( 1 - \frac{a_l^s}{x_l} \right)^2 + \frac{(b_l^s)^2}{x_l^2} \right] - \right. \\ &\quad \left. - \sum_k \lambda_l^k \ln(x_l^0 - c_l^k) - \lambda_{rel}^s \ln[(x_l^0 - a_l^s)^2 + (b_l^s)^2] - H_l(t, t_0) \right\} / 2\lambda_{iml}^s; \\ &\quad \sum_k \lambda_l^k + 2\lambda_{rel}^s = 0. \end{aligned}$$

At that, value of  $\sum_k (\lambda_l^k c_l^k + 2\lambda_{rel}^s a_l^s)$  is real due to existence of complex conjugate balance positions. Thus, for  $|x_l| \rightarrow \infty$  and finite  $t$ , we have equation

$$x_l(t) = a_l^s + b_l^s \tan D_l(t). \quad (9)$$

Solution of this equation tends to infinity.

At that, solution of differential equation for rising  $H_l(t, t_0)$ , according to Lemma 1, can have complex roots

$$\sum_k \lambda_l^k \left[ \ln(x_l - a_l^k) + 2\pi i \Delta n_k \right] \Big|_{t_0}^t = H_l(t, t_0).$$

At that, as equation  $\sum_k \lambda_l^k = 0$  is satisfied according Lemma 3 and balance positions have real parts, values with negative real part  $\lambda_l^k$  exist, so convergence to one of the balance positions takes place. Real solution will tend to

infinity at that existence, and uniqueness condition for Cauchy problem will be breached. According to Lemma 1, at  $H_l(t, t_0)$  infinity, unknown function will tend to one of balance positions. This balance position cannot be real as the real solution is infinite. This means that the solution will have a branching point and will tend to complex balance position. That is, for balance complex positions, finite complex solution is obtained at  $H_l(t, t_0)$  change. Thus, in some point a complex solution will begin.

End of the proof.

Now we will give an example describing this property of the differential equation, transition to the complex solution. So, for the differential equation, there can be a complex solution instead of infinite real one

$$\frac{dx}{dt} = 1 + x^2.$$

And these balance positions are purely imaginary, that is, the solution cannot tend to balance position. And the real solution of this differential equation tends rapidly to infinity

$$x = \tan[t - t_0 + \arctan(x_0)].$$

Using an implicit solution finding scheme, we obtain the following equation

$$x = x_0 + (1 + x^2)\Delta t + O(\Delta t)^2.$$

Seeking solution in respect to unknown function  $x$ , we obtain the following implicit scheme

$$x = \frac{1 - \sqrt{1 - 4[x_0 + \Delta t + O(\Delta t)^2]\Delta t}}{2\Delta t}.$$

This implicit scheme with constant step correctly describes solution tendency to infinity. At reduced calculation step, this scheme yields larger value of variable  $t$ , that is, it yields larger

value of unknown function. That is, it correctly describes behavior of the differential equation solution up to infinity. When infinity is reached, under condition  $x_0 > 1/(4\Delta t) - \Delta t - O(\Delta t)^2$ , the finite complex solution will be found. Numerical computation of this equation has validated this analysis of the solution obtained.

At that, the complex solution possesses new properties; it performs complex rotation around balance position. At the same time the real solution tends to infinity, i.e. right part of the differential equation tends to infinity and existence and uniqueness condition for Cauchy problem are breached, so additional complex solution is arisen.

The solution for complex initial data is given by formula

$$x = \tan[t - t_0 + \arctan(x_0 + i\delta)]$$

for any  $t$ . Thus, approximately we have

$$\begin{aligned} x(t) &= -i \frac{\exp\{i[t - t_0 + \arctan(x_0 + i\delta)]\} - \exp\{-i[t - t_0 + \arctan(x_0 + i\delta)]\}}{\exp\{i[t - t_0 + \arctan(x_0 + i\delta)]\} + \exp\{-i[t - t_0 + \arctan(x_0 + i\delta)]\}} = \\ &= i - 2i \exp\{2i[t - t_0 + \arctan(x_0 + i\delta)]\} + i \exp\{4i[t - t_0 + \arctan(x_0 + i\delta)]\} + \dots = \\ &= i - 2i \exp[2i(t - t_0 + \alpha) - 2\beta] + i \exp[4i(t - t_0 + \alpha) - 4\beta] + \dots + \\ &\quad + \arctan(x_0 + i\delta) = \alpha + i\beta. \end{aligned}$$

If we choose branch with positive  $\beta$ , we obtain converging series. At that, this fraction denominator never becomes zero.

That is, for real plane, finite solution does not exist. In complex plane, finite continuous solution exists in the case if balance positions are not multiple.

But there is a question – what is the physical meaning of imaginary part of the solution?

### Physical Meaning of Exact Complex Solution

So, for turbulent solution corresponding to complex balance position coordinates, we have solution

$$x_l = \alpha_l^s + \beta_l^s \tan(D)h_l.$$

The solution consists of step term in the form of delta-function and smooth part

$$x_l = \alpha_l^s + \beta_l^s \left\{ \tan[D(h_l) - i0] - \tan[D(h_l) + i0] \right\} / 2 + \beta_l^s \left\{ \tan[D(h_l) - i0] + \tan[D(h_l) + i0] \right\} / 2.$$

As, at averaging over period, tangents sum without taking into account step term is equal to zero, we will study the step term of the solution. At that, this solution has singularity when condition  $D(h_l) = \pi(k + 1/2)$  is satisfied. Step term of the solution is

$$\begin{aligned} x_l &= \alpha_l^s + \beta_l^s \sum_{k=-\infty}^{\infty} \left\{ \left[ \frac{1}{D(h_l) - \pi(k + 1/2) - i0} - \frac{1}{D(h_l) - \pi(k + 1/2) + i0} \right] / 2 = \right. \\ &= \alpha_l^s + \pi i \beta_l^s \sum_{k=-\infty}^{\infty} \delta \left[ D(h_l) - \pi \left( k + \frac{1}{2} \right) \right] + \\ &\quad \left. + Vp \left[ \frac{1}{D(h_l) - \pi \left( k + \frac{1}{2} \right)} - \frac{1}{D(h_l) - \pi \left( k + \frac{1}{2} \right)} \right] / 2 \right\} = \\ &= \alpha_l^s + \pi i \beta_l^s \sum_{k=-\infty}^{\infty} \delta \left[ D(h_l) - \pi \left( k + \frac{1}{2} \right) \right]. \end{aligned}$$

That is, imaginary medium pulse is originated. Imaginary velocity means flow rotation or oscillation; flow step is originated which will be destroyed in time  $\Delta D(h_i) = \pi$  to originate repeatedly. Number of such steps is finite. But how to average this steps? You should pass to probabilistic interpretation of the description. That is, to average imaginary part over the period  $D(h_i^k) - \pi\left(k + \frac{1}{2}\right)$ . Then we have local complex average solution

$$\langle x_i \rangle - \alpha_i^s = \pi i \beta_i^s \left\langle \frac{\delta(h_i)}{\dot{D}_i(h_i)} \right\rangle / \pi = \frac{i \beta_i^s}{\dot{D}_i(h_i^k)};$$

$$D_i(h_i^k) = \pi \left( k + \frac{1}{2} \right).$$

Continuous part of the solution has positive and negative parts which are compensated when averaged. To obtain a global average value it is necessary to average with respect to value  $k$ , so we have

$$\langle x_i \rangle - \alpha_i^s = i \beta_i^s \sum_{k=-N}^N 1 / \dot{D}_i(h_i^k) / 2N.$$

We obtained complex velocity; imaginary part is defined up to multiplier. Real part of complex velocity corresponds to average value of velocity, and imaginary part is a mean square deviation. Simultaneously, there is a vortex motion consisting of positive and negative value of root from  $\beta_i^s$ .

Contribution of imaginary part to average value is equal to

$$\langle x_i \rangle = \alpha_i^s \pm i \sqrt{\beta_i^s \gamma_i}; \quad \gamma_i = \frac{1}{\dot{D}_i(h_i^k)}.$$

At that, module of average value, that defines real solution, is equal to

$$|\langle x_i \rangle| = \sqrt{(\alpha_i^s)^2 + \beta_i^s \gamma_i^2}; \quad \gamma_i = \frac{1}{\dot{D}_i(h_i^k)},$$

where balance position coordinates and time are non-dimensional, then, as we calculate

square root of imaginary part, we define branch  $\beta_i^s > 0$ . Thus, average single-valued solution is found.

This multiplier  $\gamma_i$  depends on the surface roughness and it is found from numerical experiment. As numerical experiment has shown, for round smooth pipeline the multiplier is equal to  $\gamma_i = 1$ . At that, the smooth pipeline has a constant, minimum, average module of roughness inclination tangent equal to

$$\langle |\tan \alpha| \rangle = \frac{1}{R_{cr}} = \frac{1}{2300},$$

that is associated with molecular roughness, see article II section 1. For this, one term of series which determines flow velocity is used. We calculate this value for one term of the series for smooth surface. The solution is

$$x_i(t) = \alpha_i^s + \beta_i^s \tan(h_i),$$

where  $D_i(h_i^k) = h_i^k = \pi(k + 1/2)$ ;

$$\dot{D}_i(h_i^k) = 1;$$

$$\gamma_i = \left\langle \frac{1}{\dot{D}_i(h_i^k)} \right\rangle = 1.$$

This value exactly corresponds to experimental formula for round cross section pipeline if the solution roughness is taken into account. At that, to take roughness into account for internal problem,  $h_i^k$  is multiplied by  $\left( \frac{1 + kR_{cr}/l}{2} \right)^\sigma$ ,

here  $k/l$  is a constant average tangent of flowing surface inclination. From this we obtain  $\gamma_i = \left( \frac{2}{1 + kR_{cr}/l} \right)^\sigma$ , see article II section 1. At

constant average roughness height, the coefficient  $\gamma_i$  is not a constant as  $k/l$  value is determined by other formula depending on dimensionless pressure, see article II section 1.



## STUDY OF NAVIER – STOKES EQUATION SOLUTION II. THE USE OF LAMINAR SOLUTIONS

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Laminar Solution of Navier – Stokes Equation. Value of round pipeline resistance coefficient for arbitrary Reynolds number and roughness degree are known only from experiment. It is proposed, using complex solution, to obtain a solution of Navier – Stokes equations and based on the qualitative reasons to define roughness influence on the solution of Navier – Stokes equation. It was possible to draw classical Nikuradze curves for round pipeline resistance coefficient versus Reynolds number and roughness degree with an accuracy of 10%.

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**Keyword:** large dimensionless unknown functions, solutions of non-linear partial differential equation, Navier – Stokes equation, turbulent function, fluid flow resistance coefficient, round pipeline

The problem of turbulent fluid motion description has not been solved yet. It creates difficulties when oil, gas pipelines design calculation is performed. Besides, there are no theoretical methods for description of bodies motion in turbulent environment. These methods would be necessary for description of motion of aircrafts, submarines or above-water ships in the turbulent mode. Without simulation of bodies motion in wind tunnels or water basins, design of the bodies moving in the viscous environment is impossible.

There are approximate formulas for pipeline resistance coefficient at some ranges of Reynolds numbers, see [1, 2]. But they are empirical approximate formulas and they are applicable only for particular Reynolds number ranges.

Classical experimental Nikuradze curves of round pipeline resistance coefficient versus Reynolds number and roughness degree are well known. Approximation of convective term reducing Navier – Stokes problem to linear one with effective turbulent viscosity is applied. But such transformation distorts solution of Navier – Stokes equations and for matching to experiment the turbulent viscosity coefficient can have any value, up to negative. Galerkin method which brings hydrodynamic problem solution to system of non-linear ordinary differential equations is applied. But in the case of turbulent mode, this non-linear equation system has complex balance positions, i.e. the solution is complex. Indeed, hydrodynamics equation system, in turbulent mode, in real plane does not have any solutions, the equation solution tends for infinity, see [3] and main part I of the

paper. But complex solution is finite. About physical meaning of the complex solution and oscillatory behavior of its imaginary part see [4, 5] or article III of this paper. Thus, it is necessary to solve hydrodynamic problems for turbulent mode in complex plane. At that, the turbulent solution is not single-valued, there are finite number of the solution branches.

### Calculation of Round Section Pipeline Resistance Coefficient for Incompressible Fluid

This algorithm has been used for calculation of resistance coefficient for pipeline with round cross section. The algorithm is described in article [6] in English. We will seek the solution of problem for cross section round pipeline in form  $V_z = V_0(t)[1 - r^2/a^2(z)]$ , in cylindrical system of coordinates. As external factor acts only along longitudinal axis

$$P(z) = P_2 + \frac{P_1 - P_2}{L} z$$

where  $P_2, P_1$  – pressure in initial and final part of the pipeline;  $L$  – length of the pipeline, radial and angular velocities components are neglected. External action is equal to  $h_z = \frac{P_1 - P_2}{L}$ . According to formula (6), the pressure gradient is equal to  $\frac{\partial P}{\partial z} = \frac{P_1 - P_2}{L}$ . So we have the equation

$$\frac{\partial V_z}{\partial t} + V_z \frac{\partial V_z}{\partial z} = -\frac{P_1 - P_2}{L} + \nu \Delta V_z.$$

Substituting velocity value we obtain

$$\frac{\partial V_0}{\partial t} (1 - r^2/a^2) + 2V_0^2 (1 - r^2/a^2) \frac{r^2}{a^3} \frac{da}{dz} = -\frac{P_1 - P_2}{\rho L} - \nu \frac{4V_0}{a^2}. \quad (1a)$$

Multiplying this equation by radius and performing integration over radius, as we use cylindrical coordinate system, we have

$$\frac{\partial V_0}{\partial t} a^2 \left/ 6 + \frac{(P_1 - P_2) a^2}{2 \rho L} + 2 \nu V_0 = -V_0^2 \frac{ada}{6 dz} \right.$$

To obtain finite number of solutions we will multiply equation (1a) by function  $r(1 - r^2/a^2)^n$  and integrate over volume. Then we will obtain finite number of turbulent solutions both for smooth and rough surfaces. Stationary laminar solution satisfying condition  $da/dz=0$  is single-valued as in the equation (1a) the laminar solution is identical for different values of  $r(1 - r^2/a^2)^n$ . At the same time, likewise Schrödinger equation, finite number of turbulent solutions is found, each has its own energy. At transition from one state to another, discrete energy is radiated. The own energy minimum value defines the solution choice.

After calculating a module of the right part and averaging module of deviation angle tangent, we obtain

$$\begin{aligned} \frac{\partial V_0}{\partial t} a^2 \left/ 6 + \frac{(P_1 - P_2) a^2}{2 \rho L} + 2 \nu V_0 = \right. \\ = V_0^2 \frac{a \langle |da/dz| \rangle}{6} = V_0^2 \frac{2ak}{l}. \end{aligned} \quad (1b)$$

It will be seen that when minus sign is chosen for value of average module of deviation angle tangent  $\langle |da/dz| \rangle$ , roughness presence increases flow velocity as the full derivative  $\frac{dV_0}{dt} = \frac{\partial V_0}{\partial t} - V_0^2 \frac{\langle |da/dz| \rangle}{a}$  increases and this is not correct, flow velocity has to decrease due to roughness presence.

When turbulent viscosity is taken into account, negative value of average velocity associated with process velocity correlation function  $-\rho \langle u'_l u'_a \rangle = \rho K \frac{\partial \langle u'_l \rangle}{\partial x_a}$ , see [1], is used and

this leads to plus sign for average module of roughness inclination tangent. The movement equation taking into account disturbances is

$$\begin{aligned} \frac{\partial \langle \rho u_l \rangle}{\partial t} + \frac{\partial}{\partial x_a} (\rho \langle u_l \rangle \langle u_a \rangle + \rho \langle u'_l u'_a \rangle) = \\ = - \frac{\partial \langle p \rangle}{\partial x_l} + \rho \nu \langle \Delta u_l \rangle. \end{aligned}$$

That is, convection term should be taken with minus, at right part of (1b) should be taken with plus.

Besides, it is necessary to choose plus for average module of roughness inclination tangent to obtain complex turbulent solution. Otherwise, solution describing pulse turbulent mode will not be steady.

Changing pipeline radius to diameter and dividing by value  $\frac{\nu^2 k}{(dl)}$ , we obtain

$$\begin{aligned} \frac{dR_0}{d\tau} &= R_0^2 - 2R_0 R_{cr} + \frac{T}{8}; \\ T &= \frac{(P_2 - P_1) d^3 R_{cr}}{\rho \nu^2 L}; \\ \tau &= \frac{24t \cdot \nu}{R_{cr} d^2}; \\ R_0 &= \frac{V_0 d}{\nu}; \end{aligned} \quad (2)$$

$$\frac{1}{R_{cr}} = \frac{\langle |da/dz| \rangle}{12} = \frac{k}{l} = \langle |\tan \phi| \rangle.$$

If you use another branch of root mean square unsteady solution and following equation will be obtained

$$\frac{dR_0}{d\tau} = -R_0^2 - 2R_0 R_{cr} + \frac{T}{8}. \quad (3)$$

Thus, steady solution for large difference in pressure is

$$R_0 = -R_{cr} + \sqrt{R_{cr}^2 + T/8}.$$

Laminar solutions of these two equations at small pressure difference are the same. For turbulent mode with big pressure the solution has linear dependence of Reynolds number versus pressure square root. At small pressure increase, Reynolds number also grows and, as it follows from (3), pressure is increased. So the solution is not steady. In case of the complex solution it is equal to

$$R_0 = R_{cr} - i \sqrt{T/8 - R_{cr}^2}.$$

At that, when pressure increases, imaginary part of velocity increases too and this does not lead to increase of real pressure, the real pressure keeps the value unchanged.

If micro roughness  $\langle |\tan \phi| \rangle$  is distributed all over the pipeline surface, it is also present on macro roughness and defines critical Reynolds number and resistance coefficient at Reynolds number 2300. Micro roughness

has the molecular nature, it is defined by average atom size equal to average geometrical difference between the nuclear size  $r_A$  and size of Bohr orbit  $\sigma = \sqrt{r_A a_0}$  when the distance between atoms  $a = 3,043A$  is equal to some value determined by properties of pipeline boundary, iron, titanium and carbon. Distance between iron atoms is  $a_{Fe} = 2,87A$ , between titanium atoms –  $a_{Ti} = 3,46A$ , between carbon atoms –  $a_C = 3,567A$ , see [7]. At the same time, the absolute value of tangent of micro roughness height inclination for metal surface of the pipeline is determined by formula

$$h(z) = \langle |\tan \phi| \rangle = \sum_{n=-N}^N \exp \left[ \frac{-(z-na)^2}{2\sigma^2} \right] / (2N\sqrt{2\pi}).$$

The average tangent of inclination is equal to

$$\begin{aligned} \frac{1}{R_{cr}} &= \int_{-\infty}^{\infty} h(z) \frac{dz}{2Na} = \frac{\int_{-\infty}^{\infty} \exp \left[ \frac{-(z-na)^2}{2\sigma^2} \right] dz}{2\sqrt{2\pi}a} = \frac{\sigma}{2a} = \\ &= \frac{1}{2 \cdot 3,043} \sqrt{\frac{r_A}{a_0}} = \frac{1}{2 \cdot 3,043} \sqrt{\frac{1,4 \cdot 10^{-13}}{0,5 \cdot 10^{-8}}} = \frac{1}{1150}. \end{aligned}$$

In this paper, critical Reynolds number was calculated with respect to radius. Critical Reynolds number with respect to diameter is equal to  $R_{cr} = 2300$ . But why critical Reynolds number for the sphere is equal to  $3 \cdot 10^5$ ? This is due to different definition of critical Reynolds number. This value is equal to

$$\frac{1}{R_{cr}} = \frac{da}{ds} = \frac{dl_{eff}}{ds} \cdot \frac{a}{l_{eff}} = \frac{1}{2300} \cdot \frac{a}{l_{eff}},$$

where  $l_{eff}$  – effective hydrodynamic size of the body, including medium,  $a$  – true geometrical body size, and  $\frac{dl_{eff}}{ds} = |\tan \phi| = \frac{1}{2300}$  – molecular tangent of roughness inclination. And the ratio  $\frac{a}{l_{eff}}$  can be equal to  $\frac{a}{l_{eff}} = 0,01$ .

Critical Reynolds number is equal to  $R_{cr} = 2300$ . Macro-roughness elements  $\langle |da/dz| \rangle$  are rarer and this causes increase of resistance coefficient at Reynolds numbers which is 12 or more times more.

So we obtained a stationary criterion for Navier – Stokes equations taking into account one term of the solution series for one-dimensional case:

$$R_0^2 - 2R_0 R_{cr} + T/8 = 0.$$

For one-dimensional case, on condition of pipeline cross section area constancy, the con-

tinuity equation is the same. Laminar solution of this equation is

$$R_0 = R_{cr} - \sqrt{R_{cr}^2 - T/8} = \left[ \frac{R_{cr}}{\sqrt{T}} - \sqrt{\frac{R_{cr}^2}{T} - \frac{1}{8}} \right] \sqrt{T}.$$

For external pressure equal to  $T = 8R_{cr}^2$ , a complex solution and turbulent mode take place as Reynolds number from this point is equal to critical value. From experiment and calculation, we have critical Reynolds number for round pipeline

$$R_{cr} = \frac{l}{k} = \frac{1}{\langle |\tan \phi| \rangle} = 2300.$$

The pipeline resistance coefficient for round cross section pipe is determined by formula (we substituted to the formula the pressure difference expressed through dimensionless pressure)

$$\lambda = \frac{2\Delta P_L d}{\rho V_a^2 L} = \frac{2T v^2 k}{V_a^2 d^2 l} = \frac{2T}{R_{cr} |R_a|^2}.$$

The average velocity used for Reynolds number is equal to

$$\begin{aligned} V_a &= \frac{\int_0^a r V_0 \left( 1 - \frac{r^2}{a^2} \right) dr}{\int_0^a r dr} = \frac{V_0}{2}; \\ R_a &= \frac{V_a d}{v} = \frac{R_0}{2}. \end{aligned}$$

The pipeline resistance coefficient  $\lambda_{lam}$  asymptotic for laminar mode in round cross section pipeline is calculated truly.

$$R_a = \frac{R_0}{2} = \frac{R_{cr} - \sqrt{R_{cr}^2 - T/8}}{2} \cong \frac{T}{32R_{cr}};$$

$$\frac{T}{8R_{cr}^2} \ll 1; \quad \lambda_{lam} = \frac{2T}{R_{cr} |R_a|^2} = \frac{64}{|R_a|^2}.$$

Asymptotic behavior of the pipeline resistance coefficient is obtained for small Reynolds numbers when the convective term is small.

In case of large pressure difference, we have a complex turbulent solution

$$R_0 = R_{cr} - i\sqrt{T/8 - R_{cr}^2} = \left( \frac{R_{cr}}{\sqrt{T}} - i\sqrt{\frac{1}{8} - \frac{R_{cr}^2}{T}} \right) \sqrt{T}.$$

Computing more precisely, contribution of rotary imaginary part to forward velocity of flow movement corresponds to square root of imaginary part according to formula (4)

$$\frac{R_0}{\sqrt{T}} = \frac{R_{cr}}{\sqrt{T}} - i^4 \sqrt{\frac{1}{8} - \frac{R_{cr}^2}{T}} \sqrt{\beta} = \sqrt{\frac{R_{cr}^2}{T} + \sqrt{\frac{1}{8} - \frac{R_{cr}^2}{T}}} \beta \exp(i\psi);$$

$$\beta = \left\{ \alpha / [k(T, \xi_0) R_{cr} / l(T, \xi_0) + 1] \right\}^\sigma; \quad \sigma = 0,25 \cdot \frac{3}{2} = \frac{3}{8}. \quad (4)$$

and it is necessary to use value of ratio of Reynolds number to square root of dimensionless pressure as value of order 1 in the turbulent mode. At infinite pressure, Reynolds number for the flow is proportional  $R \sim \sqrt{T} \sim d_{eff}^{3/2}$ . At that, the smoothest surface is the surface with average module of inclination tangent equal to inverse value of critical Reynolds number. For solution in the form of series, another value of  $\alpha$  will be calculated. This value is defined from identical values of resistance coefficients at large Reynolds numbers and molecular roughness. The smoothest surface corresponds to average module of tangent of inclination equal to the inverse value of critical Reynolds number as the smallest modules of tangent of inclination correspond to molecular type of roughness. At that, effective diameter is less than true diameter. The average module of tangent of inclination angle can not be less than molecular roughness and its minimum value is equal to  $\langle |\tan \phi| \rangle = \frac{1}{R_{cr}}$ . That is, 1 is the maximum value

of ratio of effective diameter to true diameter because  $\alpha = 2$ . For external problem, effective diameter will increase, and the coefficient will be determined by formula

$$\beta = \left\{ [k(T, \xi_0) R_{cr} / l(T, \xi_0) + 1] / 2 \right\}^\sigma.$$

Coefficient  $\beta$  is proportional to

$$\sqrt{T} \sim \beta = \frac{\langle d_{eff}^{3/2} \rangle}{d^{3/2}} = \left\{ 2 / [k(T, \xi_0) R_{cr} / l(T, \xi_0) + 1] \right\}^\sigma;$$

$$\sigma = \frac{1}{4} \cdot \frac{3}{2} = \frac{3}{8}.$$

At zero macro roughness, effective diameter is equal to 1, that is, when roughness is increased, effective diameter decreases. Value  $\frac{d_{eff}}{d} = [2 / (k R_{cr} / l + 1)]^{1/4}$  was obtained from numerical experiment that corresponds to fourth root of mean square deviation. At zero macro roughness, micro roughness presents. And ratio of tangent of macro inclination roughness to micro roughness is more than  $\frac{k}{l \langle |\tan \alpha| \rangle} = 1$ .

At  $l/k = 30$ , we have value of effective pipeline diameter

$$\frac{d_{eff}}{d} = [2 / (2300/30 + 1)]^{1/4} = 0,38.$$

At the same time, diameter is changed only for coefficient of pulsing part of the solution, i.e. for imaginary part from where the multiplier  $\beta = \left\{ 2 / [k(T, \xi_0) R_{cr} / l(T, \xi_0) + 1] \right\}^\sigma$  originates as the imaginary term is proportional to  $\sqrt{T} \sim d_{eff}^{3/2}$  which is averaged. At that, value  $\sqrt[4]{\frac{1}{8} - \frac{R_{cr}^2}{T}}$  corresponds to fourth root of mean square deviation.

Here, influence of walls roughness in turbulent flow on imaginary part of Reynolds number of the flow is taken into account. To obtain curves with constant roughness height, it is necessary to enter effective average module of tangent of roughness inclination angle. The effective average module of tangent of roughness inclination angle has to depend on external pressure  $\frac{k(T, \xi_0)}{l(T, \xi_0)}$ .

And in points of infinite Reynolds numbers or dimensionless pressure, we have the roughness corresponding to constant roughness height

$$\frac{k(\infty, \xi_0)}{l(\infty, \xi_0)} = \frac{k}{r_0} = \frac{1}{\xi_0},$$

where  $k$  – mean square root of the roughness height;  $r_0$  – radius of round cross section of the pipeline.

The formula is chosen in such a way that it defines correctly dependence of Reynolds number versus external pressure and pipeline resistance coefficient at infinite Reynolds numbers and external pressure

$$\text{Im } R_0 = -i^4 \sqrt{\frac{1}{8}} \left\{ 2 / [k(\infty, \xi_0) R_{cr} / l(\infty, \xi_0) + 1] \right\}^\sigma \sqrt{T}$$

at resistance coefficient equal to

$$\lambda = \frac{16\sqrt{2}}{R_{cr} [2 / (R_{cr} / \omega \xi_0 + 1)]^{2\sigma}}.$$

When average module of tangent of roughness inclination angle  $\frac{k}{l}$  is constant but roughness height  $k$  is varying we obtain a curve which differs from Nikuradze curve.

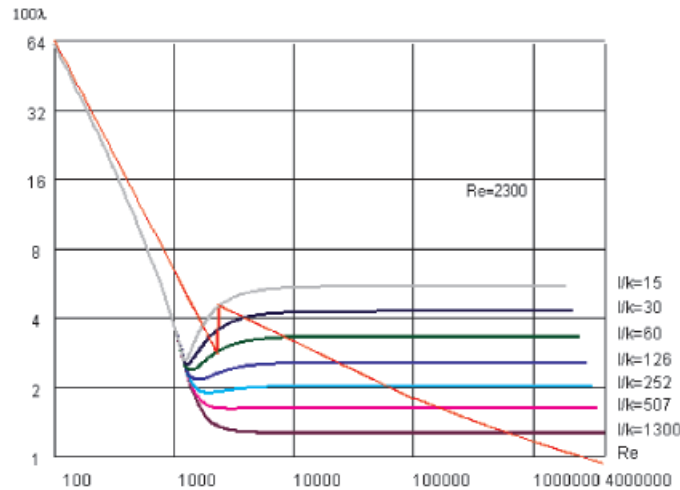


Fig. 1. Curve of round pipeline resistance coefficient versus Reynolds number for different mean square root tangent of roughness inclination angle

But Nikuradze formula is obtained for constant ratio of pipeline radius  $r_0$  to average roughness height  $k$ . The formula (4) contains effective average module of tangent of roughness inclination angle expressed through ratio of pipeline radius to average roughness height using dimensionless pressure

$$\frac{l(T, \xi_0)}{\delta(T, \xi_0)} = \left\{ \exp \left[ - \left| \sqrt{T} - \sqrt{T_{cr}} \right| / \alpha(\xi_0) \right] + \xi_0 \left[ 1 - \exp \left( - \left| \sqrt{T} - \sqrt{T_{cr}} \right| / \alpha(\xi_0) \right) \right] \right\} \times \\ \times \left\{ 1 + 0,4 \exp \left\{ - \left[ \sqrt{T} - \sqrt{T_{cr}} \beta(\xi_0) \right] / \gamma(\xi_0) \right\} \right\}; \\ \xi_0 = \frac{r_0}{k}.$$

Value  $T_{cr} = 8R_{cr}^2$ . Influence of effective average module of tangent of roughness inclination on flow property depends on Reynolds number or pressure difference.

Empirical formula for finding of coefficients  $\alpha(\xi_0)$ ,  $\beta(\xi_0)$ ,  $\gamma(\xi_0)$  is following

$$\alpha(\xi_0) = R_{cr} \frac{\xi_0}{1,5}; \quad \beta(\xi_0) = \frac{\xi_0}{4}; \quad \gamma(\xi_0) = \frac{R_{cr} \xi_0^{1,5}}{4}.$$

At the same time, at the beginning of formation of the complex solution imaginary part  $T = T_{cr} = 8R_{cr}^2$ , or at the beginning of turbulent solution, roughness inclination tangent is equal to approximately 1, and curves for different roughness inclination tangents coincide.

At that, flow resistance coefficient for round pipeline is determined by formula  $\lambda = \frac{2T}{R_{cr} |R_a|^2}$ , Reynolds number calculated

based on the average velocity of flow movement is equal to  $R_a = \frac{R_0}{2}$ . Resistance coefficient at infinite pressure is proportional to

$$\lambda = \frac{16\sqrt{2}}{R_{cr} \left[ 2 / (R_{cr} / \xi_0 + 1) \right]^{2\sigma}}.$$

Here we demonstrate curves for solution obtained using one term of the series.

To compare theoretical and experimental curves of resistance coefficient dependence versus flow Reynolds number, experimental curve by Nikuradze is given in Fig. 2, on the right. Error of the theoretical curve relative to experimental one is about 10 %. But for laminar mode two solutions (2) and (3) are possible. Averaged solution will yield zero convection term and dependence  $\lambda = \frac{64}{R_a}$  that is not taken into account at the computation. In the



theoretical curve convective term is taken into account which became equal to zero after averaging in laminar mode.

This curve was calculated for constant flow temperature over the flow cross section there-

fore in case of weak dependence of kinematic viscosity on temperature the formula will not change. For turbulent mode, it is necessary to substitute into the formula normalized pressure and ratio of pipeline radius to roughness height

$$|R_0| = \sqrt{R_{cr}^2 + \sqrt{T^2 / 8 - TR_{cr}^2} \beta}; \quad \beta = \left\{ 2 / [k(T, \xi_0) R_{cr} / l(T, \xi_0) + 1] \right\}^\sigma;$$

$$\frac{l(T, \xi_0)}{k(T, \xi_0)} = \left\{ \exp \left[ -|\sqrt{T} - \sqrt{T_{cr}}| / \alpha(\xi_0) \right] + \xi_0 \left[ 1 - \exp \left( -|\sqrt{T} - \sqrt{T_{cr}}| / \alpha(\xi_0) \right) \right] \right\} \times$$

$$\times \left\{ 1 + 0,4 \exp \left\{ -\left[ \sqrt{T} - \sqrt{T_{cr}} \beta(\xi_0) \right] / \gamma(\xi_0) \right\} \right\};$$

$$\xi_0 = \frac{r_0}{\delta_0}.$$

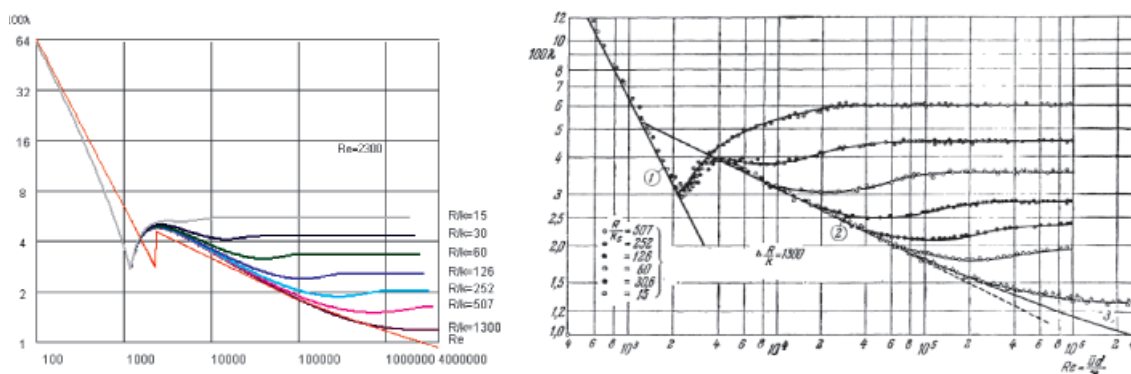


Fig. 2. Calculated and measured dependence of round pipeline resistance coefficient versus Reynolds number for different roughness

And the formula is constructed so that  $\frac{l(\infty, \xi_0)}{k(\infty, \xi_0)} = \xi_0$ . In case of the laminar mode there is a simple formula for Reynolds number:

$$R_0 = R_{cr} - \sqrt{R_{cr}^2 - T/8}.$$

### Algorithm for Solution of Internal Hydrodynamic Problem for Arbitrary Flow Geometry

Navier – Stokes equations in Cartesian coordinates is

$$\frac{\partial V_i}{\partial t} + \sum_{k=1}^3 V_k \frac{\partial V_i}{\partial x^k} = -\frac{\partial P}{\rho \partial x^i} + \nu \Delta V_i. \quad (5)$$

We will solve a three-dimensional laminar stationary problem without convective term for defined external action  $g_i$

$$\frac{\partial P}{\rho \partial x_i} = \nu \Delta V_i.$$

Let us transform this equations to dimensionless form by dividing it by  $\nu^2/d^3$ , as a result we obtain dimensionless equation

$$\frac{\partial p}{\partial y_i} = \Delta R_i; \quad R_s = \frac{V_s d}{\nu}; \quad p = \frac{P d^2}{\rho \nu^2}; \quad y_s = \frac{s}{d}; \quad h_s = \frac{g_s d^2}{\nu^2}.$$

Following function is a solution of this problem

$$R_s(y_1, y_2, y_3) = -\int \frac{1}{4\pi |\mathbf{y} - \mathbf{z}|} \frac{\partial p}{\partial z_s} dz_1 dz_2 dz_3.$$

We will seek solution of continuity equation for external action, where  $r_i$  – response to external action

$$\frac{\partial R_i - r_i}{\partial x^i} = \int_V \frac{y_s - z_s}{4\pi |\mathbf{y} - \mathbf{z}|^2} \left( \frac{\partial p}{\partial z_s} - h_s \right) dz_1 dz_2 dz_3 = 0. \quad (6)$$

From this we obtain equation for finding of flow pressure

$$\int_V \frac{y_s - z_s}{4\pi |\mathbf{y} - \mathbf{z}|^2} \frac{\partial p}{\partial z_s} dz_1 dz_2 dz_3 = \int_V \frac{y_s - z_s}{4\pi |\mathbf{y} - \mathbf{z}|^2} h_s dz_1 dz_2 dz_3.$$

We will seek the pressure value in the form  $p = \sum_{n=0}^N a_n \varphi_n(z_1, z_2, z_3)$ . Then we will substitute pressure into expression under the integral sign, multiply by  $\varphi_m(y_1, y_2, y_3)$ , and perform integration over the volume, then we obtain a system of linear equation

$$b_m = A_{mn} a_n.$$

Expressions for coefficients are

$$A_{mn} = \iiint_V \varphi_m(y_1, y_2, y_3) \frac{y_s - z_s}{4\pi |\mathbf{y} - \mathbf{z}|^2} \frac{\partial \varphi_n(z_1, z_2, z_3)}{\partial z_s} dz_1 dz_2 dz_3 dy_1 dy_2 dy_3;$$

$$b_m = \iiint_V \varphi_m(y_1, y_2, y_3) \frac{y_s - z_s}{4\pi |\mathbf{y} - \mathbf{z}|^2} h_s(z_1, z_2, z_3) dz_1 dz_2 dz_3 dy_1 dy_2 dy_3,$$

where  $h_s(y_1, y_2, y_3)$  is defined by external action. Let us transform Navier – Stokes equations to dimensionless form by dividing it by  $v^2/d^3$ , and we have dimensionless equation

$$\frac{\partial \Re_l}{\partial \tau} + \sum_{k=1}^3 \Re_k \frac{\partial \Re_l}{\partial y_k} = -\frac{\partial p}{\partial y_l} + \Delta \Re_l; \quad \Re_l = \frac{V_l d}{v};$$

$$y_l = \frac{x_l}{d}; \quad \tau = \frac{tv}{d^2}; \quad p = \frac{Pd^2}{\rho v^2}; \quad h_l = g_l \frac{d^2}{v^2} = \frac{\partial p}{\partial y_l}.$$

Then we multiply Navier – Stokes equations by area of flow tube cross section, write the equations along laminar solution and enter flow tube with constant flow, see [8].  $\Gamma_s = \int_{S_s} \frac{\Re_s ds_s}{d^2}$ . In the convection term and in pressure gradient, we enter the derivative in the direction corresponding to the direction of flow lines in laminar solution. When substituting of the solution into equation

$$\Gamma_s = \alpha_s(\tau) R_s [y_1(\alpha, \beta), y_2(\alpha, \beta), y_3(\alpha, \beta)], \quad (7)$$

where  $S_s$  – flow tube cross section in laminar mode, expression  $R_s[y_1(\alpha, \beta), y_2(\alpha, \beta), y_3(\alpha, \beta)]$  is a stationary solution of Navier – Stokes equations without convection term which is equal to zero for flow tube as it does not depend on longitudinal coordinate.

We built these flow tubes for any external action which affects pressure difference. Further we consider roughness and under certain conditions obtain complex turbulent solution which is associated with influence of quadratic convection term with small multiplier, taking into account roughness, which yields complex solution at large pressure difference. At the

same time, we reject real solution which was obtained for another sign of the module of average deviation, as it does not define fluctuating, turbulent solution. And imaginary part of the solution defines the solution pulsations.

If another sign of square root is chosen and correlation function of the process  $\langle u'_k u'_k \rangle$ , where  $u'_k$  is a velocity deviation from its average value, is taken into account, turbulent viscosity becomes negative.

Let us substitute the solution (7) into Navier – Stokes equation, integrate it over flow pipe and divide by pipeline cross-sectional area. Then the convective term will be equal to

$$\sum_{k=1}^3 \Re_k \frac{\partial \Re_l}{\partial y_k} = -\alpha_s^2(\tau) \frac{da}{ds} \int_{S_s} R_s^2 [y_1(\alpha, \beta), y_2(\alpha, \beta), y_3(\alpha, \beta)] d\alpha d\beta.$$

Taking roughness into account results in dependence of the pipeline radius  $a(s)$  on macro-roughness. Further we will extract the term  $da/ds$  associated with roughness and will find average value of its module. At the same time, we will make averaging of the equation with respect to  $s$ . It can be found out that convection term in laminar mode for smooth surface is equal to zero, and roughness has to be taken into account for non-zero value. So, we have the equation

$$\frac{\partial \alpha_s}{\partial \tau} \int_{S_s} R_s d\alpha d\beta = \alpha_s^2 \left\langle \frac{da}{ds} \right\rangle \int_{S_s} R_s \frac{\partial R_s}{\partial a} d\alpha d\beta -$$

$$\frac{\partial \int_{S_s} p d\alpha d\beta}{\partial s} + \alpha_s \int_{S_s} \Delta R_s d\alpha d\beta.$$

To take into account roughness of pipeline surface and obtain turbulent solution, it is necessary to consider the average module of tangent of roughness inclination angle. Then this convective term will have a small multiplier, and the convection term will be non-zero. This term is proportional to average value of tangent of module inclination at roughness  $\left\langle \left| \frac{da}{ds} \right| - \left\langle \frac{da}{ds} \right\rangle \right\rangle$ . At the same time, there is a term depending on variable pipeline cross section area  $\frac{d\langle a \rangle}{ds}$ . And flow lines of complex turbulent solution corresponding to flow lines of laminar solution will remain the same but there will be a solution pulsing around laminar flow lines. At that, the pulsations are defined by imaginary part of velocity, and the imaginary part of the solution, equal to a constant, means pulsations with amplitude equal to imaginary part of velocity.

Now, we will substitute the solution (7) into Navier – Stokes equations and will integrate along flow tubes, will multiply by  $R_{cr}$  in domain where this value meets a condition  $\frac{1}{R_{cr}} = \langle |\tan \alpha| \rangle$  and where  $\langle |\tan \alpha| \rangle$  – average module of inclination tangent for not removable micro roughness with envelope forming macro-roughness, and we will obtain the following equation

$$R_{cr} \frac{d\alpha_s(\tau)}{d\tau} = F_s \alpha_s^2 - 2R_{cr} \alpha_s G_s + H_s;$$

$$F_s = \left( R_{cr} \left\langle \frac{da}{ds} \right\rangle + 1 \right) \times$$

$$\times \int_{S_s} R_s [y_1(\alpha, \beta), y_2(\alpha, \beta), y_3(\alpha, \beta)] \frac{\partial R_s}{\partial a} d\alpha d\beta;$$

$$G_s = - \int_{S_s} \Delta R_s [y_1(\alpha, \beta), y_2(\alpha, \beta), y_3(\alpha, \beta)] d\alpha d\beta / 2 > 0;$$

$$H_s = - \int_{S_s} \frac{\partial p [y_1(\alpha, \beta, s), y_2(\alpha, \beta, s), y_3(\alpha, \beta, s)]}{\partial s} \times$$

$$\times R_{cr} d\alpha d\beta ds > 0,$$

where  $R_s(y_1, y_2, y_3)$ ,  $p(y_1, y_2, y_3)$  are determined from laminar solution and continuity equation, and function of external action  $h_i(y_1, y_2, y_3)$  is defined. So it was found out that micro roughness located along all length of the pipeline defines critical Reynolds number. This micro roughness is less than macro-roughness which affects resistance coefficient at large Reynolds numbers. But as Reynolds number depends on pipeline geometry through its diameter, then critical Reynolds number is inversely proportional to the average module of tangent of micro roughness inclination and depends on pipeline geometry. At the same time, reduction of pipeline radius results in negative  $da/ds$  value and, therefore, absence of complex turbulent solution in the narrow place, i.e. the critical Reynolds number raises. On the contrary, the pipeline widening causes increase of  $da/ds$  and, therefore, reduction of critical Reynolds number and can result in earlier occurrence of complex solution, i.e. the turbulent mode.

And, as Reynolds number depends on temperature through dependence of kinematic viscosity on temperature, it is obvious that occurrence of critical Reynolds number depends on environment temperature.

Coordinates of balance position are defined from a quadratic equation

$$\alpha_s^2 - \alpha_s \frac{2R_{cr} G_s}{F_s} + \frac{H_s}{F_s} = \alpha_s^2 - 2R_{cr}^s \alpha_s + T_s \gamma_s = 0;$$

$$T_s = \frac{\Delta P_s d^3 R_{cr}}{\rho^2 v^2 L}; \quad R_{cr}^s = \frac{R_{cr} G_s}{F_s}.$$

At the same time, the laminar solution  $\alpha_s = T_s \gamma_s / (2R_{cr}^s)$ , as the convective term has different signs in laminar flow. In turbulent conditions the solution the convective term of one sign is not sustainable.

In this case, turbulent formula for roughness calculation is applicable due to identical averaging method in turbulent mode

$$\frac{\alpha_s}{\sqrt{T_s}} = \frac{R_{cr}^s}{\sqrt{T_s}} - i^4 \sqrt{\gamma_s - \frac{(R_{cr}^s)^2}{T_s}} \sqrt{\lambda} = \sqrt{\frac{(R_{cr}^s)^2}{T_s} + \sqrt{\gamma_s - \frac{(R_{cr}^s)^2}{T_s}}} \lambda \exp(i\varphi);$$

$$\lambda = \left\{ 2 / \left[ k(T_s, \xi_0) R_{cr} / l(T_s, \xi_0) + 1 \right] \right\}^\sigma.$$

where  $k(T_s, \xi_0) / l(T_s, \xi_0)$  – effective average tangent of roughness inclination,  $\xi_0$  – ratio of roughness height to pipeline radius and critical Reynolds number  $\alpha_s = R_{cr}^s$  is value of Reynolds number corresponding to the beginning of the complex solution. At the same time, for small Reynolds number we obtain a laminar solution. But difficulties in obtaining of turbulent solution do not come to an end. It is necessary to define effect of the surface roughness and for this use of experimental data is still inevitable. In principle, exact dependence of Reynolds number for smooth surface on macro-roughness is necessary to be learned. But external problem has some features associated with existence of resistance crisis which is caused by presence of a trace behind the body placed into the flow. This trace does not present in internal problems such as flow in pipeline.

### Specificity of Flow Velocity Calculation for Sphere

Let us find out solution of Navier – Stokes equations for external problem. We have laminar solution for sphere motion in fluid for small Reynolds number. It yields the following velocity distribution, see [8]:

$$V_r = u \cos \theta \left( 1 - \frac{3a}{2r} + \frac{a^3}{2r^3} \right);$$

$$V_\theta = -u \sin \theta \left( 1 - \frac{3a}{4r} - \frac{a^3}{4r^3} \right).$$

At that, pressure dependence on flow parameters is

$$p = p_0 - \frac{3}{2} \rho v \frac{(\mathbf{u}, \mathbf{n}) a}{r^2}.$$

Motion equations in spherical coordinate system for solutions which do not depend on angle  $\varphi$  can be written as

$$\frac{\partial V_r}{\partial t} + (\mathbf{V}, \nabla) V_r - \frac{V_\theta^2}{r} = -\frac{1}{\rho} \frac{\partial p}{\partial r} + \nu \left[ \Delta V_r - \frac{2V_r}{r^2} - \frac{2}{r^2 \sin^2 \theta} \frac{\partial(V_\theta \sin \theta)}{\partial \theta} \right];$$

$$\frac{\partial V_\theta}{\partial t} + (\mathbf{V}, \nabla) V_\theta + \frac{V_r V_\theta}{r} = -\frac{1}{\rho r} \frac{\partial p}{\partial \theta} + \nu \left[ \Delta V_\theta + \frac{2\partial V_r}{r^2 \partial \theta} - \frac{2V_\theta}{r^2 \sin^2 \theta} \right];$$

$$\frac{1}{r^2} \frac{\partial(r^2 V_r)}{\partial r} + \frac{1}{r \sin \theta} \frac{\partial(\sin \theta V_\theta)}{\partial \theta} = 0; \quad (\mathbf{V}, \nabla) = V_r \frac{\partial}{\partial r} + \frac{V_\theta}{r} \frac{\partial}{\partial \theta};$$

$$\Delta = \frac{1}{r^2} \frac{\partial}{\partial r} \left( r^2 \frac{\partial}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial}{\partial \theta} \right).$$

Let us change coordinate system to  $\xi, \tau, \theta$  with unknown  $R_r, R_\theta, P$ , the coordinate system is defined by formula  $r = \frac{d\xi}{2}, t = \frac{d^2\tau}{2\nu}, V = \frac{R\nu}{d}, p = \frac{P\rho\nu^2}{d^2}$ , after division of the equation system by  $\frac{2\nu^2}{d^3}$  we will have equation system

$$\frac{\partial R_r}{\partial \tau} + (\mathbf{R}, \nabla) R_r - \frac{R_\theta^2}{\xi} = -\frac{\partial P}{\partial \xi} + 2 \left[ \Delta R_r - \frac{2R_r}{\xi^2} - \frac{2}{\xi^2 \sin^2 \theta} \frac{\partial(R_\theta \sin \theta)}{\partial \theta} \right];$$

$$\frac{\partial R_\theta}{\partial \tau} + (\mathbf{R}, \nabla) R_\theta + \frac{R_r R_\theta}{\xi} = -\frac{1}{\xi} \frac{\partial P}{\partial \theta} + 2 \left[ \Delta R_\theta + \frac{2\partial R_r}{\xi^2 \partial \theta} - \frac{2R_\theta}{\xi^2 \sin^2 \theta} \right];$$

$$\frac{1}{\xi^2} \frac{\partial(\xi^2 R_r)}{\partial r} + \frac{1}{\xi \sin \theta} \frac{\partial(\sin \theta R_\theta)}{\partial \theta} = 0;$$

$$(\mathbf{R}, \nabla) = R_r \frac{\partial}{\partial \xi} + \frac{R_\theta}{\xi} \frac{\partial}{\partial \theta};$$

$$\Delta = \frac{1}{\xi^2} \frac{\partial}{\partial \xi} \left( \xi^2 \frac{\partial}{\partial \xi} \right) + \frac{1}{\xi^2 \sin \theta} \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial}{\partial \theta} \right).$$

At that, in dimensionless constants, solution can be expressed as

$$R_r = R_x \frac{R_0}{R_{cr}} \cos \theta \left( 1 - \frac{3}{2\xi} + \frac{1}{2\xi^3} \right);$$

$$R_\theta = -R_x \frac{R_0}{R_{cr}} \sin \theta \left( 1 - \frac{3}{4\xi} - \frac{1}{4\xi^3} \right); \quad a = \frac{d}{2}; \quad R_0 = \frac{ud}{v};$$

$$P = \frac{p_0 d^2}{\rho v^2} - 3 \frac{(\mathbf{R}_0, \mathbf{n})}{\xi^2 R_{cr}} = \frac{p_0 d^2}{\rho v^2} - 3 \frac{R_0}{R_{cr}} \frac{\sin 2\theta}{2\xi^2} \left( 1 - \frac{9}{4\xi} + \frac{1}{4\xi^3} \right).$$

But if you consider solution for one domain  $\theta \in [0, \pi]$ , zero value will be obtained for coefficient  $R_x$ . So, the domain should be divided into two parts  $\theta \in [0, \theta_0]$ ,  $\theta \in [\theta_0, \pi]$  and value  $\theta_0$  should be found out of equality of  $R_x$  coefficients computed for different domains. At that  $R_x$  – common for either of Reynolds number components as laminar solution.

$$R_x^2 \frac{R_0}{R_{cr}} \left[ \cos^2 \theta \left( 1 - \frac{3}{2\xi} + \frac{1}{2\xi^3} \right) \frac{\partial}{\partial \xi} \left( -\frac{3}{2\xi} + \frac{1}{2\xi^3} \right) + \right. \\ \left. + \left( 1 - \frac{3}{4\xi} - \frac{1}{4\xi^3} \right) \left( 1 - \frac{3}{2\xi} + \frac{1}{2\xi^3} \right) \frac{\sin^2 \theta}{\xi} - \right. \\ \left. - \frac{\sin^2 \theta}{\xi} \left( 1 - \frac{3}{4\xi} - \frac{1}{4\xi^3} \right)^2 \right] = 3 \sin 2\theta \frac{\partial}{\partial \xi} \frac{1}{2\xi^2} \left( 1 - \frac{9}{4\xi} + \frac{1}{4\xi^3} \right) + \\ + 2R_x \left[ \frac{3 \cos \theta}{\xi^5} - \frac{2 \cos \theta}{\xi^2} \left( 1 - \frac{3}{2\xi} + \frac{1}{2\xi^3} \right) + \frac{4 \cos \theta}{\xi^2 \sin \theta} \left( 1 - \frac{3}{4\xi} - \frac{1}{4\xi^3} \right) \right].$$

Here we will show how to find solution for the first equation, solution of the second equation can be found similarly. For this, for internal problem, we will multiply equation by  $r^2 \sin \theta dr d\theta$ . For external problem, we will enter variable  $r = \frac{1}{\xi}$  for  $\xi \in [1, 0]$  and the multiplier will be following  $\frac{\sin \theta}{\xi^2} d \frac{1}{\xi} d\theta$ . Let us write down the equation with all multiplies:

$$R_x^2 \frac{R_0}{R_{cr}} \left[ \cos^2 \theta \sin \theta \left( \frac{3}{2\xi^4} - \frac{3}{2\xi^6} - \frac{9}{4\xi^5} + \frac{3}{\xi^7} - \frac{3}{4\xi^9} \right) + \right. \\ \left. + \left( \frac{1}{\xi^3} - \frac{9}{4\xi^4} + \frac{9}{8\xi^5} + \frac{1}{4\xi^6} - \frac{1}{8\xi^9} \right) \sin^3 \theta - \sin^3 \theta \left( \frac{1}{\xi^3} + \frac{9}{16\xi^5} + \frac{1}{16\xi^9} - \right. \right. \\ \left. \left. - \frac{3}{2\xi^4} - \frac{1}{2\xi^6} + \frac{3}{8\xi^7} \right) \right] = 3 \sin 2\theta \sin \theta \left( \frac{1}{2\xi^4} - \frac{9}{8\xi^5} + \frac{1}{8\xi^7} \right) + \\ + 2R_x \left[ \sin 2\theta \left( \frac{3}{\xi^7} - \frac{2}{\xi^4} + \frac{3}{\xi^5} - \frac{1}{\xi^7} \right) + \cos \theta \left( \frac{4}{\xi^4} - \frac{3}{\xi^5} - \frac{1}{\xi^7} \right) \right].$$

Integration over the angle  $[0, \pi]$  yields zero right part of the equation. So, it is necessary to divide this solution into two domains and match solutions at the boundary. At low velocity, this solution will be real but it is possible that the angle is complex.



Let us integrate this equation over two domains  $\theta \in [0, \theta_0]$ ,  $\frac{1}{\xi} \in [0, 1]$  and  $\theta \in [\theta_0, \pi]$ ,  $\frac{1}{\xi} \in [0, 1]$ , then

$$R_x^2 \frac{R_0}{R_{cr}} \left[ (1 - \cos^3 \theta_0) 0,003571 - \left( \frac{2}{3} - \cos \theta_0 + \frac{\cos^3 \theta_0}{3} \right) 0,01473 \right] - \\ - 2R_x \left[ (1 - \cos^2 \theta_0) 0,35 + 0,175 \sin \theta_0 \right] + 0,10781 \left( \sin \theta_0 - \frac{\sin 3 \theta_0}{3} \right) = 0.$$

Equation for another domain is

$$R_x^2 \frac{R_0}{R_{cr}} \left[ (1 + \cos^3 \theta_0) 0,003571 - \left( \frac{2}{3} + \cos \theta_0 - \frac{\cos^3 \theta_0}{3} \right) 0,01473 \right] - \\ - 2R_x \left[ -(1 + \cos^2 \theta_0) 0,35 - 0,175 \sin \theta_0 \right] - 0,10781 \left( \sin \theta_0 - \frac{\sin 3 \theta_0}{3} \right) = 0.$$

For laminar mode and very small Reynolds number  $R_0 \ll R_{cr}$ , we have following expression for Reynolds number

$$R_x = \frac{0,10781 \left( \sin \theta_0 - \frac{\sin 3 \theta_0}{3} \right) / 2}{(1 + \cos^2 \theta_0) 0,35 - 0,175 \sin \theta_0} = \frac{0,10781 \left( \sin \theta_0 - \frac{\sin 3 \theta_0}{3} \right) / 2}{(1 - \cos^2 \theta_0) 0,35 - 0,175 \sin \theta_0}.$$

Solution obtained is symmetrical:  $\theta_0 = \pi/2$ ,  $R_x = 0,8214$ . If non-linearity is taken into account:

$$R_x = \frac{b - \sqrt{b^2 - ac}}{a}; \quad a = 0,003571(1 - \cos^3 \theta_0) - \left( \frac{2}{3} - \cos \theta_0 + \frac{\cos^3 \theta_0}{3} \right) 0,01473; \\ b = [0,35(1 - \cos^2 \theta_0) + 0,175 \sin \theta_0] \beta; \quad c = 0,10781 \beta \left( \sin \theta_0 - \frac{\sin 3 \theta_0}{3} \right).$$

Where parameter  $\frac{R_0}{R_{cr}} = \frac{1}{\beta}$  is defined for area of Reynolds number increase. Another solution is:

$$a = -0,003571(1 + \cos^3 \theta_0) + \left( \frac{2}{3} + \cos \theta_0 - \frac{\cos^3 \theta_0}{3} \right) 0,01473; \\ b = [0,35(1 + \cos^2 \theta_0) + 0,175 \sin \theta_0] \beta; \quad c = 0,10781 \beta \left( \sin \theta_0 - \frac{\sin 3 \theta_0}{3} \right).$$

And complex Reynolds number  $R_x$  corresponds to beginning of turbulent mode.

If you take into account all coefficients, solution  $\theta_0 = \pi/2$  will not be obtained but you will have two values for coefficient  $\theta_0$ . It will be found that two angles  $\theta_1, \theta_2$  exist for each Navier – Stokes equation which correspond to two different variants of domain division. In case  $R_0 \rightarrow 0$  angles  $\theta_i = \pi/2$  are equal, we have  $R_i(\theta_i) = 1/2$ . Coefficients  $R_1(\theta_1) = R_2(\theta_2)$ ,  $R_3(\theta_3) = R_4(\theta_4)$  will be found from two Navier – Stokes equations which will be integrated separately over domains  $[0, \theta_0]$ ,  $[\theta_0, \pi]$ . At that, the two first of the angles will be found from the first Navier – Stokes equation, and the third and the fourth – from the second one.

Final solution will be found in the form

$$R_r = \Re_r \frac{R_0}{R_{cr}} \sum_{l=1}^4 R_l(\theta_l) \cos \left( \theta - \theta_l + \frac{\pi}{2} \right) \left( 1 - \frac{3}{2\xi} + \frac{1}{2\xi^3} \right); \\ R_0 = -\Re_0 \frac{R_0}{R_{cr}} \sum_{l=1}^4 R_l(\theta_l) \sin \left( \theta - \theta_l + \frac{\pi}{2} \right) \left( 1 - \frac{3}{4\xi} - \frac{1}{4\xi^3} \right); \\ p = P \left[ p_0 d^2 / \rho v^2 - 3 \frac{R_0}{R_{cr}} \sum_{l=1}^4 \frac{\sin 2 \left( \theta - \theta_l + \frac{\pi}{2} \right)}{2\xi^2} \left( 1 - \frac{9}{4\xi} + \frac{1}{4\xi^3} \right) \right].$$

We substitute the decision in two equations of Navier – Stokes and in the continuity equation, we average on space and we find the stationary solution.

And Cartesian components of velocity are equal to

$$R_x = R_r \cos \theta + R_\theta \sin \theta + R_0;$$

$$R_y = R_r \sin \theta - R_\theta \cos \theta.$$

For the following examples initial data were taken which do not match the solution. Fig. 1 shows a plot for real angles versus two angles and on condition

$$\theta_1 = \theta_3 = \frac{\pi}{2} - 0,1; \quad \theta_2 = \theta_4 = \frac{\pi}{2} + 0,1;$$

$$R_l(\theta_l) = 1; \quad R_0 = 1,5.$$

And for all plots  $\Re_r = \Re_\theta = 1$ .

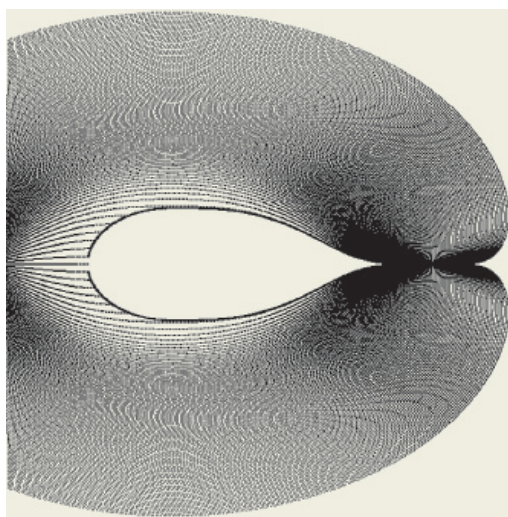


Fig. 3

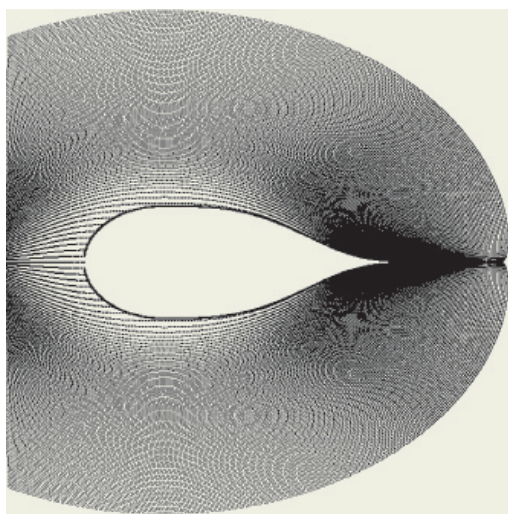


Fig. 4

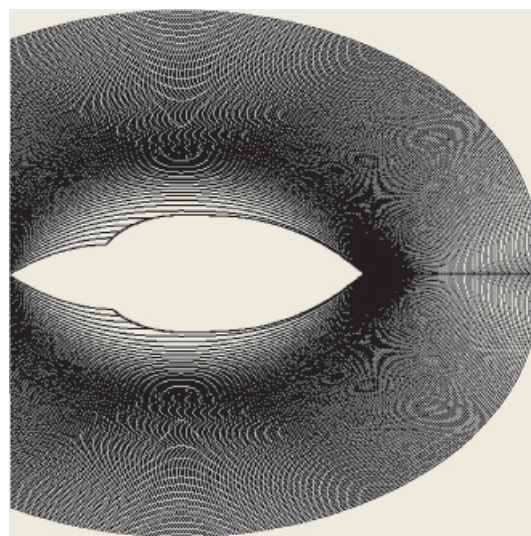


Fig. 5

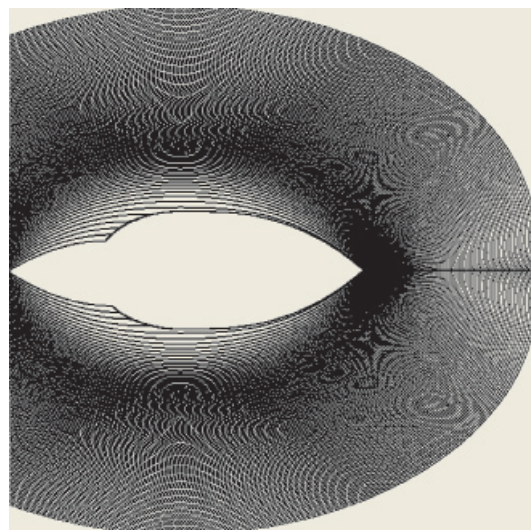


Fig. 6

Next Fig. 4 shows results for Reynolds number  $R_0 = 150$ , angles

$$\theta_1 = \theta_3 = \frac{\pi}{2} - 0,4; \quad \theta_2 = \theta_4 = \frac{\pi}{2} + 0,4;$$

$$R_l(\theta_l) = 0,1.$$

The more is Reynolds number, the more is deviation of angles  $\theta_l$  from  $\pi/2$ . Fig. 5 shows flow with Reynolds number  $R_0 = 5000$  and complex angles

$$\theta_1 = \theta_3 = \frac{\pi}{2} - 0,5 + 0,5i;$$

$$\theta_2 = \theta_4 = \frac{\pi}{2} + 0,5 + 0,5i; \quad R_l(\theta_l) = 0,1.$$

Two singular domains are seen in front of the sphere and behind the sphere. In these areas, velocity corresponds to tangent line. Plot in Fig. 6 was calculated for the same parameters as plot in Fig. 5 but Reynolds number of the body is equal to  $R_0 = 50000$ . The flow parameters are maximal, pattern remains the same as for parameter  $R_0 = 5000$ .

Fig. 7 was plotted for parameters

$$\theta_1 = \theta_3 = \frac{\pi}{2} - 0,5; \quad \theta_2 = \theta_4 = \frac{\pi}{2} + 0,5;$$

$$R_l(\theta_l) = 0,1; R_0 = 500.$$

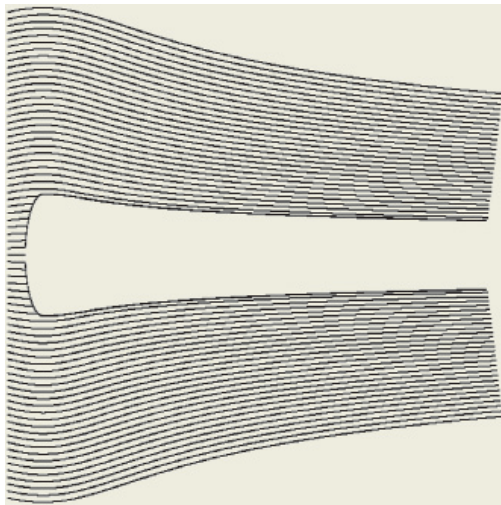


Fig. 7

Velocity distribution is so that there is a singular domain in front of the sphere – incompressible fluid can not penetrate into this area. And this area, inaccessible for fluid flow,

has large length that provides conditions for origin of long vortex path.

To change pattern, it is necessary to change angular boundaries and relation between coefficients  $R_l(\theta_l)$ . Besides, at large Reynolds number, imaginary part increases and, hence roughness effect is rather large.

For incompressible liquid the equation of continuity along a current tube with longitudinal coordinate  $s$  has an equation  $\frac{\partial V_s}{\partial s} + \frac{\partial V_n}{\partial n} = 0$ .

As the normal derivative from a normal component of speed is equal to zero for border of a special zone, we have constant longitudinal speed on border of a special zone. The convective term on border of a special zone is equal to zero. At that critical Reynolds number for external region off the body is equal to  $\frac{1}{R_{cr}} = \frac{1}{2300} \frac{a}{l_{cr}}$ , where  $a$  – specific body size,  $l_{cr}$  – length of the smooth body envelope when condition of complex coefficients  $R_l(\theta_l)$  beginning is satisfied. Ratio  $\frac{a}{l_{cr}}$  is found from

non-linear equation for  $l_{cr}$  finding, which corresponds to beginning of complex solution.

For the plots computing, following equation system was resolved in dimensionless coordinate system

$$\frac{dx}{dt} = R_x; \quad \frac{dy}{dt} = R_y; \quad x_0 = -2; y_0 \in [-4, 4].$$

For this, we write down new formula which is necessary to substitute to Navier – Stokes and in the continuity equation, to average the solution and to define new multipliers  $\Re_r, \Re_\theta, P$  by which the solution will be multiplied

$$\begin{aligned} R_r &= \Re_r \frac{R_0}{R_{cr}} \sum_{l=1}^4 \left\{ R_l(\theta_l) \left[ \cos \left( \theta - \operatorname{Re} \theta_l + \frac{\pi}{2} \right) \cosh(\operatorname{Im} \theta_l) - \right. \right. \\ &\quad \left. \left. - i \sin \left( \theta - \operatorname{Re} \theta_l + \frac{\pi}{2} \right) \sinh(\operatorname{Im} \theta_l) \right] \left( 1 - \frac{31}{2\xi} + \frac{1}{\xi^3} \right) \right\}; \\ R_\theta &= -\Re_\theta \frac{R_0}{R_{cr}} \sum_{l=1}^4 \left\{ R_l(\theta_l) \left[ \sin \left( \theta - \operatorname{Re} \theta_l + \frac{\pi}{2} \right) \cosh(\operatorname{Im} \theta_l) + \right. \right. \\ &\quad \left. \left. + i \cos \left( \theta - \operatorname{Re} \theta_l + \frac{\pi}{2} \right) \sinh(\operatorname{Im} \theta_l) \right] \left( 1 - \frac{3}{4\xi} - \frac{1}{4\xi^3} \right) \right\}; \\ p &= P \left[ p_0 d^2 / \rho v^2 - 3 \frac{R_0}{R_{cr}} \frac{1}{2\xi^2} \left( 1 - \frac{9}{4\xi} + \frac{1}{4\xi^3} \right) \right] \times \\ &\times \sum_{l=1}^4 \left[ \sin 2 \left( \theta - \operatorname{Re} \theta_l + \frac{\pi}{2} \right) \cosh(2 \operatorname{Im} \theta_l) + i \cos 2 \left( \theta - \operatorname{Re} \theta_l + \frac{\pi}{2} \right) \sinh(2 \operatorname{Im} \theta_l) \right]. \end{aligned}$$



Let us draw the curves for real boundaries of the area definition.

Vertical axis characterizes module of difference between coefficients calculated for two different areas. On horizontal axis the real angle  $\theta_0$  is shown. In Fig. 8, the only root for small Reynolds number is shown. In Fig. 9, there are two real roots corresponding to the laminar mode with Reynolds number equal to  $R_0 = 100$ .

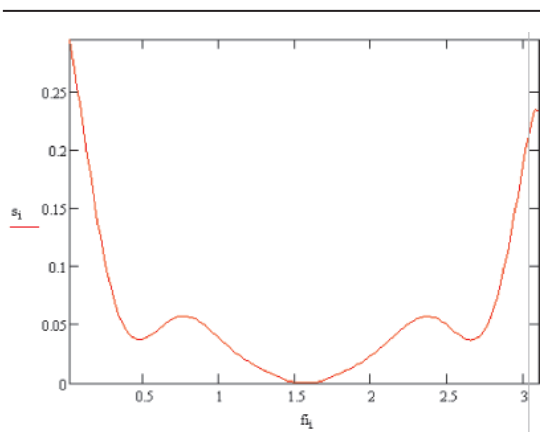


Fig. 8

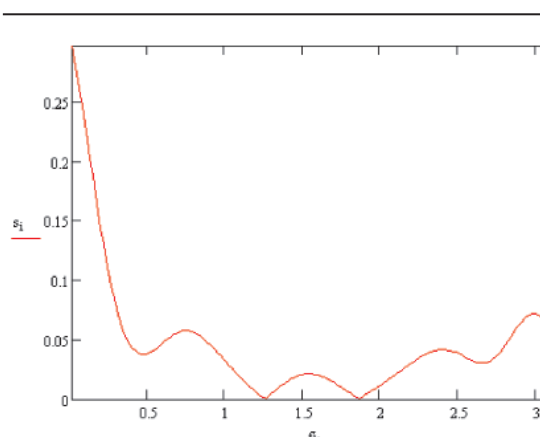


Fig. 9

In Fig. 10, 11 complex roots existence is shown, the roots are equal to

$$\theta_1 = 1 + 0,5i; \quad \theta_2 = 2 + 0,5i.$$

The imaginary axis values change in interval  $[0, 2]$ , real axis values – in interval  $[0, \pi]$ .

### Description of Singular Domain

At that, solution for fluid flow has discontinuous zones, velocity perpendicular to boundaries of these zones is zero. Therefore fluid in these zones is independent of main flow. But tangential velocity components on boundary have to coincide. Now we will find the solution in these zones. Real part of the solution  $R = R_1 + iR_2$  corresponds to component  $z$ , the imaginary part – to component  $x$ , and the  $x$  axis rotates around the axis  $Oz$  with change of angle  $\varphi$ . But the solution is to be found for fixed angle and should not be dependent of this angle. Then the solution of Navier – Stokes equation will be

$$R = \sum_{n,m=-N}^N b_{nm} \exp(in\Phi + im \ln \rho_0). \quad (8)$$

Where new scaled angular variable  $\Phi = \frac{2\pi(\theta - \theta^{\min})}{\theta^{\max} - \theta^{\min}}$  is entered, where  $\theta^{\max}$ ,  $\theta^{\min}$  – extreme values of turbulent zone boundaries. Besides, we will enter the scaled radius

$$\ln \rho_0 = \frac{\ln r/a^{\min}(\theta)}{\ln[a^{\max}(\theta)/a^{\min}(\theta)]} 2\pi,$$

where  $a^{\max}(\theta)$ ,  $a^{\min}(\theta)$  – maximum and minimum value of radius of the turbulent zone boundary. In case if denominator is zero, value  $r = \sqrt{a^{\max}(\theta)a^{\min}(\theta)}$  should be used for  $r$ . Then  $\ln \rho$  will be continuous and equal to  $\pi$  in this point. Coefficients  $b_{nm}$  will be defined from values of the laminar solution within turbulent zone boundaries  $r = a^{\min}(\theta)$ ;  $s = a^{\max}(\theta)$ , where  $\theta \in [\theta^{\min}, \theta^{\max}]$ .

Разность коэфф. двух решений в разных областях

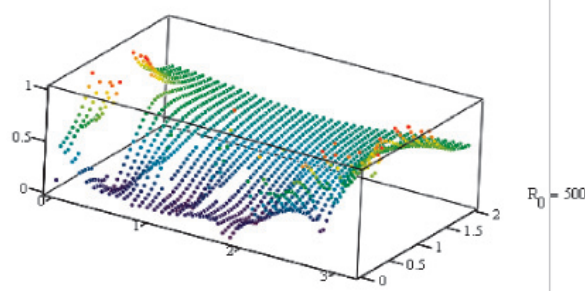


Fig. 10

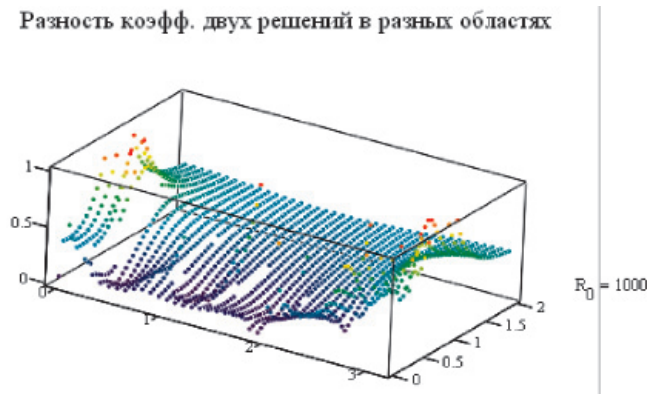


Fig. 11

Coefficients  $b_{nm}$  will be determined by formula

$$\int_0^{2\pi} \int_0^{2\pi} R[r(\ln \rho_0, \Phi), w(\Phi)] \exp(-in\Phi - im \ln \rho_0) d \ln \rho d\Phi = \frac{b_{nm}}{4\pi^2}.$$

As boundary values at the beginning and the end of the period differ and area boundaries expressed in coordinates  $r, \theta$  are not rectangular (in coordinates  $\Phi, \ln \rho$  velocity on the boundary is variable), a series will be discontinuous, that is, the coefficient  $b_{nm}$  decreases as  $b_{nm} \sim \frac{1}{nm}$  when  $n, m \rightarrow \infty$ , i.e. this solution is discrete. In singular domain, in coordinates  $\ln \rho, \Phi$ , the solution is discrete due to discretization of functions  $R(\ln \rho_0, \Phi)$  in the form of discrete series. But as the description of singular domain is performed relative to coordinates  $\ln \rho_0, \Phi$ , the singular domain is discrete. Vortex path or pulsing turbulent mode with variable boundary is formed in this area at laminar mode.

The formula (8) can be rewritten in the form

$$\sum_{n,m=-N}^N b_{nm} \exp(in\Phi + im \ln \rho_0) = \sum_{n,m=0}^N A_{nm} \operatorname{sgn}(\Phi - \Phi_n^0) \operatorname{sgn}(\Phi_n^1 - \Phi) \times \operatorname{sgn}(\ln \rho_0 - \ln \rho_m^0) \operatorname{sgn}(\ln \rho_m^1 - \ln \rho_0), \quad (9)$$

where in this case we have

$$\operatorname{sgn}(x) = \begin{cases} 1, x \geq 0 \\ 0, x < 0 \end{cases}$$

and then step with amplitude  $A_{nm}$  and phase  $\Phi_n^0, \ln \rho_m^0, \Phi_n^1, \ln \rho_m^1$  will be found from equations

$$4\pi^2 b_{nm} = \sum_{p,q} A_{pq} \sin \left[ \frac{n(\Phi_p^1 - \Phi_p^0)}{2} \right] \exp \left[ \frac{in(\Phi_p^0 + \Phi_p^1)}{2} \right] \times \sin \left[ \frac{m(\ln \rho_q^1 - \ln \rho_q^0)}{2} \right] \exp \left[ \frac{im(\ln \rho_q^0 + \ln \rho_q^1)}{2} \right] / (nm),$$

where indexes  $n, m = -N, \dots, -1, 1, \dots, N$ .

It should be noted that  $A_{00} = b_{00}$ . If the series in the left part of (9) is not summarized directly as this requires too large number of terms, then the right part of (9) will determine its discrete sum for finite number of terms. It should be noted that

$$\Phi_n^0 + 2\pi p \leq \Phi_n \leq \Phi_n^1 + 2\pi p; \quad \ln \rho_m^0 + 2\pi q \leq \ln \rho_m \leq \ln \rho_m^1 + 2\pi q$$

is almost periodic coordinate of the step.



Why the turbulent solution in singular domain has the pulsing character with variable boundaries? The turbulent area boundary is not smooth function due to discreteness of the turbulent solution, unlike the laminar solution. This results in non-equality of tangential component of the solution and boundary pulsation in case of turbulent mode.

For description of laminar flow, it is necessary to enter dependence of specified radius on time

$$\ln \rho = \frac{[\ln \rho_0 - \omega \cdot t(2\pi - \Phi)\Phi/4\pi^2](\Phi - \pi)}{\pi};$$

$$\omega = 2\pi Sh \frac{u_0}{d},$$

where  $Sh$  is a Strouhal number. At that, the pattern will fluctuate with Strouhal frequency according to value of  $\ln \rho_0$  and this will lead to vortexes rotation in opposite directions as the frequencies under condition  $\Phi = \frac{\pi}{2}$ ,  $\Phi = \frac{3\pi}{2}$  have different signs. At the same time, on the area boundary, frequency is zero, i.e. the solution on boundary is continuous in laminar mode.

$$R_r = \frac{\Re_r \{g_r [\xi, \theta - \theta_{r1}(\varphi) + \theta_{0r}(\varphi), \varphi] + g_r [\xi, \theta - \theta_{r2}(\varphi) + \theta_{0r}(\varphi), \varphi]\}}{R_{cr}},$$

$$R_0 = \frac{\Re_0 \{g_0 [\xi, \theta - \theta_{01}(\varphi) + \theta_{00}(\varphi), \varphi] + g_0 [\xi, \theta - \theta_{02}(\varphi) + \theta_{00}(\varphi), \varphi]\}}{R_{cr}},$$

$$R_\varphi = \frac{\Re_\varphi \{g_\varphi [\xi, \theta - \theta_{\varphi1}(\varphi) + \theta_{0\varphi}(\varphi), \varphi] + g_\varphi [\xi, \theta - \theta_{\varphi2}(\varphi) + \theta_{0\varphi}(\varphi), \varphi]\}}{R_{cr}},$$

$$p = P \{p [R_0, \xi, \theta - \theta_{r1}(\varphi) + \theta_{0r}(\varphi), \varphi] + p [R_0, \xi, \theta - \theta_{r2}(\varphi) + \theta_{0r}(\varphi), \varphi] +$$

$$+ p [R_0, \xi, \theta - \theta_{01}(\varphi) + \theta_{00}(\varphi), \varphi] + p [R_0, \xi, \theta - \theta_{02}(\varphi) + \theta_{00}(\varphi), \varphi] +$$

$$+ p [R_0, \xi, \theta - \theta_{\varphi1}(\varphi) + \theta_{0\varphi}(\varphi), \varphi] + p [R_0, \xi, \theta - \theta_{\varphi2}(\varphi) + \theta_{0\varphi}(\varphi), \varphi]\}. \quad (10)$$

#### Solution of the Flow Problem for Arbitrary Smooth Body in Spherical Coordinate System

Laminar solution of the flow problem for arbitrary body in spherical coordinate system we regard resolved in the form of final formula. That is, value of Reynolds number and pressure for laminar mode is found:

$$R_r = \frac{R_0}{R_{cr}}(\xi, \theta, \varphi);$$

$$R_0 = \frac{R_0}{R_{cr}}g_0(\xi, \theta, \varphi);$$

$$R_\varphi = \frac{R_0}{R_{cr}}g_\varphi(\xi, \theta, \varphi);$$

$$p = p(R_0, \xi, \theta, \varphi).$$

We resolve each Navier – Stokes equation

by multiplying by  $\frac{\sin \theta}{\xi^2} d\frac{1}{\xi} d\theta$ , integration over

inverse radius and angle  $\theta$ , over two areas, which have one of the boundaries  $\theta_l$ ,  $l = 1, 2$ . We defined this boundary from equation  $R_r[\theta_{r1}(\varphi), \varphi] = R_r[\theta_{r2}(\varphi), \varphi]$ . As the equation for

these angles finding is the second degree one, two angles,  $\theta_{k1}$ ,  $\theta_{k2}$ , are found. We define value  $\theta_{0r}(\varphi)$  for laminar solution and consider this in formula for Reynolds number taking area boundaries into account.

We do the same operation with other components of Reynolds numbers. Further we find out the solution by entering four unknown constants

We substitute these functions into Navier – Stokes equations and continuity equation, we integrate over the volume and then we obtain 4 constants  $\Re_r$ ,  $\Re_0$ ,  $\Re_\varphi$ ,  $P$ . These coefficients can be complex describing the complex turbulent solution. Real part of the solution will be an average solution, and imaginary part – mean square deviation. At that, as the angle enters into solution function in non-linear way, it is possible to integrate on periodic angle  $\varphi$  without obtaining of zero integral. When solving non-linear equation, there can occur complex function  $\theta_{rl}(\varphi)$ ,  $\theta_{0l}(\varphi)$ ,  $\theta_{\varphi l}(\varphi)$ ,  $l = 1, 2$ . Similarly,

it is possible to find the problem solution for sphere, determining not laminar pressure, but such solution will be complicated. It is possible to add angle dependence of the sphere solution versus angle  $\varphi$  in Cartesian coordinate system and to solve a problem defining  $\theta_1(\varphi)$ ,  $\theta_2(\varphi)$ , then dependence of the solution on angle  $\varphi$  will be found. At the same time, it is necessary to

From this we define  $\frac{\partial}{\partial x_i}$  through dependence  $\frac{\partial}{\partial r}, \frac{\partial}{\partial \theta}, \frac{\partial}{\partial \varphi}$ . The second derivatives with respect to  $x_i$  can be found similarly but in this case dependence on mixed derivatives with respect to  $r, \theta, \varphi$  will occur.

$$R_x = \frac{\Re_x}{R_{cr}} \sum_{l=1}^2 \left\{ g_r [\xi, \theta - \theta_{xl}(\varphi) + \theta_{0x}(\varphi)] \cos \theta + g_\theta [\xi, \theta - \theta_{xl}(\varphi) + \theta_{0x}(\varphi)] \sin \theta \right\} \cos \varphi;$$

$$R_y = \frac{\Re_y}{R_{cr}} \sum_{l=1}^2 \left\{ g_r [\xi, \theta - \theta_{yl}(\varphi) + \theta_{0y}(\varphi)] \cos \theta + g_\theta [\xi, \theta - \theta_{yl}(\varphi) + \theta_{0y}(\varphi)] \sin \theta \right\} \sin \varphi;$$

$$R_z = \frac{\Re_z}{R_{cr}} \sum_{l=1}^2 \left\{ g_r [\xi, \theta - \theta_{zl}(\varphi) + \theta_{0z}(\varphi)] \sin \theta - g_\theta [\xi, \theta - \theta_{zl}(\varphi) + \theta_{0z}(\varphi)] \cos \theta \right\};$$

keep dependence on spherical coordinate system at Cartesian components versus velocity and pressure. In curvilinear coordinate system, the derivative is determined by formula

$$\begin{aligned} \frac{\partial}{\partial r} &= \frac{\partial x_1(r, \theta, \varphi)}{\partial r} \frac{\partial}{\partial x_1} + \\ &+ \frac{\partial x_2(r, \theta, \varphi)}{\partial r} \frac{\partial}{\partial x_2} + \frac{\partial x_3(r, \theta, \varphi)}{\partial r} \frac{\partial}{\partial x_3}; \\ \frac{\partial}{\partial \theta} &= \frac{\partial x_1(r, \theta, \varphi)}{\partial \theta} \frac{\partial}{\partial x_1} + \\ &+ \frac{\partial x_2(r, \theta, \varphi)}{\partial \theta} \frac{\partial}{\partial x_2} + \frac{\partial x_3(r, \theta, \varphi)}{\partial \theta} \frac{\partial}{\partial x_3}; \\ \frac{\partial}{\partial \varphi} &= \frac{\partial x_1(r, \theta, \varphi)}{\partial \varphi} \frac{\partial}{\partial x_1} + \\ &+ \frac{\partial x_2(r, \theta, \varphi)}{\partial \varphi} \frac{\partial}{\partial x_2} + \frac{\partial x_3(r, \theta, \varphi)}{\partial \varphi} \frac{\partial}{\partial x_3}. \end{aligned}$$

Where

$$x_1(r, \theta, \varphi) = r \sin \theta \cos \varphi;$$

$$x_2(r, \theta, \varphi) = r \sin \theta \sin \varphi;$$

$$x_3(r, \theta) = r \cos \theta.$$

At that, as  $\frac{R_y}{R_x} \neq \tan \varphi$ , velocity component  $R_\varphi$  will occur. As  $\theta_{xl} = \theta_{0x}$ ,  $\theta_{yl} = \theta_{0y}$ ,  $\theta_{zl} = \theta_{0z}$ , this dependence vanishes at small Reynolds number.

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# STUDY OF NAVIER – STOKES EQUATION SOLUTION III. THE PHYSICAL SENSE OF THE COMPLEX VELOCITY AND CONCLUSIONS

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In this part of the article is described the physical meaning of complex velocity. The relationship between the Schrödinger equation and the Navier – Stokes equation obtain. Schrödinger equation and the Navier – Stokes equations are, in general, have a countable number of turbulent energy and solutions.

**Keyword:** large dimensionless unknown functions, solutions of non-linear partial differential equation, Navier – Stokes equation, turbulent function, fluid flow resistance coefficient, round pipeline

## Physical Meaning of Complex Solution

Let us explain physical meaning of the complex turbulent solution. So, we will consider real solution of ordinary differential equations system  $x_\alpha(t)$ .

Let us assume that initial data have an average value  $x_\alpha^0$  and mean root square  $\langle [\Delta x_\alpha^0]^2 \rangle$ .

Mean root square of initial data for Navier – Stokes equation is defined by surface roughness or by initial data which are not precisely defined. Then, for mean root square of the solution we have

$$\begin{aligned} \langle [\Delta x_i]^2 \rangle &= \langle [x_i - \langle x_i \rangle]^2 \rangle = \\ &= \langle x_i^2 \rangle - 2\langle x_i \rangle \langle x_i \rangle + \langle x_i \rangle^2 = \langle x_i^2 \rangle - \langle x_i \rangle^2. \end{aligned}$$

Then

$$\langle x_i^2 \rangle = \langle x_i \rangle^2 + \langle [\Delta x_i]^2 \rangle = \left| \langle x_i \rangle + i\sqrt{\langle [\Delta x_i]^2 \rangle} \right|^2. \quad (1)$$

Here I will provide the formulation of inverse Pythagoras theorem. For any three of positive numbers  $a$ ,  $b$  and  $c$ , such that  $a^2 + b^2 = c^2$ , there is a rectangular triangle with legs  $a$  and  $b$  and hypotenuse  $c$ . Hence, mathematical mean value and mean square deviation form legs and hypotenuse is an average square root of the value. That is, average  $\langle x_i \rangle$  is orthogonal to

mean square deviation  $\sqrt{\langle [\Delta x_i]^2 \rangle}$  which forms imaginary part of the body coordinate. Thus, the Cartesian space with oscillatory high frequency velocity (period of fluctuation is less than measurement time), obtained as a result of averaging in time, becomes complex space. That is, in case of large mean root square of the real space, it should be considered as complex three-dimensional space where imaginary part corresponds to mean square deviation. At the same time, there is following relation be-

tween variables  $\sqrt{\langle x_i^2 \rangle} = \left( \langle x_i \rangle + i\sqrt{\langle [\Delta x_i]^2 \rangle} \right) \alpha$ ;  $|\alpha|=1$ , and the complex number  $\alpha$  is chosen in such a way that the imaginary part had positive or negative value. Mean square deviation satisfies this condition. But sometimes the mean square deviation is positive, for example, in case of dielectric permeability where positive and negative charges have an influence.

In this case we have a formula  $\varepsilon = \varepsilon_0 + \frac{4\pi i \sigma}{\omega}$  where real part is proportional to positive mean square dipole deviation and conductivity is proportional to average value. But conductivity is divided by frequency which has positive and negative sign.

Therefore, algorithm for finding of average solution or average solution in phase space and its mean root square is reduced to finding of complex solution. The average solution corresponds to real part of solution, and second power of complex part corresponds to mean root square of the solution. This is physical meaning of complex solution, real part is an average solution, and imaginary part is a mean square deviation. And real and imaginary parts are orthogonal and form complex space. Really, according to inverse Pythagoras theorem, due to formula (1) mathematical mean value and mean square deviation form legs and average square is a hypotenuse.

Here we would like to note that when calculating the flow motion and one term of a series is taken into account, it is necessary to take square root of imaginary part as forward velocity is calculated. The imaginary part corresponds to square root of oscillatory part of dimensionless velocity.

This situation is similar to calculation of deviation at random choice of forward or back step with probability 1/2 and the point position after  $N$  steps is defined by  $\sqrt{N}$ .

Real and imaginary parts of the solution are located on different axes of complex space. But if you average imaginary dimensionless part, you will have

$$\langle x_\alpha(t) \rangle + i\sqrt{\langle [\Delta x_\alpha(t)]^2 \rangle} \rightarrow \langle x_\alpha(t) \rangle + i\sqrt{\langle [\Delta x_\alpha(t)]^2 \rangle}.$$

And the solution is equal to the module of the last value and, for different roughness, the imaginary part of the solution should be multiplied by averaging multiplier. At the same time, if all coefficients of a series in non-linear equations system are calculated, it is not necessary to calculate square root of imaginary part. It is necessary to summarize complex values and to calculate module of the sum.

Now we will show that the imaginary part of complex derivative of coordinate in phase space of the differential equation forms pulsing coordinate motion in phase space, i.e. in space of variables

$$\langle x_k(t) \rangle + i\sqrt{\langle [\Delta x_k(t)]^2 \rangle}.$$

Average values are used for variables as, at molecular level, the medium is not smooth.

**Lemma.** Complex solution yields fluctuating pulsing function of flow motion coordinates.

The imaginary part of velocity corresponds to rotation speed in phase space. As rotation ra-

dius is known, it is also possible to determine rotation frequency. In the rotation plane, complex velocity with constant rotation radius and constant frequency can be written in the form

$$V_x + iV_y = V_0 \exp(i\omega t).$$

In case of varying over the space stationary speed, locally, this formula can be written for one plane as

$$V_x(x, y) + iV_y(x, y) = V_0(x, y) \exp \left[ i \int_0^t \omega(x, y, u) du \right],$$

and frequency is dependent on time as the phase shift is provided as a result of harmonic oscillations in neighboring points. Sum of harmonic oscillations with different time-dependent frequencies defines pulsing mode in phase space at stationary complex velocity. That is, this complex velocity defines the coordinates of phase space points pulsing in time. The situation is similar to existence of several stationary vortices defining the pulsing rotation of the flow.

**Lemma 6.** Three-dimensional flow velocity can be written in the form

$$V_l = V_{tl} + iV_{nl} = V_l \exp(i\varphi_l); \quad \varphi_l = \arg(V_{tl} + iV_{nl}).$$

And velocity is defined in the form of integral of tangent acceleration by formula

$$\begin{aligned} V_{tl} &= \int_{t_0}^t t_l(u) w_t(u) du + V_{tl}(t_0) = \int_{t_0}^t t_l(u) \frac{d \sqrt{\sum_{k=1}^3 V_k(u) V_k^*(u)}}{du} du + V_{tl}(t_0) = \\ &= \int_{t_0}^t t_l(u) \frac{d \sqrt{\sum_{k=1}^3 [V_{tk}^2(u) + V_{nk}^2(u)]}}{du} du + V_{tl}(t_0). \end{aligned}$$

Integral of perpendicular component of acceleration defines perpendicular component of velocity by formula

$$\begin{aligned} V_{nl} &= \operatorname{Im} V_l(\tau_0) = \int_{\tau_0}^{\tau} w_{nl}(u) du = \int_{\tau_0}^{\tau} \frac{n_l(u) |\operatorname{Im} \mathbf{V}|^2}{\rho(u)} du = \int_{s_0}^s |\operatorname{Im} \mathbf{V}(s)| \frac{n_l(s)}{\rho(s)} ds = \\ &= \int_{s_0}^s |\operatorname{Im} \mathbf{V}| dt_l = \begin{cases} |\operatorname{Im} \mathbf{V}| [t_l(s) - t_l(s_0)], & |\operatorname{Im} \mathbf{V}| = \text{const} \\ \int_{s_0}^s |\operatorname{Im} \mathbf{V}| dt_l, & |\operatorname{Im} \mathbf{V}| \neq \text{const} \end{cases}; \\ \sum_{k=1}^3 [V_{tk}^2(u) + V_{nk}^2(u)] &= |\mathbf{V}|^2; \\ dt_l(s) &= \frac{n_l(s) ds}{\rho(s)}; \\ t_l(\tau) &= \frac{\operatorname{Im} \mathbf{V}_l}{|\operatorname{Im} \mathbf{V}|}. \end{aligned}$$

At that value of local velocity is  $V_{nl}(\tau_0) = \text{Im} V_l(\tau_0)$ ,  $V_{il}(\tau_0) = \text{Re}(V_l)\tau_0$ . But value of velocity obtained as a result of integration of centripetal acceleration is not zero ( $V_{nl}(\tau) \neq 0$ ), but this velocity become equal to zero for the same initial point, at constant particle velocity and constant curvature radius with rotation period  $T = \frac{2\pi R}{|\mathbf{V}|}$ , where  $R$  – curvature radius. For variable particle velocity depending on time, when one of the integrals  $\int_{\tau_0}^{\tau} |\mathbf{V}| dt_l = 0$ , which, at finite curvature radius of one sign of the trajectory, is finite and equal to

$$T = \int_0^{2\pi} \frac{R(\varphi) d\varphi}{|\mathbf{V}(\varphi)|} = \int_{s_0}^{s_0+2\pi} \frac{ds}{|\mathbf{V}(s)|}; \quad 2\pi = \int_{s_0}^{s_0+2\pi} \frac{ds}{R(s)},$$

as tangential direction  $t_p$  changes sign in the course of rotation.

Tangential acceleration is defined by formula

$$w_t = d \sqrt{\sum_{k=1}^3 [V_{tk}^2(t) + V_{nk}^2(t)]} / dt.$$

Direction of velocities  $\Delta V_{il}$ ,  $\Delta V_{nl}$  is orthogonal, their sum yields increase of motion velocity module

$$\sum_{l=1}^3 (dV_l)^2 = \sum_{l=1}^3 [(dV_{il})^2 + (dV_{nl})^2] = \sum_{l=1}^3 |dV_{il} + idV_{nl}|^2,$$

$$\text{as } \sum_{l=1}^3 (w_l)^2 = \sum_{l=1}^3 [(w_{il})^2 + (w_{nl})^2].$$

Components of these projections, differentiable with respect to time, define tangential and orthogonal accelerations. At the same time, concepts of tangential and orthogonal velocities are entered which, in the Cartesian space, are not orthogonal to  $(\mathbf{V}_p, \mathbf{V}_l) \neq 0$ , but in six-measured complex space they are orthogonal, and their module of complex vector  $V_l = V_{il} + iV_{nl}$  is equal to

$$\sum_{l=1}^3 |V_l|^2 = \sum_{l=1}^3 [(V_{il})^2 + (V_{nl})^2] = \sum_{l=1}^3 |V_{il} + iV_{nl}|^2.$$

It can be proved by use of expression  $\mathbf{V}_t = \sum_{l=1}^3 V_{il} \mathbf{e}_{il}$ ,  $\mathbf{V}_n = \sum_{l=1}^3 V_{nl} \mathbf{e}_{nl}$  and calculation of module as product of complex conjugate vectors taking into account orthogonality of six real unit vectors.

### Conclusions

Thus, solution of Navier – Stokes equations for not multiple balance po-

sitions is obtained. It is defined by expressions

$$\mathbf{V}(t, \mathbf{r}) = \sum_{n=1}^N \mathbf{x}_n(t) \varphi_n(\mathbf{r});$$

$$\sum_{s=1}^S \lambda_l^s \ln(x_l - a_l^s) \Big|_{t_0}^t = H_l(t, t_0), \quad l = 1, \dots, 2N;$$

$$\lambda_l^s = \frac{1}{(a_l^s - a_l^1) \dots (a_l^s - a_l^{s-1})(a_l^s - a_l^{s+1}) \dots (a_l^s - a_l^S)},$$

where values  $a_l^s$  are coordinates of balance positions.

Laminar solution corresponds to the solution of linear problem with convective term averaging; structure of turbulent solution is

$$\mathbf{V}(t, \mathbf{r}) = \sum_{n=1}^N \sum_{k=-\infty}^{\infty} \frac{a_{nk}}{g(t) - g_{nk}(t_n)} \varphi_n(\mathbf{r}) + \mathbf{a}^s,$$

where  $g_{nk}(t)$  – known defined continuous function, value of  $g_{nk}(t_n) = g_k(t_0, x_k^0) + \pi n$  is defined from initial conditions, and  $\lim_{t \rightarrow \infty} g(t) = \infty$ .

At that, the solution contains a lot of poles which, for real solution and real initial data, yield infinity.

At real time and complex initial conditions which define complex value of  $g_{nk}(t_0, x_k^0)$ , and, as  $g(t)$  is real, the complex solution is finite.

At that, formula

$$\sum_{s=1}^S \lambda_l^s \ln(x_l - a_l^s) \Big|_{t_0}^t = H_l(t, t_0), \quad l = 1, \dots, N. \quad (2)$$

may have branching points in which the solution continuously passes into other branch of the solution. This does not contradict the theorem of solution uniqueness for Cauchy problem as the left part of the differential equation tends to infinity in branching point. Derivative of right part of ordinary differential equation also tends to infinity in branching point. So we have a point of discontinuous solution. But this solution can be continued by a formula (2).

This situation is similar to Schrödinger equation when generally we have finite number of solutions. It is not surprising as Schrödinger equation can be reduced to Navier – Stokes equation. Now we will prove it. For this we will write down Schrödinger equation and will transform it using equality

$$\frac{\partial^2 \Psi}{\partial x_l^2} = \Psi \left[ \frac{\partial^2 \ln \Psi}{\partial x_l^2} + \frac{1}{\Psi^2} \left( \frac{\partial \Psi}{\partial x_l} \right)^2 \right];$$



$$i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar^2}{2m} \sum_{l=1}^3 \frac{\partial^2 \psi}{\partial x_l^2} + U\psi = -\frac{\hbar^2}{2m} \psi \sum_{l=1}^3 \left[ \frac{\partial^2 \ln \psi}{\partial x_l^2} + \frac{1}{\psi^2} \left( \frac{\partial \psi}{\partial x_l} \right)^2 \right] + U\psi.$$

Dividing the equation by mass  $m\psi$  we obtain the equation

$$i \frac{\hbar}{m} \frac{\partial \ln \psi}{\partial t} + \frac{\hbar^2}{2m^2} \sum_{l=1}^3 \left( \frac{\partial \ln \psi}{\partial x_l} \right)^2 = -\frac{\hbar^2}{2m^2} \sum_{l=1}^3 \frac{\partial^2 \ln \psi}{\partial x_l^2} + \frac{U}{m}.$$

Now we will write a private derivative equation, will take a gradient of both parts of equation and will enter real velocity to the formula

$$\mathbf{V} = -i \frac{\hbar}{m} \nabla \ln \psi;$$

$$\frac{\partial i \frac{\hbar}{m} \nabla \ln \psi}{\partial t} + \frac{\hbar^2}{m^2} \sum_{l=1}^3 \frac{\partial \ln \psi}{\partial x_l} \frac{\partial \nabla \ln \psi}{\partial x_l} = \frac{i\hbar}{2m} \sum_{l=1}^3 \frac{\partial^2 i \frac{\hbar}{m} \nabla \ln \psi}{\partial x_l^2} + \frac{\nabla U}{m}.$$

Substituting velocity value into transformed Schrödinger equation, we have

$$\frac{\partial V_p}{\partial t} + \sum_{l=1}^3 V_l \frac{\partial V_p}{\partial x_l} = v \sum_{l=1}^3 \frac{\partial^2 V_p}{\partial x_l^2} - \frac{\partial U}{\partial x^p} / m; \quad v = \frac{i\hbar}{2m}.$$

Now we have three-dimensional Navier – Stokes equation with pressure corresponding to potential. Nevertheless, the hydrodynamic problem differs from the equation of Navier – Stokes derived from Schrödinger equation and continuity equation.

At the same time it is possible to draw an analogy between laminar single-value mode and free, single-value description of bodies.

Between turbulent mode, having finite number of solutions, and description of bound particles having finite number of solutions. In case of turbulent complex and laminar real modes there is a boundary between them and critical Reynolds number. The similar boundary is available between free and bound particles description, which corresponds to energy transition from negative to positive state. In turn, Navier – Stokes equation has to have discrete energy levels of turbulent flow states, transitions between these states with energy emission or absorption have to be realized.

The boundary between free particles description and bound particles description can be defined, this is transition to complex quantum number or to infinity of the main quantum number of hydrogen atom. At that, infinite quantum number of hydrogen atom, passing through zero value of expression  $1/n^2$  where  $n$  – main quantum number, becomes imaginary and continuous. Wave function of free motion, which is continuous at continuous energy, corresponds to laminar solution of hydrodynamic problem for which single valued solution exists. And for large quantum number, the system is quasi-classical, i.e. for quantum number which is close to boundary (quantum number is equal to infinity) system is almost classical.

And there is a boundary between free solution and solution which describes bound states. This is zero energy value and, likewise non-linear private derivatives equations, boundary exists between turbulent complex solution and laminar real solution.

## INFLUENCE OF MICROWAVE IRRADIATION ON EXTRACTION YIELD OF BITUMINOUS SUBSTANCES OF BROWN COAL

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The article describes the results of the study of the pre-treatment of brown coal extraction yield of tar substances. It is shown that the use of microwave irradiation treatment increases the yield of products during their processing. It is shown that the number and composition of the target organic components extracted from coal may vary widely depending on the type of solvent and feedstock pretreatment conditions.

**Keywords:** lignite, extraction, bitumen, demineralization, microwave effect

Raw lignite wax yielded from lignite tar by extraction with organic solvents (benzene, toluene, alcohols, etc.) is actually a mixture of wax and resin components. Mineral wax and its products due to a number of valuable properties are used in more than 200 industries [1–3]. For an acceptable cost-effectiveness, concentration of bitumen in raw coal must be higher than 6–6,5%. However, the usual concentration found in raw coal ranges between 0,3 and 5%. According to [2–7], pretreatment of coal with chemicals or use of physical exposure leads to an increase in output of bituminous products.

The purpose of the study was to increase the efficiency of the process of extraction of bituminous products from raw brown coal of grade B3 by application of demineralization and microwave processing.

### Materials and methods of research

To investigate the effect of physico-chemical methods on the yield bituminous products samples of brown coal of grade B3 from Maikuben deposits (Kazakhstan) were used. These samples had following characteristics, %:  $A^d$  7,3,  $W^a$  16,8,  $V^{daf}$  48,0,  $S^{daf}$  0,82,  $C^{daf}$  76,0,  $H^{daf}$  4,7,  $N^{daf}$  1,0,  $O^{daf}$  18,0. Demineralization process of brown coal sample (fractions below 0,2 mm) consisted of fol-

lowing steps. The portion (5 g) of coal was treated with 0,2 N aqueous hydrochloric acid and underwent sessions of microwave exposure (ME) in steps of 1 min each. The total processing time was 2 hours. Microwave power varied between 70 and 750 W (Monowave 300 Anton Paar, Austria). Demineralized samples were washed with distilled water and dried 3 hours with stirring under water pump vacuum at a temperature 110°C. The extraction process was conducted in Soxhlet apparatus for 5 hours with solution temperature 70–75°C. Benzene and benzene-ethanol mixture (1:1) were used as solvents. The resulting extracted product was dried 3 hours under water pump vacuum at a temperature 95°C. The yield of the extracted substances was measured by decrease of the organic carbon mass as well by weight of substances that have fallen into the extract. For the final result of the arithmetic mean value of three parallel measurements. Chromatography-mass spectrometry (CMS) analysis of individual composition of tar extract was carried out on the instrument Agilent Technologies 7890 A with mass spectrometric detector 5975°C. The chromatograms and mass spectra were processed using the program MSD Chem Station E-02.00.493.

### Results of research and their discussion

The following Table provides a comparative analysis of the influence of the nature of the solvents used and the method of processing the original sample to the yield of bitumen from brown coal.

Influence of the nature of the solvents and the processing method on the yield of bitumen lignite

Solvent	Methods of processing raw coal *						
	A	B	B+ ME in different capacities (W)				
			70	150	350	500	750
Yield of bituminous materials, %							
Benzene-ethanol (1:1)	2,4	2,8	2,8	4,6	3,4	3,2	2,6
Benzene	0,3	1,3	1,7	2,6	2,4	2,0	2,2

Note: \* – A – without demineralization; B – demineralized; B+ME – demineralized with microwave exposure.

As can be seen from the Table, the use of pretreatment of coal samples 0,2 N aqueous hydrochloric acid leads to increased extractability of bitumen. Additional processing of demineralized coal with microwave radiation leads to an even more significant increase, almost 2 times the output of tar substances. The highest yield of bitumen (4,6 and 3,4 % depending on the nature of the solvent) was obtained at 150 W radiation power. Further increases in radiation power is not advisable, since its effect on yield drops significantly.

CMS analysis of bituminous benzene-alcohol (1:1) extract reveal that it contain aromatic hydrocarbons (33,4–34,5 %), alkanes (25,1–6,2 %) and oxygen-containing hydrocarbons (23,7–25, 5 %). The benzene extract is observed to have a high content of aromatic hydrocarbons (37,3–38,2 %). A comparative analysis of brown coal tar substances yields reveal that demineralization and microwave exposure produce the increase in the content

of carboxyl and hydroxyl groups alongside. The findings lead to the conclusion that pretreatment of brown coal and usage of microwave irradiation result in a change in composition, structure and increased yield of extractable products.

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## THE QUALITATIVE LEAP IN THE AREA OF BUILDING COMPUTING DEVICES BASED ON THE NEW GENERATION OF ELEMENTARY AUTOMATA WITH MEMORY

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The article describes the prospects for the development of computing technology, giving a clue as to what a new research direction is in the field of digital computing, with a brief presentation of the system of the existing knowledge of digital computing in the flip-flop and defining their fundamental limitations. While considering the concept of hierarchical information, the author described the new system of knowledge in the field of computer technology, which allows simultaneous processing of hierarchical information levels together. Taking into account the enumeration of features that extend the existing system of knowledge, the new scientific direction in the field of computing devices is determined. This is the theory of multi-functional and multi-level automata, the microstructure synthesis of multi-functional and multi-level memory circuits, methods of building of typical computers, the principle of the hierarchical programmed control, as well as methods of building the digital neuron and neuron networks.

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**Keywords:** theory of automata, memory circuits, hierarchical information, neuron, neural networks, the principle of hierarchical programmed control, software handling of hierarchical information

Any new direction in the field of digital computer technology is a system of knowledge, which can be viewed in terms of its basic criteria.

1. It should always have a theoretical basis, which differs from the previous knowledge and the opportunity to create a new and effective step forward.

2. It must have a distinctive language in which we can discuss the objects of its investigation, the rules by which the observation can be performed to bring in a coherent system aiming to show their efficiency in comparison with known science or known trends in science.

3. It must have a method to create new objects with new properties and qualitatively assess their results compared with known similar objects in the field of information systems.

4. It is desirable that this new direction in the field of information systems would be interdisciplinary and would cover such typical areas as: automata theory, methods of construction of the elementary memory circuits, methods of construction of typical devices and new approaches and methods in building the software of not only deterministic devices but also probabilistic ones being developed.

### **The system of existing knowledge of digital computer technology**

The system of existing knowledge of computer technology has hierarchical interdisciplinary connections described by V.M. Glushkov [1].

Performance limitations of modern computer systems and networks are due immutable features of elementary memory circuits (flip-

flops), which affect the principles and methods of devices design theory of computers and computer systems.

“The transition from the deductive method that satisfies the existing deterministic systems to inductive methods associated with probability systems requires a different way of thinking. The inertia of the old way of thinking has not yet been overcome. The real obstacle to the development of a new direction is not the complexity of the problems, but conservative people”, wrote St. Beer [2].

These interdisciplinary developments of theoretical knowledge in the field of modern computers and neuro-computers have been and are now based on the element basis of integrated circuits. This basis implements functions of combinational circuits based on Boolean algebra, and multi-state triggers and memristors are used as memory, which imposes the fundamental limitations on the developed computer systems and those being developed now [3–4].

The author believes that all the above reviewed work on reconfigurable memory circuit was conducted by reconfigurable excitation and outputs functions, based on RS-trigger. They have fundamental limitations with significant impact on the building of computers and systems, namely [5]:

1. They all operate in the automaton discrete time  $t_i$  ( $i = 1, 2, \dots, n, \dots$ ).

2. The basic memory circuit (RS-trigger) does not allow rebuilding of stores states work.

3. All these devices are described by Mealy and Moore automata that define the consecutive operation of the devices.

4. The transition in the memory circuits occurs using one variable  $x(t)$ .

5. The used principle of program management, proposed C. Babbage, does not allow simultaneous processing of general and local information.

#### Presentation of hierarchical information

Modern computer and neuro-computing systems built on the modern basis use the consistent information as input data signals  $x(t)$  and use this information in the discrete automaton time [1–4].

In fact, the information is hierarchical being the third element of the universe alongside with matter and motion [6].

The author could hardly disagree with this, since he has been involved in creation of a trend in the field of digital computer technology, which deals with the storage and processing of hierarchical information, for almost forty years [7].

Instead of the input signal  $x(t)$ , supplied to the memory circuit (trigger) of the computing devices the author used the input word  $p(T) = x(t)$ ,  $e(\Delta)$ , consisting of two consecutive signals  $x(t)$  and  $e(\Delta)$ , supplied to the multi-level memory in a single machine cycle  $T$  [47–48]. That difference was enough to have the opportunity to simultaneously process the general and local information in a single machine  $T$  cycle, which could not be principally implemented in devices with memory on triggers and memristors [8].

#### New system of knowledge in computer engineering

So what is the new system of knowledge that determines the new scientific direction in the field of computer technology?

Multifunctional and hierarchical abstract machines capable to process hierarchical information (of general and local type) simultaneously in a single machine  $T$  cycle and 4-th kind machines, which control operation of the memory elementary circuits, were originally developed by the author [7].

1. There were developed multifunctional machines of the 1st, 2nd and 3rd kind that work in the automaton uninterrupted time  $T_i = t_i + \Delta_i$  ( $i = 1, 2, \dots, n, \dots$ ). Monofunctional Mealy and Moore automata, which operate in a discrete time, are a special case of multifunctional machines of the 1st and 2nd kind.

2. Multifunction machines can be considered as deterministic, having two deterministic transitions: simple and enlarged, which expands the functional properties of deterministic Mealy and Moore automata as probabilistic and fuzzy. Multifunction machines are able

to make the transition in a matrix structure of states of two variables:  $x(t)$  and  $e(\Delta)$  in one  $T$  cycle of machine time.

3. A mathematical model of hierarchical abstract machine with multi-function organizational system memory was designed.

4. There were developed 4th kind machines controlling operation of memory elementary circuits.

The theory of microsynthesis and analysis of multi-functional and multi-level memory elementary circuits were originally developed by the author [7].

1. The theory of microsynthesis and analysis of two classes of multifunctional memory circuits (MFMC) was developed. The MFMC have a matrix structure of storing information and two input variables:  $x(t)$  and  $e(\Delta)$ . The MFMC have flexibility, selectivity, improved reliability, reduced need in logic elements per one state and are open structure and thus positively differentiating from an asynchronous RS-trigger. The techniques incorporated in this theory, allow the developer according to the criteria and the number of states or the number of reconfigurable subsets of states to easily design the structure and functional memory circuit.

2. The theory and analysis microsynthesis two classes of multi-level memory circuits (MLMC). The MLMC have the half-closed structure. The MLMC allow simultaneous storing of general and local information, and have such features as flexibility, selectivity, improved reliability, reduced need in logic elements per state and thus positively differentiating from an asynchronous RS-trigger. The techniques incorporated in this theory, allow the developer based on the criteria and the number of states or the number of reconfigurable subsets of states to easily design the structure and functional memory circuit.

Constructing methods of standard computing devices on MFMC and MLMC were originally developed by the author [7]. These are:

1. Reconfigurable registers on MFMC and MLMC.
2. Reconfigurable counters MLMC.
3. Reconfigurable control devices.
4. Computer reconfigurable structure.

The human brain has several advantages over all the techno-cybernetic devices on such important, in the author's opinion, properties.

Firstly, the input signals from the external environment, affect eyes, ears, body, taste of food and have multifunctional, matrix structure.

Secondly, the information coming from the environment is summarized. This is illustrated



by the eye. There are 18–20 million receptors in the eye. The cones that summarize the visible information through the eyes receptors amount to about 72 thousand. So the data compression in approximately 256 times occurs at the second level. It is important to understand and technically solve the issue of information compression.

Thirdly, one must consider the natural growing links between the neurons of the human brain. The child gradually establishes connections necessary to generalize the received (expandable) information, construction of relevant templates and models, reflecting the real world of the individual.

Fourthly, the human brain has between 14 and 20 billion neurons. This is a fairly large structure in terms of the number of neurons, which is difficult to physically set up at the present stage of technological development, and moreover to manage it.

The talented mathematician Frank Plumpton Ramsey proved that complete disorder is impossible in such large structures as human brain, the universe, etc. Thus, each reasonable large set of numbers, points, or objects necessarily has the ordered structure. Researches in this field confirmed this important result [9]. However, the problem of creating ordered structures in models of the human brain remains.

Fifthly, the brain is not a computer; it does not have logical theories, positional number systems, but only its own logic of getting the information, data compression, the choice of communication path with other cells, to summarize this information. The calculations, reasoning, number systems, and any other algorithms are derived from those models that have generalized and represent human interest, according to the interesting work by A.V. Nikitin "Cell control logic" [65].

The sixth point is about the neuron structure, which has two sets of input signals: excitatory and inhibitory. Triggers and memristors do not have this feature, and they use only setting (excitatory) input signals  $x(t)$ .

Multilevel memory circuits that have two sets of input signal: setting (excitation)  $x(t)$  and stored (selecting)  $e(\Delta)$  have been firstly proposed as neurons and neural networks. In the scope of neurons, neural connections and architectural ensembles of neural models, the author offers the following results, which follow from the proposed new direction [10–12].

Let's consider construction of neurons based on MLMC and its characteristics:

1. The brain neurons have different structures that can be created in analog form in MLMC. In addition, these structures correspond to the laws of nature, which is expressed as the golden ratio. This law manifests itself in many structures, such as: human being, shells, fish, etc. For example, MLMC, which stores 18 states and consists of 10 elements, is characterized by 1,8, which is close to the number of  $\Phi = 1,618$ .

2. The neuron on MLMC has two sets of input signals: setting (excitatory)  $x(t)$  and storing (selective)  $e(\Delta)$ .

3. The functioning of such neuron in the automaton uninterrupted time is described.

4. The efficiency of the neuron can be tested by the controlling machine of the 4th kind.

5. In case of failure or non-use in the process, it can be turned off, similar to the biological neuron.

6. Most importantly, such neuron can selectively store information in its matrix structure of states memorizing.

Based on the properties of the three-level memory circuits, the axon register, which can selectively connect the output of the neuron to one or more neurons in deterministic, probabilistic or fuzzy modes, can be built [12]. This allows building models of neural networks, both deterministic and probabilistic and fuzzy.

In the field of computer software and neuro-computers it also allows to use re-configured microprocessors that are able to change the structure of commands without loss of performance due to the introduction of common code in the address system of commands based on the hierarchical principle of programmed control [12].

In due time, the described achievements have been applied in specific devices under the author's guidance. Theoretical and practical results of these studies are presented in the author's doctoral thesis. At the moment the work on the development of this new direction is continued by author's postgraduates under his guidance.

This new computer technology knowledge led to the following conclusions:

1. All devices on MFMC and MLMC work in the automaton uninterrupted time  $T_i$  ( $i = 1, 2, \dots, n, \dots$ ).

2. The basic memory circuits MFMC and MLMC to reconfigure the work of the storable states.

3. There is a description of all devices with memory on MFMC and MLMC by Marachovsky automata (multifunction

automata of the 1st, 2nd and 3rd kind), which define the nature of the devices reconfigured.

4. The transition occurs in the memory circuits in the two variables  $x(t)$  and  $e(\Delta)$ .

5. The used principle of hierarchical programming control, proposed by L.F. Marakhovsky allows simultaneous processing of general and local information.

Usually scientific paradigm change is among the most dramatic events in the history of science. When discipline is changing one paradigm to another, it is called "scientific revolution" or "paradigm shift". The decision to abandon one paradigm is always at the same time a decision to accept another paradigm, and the verdict leading to this decision includes both a comparison of both paradigms with nature and comparing paradigms with each other.

### Conclusion

References to knowledge in interdisciplinary areas of knowledge of the new directions in the field of computer systems allow raising the processing level of hierarchical information to a higher level, are described. The favorable efforts to implement these developments, unfortunately, are made only by leading companies such as Intel, IBM etc., or government programs, because the development should start from a scratch.

Companies will be allowed to be ahead of their competitors, and countries – to raise their prestige and economy.

Also, it will make a step forward in the field of computers, and neuro-computers, and will create competitive devices compared to

present ones on the existing integrated circuit technology.

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## DETERMINATION OF THE EFFECTIVENESS OF THE USE OF ROBOTIC SYSTEMS IN MECHANICAL ENGINEERING

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Reduced to the following with the current pace of development of science and technology the main requirement for high-performance and highly efficient production: the production must be ready and able at any moment to break even stop production of reclaimed products and in a short time begin to release any in the number of the party of new products, including those different from each other.

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**Keywords:** robotic system, efficiency

Taking into account the actual conditions of production goals of improving engineering technologies are now:

- Productivity increase in primary and secondary production, as well as in the field of technical preparation of production;
- Raising the intellectual level of work of all participants in the proceedings.
- The preservation of previously expended labor resources (physical labor of workers and intellectual work of designers, engineers and programmers).
- Saving material and energy resources.
- Reducing the cycle of design and technological preparation of production, widespread use of standardized and typical means of technological equipment and machinery by increasing their lifetime and continuity in the restructuring of production.
- Large-scale and mass production have to give a certain flexibility, while retaining all the benefits of full automation, and small-scale necessary to automate complex so that, along with the flexibility it gained mass production features – continuous, rhythmic, high rate of production output, stability of technological processes.

To solve these problems on a common basis allows the creation of flexible manufacturing systems, such as robotic technological complexes (RTC). Their basis – CNC machine tools, industrial robots and manipulators, controllers based computers. It is necessary to carry out the union of a single automation system in the group, controlled by the computer. Thus the reduction may human intervention in the production process, more than 3 times.

The analysis of machining parts at plants of mechanical engineering, identified areas, which in the long term development must be replaced by RTC. In particular, the processing details “Ball joint knuckle” item, which has more than 3 versions for different ve-

hicles, the total annual output of more than 50 000 items. The analysis of methods and approaches of economic efficiency evaluation RTC on the example they replace outdated complex automatic line “MZAL”, which is produced machining parts.

In this case, when the introduction of RTC performed for modernization of the existing process, followed by the replacement of obsolete equipment, the cost effectiveness is determined by comparing the performance of two production variants: robotic systems of production and replace equipment.

The current methods and approaches of economic efficiency evaluation RTC have a number of disadvantages that are not pozvolya-yut get an objective assessment of the economic impact. In the calculations of each of the criteria was not considered the time factor: neither profit nor the volume of funds invested in the project on introduction of RTC does not lead to real value. The only profit viewed as an indicator of the return on invested capital use. Currently, however, the investment return in the form of cash flow, consisting of the sum of net income, depreciation and amortization. Assessment of the socio – economic efficiency of RTC only on the basis of profit distorts the results of the calculations, overstating the estimated coefficient of efficiency and understating the payback period of capital investment. Considered criteria allow only get a one-sided assessment of the socio – economic efficiency, since they are both based on the use of time-constant initial data – the amount invested in the acquisition and implementation of RTC and the amount of profit. Thus, it can be argued that existing methods is impractical to use in a market economy, as they will distort the real assessment of the economic efficiency of RTC in the production process to handle the details.

The problem of assessing the economic efficiency of robotic technological complexes requires the determination of the main factors and sources of formation of economic results. The main purpose of determining these factors and sources available is to establish a system of levers and RTC management to achieve optimal economic and social results.

The annual economic effect

$$E_y = Z_1 - Z_2 = (C_1 + E_N K_1) - (C_2 + E_N K_2), (1)$$

где  $E_y$  – annual economic effect of using RTC, rub.;  $Z_1$  – The given costs consumers in the baseline scenario for the annual volume of production, rub.;  $Z_2$  – The given costs consumers when using RTK, rub.;  $C_1$  – for the cost of the basic variant in the calculation on the annual volume of production, rub.;  $C_2$  – the cost of annual production, produced by RTC, rub.;  $K_1$  – capital investment consumption on the basic variant in the calculation on the annual volume of production, rub.;  $K_2$  – capital investments consumers when using RTC, rub.

The effectiveness of the introduction of RTC will be achieved by a positive difference  $Z_1 > Z_2$ , costs, while the payback period to be less than 5 years.

The payback period of capital investment is calculated by the formula<sup>^</sup>

$$T_{OK} = \frac{K_2 - K_1}{C_2 - C_1}, (2)$$

Calculation of capital costs associated with the introduction of RTC, is given by::

$$K = K_{RTK} + K_{NIOKP} + K_{BO} + K_{TO} + K_{IR} + K_{CS} + K_{ET} + K_{CMP} + K_{AR} + K_{OC} + K_{DP} - K_L, (3)$$

where  $K_{RTK}$  – acquisition costs (development) Project RTK or pre-production costs, including the costs of research, design and technological elaboration of RTK, the cost of equipment upgrades and alterations to stations RTC, the costs of marketing and other studies;  $K_{NIOKP}$  – he cost of R & D (research and development, design and construction of RTC, process design, manufacturing and testing of prototypes RTC correction of technical documentation and adjustment of permutation RTC) related to the introduction of RTC;  $K_{BO}$  – expenses for purchase of auxiliary equipment for RTK operation, taking into account transport costs;  $K_{TO}$  – he cost of purchasing basic technological equipment;  $K_{IR}$  – acquisition costs of industrial robots;  $K_{CS}$  – the cost of acquisition of

the control system, software and certification;  $K_{ET}$  – the cost of purchasing expensive tools, equipment and RTC devices;  $K_{CMP}$  – the cost of construction – installation work required to install RTC, as well as main and auxiliary equipment (the cost of redevelopment jobs, the costs associated with seal supply systems RTC (electric cables, pneumatic systems, air ducts);  $K_{AR}$  – the cost of production area, including taxes on land and real estate;  $K_{OC}$  – the amount of working capital associated with the introduction of RTC;  $K_{DP} - K_L$  – the cost of disposal of productive assets and current assets (including depreciation), net of their residual value (taking into account the selling expenses of retiring funds).

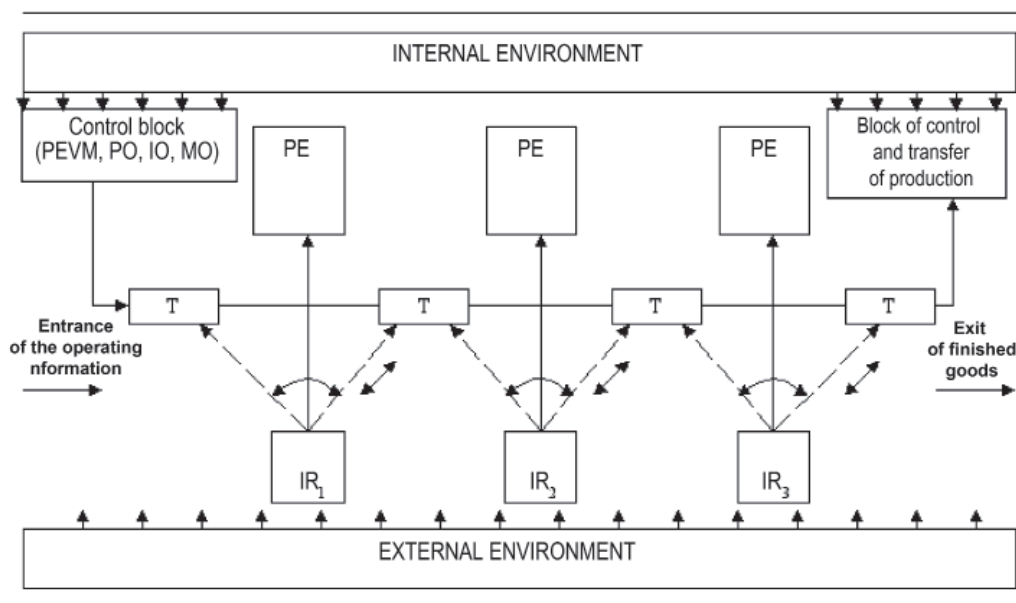
The second group of costs directly related to the use of RTC in production. Current costs are defined as follows:

$$C = C_{CM} + C_{WW} + C_{AW} + C_{CS} + C_F + C_{FFL} + C_M + C_{BSP} + C_{MAR} + C_{TR} + C_{SOFT}, (4)$$

where  $C_{CM}$  – the cost of raw materials except for the cost of returnable waste;  $C_{WW}$  and  $C_{AW}$  – the cost of basic and additional wages of workers – fitters RTK and RTK operators, as well as wages of auxiliary workers serving RTC, taking into account contributions to social and compulsory health insurance;  $C_{CS}$  and  $C_F$  – energy costs and fuel required for the production process;  $C_{FFL}$  and  $C_M$  – the cost of maintenance and operation of RTC equipment costs for fuel and lubricants and maintenance;  $C_{BSP}$  – the cost of maintenance of buildings, structures and plant equipment, maintenance RTC;  $C_{MAR}$  – the loss of a marriage;  $C_{TR}$  – the costs of training, education, training and retraining;  $C_{SOFT}$  – the cost of software and hardware RTC.

When calculating the cost-effectiveness should be considered as a synergistic effect of RTC – this increase socio – economic efficiency of robotic technological complexes as a result of the integration of industrial robots, technological and auxiliary equipment in a single system. In this case, the effect of interaction of participants of association within the system exceeds the sum of the effects of each industrial robot and robot system elements separately. To determine the synergistic effect, consider the case of interaction of industrial robots in the scheme of RTK processing details of the “ball bearing steering knuckle”. This type of line is a sophisticated form of organization of robotic technological complex. The layout of the complex elements of the robot is shown in Figure.





RTC processing details "Ball joint knuckle":

PE – process equipment, T – transfer device, IR – industrial robot

From the control unit, which consists of computer systems, software, information and software, control information for processing of products supplied. The products will be processed on the main equipment and industrial robots and transferred to the next process areas, going through several stages of the production cycle. The output after processing products using the RTC formed finished product, which comes in the quality control unit and transmission products. The essence of such a combination in a complex industrial robots is that a new structure that has emergent properties, i.e. by reacting three robots and processing equipment there is a synergistic effect, providing the effect of the excess of the joint operation of robots and equipment on the sum of the effects of their autonomous activity.

Mathematically, this condition can be expressed as follows:

$$E_1 + E_2 + E_3 < SE, \quad (5)$$

where  $E_1$ ,  $E_2$ ,  $E_3$  – the effects of the independent, autonomous operation industrial robots, process equipment and transport device;  $SE$  – effect of their joint activities in the RTC structure.

Thus, the synergistic effect is measured difference value  $ES$ :

$$Se-Es = (E_1 + E_2 + E_3). \quad (6)$$

At the same time, the larger the synergistic effect of ES, the deeper process of economic interaction and the more stable the combination of industrial robots in the complex, and the smaller the value of the ES, the less the effect of the complex and unstable; in this case the union breaks up robots and does not bring the necessary economic results.

Sources and factors of formation of the positive synergies RTC:

- Reduction of production areas.
- Reducing the duration of the production cycle.
- Improving product quality.
- Clear organization of production operations.
- Cost reduction.
- Reduction of operating costs.
- A reduction of wages of workers spending.

The problem of assessing the socio – economic efficiency of robotic technological complexes requires the determination of the main factors and sources of education socio – economic results.

Key factors and sources of the socio – economic results of the introduction of robotic technological complexes in the industry: reduction of losses of working time, increasing productivity, reducing costs of primary and secondary s/n, dop.sokraschenie vnutrismennyh tselosmennyh and loss of time, execution of operations with absolute precision reduction marriage, improving the



quality of the replacement of workers on the labor of industrial robots, improved working conditions, the reduction of occupational diseases and injuries, reducing the cost of routine repairs RTC, reducing the amount of current repairs of RTC, the emergence of synergies RTC, an increase of the effect of the previous sources, the reduction of operating costs RTC.

An important part of the results of the application of RTC is a social effect. It is determined on the basis of factors and sources of education effect associated with the elements of the social working conditions. On a quantitative level, the social effect can be calculated by using a specific mathematical apparatus. Total social impact of the introduction of RTC in the production process is calculated as follows:

$$S_{soc} = \frac{S_{BA} + S_{On} + S_{TWn} + S_{TDn} + S_{NPn} + S_{LPn} + S_{On} + S_{SFn} + S_{TTn}}{(1+r)^n},$$

where  $S_{BA}$  – saving basic and additional s/n as a result of the introduction of RTC;  $S_O$  – savings pay for overtime;  $S_{TW}$  – payment saving treatment workers;  $S_{TD}$  – to save on payment for temporary disability;  $S_{NP}$  – saving by reducing losses in net profit for the illness employee;  $S_{LP}$  – savings due to the elimination of the loss of productivity associated with hiring and dismissal;  $S_O$  – saving by reducing tuition employee costs and training;  $S_{SF}$  – savings by eliminating the need to build additional social facilities;  $S_{TT}$  – economies of reduction of surcharges for heavy and harmful work in implementing RTC/

Analysis of current trends in robotics development has shown that the use of industrial robots and robotic technological complexes in the industry significantly increase

productivity (labor through the introduction of robots), the quality of the product (due to the absolute accuracy of the operations), which contributes to a significant reduction in production costs and obtain high returns. Analysis of existing methods and approaches for assessing the socio – economic efficiency of robotic technological complexes has shown that there is currently no method of performance evaluation, which can take into account all the factors and sources of its formation. A method for determining the costs of establishment and operation of robotic technological complexes in the industry by the example of machining a workpiece “Ball joint knuckle”, manufactured in the mechanical production.

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## REVIEW PROTOTYPING TECHNOLOGIES AT COMPLEX DESIGN

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While working on a new project, especially at the stage of designing the complex, difficult to detect a variety of errors and shortcomings, using only the display screen. Having a real physical model of the future product can detect and eliminate various errors, correct way to continue the design process. A prototype of the product can be used as a conceptual model for visualization and analysis of the structure; It allows designers to perform revision and spend some functional tests; Master can serve – as a model for the manufacture of tooling. The prototype may be used for marketing purposes or in determining the manufacturing cost.

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**Keywords:** prototyping, CAD, simulation, physical model

Test models reduce the costs of design and pre-production due to possible errors in the early stages. Also, physical models designed products enhance communication and mutual understanding between designers and customers, reducing the time to market the product.

The traditional way of producing physical models of future products – making them easily from processed materials by hand or on conventional machine tools. Spent on manufacturing model from several weeks to several months, which results in increased costs for new product development and delays the timing of issuance of new products.

### Rapid Prototyping

Rapid Prototyping (Rapid Prototyping – RP) – is a new technology, is actively developing in the design and production industry. It provides the opportunity to receive physical parts and models without instrumental of their production, by converting data coming from the CAD-systems, and receive drawings and designs in 3D-representation, just by pressing the button. Upon completion of the work on CAD-workstation at the idea or project, you can give the command “Print”, and within a few hours or days, depending on the size, get a physical model of the product.

Compared with other methods (making patterns from foam, wood, wax by hand or on CNC machines) that existed until the mid 80s, the emergence of rapid prototyping systems has been a revolution in technology. Instead of waiting for the physical model over several weeks, designers can receive them within a few days or hours.

Currently on the market there are different systems RP-producing patterns on various technologies and various materials. However, all the systems for rapid prototyping, available today, are working on a similar, layer by layer

to the principle of building a physical model, which is as follows:

- reading the three-dimensional geometry of the 3D CAD-systems in STL format (usually solid-state model, or a model with a closed surface contours). All solid modeling CAD-systems can produce STL files;
- partitioning a three-dimensional model cross-sections (layers) using a special program that comes with the equipment, or used as a supplement;
- building sections parts layer by layer from the bottom upwards, until until a physical prototype model.

The layers are arranged from bottom up, one over the other, physically linked together. Building a prototype continues as long as data is received on sections CAD-model. RP-operation of some systems based on photopolymerizable – chemical process in which a liquid resin (polymer) is converted into a solid polymer by exposure to ultraviolet radiation or it visible spectrum radiation.

Other RP-systems operate using thermal processes for the construction of physical models. This technology, in which the thermoplastic material is pressed out of the injection heads, forming layers, the sequence which constitutes the physical body; technology sintering powder materials under the influence of thermal processes; “Bonding” sheet materials.

Variety rapid prototyping processes corresponds to the number of manufacturers. Consider the basic technology of quick product prototypes.

### 1. Stereolithography

Stereolithography is the first and most common method of prototyping, largely due to a sufficiently low value of the prototype. The principle of the method consists in stratified

cured liquid photopolymer laser beam scanning system guided. The elevator is in the container with the liquid photopolymer composition, and then curing the next layer is shifted down in steps of 0,025–0,3 mm. It uses solid enough, but the delicate translucent material, which is subject to warping under the influence of atmospheric moisture. The material is easily processed, glued and painted. Quality surfaces without finishing good.

## 2. Mask stereolithography

Faster version of this technology was developed by Cubital Inc. It is called “stereolithography Mask” (Solid Ground Curing or SGC). The working material used is the same photopolymer directly illuminates only its entire surface with a UV lamp through a photomask. Photomask for each layer is printed on the glass. It uses the technology resembles the laser printing. It is obvious that this method gives a significant performance gain by simultaneously blowing out the entire polymer layer instead of pointwise scanning.

## 3. Laser sintering of powder materials

Technology SLS (Selective Laser Sintering – laser sintering of powder materials).

The SLS technology as a working material used powdered plastic, metal or ceramic, similar properties to structural grades. At the surface a thin layer of powder which is then sintered by a laser beam, forming a solid mass that corresponds to the cross section and a 3D-model defining part geometry. SLS is the only technology that can be used for the manufacture of metal parts and shaping plastic and metal casting. Prototypes of plastics have good mechanical properties can be used to create full-featured products.

## 4. Layered imposition of the Molten polymer filaments

FDM technology (Fused Deposition Modeling – layering imposition of molten polymer filament).

Yarn used in ABS, polycarbonate or wax. The properties of the plastics are very close to structural grades. Thermoplastic modeling material is squeezed out through the head at a controlled temperature, heating it to a semi-liquid state. The head gets very thin layers of material on a fixed base with the highest accuracy. Subsequent layers lie on previous, harden and connected to each other. The technology is used for single samples of products in terms of functionality close to the serial, as well as for the production of cast models for metal casting.

## 5. The technology jet modeling

Different varieties of this patented technology called: MJM (Multi-Jet Modeling) – 3D Systems; PolyJet (photopolymer jetting) – Objet Geometries; DODJet (Drop-On-Demand-Jet) – Solidscape. All technologies have their own characteristics, but operate on the same principle. The head, comprising two nozzles 96 and causes the model to the plane supporting material layer. After application of the layer, it may be carried out photopolymerization and mechanical alignment. As the support material is generally used wax, and as a model – a wide variety of materials that are very close to the properties of engineering thermoplastics. This method allows to obtain a transparent and colored prototypes with different mechanical properties – of soft, rubbery to hard, similar plastics.

## 6. Powder bonding technology

Used starch-cellulose powder and liquid water-based adhesive, which comes from the ink jet head and binds the powder particles forming the circuit pattern. After constructing the excess powder is removed. To increase the strength of the model, the available voids may be filled with liquid wax. Such technologies allow not only to create 3D-objects of arbitrary shape, but also to paint them.

## 7. Bonding of the waterline cross sections, laser cut from sheet material

Technology LOM (Laminated Object Manufacturing – laminating sheet materials). prototype Layers are created by laminating a paper sheet. Circuit laser cut layers and the surface, which must then be removed, cut into small squares laser. After removing the parts, finely chopped excess material can be easily removed. The structure of the prototype is similar to wood, afraid of water.

What a fantastic opportunity opens up rapid prototyping. Touch it, created a computer model of a few hours. Besides, we get an exact copy of our computer 3D model. Moreover and in any scale.

For if we do not come up on the computer, you can get it in a few hours.

What is the scope for creativity is open to sculptors, 3d modelers, advertisers, and many business people who can see this technology is a huge business potential.

The main advantages of rapid prototyping technology is:

- reduction of the duration of the technical preparation of production of new products in 2–4 times;

- reduction of production costs, especially in small batch or unit production by –3 times;
- a significant increase in production flexibility;
- improving the competitiveness of production;
- through the use of computer technology, integration with CAD systems.

This technology is a real boon for companies that are engaged in artistic casting of metals or plastics. Sculpture studio, advertising agencies, engineers, students of art schools. How the technology will expand the capabilities in areas such as:

Casting of liquid marble, gypsum, plastics into flexible molds. Manufacture of interior and park sculptures, bas-reliefs, columns, fireplaces, souvenir and premium products.

But the trouble is that the equipment for rapid prototyping costs a lot of money. And many here are not relative concept. The price range of 20 thousand. up to a million green.

It is clear that spending so much money can afford not everyone. In prototyping needs have almost everyone who is engaged in business or industry.

It is necessary to mention one more pitfalls.

Cost of production of prototypes ranges from 1 to \$ 5 per 1 cu. cm. In order to better orient imagine any object, the size of 10×10×10 cm. And a prototype will be released in price from 500 to 5000 \$, depending on the equipment used for the manufacture of the prototype. Not surprisingly, the rapid prototyping services are used by very few people.

#### **The multi-jet modeling with help of 3D-printers**

Classic RP-system of the first generations have a number of drawbacks. This is primarily a very high cost (up to a million dollars depending on configuration), the complexity of the operation, special requirements for premises and operator skill. If we draw an analogy with the development of computer technology as a whole, these systems are similar to the first computer – a huge, highly complex and expensive work which could only highly skilled programmers. It is not surprising that the mass distribution of rapid prototyping technology received only with the appearance on the market a new class of devices – three-dimensional (3D) printers. This class of systems is deprived of many of the shortcomings of their predecessors – 3D printers are designed to work in a typical office environment, easy to use, automatically prepare a file to build and do not require post-processing complex models after

printing. The increasing popularity of rapid prototyping technology is linked with the appearance on the market in the past five years, 3D printers. 3D printers have played a role in the spread of rapid prototyping technologies similar to the role of personal computers in the spread of digital technology in our lives. According to the given data we can conclude that on a global scale rapid prototyping technology is already widely recognized. You can talk about the growth of the popularity of these technologies in Russia, but so far our country lags behind the industrialized countries of Western Europe, USA and Japan.

All of the above systems have a working principle, laser-like three-dimensional printing, but there is also a “blast” three-dimensional printing. The simplest of these technologies – modeling of diffusion-coated (Fused Deposition Modeling or FDM).

#### **1. Simulation of diffusion-coated**

Based on this technology were developed in 1988 by Scott Crump, a manufacturer of equipment for the FDM was the company Stratasys.

The main advantage of such systems is controlled by two coordinate heating head. The idea is very simple – the liquid thermoplastic material is extruded from the head of the printer, and then put a thin layer. Material is fed from the reel in a wire diameter of 1,25 mm. The wire head is heated and melted at a temperature above the curing at 10C. The liquid substance hardens very quickly. Thanks to two-coordinate the movement of the head material is placed in a uniform layer. The width of the diffusion layer ranges from 0,22 to 2,5 mm depending on the material deposition rate, nozzle size and head positioning accuracy. After application of a single layer platform is lowered by the amount of 0,03 to 0,7 mm. It is important to control the process by a computer, such as when milling. FDM technology allows with sufficient accuracy (minimum thickness – 0,12 mm) to produce fully ready to use parts quite large (up to 600×600×500 mm).

#### **2. Multi-phase jet solidification**

Conventional 3D-printers do not provide high accuracy and strength of the finished prototype, but the mechanical properties of such models is sufficient to render the developed product.

Stuttgart and Bremen institutes have developed a technology multiphase jet solidification. In this technology, a mixture of fibers and



powder is deposited on the surface with a nozzle managed. The mixture is heated to a printer 70–100 °C compartment temperature depending on the properties of the working material. As a material used powders used for injection molding. At this temperature, the mixture becomes uniform in density and is capable of passing through the nozzle. It is important to provide a low surface tension material for forming without shrinkage. Subsequently, the prototypes are being finalized with the help of technology, reminiscent of metal injection molding. Sintering material and obtain a new molecular rugged grid.

Currently, this technology is used in of 3D printers Actua 2100 the company 3D Systems. Material prepared the prototype looks like a solid wax. The thickness of the overlay layer is 0,0015 inch (0,04 mm) with a resolution of 300 dpi. The installation cost of about 65 thousand. dollars.

There is another technology of “inkjet” already using powdered materials. It was developed at the Massachusetts Institute of Technology, as the first and main manufacturer of the equipment was the company Z Corporation. Its 3D printers are relatively inexpensive and work much faster than the above devices. The technological process is as follows: a special ink jet head is sprayed onto the powdered adhesive material. As used conventional gypsum powder or starch. The “spattered” powder glued locations, and generates a model. Printing as in the previous cases, is layered, and excess powder is shaken off in the end. However, there is a significant difference – the printer can use a liquid adhesive with the addition of dyes and pigment print color model. The color printer from Z Corporation fitted with four ink jet heads – basic adhesive colors so that the resulting model can reproduce not only the shape but also in color (i.e., texture) of the virtual prototype. However, the plaster model obtained is not very strong, but once they can be used as molds for casting. Detailing the resulting object – very high.

### **3. The use of three-dimensional models for rapid prototyping**

Currently, there are different trends and approaches to the implementation of rapid prototyping technologies. As used materials can be divided into methods for applying liquid (photopolymers, electrolytes, water), powders (sintering homogeneous or two-component compositions), solid materials (plastics, waxes, metals), the sheet material (laminated paper, plastic), gases. Some of the methods is in the

stage of research development part has a commercial application.

Rapid prototyping is a very wide range of applications, however, the main ones include:

- visualization;
- check collection units and mechanisms;
- production of small batches of preparation methods for rapid tooling.

Visualization still stands on one of the first locations in a number of areas due to the use of prototypes product model representation clarity, on the one hand, and the lack of need for hardware – the other.

Often there is a need to conduct market research and demonstration of the product to the customer or at the exhibition before its serial production, in order to assess the potential customer demand and to decide whether to promote this product to the market.

If necessary, make changes in product design material and time costs are minimal in comparison with the need to rework tooling, manufacturing of which takes, as a rule, more than one month.

Another very important factor is the ability to verify the quality of assembly units and mechanisms, assessment of the convenience and reliability of fixing parts. The three-dimensional model created in the CAD-system, does not give a complete idea of how tough the fixation parts in an assembly unit. Prototypes of the same, being the analogue final manufactured products, allows to analyze the characteristics of their design and quickly identify possible shortcomings.

Simulation of mechanisms to assess their functional qualities – is another area of application of rapid prototyping. This applies to both new products and upgraded to a change in one or more parts in the assembly.

Emerging in the recent downward trend in batches of manufactured products, increasing their structural complexity and reduce delivery times cause the rapid spread of technology training equipment (Rapid Tooling), which include vacuum casting in silicone molds; metal-casting mold; metal casting by lost wax, obtained by casting in silicone mold technology, and other methods. These technologies are inextricably linked with the technology of rapid prototyping and are their logical continuation in the chain of design – design – prototype – parts – finished product.

Rapid prototyping is becoming more common and is becoming an integral part of the preparatory process for the production of new products. In industrialized countries, a number of firms in this step is optional and



transition from product design to the development of technology is impossible without the prototype.

Research in the field of rapid prototyping are in full swing. For example, a group of scientists from the University of California is developing a three-dimensional printing technology, which would allow both to create and shape and content of the object. By content is meant here e-filling, i.e., The printer prints a mobile phone plastic housing and also type in the body all the electronics. Even today, there are ways to print plastic semiconductor devices and their connecting wires. It remains only to combine these methods with the technology of 3D printers, and is ready to a revolutionary breakthrough in modern production.

Another example – the development of the University of Missouri, allow using inkjets display unique biological organ harvesting is printed. As an ink used with the specified type of cell clumps. Instead, the paper advocates a special bio-gel, which fixes the position of the cell clusters in space. Printing is done in several layers. The result is a volume of the cell structure which, in principle, any organ can mimic (after sprouting cells gel dissolves, so that is possible to obtain hollow structures). Of course, the full body of the seal is to be transplanted seems too challenging, but the work in this direction is underway.

Rapid prototyping plays an important role in the technical preparation of the new machine tool products. Using the layout tools or separate units in the process of construction engineering and discussion at technical meetings became the norm. This estimated design and

layout decisions, simulates the movement of individual units, and so on. D.

According to the principle of work all rapid prototyping system can be divided into two broad classes: the actual RP-systems- and 3D printers.

Currently on the market as a whole, including the Russian market is represented by most of the leading companies – developers, like the classic big RP-systems and of 3D-printers. In spite of the general principle of work – building a three-dimensional model of the two-dimensional planar layers of different systems are markedly different from each other techniques of construction of each layer. And it defines the scope of the equipment. In my opinion, from a practical point of view there are two main parameters that characterize any system for rapid prototyping – a thick layer of construction and materials with which the machine operates. It is the thickness of the layer determines the quality of the construction of the final model, and model material properties determine the applicability of the prototype.

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# Short Reports

## THE MAIN DESIGN FEATURES OF THE TEMPLES

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Russian Orthodox churches are unique architectural structures, amazing by their beauty with a long history of the establishment. Some of them were constructed in the middle ages. Great masterpieces of the architects, the past masters, sometimes had been created for more than several decades and every detail of the temple has a deep meaning and significance. Volumetric layout design of the temples is necessary to analyze the design features for the engineering systems to establish and maintain the required indoor microclimate characteristics in the buildings for public worship.

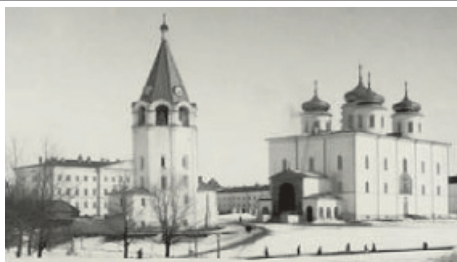

The main feature of temple construction art and creativity is the necessity to follow the canonical church requirements, based on the Orthodox dogma and tradition [1].

Orthodox churches can be divided into several groups, depending on the differences related with the functional features of the temples, their types, volumetric layout design, wall materials and the capacity.

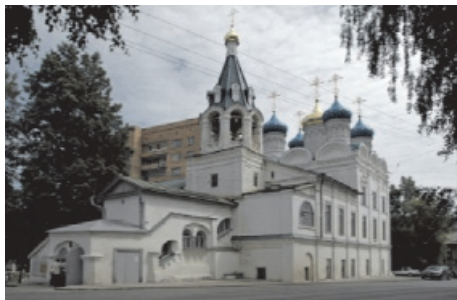
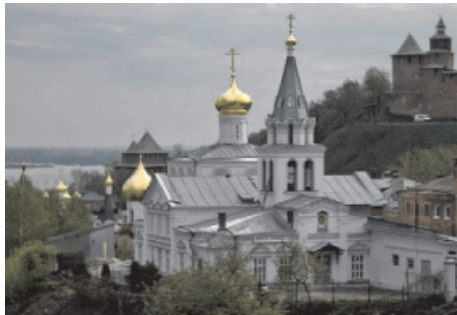
By a capacity the parish churches are divided into the following types: small size churches, with the area of the middle part from 25 to 90 m<sup>2</sup> with a capacity from 60 to 600 people; middle size temples, with the area of the middle part from 90 to 250 m<sup>2</sup> with a capacity from 300 to 300 people; large size parish churches, with the area of the middle part from 250 to 500 m<sup>2</sup> with a capacity from 600 to 1,500 people; very large parish churches, with the area of the middle part of more than 500 m<sup>2</sup> and a capacity of more than 1,500 people [2].

There are several types of the temples: cross-domical, central-domical church, basilica, pillar-shaped. According to the functional features the temples are divided into: cathedrals, temples, monasteries, parish, manor, cemetery, tombs, monuments, home churches, temples at the public institutions (schools, nurseries, prisons) and chapels. Basic constructions of temples are shown in Table.

Construction of temples

Construction Scheme	Description	
1	2	
1. Cross-domical summer temples		
Cross-domical cathedrals having six internal pillars		Constructive basis is the span or three-span arch-rack systems. Exterior walls are a key stiffening component. In the temples with six internal pillars bearing is carried out on the four eastern pillars
Monastery temples having four internal pillars		
2. Temples having two pillars		
Temples having two pillars		The system of three parallel barrel vaults was used in the overhead cover. They were supported by 2 pairs supporting arches which were moved from the pillars on the eastern and western walls. They can be symmetric and asymmetric. In symmetric system there is a big light cylinder, which is located in the centre. It is supported by the pendentive on the borders edges of the light cutout. In asymmetric system the light cylinder is above the eastern central cell and supported by the eastern and central supporting arches and partially on the tetrahedron eastern wall

## Termination of the Table

1	2
Pillarsless temples	Pillarsless overhead covers became widespread as a simple or steeped cylinder vaults which were supported by the lengthway walls in the XV–XVI centuries. Since XVI c. the crossed vaults were used for the small sized overhead covers. They represented the combination of 2 pairs crossed cylindric arches, bearing light cylinder, with the corner parts of the cloister vault
Pillar shaped temples	Distinguished by the hard centre and almost complete symmetry
Steepled temples	There are two types of constructions. The first type uses the method of complitness of the tetrahedron by the open inside tent. In the second type the tent functioned only as a decorative element and was put on the cloistered four-chuted vault covering the tetrahedron
Temples with no pillars and cloistered vault	 <p>One of the methods of ending is five-domed. It represents the imitation of the forms of the temples having four pillars. The other way is to end the tetrahedron as a hillock of kokoshniks. Often such temples were ended with one hollow or light dome</p> <p>Church of the Holy Myrrhbearers, Nizhny Novgorod</p>
Parish churches «ship-sized»	 <p>While constructing the parish churches the compositional methods were widely used. Along with the asymmetric groups of churches, the churches with the lengthway axial symmetry began to appear. The main volumes were put along one axe from east to west</p> <p>Church of Elijah the Prophet, Nizhny Novgorod</p>
3. Types of church buildings with complex composition	
Churches with Γ-shaped and T-shaped planning	The room of the warm church which was adjacent to the back wall of the cold church was becoming larger in the lengthway size by the means of setting the side chapels with the altar apses

The basic materials for the walls of the temples are: boulder, white stone, brick and wood. The form of the temple can be quite diverse.

To intensify the aeration the architects applied the principles of aerodynamics. Here we are considering the increasing of the airflow with the help of outside and inside the streamlined forms of the structure such as: kokoshnik, barrel, tent.

Nowadays during the reconstruction and construction of the temples, special attention should be paid to ensure the required parameters of the microclimate. To provide the Orthodox churches comfort, reduce heat loss and increase the duration of operation and maintenance period of the building envelope it is necessary to design heating and ventilation systems.

When designing the ventilation systems in the prayer halls of the Orthodox churches the preference should be given to the natural ventilation systems. However, for the design of natural ventilation systems the factors that affect the internal and external aerodynamics of the Orthodox churches should be taken into account. One of these factors to make the heat balance of the prayer's hall is the consumption of the church candles in an Orthodox church.

In comparison with the mechanical ventilation systems the natural ventilation systems do not consume electrical energy, require less maintenance costs and installation due to the self-regulation, and changes in the difference between the balance of supply and discharge of air heat we can achieve the heat savings from 20 to 50 % [2].

In conclusion it should be noted that the forms of the temples significantly affect the uniformity of airflow inside the temple, which requires the carrying out the research work in order to provide the required parameters of the microclimate in the temple [3].

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#### CASE METHOD AS ONE OF THE INNOVATIVE TEACHING METHODS

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Foreign language fluency applicable to the professional world is a necessary component in making modern education relevant [1]. This includes knowledge in a second language relevant to business and other fields of employment. Its success depends on innovative ways of organizing the learning process, such as through a case study method [2].

The case study method has long been used in education overseas, and its value is well established. The purpose of this method is to use descriptions of specific situations or problems, emulating from daily life or in different organizations. It focuses on studying the problems and searching the options for its solutions, followed by analysis of the value or detriment each option may elicit. To make this work, it is imperative that the examples selected for each case study be rooted in plausible, potential scenarios which professionals face in their work.

Educational tasks should involve students in discussions, contemplate the problems and should not have a unique solution. Such activity is usually a group activity and takes the form of a discussion in which students organize disputes and express their opinion. During the discussions, the students apply their knowledge of dealing with such problems; apply the knowledge previously obtained in learning foreign languages [3].

Using such methodology in teaching foreign languages helps develop language skills and general common competences: to make decisions in standard and non-standard situations; work in a team; effectively communicate with colleagues and customers, and; find and use information necessary for the efficient performance of tasks [4].

The value of such an approach is well documented. Students have demonstrated a positive at-

titude to case studies. It best prepares them for the unexpected, and creates confident workers. This method helps students to get theoretical information and to use it in practice. It generates interest and positive motivation to learning.

Teachers should know that case-study method is not the only method in teaching foreign languages. Students involved in the decision of the case, can compare, give definitions, suggest solutions to problems, etc. The teacher, using the case study method should know that students could suggest either correct or wrong solutions or decisions. The role of the teacher is to guide the students through the Socratic process of considering options, not denying the student this process of discovery by telling them a singular answer. One of the main tasks for the teacher, using the case study method is the involvement of students in the analysis, discussion and problem solving. A case example selected must be of relevance to the students' professional interests. The students should contribute to their own education and experiences to their group. Interesting stuff and the possibility of applying professional knowledge encourage students to participate in the debate. The desire to solve the problem encourages students to not only read the case, but also carefully study it, to master the facts and details. The students will also improve and enlarge their vocabulary, learn idioms, new syntactic structures etc. Furthermore, students should be carefully prepared to prove and justify their views in a foreign language. Professional knowledge and confidence in the ability to solve the problem facing the group, is an incentive for mastering communicative skills in a foreign language.

This process stimulates a desire to work toward improving the knowledge of a foreign language [5]. Students improve grammar, help participants clearly express their thoughts and to convince the members of the group [6].

This method of learning a foreign language based on real or fictitious situations has great prospects in the professional training of future specialists. In learning a foreign language in high school, the case study method is used to create a language environment and conditions for formation the situation necessary to use a foreign language as an intercultural communication means.

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## SOCIAL RESPONSIBILITY POLICY OF RUSSIAN CREDIT ORGANIZATIONS IN A RECESSION

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The stabilizing effect of the banking system is not unlimited and can only smooth out, and that to a certain extent, the negative effects aimed at undermining its long-term action, made by the participants of the system, government regulators, or foreign partners. The Russian model of CSR was evolving over the last 20 years, and in view of contradictory tendencies that define multi-vector development of political and social relations in Russia, different character of the crisis, is not yet fully developed. And even against the backdrop of the ongoing crisis Russian banks do not tend to curtail their social programs, adhering to the existing CSR strategies.

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**Keywords:** commercial banks, recession, corporate social responsibility

The banking system plays a major role in any economy, and in rapidly changing environment becomes a core stabilizing mechanism not only of financial, credit, business, and social development also. It provides the financial stability of the country, and at a sufficiently efficient organization can reduce the social consequences of the economic crisis and even fend off the threat of attack. The effectiveness of the implementation of main banking system functions is largely determined by external conditions – the political situation in the country, the level of legal relations, the evolution of world commodity and financial markets, the possibility of targeted challenges from foreign partners. The ability to respond to the dynamics of the environment, rebuild priority in the allocation of assets and highlight key points in the range of credit services, adapt management structure to the new conditions, as well as the willingness of banks to solve jointly common problems taking into account sectional interests, improve the efficiency of both the whole banking system, and the elements comprising it.

### Methodology and information sources

A wide toolkit was used within the framework of theoretical research and practical developments carried out in the work. The main methods of investigation were systematic, statistical and functional analysis, theoretical studies within the boundaries defined by the area of research, logical methods, due to the specific goals and objectives. When in the theoretical part of the work official sources of information were used, such as the publication of the Central Bank of the Russian Federation. Information is also gathered from RosBusinessConsulting, Expert, World Bank analytical reviews, Standard & Poor's rating agency analyzes.

### Factors determining the current state of the banking system

Any component of the banking system (single credit institution or their union) is closely linked to economic and social development of the state. The successful and safe operation of a single commercial bank will reflect positively on clients both the juridical persons (ie different enterprises, organizations, companies and, more generally – branches and sectors) and the private individuals who invest money on deposit and other accounts in banks. Although the size of these accounts is relatively small compared to the scale of investments of legal entities, their large amount at a decent quality of service and high reliability provides a favorable social background, which excludes panic in the event of one-off incidents in the banking system – Information stuffing, corruption scandals, exchange rate fluctuations, changes in the key rate, etc [1].

The positive impact of stable functioning of the banking system is expressed thus in the formation of an optimistic behavior patterns of the population when planning personal budgets and improving the quality of people's lives. In turn, it allow to industrial enterprises, commercial structures and public organizations to determine the vector of long-term development, to maneuver freely available funds, to invest relying on favorable market forecasts dominating in the public consciousness. Such a pattern is due primarily to the fact that the very appearance of the banks and the evolution of the banking system in any country is a result of requests to meet existing society. Banks originally were created to optimize the economic relations in society, and continue to carry out this task, though not put it as a priority, as do some other social institutions. Factors that influenced the occurrence of banking and its development are considered in Fig. 1.



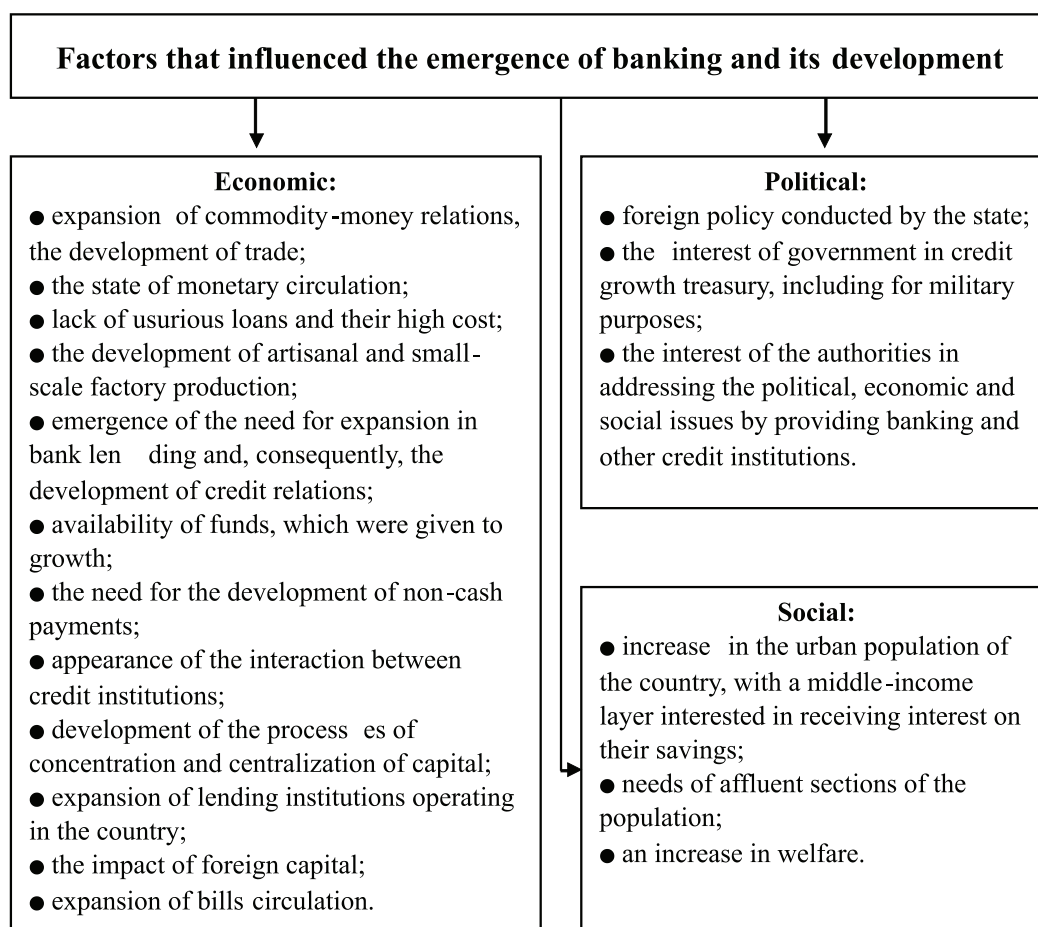


Fig. 1. Factors determining the development of the banking activity

The emergence of the need for development of cashless payments, the appearance of banks emission functions, expanding the sphere of circulation of bills, the occurrence of the processes of interaction between credit institutions – these factors contributed most to the emergence of a system banking activity.

The evolution of the economic, social and political conditions of bank system led to the transformation of a number of external factors of the system to internal. These factors are shown in Fig. 2.

Note that the stabilizing effect of the banking system is not unlimited and can only smooth out, and that to a certain extent, the negative effects aimed at undermining its long-term action, made by the participants of the system, government regulators, or foreign partners. Anxious waits in society are able to build up, not showing for a long time, and then as a result of the cumulative impact of several factors lead to serious social upheavals. These factors in our country can be attributed the high inflation rates, undue

political expectations, the destabilizing actions both of the individual components of the banking system and its leadership [2].

In Russia there is a clear trend towards liquidation (bankruptcy) of commercial banks by the Central Bank. According to the Department of Banking Supervision of the Bank of Russia, the total number of credit institutions with revoked (canceled) license to conduct banking transactions (including credit institutions about which was made a recording their liquidation in the State Register) for the period from 1 January 2014 until 1 August 2016 reached 2000 organizations. There is an impression that to the Central Bank and the players of the financial market (or leading financial institutions) is more profitable to liquidate the bank, by paying the sum insured depositors set by the Deposit Insurance Agency, than to carry out the rehabilitation of the bank. In addition, due to the Central Bank refinancing large banks have the opportunity to acquire a network of failed bank and its customers.

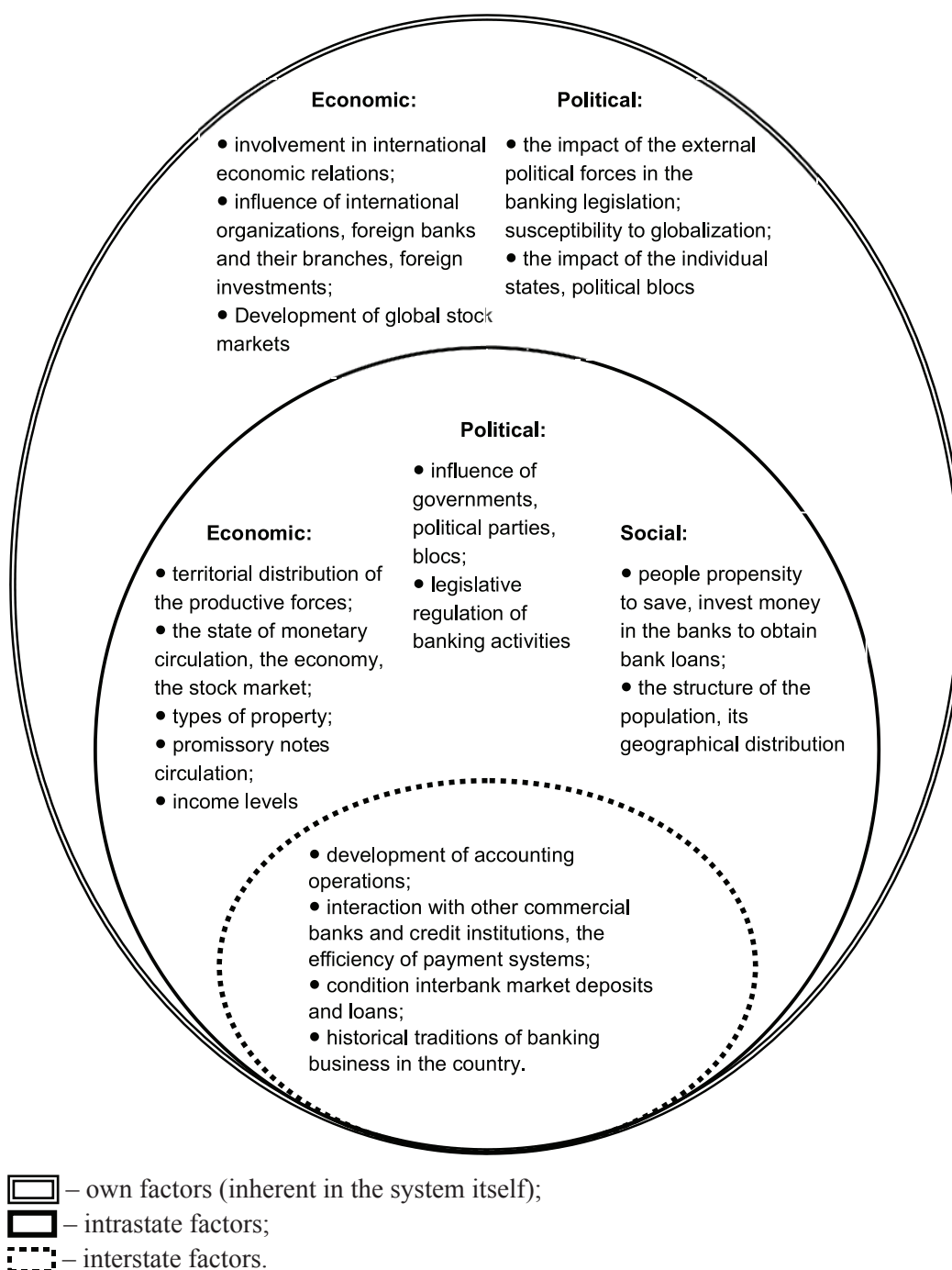


Fig. 2. Factors determining the current state of the banking system

Within a few years, the number of depositors who have lost a large part of their savings due to the elimination of their banks “from above” has steadily increased quantitatively but not manifest themselves qualitatively. However, during the summer and autumn of 2014 against the background of foreign policy

crisis, the sharp decline in world oil prices and the resulting devaluation of the ruble, a significant portion of customers of even feeling confident banks rushed to withdraw their funds without waiting for the end of the term.

First of all, it concerned the ruble accounts, funds from which were directed by the public

to purchase foreign currency or durable goods manufactured abroad. Typically, such purchases were made without real need, but only as a form of saving money. Thus, as a result of the above policy Central Bank deposits ceased to be realized by the bulk of the population not only as a reliable means of accumulation and augmentation, and even saving money. As a result, one of the measures designed to repay, along with other panic in the community, was the increase above the sum insured immediately doubled (1 400 thousand Rubles). From the budget of the Deposit Insurance Agency an additional one trillion rubles has been allocated. These resources were not thrown into the currency market. This decision was taken not to supply the leaders of the banking system and on the initiative of the legislative bodies of the country, with the assistance of its enforcement of the Accounting Chamber.

Thus, the lack of awareness of the social role of the regulator of the banking system, has generated significant additional expenditures of the state budget. The loss of reputation of the banking system – loss of confidence in a significant part of the population, a return to the popular in the 90s keeping cash at home – is incalculable.

#### **Corporate social responsibility in the Russian banking system**

However, even against this backdrop Russian banks retain the ability to carry out socially responsible policy. Social responsibility should be realized by any corporation and produce such conduct business in which the company is transforming the economic, environmental and social risks into opportunities. Of course, the financial institutions have in this respect their specificity. Any large modern company uses raised capital, the source of which are financial institutions, which are thus always indirectly affect the social and environmental impacts, and should be aware of their responsibilities, which often manifests itself in a particular practice.

Russian banks alone or together with their partners (non-profit organizations) undertake projects to support microenterprises, are working to attract customers with disabilities and to take them to work, sponsor educational programs, activities in the nonprofit sector and volunteer initiatives. Many banks have set high standards for project finance, avoiding lending institutions conducting a weak social policy and not in compliance with their projects in environmental standards (for example, support the initiative for mandatory disclosure of

corporate information on greenhouse gas emissions). If earlier the company just bought gifts to orphanages, but now many people think about the support of educational programs for orphans. Social investments of financial institutions are above all investments in human resources, which will grow in economic terms.

Modern banks are usually already developed a clear strategy in the area of corporate social responsibility (CSR), aimed at combating the financial literacy of the population, support for people with low incomes, the development of special products for them, the implementation of financial advice for illiterate clients. Banks usually have a wide range of banking products for different categories of customers. If the customer did not come across before to banking activities, it is attached to the most simple products, enabling it to gradually grow to a higher level.

Another aspect of social responsibility is the ratio of the bank's own employees. During the training and implementation of training programs the employees are acquainted with the internal policies and procedures of the bank, which concern not only businesses, but also of the corporate culture, internal rules of conduct. Thus, CSR creates a new approach to personnel policy in terms of staff retention by offering employees a wide range of opportunities for career and personal growth.

In the concept of long-term socio-economic development of the Russian Federation for the period up to 2020 as the first targets of importance are called "high standards of human well-being" and "social well-being and harmony". Achieving this strategic objective, particularly in terms of foreign policy today, is only possible through the transition to an innovative, socially oriented type of development based on modernization. The new institutions and infrastructure innovations and investments involve the definition rules of alignment effective mechanisms of cooperation between the state, business and society to ensure the interests and coordination of all sectors in the development and achievement priorities of social and economic development.

Any enterprise that functions in a certain area, integrated into the economy of the region, using the country's resources – physical, natural, human and information – in the course of business, is built into the existing structure of the commercial and industrial, as well as social ties. Interacting with other businesses, government agencies and public organizations, it is included in a complex process of self-organization, characterized by comprehensiveness,

the nonlinear nature of development and feedback [3]. Awareness of the owners and management of the company to support the importance of these relations in all their diversity, expressed, as a rule, in building with the environment – society – relations strategy that provides for the enterprise business the most favorable, political, environmental and humanitarian background. The degree of involvement of enterprises in the country (region) in collaboration with civil society organizations is an indicator as the level of economic development, and the degree of maturity of society. All of the above said is true for financial institutions in the first place – for banks, as any large company uses capital raised, the source of which are financial institutions. Banks thus are always involved indirectly in the course of their activity.

With regard to the banking work, in different countries and in different societies inconsistency between its positive impact on the socio-economic situation and its negative perception on the part of society are often noticeably apparent. Although well organized system of payments, to afford a reliable income on deposits and the availability of credit to provide for the needs of the population in the consumption of a variety of goods in the minds of many individuals and entire social groups, banks appear a kind of parasitic organizations (such as the duality of perception is observed in respect of the stock markets and insurance companies). Therefore, the leadership of any bank faces challenges not only direct investments in the social sector in the region, in whose territory it operates, but also the problem of increasing the confidence of individuals to its services and products.

Many banks have successfully decided this problem by an elaborate program of work with clients. At the initial stage of communication with the client, especially with inexperienced in financial terms, a bank employee, producing an initial consultation, offers a choice of a limited number of the most simple banking products. Later, as you become a client of positive experience of using simple services, it is proposed to increase the degree of interaction with the bank. In course of the consultants pass

to discuss the provision of investment services or complex structured deposits [4]. At the same time responsible bank can afford to have a noticeable impact on the partners (to a greater extent, of course, on borrowers than savers), encouraging them to conduct a responsible social policy, for example, issuing loans for projects that provide environmental responsibility, respect for the natural resource, providing the solution of common social problems, which ultimately allows for interaction of a whole group of enterprises with local authorities, government agencies and public organizations.

### Conclusion

Erupted in the autumn of 2014 the currency crisis has spawned a prolonged recession in the Russian economy. Following the fall in world oil prices the Russian ruble rapidly, more than doubling depreciated. Unstable exchange rates in the absence of effective measures of the Government and the Central Bank creates a further decline of the ruble. The forecast for the further development of the Russian economy is disappointing.

However, even against the backdrop of the ongoing crisis big banks do not tend to curtail their social programs, adhering to the existing CSR strategies. To a large extent this contributes to the fact that CSR programs are mainly expressed in rubles (only international initiatives require the cost of foreign currency, as they make up a small part). Apparently, Russian banks are fully aware of the importance of collaboration with civil society organizations for the mitigation of the economic impact caused by the crisis the poorest segments of society.

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## PART OF SCIENTIFIC-TECHNICAL PROGRESS IN EFFICIENCY OF USING LABOUR RESOURCES (AT THE EXAMPLE OF AGRARIAN SECTOR OF ECONOMY)

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The article studies basic aspects of using labour resources in agrarian sector of economy and increase in efficiency on basis of scientific-technical progress.

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**Keywords:** labour resources, agrarian sector, economy, scientific-technical progress, efficiency

As known, factors and indicators of social-economic efficiency of using labour form a methodological foundation for developing methodics of defining demand in personnel for agrarian enterprises. In this case term "labour" includes explanation of the implemented methods and basic factors that have influence upon them, means of calculating that consider various professional groups, region, district, enterprise. A specific result of any methodic is development of methodical approaches, models, labour regulations.

Theoretical aspects of predicting demand of agricultural enterprises for labour are not studied sufficiently. Therefore, bibliographic sources suggest various approaches and methods of defining an enterprise's need in workforce (prediction of demand in labour can be received upon extrapolation of legislations in change of workers' number for different functions that was formed in many years of practice (linear, parabolic, etc.) [1]; the foundation of planning staff needs is perspective labouriousness of product; prediction of the demand in labour costs must be carried out via normative method, calculated per labour costs per 1 hectare of land, 1 animal, etc) [3]. However, the suggested methodics contain a great difficulty of defining total labouriousness, temper of its reduction, possible structural shifts in perspective [2].

A more reliable method of defining planned number of workers is calculation according to labour efficiency forecast, as less errors are allowed in prediction. In order to predict labour efficiency different methods are implemented: calculative-construction, normative, method of enlarged calculations, extrapolation, method of factor modeling, method of experts' evaluations.

A special significance is devoted to difference between defining demand for labour during the current year and future periods in

terms of separate professions, enterprises and district/region/country. At the same time, planning of labour indexes for the current year is carried out in detail at enterprises, they consider professional specifics, basic and auxiliary sectors with facilitation of technological cards, existing forms of cattle care, etc.

Methodic of perspective planning for labour indicators is also insufficiently developed. For example, while predicting demand for labour in separate enterprises, it is possible to foresee possible changes, but the prediction might already be made according to global indications. In predicting demand for labour in totality of enterprises/region enlarged calculations are applicable as they allow for less errors.

We should underline that predicting enterprises' demand for labour embraces different sides of labour economy and, therefore, requires not one, but a totality of methods. In order forecast employment in agricultural sector one certain methods can be used, and to explain the demand for employees of certain profession it is necessary to implement different approaches, correlation between constant and seasonal labour will require yet other means of analysis.

Therefore, the foundation of defining demand for labour at agricultural production, personnel number of which is a calculated value, must be prediction of labour efficiency. The most widespread method of economic prediction, particularly prediction of labour efficiency, is multi-factoral modeling at the foundation of correlation-regressive analysis. Advantage of this method is in possibility to influence value of certain factor in order to receive the desired result.

Research has shown that increase in yearly time fund and implementation of hired labour testifies for imbalance in labour provision among enterprises.



As researches show, actual labour provision of various agricultural enterprises of a region is close to 100%, and it is even higher in collective and state enterprises. Calculated labour provision is slightly lower, and all agricultural formations are unprovided with labour. Basic reasons of it are: low level of works mechanization, irrational work organization, reduction in personnel number. Staff deficit can be decreased or removed completely at improved enterprises due to economy of labour, reduction of time losses, improvement in output organization and work discipline.

Among many labour regulations the defining part is devoted to hourly labour efficiency, expressed in output of total agricultural product in calculation per 1 human/hour. It is an enlarged, generalizing indicator that serves as final one within the system. In order to define demand for labour at a agricultural production it is necessary to predict hourly labour output. Yearly labour efficiency (output of total product per 1 worker) depends completely on hourly indicator in terms of socially-required level of employment.

Correlation analysis requires overview of basic factors that impact labour efficiency. We have studied their totality. Correlations have been established between labour efficiency, effectiveness of using workforce and facilitation of land, fund provision of labour, provision of funds and employment, employment of workers, their composition, wage level and work regime, development of non-productive sector. Depending on nature and relations between factors and final result, we have outlined direct and opposite relations.

Formation of seasonal labour market has a great significance for agriculture. There is no more free transition of workforce from cities, as there was before, attraction of staff now exists on contract basis with a corresponding wage. As attraction of labour for seasonal works becomes costly, agricultural enterprises must have definite data on their demand for seasonal workforce. Enterprises also need monthly balance calculations for this group of employees.

Village market of labour also includes motion of staff from the sector, and it is expressed in liberation of constant and seasonal workforce, personnel flow, exclusion of employees from working teams. Employable part of population that comes from agriculture transits to other branches of economy. At the same time, vacant positions that emerge in regard to personnel flow in agricultural enterprises, must be replaced by flow from other sectors and enterprises.

Within village market of labour we must outline market of constant and seasonal workforce. Market of constant workforce is formed of demand for constant employees among agricultural enterprises. In total labour market village part occupies a significant share. According to our calculations, over 20% is formed of constant labour market for agricultural enterprises. In reality this sector of market is significantly bigger as it includes seasonal workforce as well.

The liberated seasonal workforce will come through labour market in volume that is defined by number of employable workers. Besides, additional demand for seasonal workforce that is not covered by local labour resources, will also go through labour market. Enterprises should address claims to official bodies of labour provision with indication of time period and specific aspects of work. At the same time these institutions will form supply of seasonal workforce. Information on regions and enterprises is accumulated in district labour management and employment bodies. Thus, market of seasonal labour is formed of demand for it on behalf of enterprises and supply of workforce.

It is reasonable that seasonal labour market is totally dependent on seasonal nature of employment. In case of 10% seasonal work 9,8 seasonal employees per 100 constant workers are required in may, up to 18 workers – in august, in case of 15% seasonal nature – 18,7 and 34,3 employees correspondingly.

Efficiency of labour market is expressed in positive and negative aspects. On the one hand, personnel flow is targeted, and significance of work quality, its discipline, and value grows, on the other hand, unemployment and category of the unemployed emerges. Social protection of workers will be regulated by system of social-economic relations. In its foundation must lay system of material interest, formation of favourable conditions of workers' life in the village.

As the analysis shows, final results of production are greatly dependent on labour resources' provision. In order to make agricultural labour attractive, it is necessary to improve work conditions and review programmes of social development in village.

1. First of all, it is necessary to create favourable conditions of economic environment for consumers and producers of socially-infrastructure services through taxing, price, and budget mechanisms as well as via investing from local and federal budget in order to carry out certain key directions that have general state significance (construction of roads, etc).

2. Create the required market infrastructure and establish development of market processes that will provide for increasing volume of output and growth in income of village producers

3. Develop profitable conditions of market economy in village that will align with agriculture and enrich its forms of activity such as subsidiary trades, procession of agricultural products, production of construction materials from local raw materials and pre-made constructions (for example, countryside houses). At the same time, organization-legal forms can vary, the greatest attention is devoted to cooperation.

Thus, industrialization of agriculture, introduction of progressive technology, skillful combination of economic, technical, chemical, biological, and natural factors, improvement in organization of output, improvement of social conditions among employees – all these factors provide for efficient implementation of labour resources.

The undertaken analysis of labour market in countryside has revealed basic problems and objectives that must be solved in pursue of increasing efficiency of agricultural production and facilitation of labour within it. First of all, it is necessary to establish employment not just for its own sake, but to increase efficiency, complete realization of a person's right for labour, creation of worthy conditions for live in village.

To define perspectives of developing labour market in a region it is necessary to make its economic evaluation according to predicted labour efficiency. Factors and indicators of efficiency in using labour resources, defined by earlier researches, form methodological foundation for calculating demand of agricultural enterprises for workforce. Correlation analysis has shown that growth in number of employees and yearly employment decrease hourly labour efficiency. However, growth in number of employees also has a positive effect upon general labour productivity. A detailed analysis has shown that along with decrease in personnel, volume of output is reduced faster.

Thus we think that the basic objective for executives at agricultural enterprises for the nearest future is stabilization of production. It is necessary to stop its further degradation with all available factors (economic, organizational, technical, and social tools). Decrease in number of personnel in agriculture should be slowed, and this factor of production must be implemented more efficiently to increase output of product into consumer market.

As it was revealed earlier, there are reserves of increasing efficiency in usage of agricultural labour. At the same time, the basic factor that influences efficiency of labour and mostly depends on actions of working collective and each separate worker, is yearly involvement. It was established that yearly involvement of workers is basically related to provision of an enterprise with workforce and depends on working hours facilitation, organization of output, labour, and management.

The method, applicable for economic prediction of labour usage efficiency, is multi-factoral modeling at the foundation of correlation analysis. The advantage of this method is that it provides possibility to influence value of certain factor in order to receive the desired result.

The basic element of forecast is level of hourly labour effectiveness. Multi-factoral modeling is applied at the foundation of dynamic rows. Length of dynamic row is 14 years. The advantage of dynamic models is that they allow us to study influence of factors upon result over certain periods of time.

Thus, perspectives of efficient facilitation of labour resources in agricultural production are related to:

- stabilization of demand for labour from producers of goods;
- decrease in yearly involvement of workers down to normative level in order to reduce losses of work time and increase workers' leisure time;
- improvement in employees' qualification and their professional level;
- decrease in staff flow;
- increase in material interest of employees.

Effect of all mentioned factors eventually leads to increase in efficiency of agricultural labour and growth in its productivity. In short-term period growth in efficiency of using labour resources is predicted due to increase in product output and decrease in early involvement of workers.

In long-term period, when growth in output takes place, increase in labour productivity is planned due to fund provision and personnel cuts. Only technical re-equipment of agricultural enterprises is able to increase output level, transit towards production of new, competitive products. Scientific-technical progress defines reduction in staff numbers directly at agricultural enterprises, but at the same time it creates new modern processing enterprises and types of product, development of social sector, provides for broadening of production, creates new needs, and thus leads to additional demand for labour.

In the predicted period supply of labour will exceed demand for it. Unemployment will also take place. During the years to come employment policy must be directed towards intensification of social-professional protection for employees of all categories at labour market, maximum broadening of employment possibilities for socially-vulnerable groups and layers of village population in their employable age, especially women and youth. It should be considered that policy at labour market must base upon flexible combination of market mechanisms that provide alteration in structure of employment and additional state measures of selective support for employable village population who have lost their job but wishes to work efficiently and looks for new types of activity. Considering the fact that during nearest years imbalance of agrarian labour sector will remain, and number of the unemployed population might grow, it is necessary to develop regional programme of employment assistance for village population that will consider specific interests of the sector.

Particularly, the programme should imply measures on:

- preservation and stabilization of employment, especially for qualified staff, in case of owner change, privatization, enterprise bankruptcy, change in its specialization;
- increase in competitiveness of employees, creation of psychological setting for re-training, receiving additional profession or specialty;
- intra-sectoral transit of labour between districts at regional and inter-regional level, assistance in resettlement of workers;
- stimulation of flexible employment and self-employment forms (work at home, part-time jobs, non-standard working regimes, etc.);
- maximum facilitation of funds by state employment fund of Russian Federation in compensating employer's costs in creation and maintenance of additional work positions at the foundation of agricultural enterprises (loans, favourable credits); economic stimulation of agricultural enterprises that create additional working positions for youth, other socially-vulnerable groups of employable population;
- broadening practice of hiring young graduates (agricultural universities, col-

leges, etc.) that have not yet found employment, via contracts with employment service with condition of redirecting salary from employment fund;

– creation of new work positions in the village in the sector of small and moderate business, directed towards market, due to development of local industry (first of all, production of construction materials), small workshops of processing agricultural raw materials, village trades, etc.

Thus, reserve of increasing general labour productivity in different agricultural formations are not same. It is explained by the fact that general labour productivity depends on facilitation of all production factors, their correlation. All factors of production stand in totality, interact with each other. This interaction is expressed in various quantitative characteristics and represents total labour productivity. Here applies law of replacing one production factor with the other considering the new possibilities as well as law of decreasing return, when utmost ability of any production factor begins to reduce. All these aspects must be considered in revealing growth reserve for total labour productivity.

Thus, introduction of scientific-technical progress results, carried out at separate enterprises, united by processes of cooperating and combining production within the whole national economic complex, has a positive effect upon efficiency of using labour resources and results of an enterprise activity. When implementing certain measures on technical re-equipment of production, each enterprise is directly interested in decreasing product value. It is necessary to implement the most viable option within development of economic system that will provide minimal capital investment and the most efficient facilitation of labour resources.

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## Short Reports

**DEVELOPMENT PECULIARITIES  
OF ECONOMIC AND MATHEMATICAL  
MODELS OF FINANCIAL EXPENDITURE  
WHILE GEOLOGICAL PROSPECTING  
BORING OF OIL AND GAS DEPOSITS  
IN UNCERTAINTY TERMS**

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Mineral and source sector has one of the central places in economies of oil-and-gas producing countries including Russia and Azerbaijan that causes high significance of dynamics and development of its mineral and source basis.

But we shall remember that oil and gas industry as a system is characterized by certain specific particulars which differ it from other productive industries. From the point of view of risk assessment the most significant one among them is a big dependence of the indexes and criteria of cost efficiency on

(i) geographical description, utilization level of explored and extractable hydrocarbon resources;

(ii) dynamic specifications of geographical factors;

(iii) probabilistic character of the majority of technical and economical indexes of design of oil and gas deposits; change of reproduction structure of capital investments in the scale of branch in the way of increase of their shares directed to compensation of output fall in old deposits; big duration of project implementation; high capital intensity of oil production, necessity of huge investments, and long period of initial capital reimbursement [1, 2].

Besides of these risks specific for oil-and-gas producing branch we can note the risks of deposit non-discovery; risk regarding inaccurate determination of geological and field specifications of development facility (volume of geological reserves, dynamics of hydrocarbon production and etc.); risk due to project non-completion; risk connected with the terms of outlets of oil, gas and oil products; risk associated with the quality of project participants; risk caused by excess possibility of appearance of force majeure situations and etc.

Uncertainty of the resources of developed deposits, their geological and technical specifications, prices of hydrocarbon raw materials and other initial indexes applied while working out and implementation of engineering projects and long-term develop-

ment plans of an enterprise lead to the fact that it is just impossible to plan economic loss beforehand in the case of unfavorable outcome [4, 5, 6].

In consideration of all aforesaid, to our mind the most scientific and practical novelty can be presented by making of economic and mathematical models of financial expenditure while equivocation terms for geological and economic assessment of the resources of oil and gas areas of different sizes as:

$$P_3 = \frac{A_3}{L - x_1} = \frac{\int_{k_1}^{k_{2L}} \bar{z}_2 d\bar{s}_2 - \int_{k_1}^{k_{1L}} \bar{z}_1 d\bar{s}_1}{x_L - x_1},$$

where  $P$  – general finance charge for  $l$  deepening along a whole depth up to  $L$  bottomhole;  $P_3$  – costs caused during geological prospecting boring works associated with unforeseen departures of schedule and specifications of implemented technical and technological events;  $A$  – size of a whole work;  $A_3$  – work connected with implementation of unforeseen and unplanned works.

The work on present project will allow to unite scientific and engineering potential of Russia and Azerbaijan around of a very significant and concrete task, to solve not only social and economic problems similar for our states but also to create one more area for mutual, fruitful, and long-term scientific and cultural cooperation among our peoples [3].

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## CREATING INNOVATIVE EDUCATIONAL MODEL FOR RUSSIAN TRADITIONAL CULTURE SCHOOL

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The article deals with some aspects of innovative education content modeling on the basis of the educational course "Russian traditional culture" connected with an all-round integrated personality development. Approaching education through the theory of invariant pragmatic arrangement for educational content will serve as a basis of creating an integrated education process in the Russian traditional culture school.

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**Keywords:** education content, traditional culture, ethnocultural education structure, basic personality traits, subjects and courses, Russian traditional culture school education branches

According to V.S. Lazarev, developing schools concentrate mostly on the education content as it is the education content that is affected by development and serves as its indicator. For our School of traditional Russian culture it is designing educational and instructional system as a single unit and as a comprehensive pedagogical megasystem. And as educational content is connected with a renovating educational process, in other words with an innovative process, modeling of which serves as a basis of all systematic changes in the personality and school development management, designing education content model for our school is at the bottom of all its innovation activities. According to V.S. Lednev all activities in a renovating school are factors in personality development which means school development as a whole, and are elements of education content structure at the level of separate subjects [4].

As we already mentioned, education content as an innovation and as a development process consists of four levels:

- 1) theoretical;
- 2) designing curriculum and course programs;
- 3) designing a definite education process in the form of plans for the whole year;
- 4) a separate class.

Designing educational content gives a scientific ground for renovating educational activity of the School of traditional Russian culture and its development management.

As modern pedagogical science states, education is a process and the result of personality development and upbringing in a definite historical and cultural environment. Education is a controlled by society standardized process of constant transfer of socially significant experience from preceding to succeeding generation which ontogenetically represents the process of personality development in accordance with the genetic and social programs [2, p. 24] This systematic and multifunctional definition

implies the transfer of spiritual experience by preceding generations as expressed in steady customs – traditional culture. "...The process of education includes not only personality education, but also the transfer of culture by the preceding generations" [4]. Education content means a system of scientific knowledge and skills which ensure all-round personality development [6, p. 366] including spiritual development. Education content presupposes a well-planned educational activity which brings about changes in a person, changes in his or her traits and characteristic features. [5, p. 54], that is why the social experience of people and traditional culture transformed into educational activity are taken into consideration in setting education goals.

Today traditional culture in its broadest meaning is absent in society and it doesn't function as an environment either. That is why bringing it into education content not only doesn't decrease in value the main education components but it creates additional stimuli for renovating the whole content the goal of which is to create (bring up) an integrated personality using the traditional mechanisms of cultural experience transfer.

Education content includes:

- 1) assimilating the experience of preceding generations;
- 2) training typological behavior traits;
- 3) psychological and physical personality development.

For the School of traditional Russian culture that means:

- 1) knowledge of traditional culture plus skills and competencies acquired by mastering crafts and through application of cultural knowledge;
- 2) adopting behavioral anchors through folklore and its ceremonial and play content;
- 3) adopting and accepting values of Orthodox morality.



Education content also includes four types of main elements which we use in the education activity of the School of traditional Russian culture “Vasyuganie”:

- 1) system of knowledge;
- 2) system of skills and competencies;
- 3) creative experience;
- 4) emotional and prudent attitude to the world.

For the School of traditional Russian culture “Vasyuganie” the knowledge system is connected with the language component and the knowledge of traditional culture as a whole and the system of skills and competencies is connected with crafts and folk art. Experience of folk art is the main part of the whole education and upbringing process in the School of traditional Russian culture “Vasyuganie”. The experience of emotional and prudent world attitude is connected with spiritual or moral spiritual student activity both in theory and in practice. Let us consider the structure of education content of our designed model based on “assimilating the experience of preceding generations”, which in our innovative model means: the knowledge of traditional culture, skills and competencies acquired through mastering crafts and through applying cultural knowledge.

Invariant part of ethnic cultural education and upbringing structure in the School

of traditional Russian culture “Vasyuganie” is connected with experience transfer through traditions and, thus, the development of basic personality traits: moral, communicative, aesthetic, physical, and occupational.

That is why the structure of traditional personality experience covering cognitive component and set of values as expressed in

- 1) personality traits;
- 2) personal experience;
- 3) qualification (special and general education);

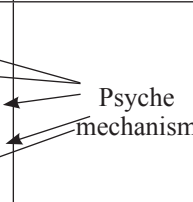
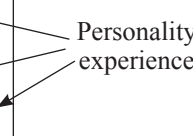
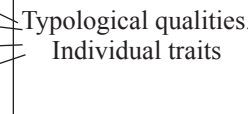
4) creative experience is reflected in the education content structure.

The particular feature of education (studying) in the School of traditional Russian culture “Vasyuganie” is the influence of culture transfer mechanisms on educational and creative activity and the effect of additional reserves which affect personality psychology. The education in the School of traditional Russian culture “Vasyuganie” is also connected with upbringing in the broadest meaning of the world and its content ensures all-round personality development: personality traits, experience, etc. That is why personality structure serves as determinant of the education content structure (Table 1).

Let us consider subjects and courses of our innovative education model.

**Table 1**

Personality structure and education content  
in the School of traditional Russian culture (Determinants' Table)

Personality components	Personality structure (personality sides)	Upbringing, personality traits development	Educational skills	Subjects
<i>Sensory</i> <i>Memory</i> <i>Thinking and speech</i> <i>Psychomotor system</i> <i>Control</i>	 Psyche mechanism	Will, concentration, and thinking, etc, training and development	Folk art, language, cultural anthropology	Musical ethnography, types of folk art, folk craft basics
<i>Knowledge, skills, abilities</i> <i>Personality traits</i> <i>Activity experience</i>	 Personality experience	Intellectual skills, personality traits (Communicative, aesthetic, occupational, etc.)	Cultural and spiritual anthropology, crafts, folklore, traditional culture, technology, religion, history, art, artistic labor, man, society, scientific activity	Crafts, folk arts, crafts, orthodox culture, musical folklore
<i>Character</i> <i>Temperament</i> <i>Disposition</i> <i>Abilities</i>	 Typological qualities. Individual traits	Creative abilities, intellectual skills		

Education content structural units in the School of traditional Russian culture comprise subjects and subject cycles, courses and disciplines, as well as theoretical and practical education. Relying on the theory of invariant and active education content V.S. Lednev singles out separate activity types invariant to the scientific knowledge structure. These types are to be found in traditional culture. Among them he singles out cognitive, goal-oriented and conative, communicative, transformative, artistic, and physical activities which correspond to the division of scientific knowledge into subject cycles: intellectual, social, linguistic, aesthetic, occupational, physical and moral and spiritual. Applying this theoretical provision to our school we get the following subject cycles:

1. Aesthetic – artistic cycle:

1) painting (folk painting, drawing, composition, working with different materials);

2) music (folk musical instruments, solfeggio, general piano, etc.).

2. Occupational cycle: craft basics (craft technology, craft types); artistic occupation (handicraft types, bead weaving, willow weaving, etc.)

3. Social cycle: spiritual anthropology, Christian anthropology (Orthodox culture), and folk games.

4. Linguistic cycle – folklore, language history, philology.

5. Intellectual cycle: ethnography, cultural anthropology, philosophy, scientific research, and project activity.

The education content determines the study material and characterizes the learning process connected with personality development and personality focus. That is why subjects and

subject cycles are organized in accordance with the personality experience structure, the activity structure and also in accordance with the object of study structure, in our case it is traditional culture as a whole.

The education content structure in the School of traditional Russian culture is influenced by the activity structure and the corresponding structure of personality experience (Table 2)

Let us consider subjects and study disciplines that touch upon many fields (pass-through subjects). In the School of traditional Russian culture such subjects are: specialized (musical and artistic); general cultural (general aesthetic, ethno aesthetic); pre-professional – profession –oriented (craft, ethno pedagogics); general studies (artistic occupation, technology, lore). Pass-through subjects in the subject cycles are: general humanities (for music department – general piano, solfeggio, music history, decoding of folk songs; for art department – drawing, painting, composition; for all departments – ethnography basics, language history, world art). Pass-through subjects for all departments in the School of traditional Russian culture are:

1. Orthodox culture.

2. Artistic occupation (crafts, handiwork).

3. Ethnographic research (expeditions to study regional natural history).

4. Traditional culture as a theoretical and practical subject (folk holidays, folk games, folk rituals, folklore).

All of them serve not only their specific purposes but contribute to the task of creating spiritual component of personality culture and at different education levels.

**Table 2**

Personality structure (personality spheres)	Personality culture	Subjects	Knowledge fields
Cognitive	Intellectual Behavioral (communicative) Physical Occupational	Ethnography, Ethnology Folklore, traditional culture Folk games Crafts	History, anthropology, philosophy. Lore, philology, man, society Traditional culture Labor, technology
Catechetical	Artistic and aesthetic	Folk arts types	Art
Axiological	Moral Aesthetic	Orthodox culture, Scripture, liturgical singing Folk arts and crafts	Spiritual anthropology, man, society, morality, art Art

Table 3

Aspects of personality culture	Study subjects	General fields of knowledge
Intellectual culture	Ethnography, anthropology, traditional culture.	History, philology, anthropology, philosophy.
Moral culture	Orthodox culture.	Spiritual anthropology, man, society.
Communicative culture	Folklore, folk singing, language history	Philology, traditional culture.
Aesthetic culture	Folk arts	Art
Traditional culture	Crafts, art work	Handicraft
Physical culture	Folk games	Traditional culture

The particular feature of these fields of knowledge is their integrity, interchangeability, and complementability. And this helps the child to choose an activity.

Structural units in the designed education model in the School of traditional Russian culture (activity types, courses, subjects, subject cycles).

Each activity (and there are seven of them in the School: aesthetic, artistic, intellectual, cognitive, communicative (communicative and game, ceremony and game), occupational, moral and spiritual) has two sides: it is a separate subject and a component of another study course. Thus such subject as Orthodox culture is a component of folk singing, liturgical singing, music folklore, artistic modeling, handiwork, crafts, and folk painting.

Separate courses include different subjects adding to the content of the course. Thus solfeggio includes music theory and music literacy. Folk singing includes ensemble and solo singing. Orthodox culture is based on Scripture, the Church Slavonic language, patristic literature, and devotional arts.

Separate disciplines, courses and subjects comprise structural units in the education content in the School of traditional Russian cul-

ture. Study complex is arranged according to the following model:

1. Subject basics – intellectual formation, building world outlook (cultural anthropology history, philology, philosophy).
2. Social studies: Orthodox culture, traditional culture, world fiction.
3. Linguistic studies: lore, philology, folklore.
4. Aesthetic studies: folk art.
5. Occupational studies: crafts and handiwork.
6. Physical activity: folk games

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## ROLE AND THE PLACE OF CONTEXT MATHEMATICAL PROBLEMS IN THE FORMATION OF THE KEY COMPETENCES OF ENGINEERS OF TECHNICAL SPECIALTIES

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This article presents the concept of a "key task" and a "context task" and their place in the educational process; describes the activities, carried out at the Tomsk Polytechnic University, which contribute to the formation of the core competences of engineering students; the example of the context task, composed by the student within the conference week is given.

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**Keywords:** higher education, core competence, conference week, contextual problems

The development of modern society is impossible without a certain foundation. One of the components of this foundation is well brought up and educated man. So Professor E. Glaeser, working at Harvard University, revealed a direct dependence of income and population growth on the number of residents with higher education [1]. Later American scientists proved that by increasing the percentage of people with higher education increases the efficiency of all workers, as well as wages of all categories of employees [2]. According to UNESCO experts [3] 250 million children around the world today do not get the basic educational skills, which results in many countries economic losses at the rate of \$129 billion per year.

Therefore, education in general and higher education in particular is becoming a cornerstone in the development of society. Requirements for graduates of schools and universities have changed significantly. Nowadays, according to the standards of the new generation, the aim of the university is to prepare such a specialist, who would not only possess knowledge in the context of a one subject, but could apply that knowledge beyond discipline. That is every college graduate should possess core competencies, which, with regard to professional education, are treated as the students ability to act independently in an uncertain situation in dealing with immediate problems. These abilities can be realized beyond professional education [4].

Some of the requirements for core competencies, formed by the university, should be noted:

- core competence – is the student's ability to act effectively not only and not so much in the learning process, but in reality;

- core competence – is the ability to act in such 3 situations where you have to define the problem, to clarify its conditions, as well as to find the solutions and more importantly to assess the result;

- core competence – is the ability to solve problems relevant to the students themselves.

It should be pointed out that to prepare a specialist who meets the requirements of the new standard of education becomes a fundamental task for universities. One of the problems in solution to a question is related to the low levels of school education in general and mathematics education in particular. This is evidenced by the data presented in the paper by L.P. Kostenko [5], where he has been analyzing the state of knowledge of the first year students and schoolchildren since 1920 to the present day. The author notes that to date the number of mathematically literate pupils and students is 80 %. Analyzing the results of various international tests in mathematics for the last two decades, we can see that the Russian students are in the group of countries, where the results are significantly lower than the results of the countries of Organization for Economic Cooperation and Development (OECD). In 2012 PISA test results on 15-year-old Russian pupils scored 482 points, while the average for the OECD countries – 494.

From above it can be concluded that many of the students, who enrolled at a technical university, do not have sufficient knowledge of school subjects of natural science cycle that are the springboard for a successful study of various disciplines at the university.

In this article we would like to describe the experience of solving the problem of specialist training at Tomsk Polytechnic University (TPU), satisfying the requirements of modern society on the example of teaching further mathematics.

We can identify three areas in the solution of the problem. Firstly we must understand that there are so many specialties at TPU as a technical university and for each specialty to study profession-oriented subjects different

amounts of mathematical knowledge is needed. In some specialties the more in-depth study of mathematics is important, in others it is not. Therefore the so called “clusters” of subjects are introduced. In each cluster on similar specialties the description of the work program on further mathematics and the number of hours to realize it are given. The work program puts an emphasis on the study of those branches of mathematics that are necessary and sufficient to a greater extent for the study of subjects in the specialty. Thus, in the practice of TPU 6 clusters in further mathematics are implemented. For example, a teacher, who works with students enrolled in the specialty “Engineering”, should be based on the work program of further mathematics for cluster 1, and the humanities – for cluster 6 [6].

However, the introduction of clusters was not sufficient. Starting studying at high school, many students can not get involved in the learning process because of the low level of knowledge in school mathematics, so necessary for a college education. TPU solution to this problem has led to the introduction of a course entitled “Mathematics A”, which aims to eliminate the gaps in students’ at high-school mathematics and bring them to at least that level of knowledge, which is necessary for the study of further mathematics course on a particular cluster. At the first lesson control test in mathematics is conducted and those students who do not fulfill the half of tasks get into the group, who must attend a course “Mathematics A”. It should be noted that those students whose control test was well written, still attend this course, considering it necessary to reinforce and review learned at school material in mathematics.

However, we must really understand that all these measures do not give us the greatest challenge decision – the formation of core competencies. All this is the only platform on which the teacher must correctly build a learning process.

But as practice shows, the main solution to this problem is to conduct a conference week. This week is held in the middle of each semester and focuses on the creative work of students. This week the teacher does not give classes but indicates the range of questions in advance that a student can explore on their own or to undertake a study and make a report.

We describe the experiment of the conference weeks on the example of specialty “Engineering”. Students of specialty “Engineering” are trained in cluster “Math 1”. Under the program, the cluster of further mathemat-

ics teaching occurs within 3 semesters. In the first semester the main branches of algebra, analytic geometry and differential calculus of functions of one and several variables are studied. In the second semester the study of integral calculus and differential equations is conducted. In the third semester – series and a comprehensive analysis.

To the first conference week in the first semester the students are just beginning to learn the basics of mathematical analysis and such a fundamental to this course concept as the limit of function. As a rule, they are not able to conduct any independent researches, so this week as a creative task they are offered to prepare an abstract on any mathematical topic, even scoping.

In the second semester, when the student has already an experience in successful examination, which for many of them is a difficult task to overcome, they are encouraged to prepare for the conference week task of applied nature. For example, by the middle of the second semester the concepts of definite, double and triple integrals are already studied. As the number of hours to study these topics is small, the application of these integrals in practice are not considered. Therefore, in practice, it is advisable to offer the students themselves to find problems on application of integrals and to study their methods of solution, but it’s still not quite a creative task. More often the students solve tasks of finding the volume of the body, the weight of the disk or the liquid pressure on the body.

By the third conference week (this is the third semester), when learners have received almost all of the mathematical knowledge specified in the work program, students are encouraged to prepare one contextual problem with its decision. This requires the integration of knowledge that gives rise to the formation of core competencies.

Under the contextual tasks used in the study of mathematics are regarded such tasks, in which the main objective is to allow both standard and non-standard situations (subject, intersubject or practical), with the use of an appropriate method of optimal resolution with the mandatory application of mathematical knowledge [7]. The higher priority function of such tasks consists in getting cognitive and professionally significant result by the student.

A special place among all contextual tasks take the practical context problems. Their solution requires a more detailed analysis of the text of the problem, analysis of the task for excess and deficiency conditions, identification



of the best way of solving, that involves the establishment of relationships of various branches of mathematical science with other subjects and the scope of professional activities. Solution of such problems proposes a composition of a mathematical model, intramodule solution and interpretation of the result.

Our experience shows that the solution of context problems helps students to acquire knowledge, which will help them in their professional activity and learn how to apply this knowledge not only in solving various problems, but in a changing problem situations.

Construction and solution of the context problems serves as a means of forming and diagnosing the level of formation of the student's key competencies. There are two approaches to formation of the context problems:

- 1) to take a ready made mathematical model and to pick up the proper narrative situation;
- 2) to take any real situation, connected with a professional activity, to build a mathematical model on its bases, which allows solve this situation.

As practice shows, at first the student goes the first described way, but gaining the experience, he is able to perform the procedure given in the second approach.

Let us give an example of the context mathematical problem, which was proposed by a student at the conference week.

The Task. There were several welding transformers on the pipeline in Tyumen, but after long work they fell out and could not be reversed. Since the shift is in a very remote area, the shipping of new transformers will

take a lot of time, which leads to large financial losses. So the team takes decision to make new welding transformers from improvised materials. But first of all it is necessary to calculate welding transformers under already available materials. We assume that the welding transformer is designed for the operating current of the secondary coil  $I_2 = 160\text{A}$ , with the output load voltage  $U_2 = 50$ , mains voltage  $U_1 = 220$ , the value of POS (period of service) is taken as 20 %.

Obviously, solving this problem requires not only knowledge of mathematics, but also knowledge on the subject of welding production.

Our experience with the context of mathematical problems in the training of specialists in the field of engineering shows that it promotes the absorption of both subject knowledge and skills and the assimilation of professionally significant knowledge and skills. In general, it raises cognitive motivation.

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## FORMATION OF CROSS-CULTURAL COMMUNICATIVE COMPETENCE OF STUDENTS

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The article updated the issue of training of students – the future bachelors of international relations to intercultural cooperation in their future careers. The author emphasizes the need for a model of the formation of students' cross-cultural communicative competence in the process of learning a foreign language, which is one of the main goals when they receive higher education.

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**Keywords:** student, bachelor, international relations, intercultural cooperation, cross-cultural communicative competence

The aim of the Russian educational policy until 2020 is to improve the quality and accessibility of professional education. To date, training of specialist of any type should be considered in accordance with the rapidly changing conditions of competition, including international. Readiness of specialists to work in such an environment requires fluency in their profession, continuing education and professional development, social and occupational mobility.

In the transition to multi-level training of professionals there is the need to talk about improving the quality and effectiveness of training. This is especially important for future bachelor's and master's degrees in international relations in the sphere due to the nature of their professional activities, including communication processes in interpersonal, social, political, economic, cultural and international spheres.

At present, the issue of formation of professional competence in students is seen as a priority in the university training. When training students of international affairs one of the main goals is to develop cross-cultural communicative competence, especially through foreign language, and often several foreign languages.

Need of it follows from the irreversible process which has begun in the mid XX century: transition of traditional, so-called «two-way» diplomacy («old» or «bilateral» diplomacy), to the «omni» («multilateral») diplomacy, when post-World War II international arena became too large and complex in terms of cooperation between the countries. It has become not only important development of the sphere of the international relations, but also led to the expansion of professional problems of diplomats, among which communication skills are the first ones.

The new diplomacy focuses on the ability of specialists in international affairs to speak publicly, using appropriate rhetorical techniques and possessing features of cross-cultural communication and the ability to skillfully negotiate. And if even half a century ago

there was some preference of predominantly written communication in matters of international importance, now the preference is given to the need for personal contact, «face-to-face exchanges», that is, verbal communication [5].

Communicative competence usually is understood as ability to establish and maintain the necessary contacts with other people. The structure of competence includes a combination of knowledge, skills and abilities to ensure effective communication. This kind of competence involves the ability to vary the depth and range of communication partners in dialogue to understand and be understood by them. Communicative competence involves adaptability and freedom to own verbal and non-verbal means of communication and may be regarded as a category regulating the system of relations of person to himself or herself, the natural and social world. In the broadest sense competence of human communication can be defined as the competence in interpersonal perception, interpersonal communication and interpersonal interaction [2, p. 33].

Cross-cultural communicative competence is the ability to reach understanding with people of different cultures even with mediocre command of foreign languages on the basis of knowledge, understanding, and respect for universal rules and standards of conduct that make international communication etiquette. Cross-cultural communicative competence allows an individual to establish relationships with people of other cultures – to recognize their cultural values, to tolerate the differences revealed in the manner of communication, styles of behavior, way of life, customs, traditions, etc. [3].

Hence, successful professional cross-cultural communication of specialists in the field of international relations is an appropriate communicative behavior during the relationship of professional cooperation. It involves a high level of knowledge of foreign languages, and the ability to understand and accept the socio-cultural diversity of partners in dialogue to solve

professional problems. The aim and the main feature of teaching cross-cultural communication is to educate students' communicative-oriented foreign language proficiency in professionally significant situations of cross-cultural business communication.

So it is clear that today while training high school students in international affairs such disciplines as "Foreign Languages" and "Cross-cultural Communication" should be closely related. You also need to build a whole model of teaching cross-cultural communication through the study of foreign languages. Moreover, in each department, focused on the preparation of bachelors in international relations, such a model can have its own characteristics.

These features may include: the need to acquire necessary knowledge and skills through direct cultural contacts, the importance of foreign training and practices of future professionals, inviting foreign teachers and participation in international conferences, forums and projects.

When teaching cross-cultural communication in the process of learning a foreign language, one should take into account the so-called hidden difficulties of speech production and communication. They are due to original lexical and phraseological compatibility of each word in a specific language. Such specificity is evident when comparing languages. Therefore, when studying foreign languages it is important to memorize the words not in isolation, but in natural, stable combinations. Another difficulty is the conflict between cultural perceptions of different people about the reality, which is designated by equivalent words of the languages [4, p. 137].

You can talk about many features of cross-cultural communication training, including the study of foreign languages. To date they work out training manuals, workshops and techniques, the purpose of which is development of speech, language and cross-cultural competence of students. They are designed to facilitate the development of grammatically correct and logically meaningful speech, improve analytical reading skills, expand vocabulary skills, ability to discuss and write, and at the same time reflect the actual problems of modern life. They serve as the basis for a specific model of teaching future specialists of international relations.

Today's graduates of university will have to work in multicultural environment. One should be aware that the duality and differences in the interpretation of certain phenomena by students of different cultures is inevitability inherent in the structure of the modern world. Therefore, according to modern scholars and

teachers it is more important to teach students how to skillfully use a variety of competencies instead of writing what is prohibited or allowed in a particular country [1, p. 42].

Thus, it is important not only to know the principles of cross-cultural communication, but also to use and improve them in practice. So it is also useful and necessary to develop students' quick thinking and their ability to express ideas in different ways. An invaluable skill for a specialist in the field of cross-cultural communication is the ability to mediate between people, that is to represent the interlocutors to each other and talk correctly in a specific situation of communication. The process of cross-cultural communication makes high demands on the good command of the vocabulary and grammar skills. Fluent foreign language can only be achieved through integrated learning of all kinds of speech activity – speaking, listening, reading and writing [4, p. 137].

As in many professional fields today, the training of specialists in international affairs should be conducted in the context of continuing education, since only under this condition, it is possible to master foreign languages and cross-cultural communication on a qualitative level.

A specialist who graduated from university today, of course, has to be a thoroughly educated person. World civilization dictates a number of requirements to the modern level of education and its fundamental nature. Talking about such an important profession of our time, as a specialist in the sphere of international relations, it must be emphasized that the professionalism of the graduates, possessing knowledge in the area of cross-cultural communication, is based not only on the fundamental and comprehensive training in the language, but also in broadening and deepening the role of the socio-cultural component in the development of communication skills.

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## FOLK PEDAGOGY – THE BASIS OF THE FORMATION OF ECOLOGICAL CULTURE OF STUDENTS

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Centuries-old experience of cooperation of Tatar, Russian and other people and their joint residing at one ecological space promote development of the common ecological culture. The ethnopedagogics develops on the basis of natural living conditions, language, psychology, religion of the people occupying the country. The national culture is historically formed on the basis of ethnic culture, it incorporates elements of various ethnic cultures and acts as the dominating one. Hence, in modern conditions it is necessary to use ecological education and upbringing from the early childhood continuously and purposefully on the basis of ethnopedagogics. The problem chosen by us and the created concept is a basis of formation of ecological culture of pupils in ethnopedagogical aspect, and simultaneously it has ecological, scientific and pedagogical, historical, sociopolitical value.

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**Keywords:** ethnopedagogics, ethnoecological consciousness, ecologically cultural person

Today's global crisis does not have sociopolitical and economic roots only, but it is also an ecological crisis. Its prevention is possible only if we change the system of values which are formed by secondary school. It will be successful, especially if we use scientific knowledge based on the national pedagogies. As the national poet of the Tatar people Tuqai wrote, "People is great, mighty, he is talented, lyrical, he is a writer, he is a poet" [2]. The term "ecology" is derived from the Greek word "οἶκος" – the house, the Homeland, however it does not completely show the heart of the problem as all the steps taken to protect the environment are defined by human behavior, their attitude towards the nature. According to the results of our researches on the problem of formation of school students' ecological culture at the lessons of Geography on the basis of local history materials it is possible to argue that, the following statements are very important:

### 1. National pedagogical content knowledge, ecological thinking and consciousness

The basis of formation of school students' ecological culture is scientific and national ecological knowledge, which can be used at the lessons of Geography. We can consider such well-aimed sayings of our people about interaction of a human-being and the nature like: "Ineptly planted tree dries quickly", "We don't appreciate water until the well gets dry" to be national ecological knowledge. Such national and pedagogical knowledge reflects the main regularities and relationship of the components of geographical cover (lithosphere, atmosphere, hydrosphere, anthroposphere), existing in the nature and

the society whose violation generates negative and irreversible processes. They help to form creative thinking. Thinking is the highest step of human knowledge. A student mentally interacts not only with close, but also with remote in space and time natural phenomena and social objects. People say: "There is nothing as fast as a thought". Ecological consciousness is formed on the basis of ecological thinking. Consciousness is the highest form of mental reflection of reality. We have every reason to repeat the folk saying "Mind is dearer than gold".

### 2. Ecological work and ecological folk games

Due to the work at the lessons of geography moral and ecological education and development of pupils is carried out. Work plays the key role in their material and spiritual life. People say: "When work is pleasure, life is treasure", "Learning and work go hand in hand". The source of labor activity of school students in Tatar national school is "help" ("oma") [5]. It is an organized collective work of people, custom of mutual aid of Tatars. Any types of "oma" is directly connected with the nature. Sometimes they were organized according to the decision of the Council of

Elders – aksakals, to support widows, orphans, fire victims, to keep in order local roads, streets, places of the general using, springs, etc. Many of them were held as youth holidays with songs, games, ceremonial actions [3]. Tatars still have tradition of mutual helping in nowadays, it is closely interconnected with natural phenomena and promotes formation of ecological culture in school students.



Besides, game songs of the people connected with ancient calendar holidays, for example with the spring equinox – on March 21 – “Nauruz”, with the winter solstice – on December 22 – “Nardutan”, with wedding, ceremonial youth games during a sit-round gathering – “Aulak ij” [1]. They all have a geographical content and promote formation of ecological culture in children.

### **3. Ecological moral – esthetic attitude of people to the environment, its emotional sensory experiences**

One of ways of overcoming of ecological and spiritual crisis in the younger generation is familiarizing young generation with the world of beauty. Therefore the task of a teacher of Geography is to show to pupils the beauty of the environment. People say: “To admire beauty is a part of paradise”, “Beauty does not need ornaments”. Therefore, geographical knowledge and skills of the people contain moral-esthetic bases and promote the formation of ecological culture in a person. Moral is the basis of life. Famous American public figure, B. Washington, wrote once: “Up-bringing of an intellectual individual, without any moral, means, to bring up threat for society”.

### **4. Ecological means of folk pedagogy**

Ecological education of pupils by means of national pedagogy at the lessons of geography allowed us to conclude that proverbs, sayings, riddles, legends, fairy tales, songs passing from a generation to generation, create visual images of ecological activity. For example, at geography lessons when studying topic “Hydrosphere” in the 6th class we used such a national saying: “Don’t spit in the old well, dig out a new one”. When studying the topic “The geographical cover” it is possible to use the following national ecological knowledge, reflected in sayings: “Once you have planted a tree, you will have become the honorable person”, “If there is a garden around your house, a nightingale will come with pleasure”. People have always had special attitude to places of their own dwelling, they have especially respected springs therefore in the world of the nature there were special rules of behavior. On this basis, at geography lessons of the 6-th level when studying subject “The rivers and lakes” we used the following rule of the people’s attitude to water: “Fluid pure water is medicine it-

self”. Such way of life had special value in preservation of nature. The folklore of the region contains ecological education of not only Tatar people but also the one of other peoples of the region. For example, Russian saying says: “Spitting on water is all the same as spitting in your mother’s eyes”. Chuvashs say: “Tasa dalkudran tara tiv yukhat” (“Pure water comes out of pure spring”). The Udmurt people have such saying: “Mugoris deriez vuen no giltini lue, nosh vu pozhashkiz ke main soe dunmalod” (“If the hand is dirty, you can wash it with the water, and if the water is dirty how can you wash the water?”). Germans of Volga region consider: “Das Wasser ist am besten beim Ursprung” (“The purest water is at the springhead”) [5].

Thus, the experience of cooperation of Tatar, Russian, Bashkir, Chuvash, Udmurt, Mari, Mordvins and other peoples of the region and their collaboration in one ecological space promote the development of collective ecological culture. They were the first unwritten laws on protection of the environment, first and foremost ecological culture, and they can provide formation of the basics of an ecological world view, moral and culture in modern generation at geography lessons.

### **5. Religious ecological culture**

The religion is a complicated form of culture. Religious belief is not the way of solution of definite tasks, but a naturally arisen since ancient times phenomena. Today it is not that important what religion a man belongs to, much more important that religion is not used to inspire the hatred between believers and non-believers which takes to the split of the society. Therefore at the lessons of “Geography of continents and oceans”, “Geography of Russia” and “Economic geography of foreign countries” while studying various chapters teacher can use local materials. For example, Islam played a great role in formation of ecological culture of Tatar people. Today they say a lot about terrorism in Islam, however the essence of Moslem culture is expressed in the main principles of the Qur’an, and true Islam has no relation to terror and terrorism. The senior generation taught the younger one according to the Qur’an: “Don’t spread misfortune on the earth, we came here for creating”. A certain part of the Qur’an consists of its legal, moral and esthetic aspects, thus moral and ecology are inseparable.



Islam professed by Tatar and Bashkir people, and Christianity professed by Russians, Chuvashs, constitute the legal, moral and esthetic aspects, and moral and ecology are inseparable. Islamic the religion of Tatars and Bashkirs, and Christianity the religion of Russians, Chuvashs, Maris, Udmurts and others peoples of our region teach mercy, friendliness, kindness, generosity, responsibility to their believer, ecologically bring the person up from within and help believers to foster ecological culture. According to the Constitution Russia is a secular state in which the religion is separated from the state, and school – from church and mosque for ensuring spiritual freedom of citizens. It is implemented in all civilized countries that does not prevent the western countries to build the life resting on the unity of two beginnings – religious and secular [4].

Thus, in our understanding ecologically educated person is an intelligent and civilized person possessing not only geographical knowledge, but also developed ecological knowledge of his/her people, being able to think and operate ecologically, taking care of the natural and social environment. We train such Person and we bring him/her up at geography lessons.

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## ART THERAPY IN WORK WITH JUNIOR HIGH SCHOOL STUDENTS WITH MENTAL RETARDATION

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The article addresses the issue of deviation in behavior of primary school children with mental retardation. It focuses on specific forms of deviant behavior of younger students with mental retardation. In this regard, the use of art therapy is updated as the main method of working with the studied category of children. In addition, some benefits and the specific use of art therapy in the aspect of prevention and preventing the development of deviant behavior in these children are identified.

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**Keywords:** primary school age, younger students with mental retardation, deviations of behavior, deviant behavior, art therapy, art therapy as a method of working with children with behavior deviation

Currently, according to psychological and educational research the problem of study of deviations in behavior of primary school children is updated, particularly children with mental retardation.

Primary school age is a period of further development of the psychological individual-typological and the formation of basic social and moral qualities and traits of a person. In primary school age the determinant of moral behavior is laid; a child acquires the moral norms and rules of behavior, and social orientation of an individual begins to form.

Throughout the period junior high school students learn to control and manage their behavior. It is at this age the child becomes aware of the relationship between him or her and others, starts to understand the motives of social behavior, moral evaluations, to analyze the causes of conflict situations.

Generally, this age period is characterized by fixing arbitrary behaviors and activities, the formation of a new cognitive relation to the reality and the development of conscious mechanisms of social interaction.

Features of the cognitive development of children with mental retardation substantially impede the process of self-generalizing of those behavioral actions that are transformed into common ideas, beliefs and attitudes determining behavior of an individual in society.

In this context, special attention to the aspect of the problem being studied, according to correctional educators, special psychologists, teachers, psychologists, social workers, should be focused on behavioral deviation of primary school children with mental retardation. Psychological and pedagogical research suggests that these children differently than their normally developing peers perceive the social world and function in it: inadequate, uncritically, affective, selfish, and often infan-

tile. Thus, the problem of deviant behavior in children with mental retardation is of particular importance.

The study of psychological and educational characteristics of children with mental retardation indicates high risk emergence of various forms of deviant behavior. Numerous studies of personality and behavioral characteristics of children of primary school age with mental retardation suggest that these children usually have:

1) heightened suggestibility and impressionable, carelessness, subordination in the interaction, the inability and unwillingness to act on the social rules and norms, the instability of social contacts;

2) an exaggeration of their potential, overlooking the particular personality of others;

3) lying, conflict, persistent impulsiveness of behavior, regardless of the circumstances, short temper, greed, selfishness, unreliability, irritable, stubborn, aggressive behavior, hostility, negativism, and vindictiveness, a tendency to demonstrative behavior, boasting;

4) the prevalence of destructive behaviors;

5) the lack of a sense of responsibility, persistent attachment, low self-criticism and increased demands of others, mostly negative emotional experiences;

6) the instability of personal motives and interests;

7) unformed personality-sense regulation that limits the reflection of their internal plan of action;

8) the lack of any regulation and underdevelopment of emotional and volitional organization of behavior;

9) dependence of the behavior from the situation, the inability to resolve even minor stress in the prescribed manner;

10) the instability and spontaneity of emotional response, hypermotivity polarized with severe emotional downturn;

11) surface reactions and often inadequate behavior to situations, causing these reactions;

12) avoidance of the school and the school community, escaping from the house, school truancy, running away;

13) social isolation, confusion in the manifestation of compassion, empathy, care, generally shallow experience, the lack of formation of moral standards and values, etc.

The above mentioned behavioral disorders for such children are a familiar way to respond to adverse environmental factors and represent a kind of behavioral stereotypes.

According to L.L. Pelevina one should focus on the fact that in this group of students some skills of social and moral behavior, formed at a certain stage of age, can be relatively easily and quickly deteriorate, positive interests superseded by negative and asocial, and skills of social and psychological orientation can deteriorate [9].

Based on the above, in the context of studying the characteristics of manifestation of deviations in the behavior of school-age children with mental retardation has been suggested that art therapy is an appropriate and effective method of working with children in this category.

According to A.I. Kopytin, that art therapy can meet the challenges of prevention and correction of behavioral and emotional disorders in children developing their complex psychological skills needed to succeed in psychosocial adaptation [4].

Art therapy is, by definition of M.V. Kiseleva, method of development and changes in the conscious and unconscious sides of the individual psyche through different forms and types of art [3, p. 15]. The researcher points out that this method allows you to experiment with feelings, explore and express them on a symbolic level [ibid.]

L.D. Lebedeva focuses on the fact that art therapy as a technique is based on the belief that the internal "I" of a person is reflected in the visual images whenever he spontaneously, without thinking about his works, draws, paints a picture or sculpts. It is considered that the images of art reflect all kinds of subconscious processes, including fears, internal conflicts, childhood memories, dreams. With their verbal description, especially in children, there may be difficulties. In this regard, it is non-verbal means such as art therapy, in most cases, that are the only possibilities for the expression and clarification of strong emotions [6, p. 28].

So, the main purpose of art therapy is to harmonize the development of an individual

through the actualization of the ability of self-expression and self-discovery.

Art therapy, in terms of E.A. Medvedeva, is a set of corrective treatment methods that have differences and features that are defined both by the genre belonging to a specific art form and by orientation, technology of psychocorrectional therapeutic use [1, p. 165].

Therefore, art therapy in the aspect of the problem being studied is considered as a set of methods and techniques based on the use of the arts in a kind of symbolic form and determining corrective effect on the psycho-emotional, behavioral, cognitive, and other areas of personal development of children with mental retardation.

Typically, children with mental retardation in most cases find it difficult to verbalize their concerns and experiences, in internalization and extrapolation of norms and rules of behavior and interaction, in reflection of reality, current events and circumstances. In addition, these children have poorly developed reflexive self, and some of them are characterized by negative self-concept, and respectively, using the methods of art therapy is especially important in working with them.

Thus, in the aspect of application of art therapy in working with younger students of studied category it is possible to recommend some tasks on a specific topic with specific material (drawings, sculpture, appliqué on any subject) or to offer the children some tasks on arbitrary subject with independent choice of material. One of the options is direct reference to the works of art (paintings, sculptures, illustrations, calendars) with the aim of reflection. A combination of several types of work has an important role, such as when a child is shown a reproduction of the artist's painting and asked to draw the same one, not limiting his work. In addition, it is possible to implement work together with the child, giving him or her space for independent activity [8, 10].

O.A. Matveeva stresses that work with children of primary school age with mental retardation the most important is the use of art therapy, as art therapy allows to designate a specific task to think, write, do something themselves, modeling their experiences, interests, needs, desires and building up on the basis of this new work, divergent solutions of given task [7].

However, this is not enough, because, according to S.G. Rybakova [11], the formation of motivational determinants of behavior that determine the child's achievement of success and recognition is also essential.

As A.A. Koroleva points out, in the process of art therapy urgent need for the child in a positive attention, feeling of success and self-worth is satisfied. Psychological energy is released and is wasted on ineffective stress. Consequently, a child begins to feel calm, relaxed. Psychological defense in the form of demonstration, negativity, aggression, conflict and mendacity is replaced by initiative, kindness, creativity, constructiveness [5, p. 37–38].

Art therapy allows children to form adequate attitude to themselves, others and the real world. Art therapy effects on a child's personality is aimed at developing the child's sense of empathy, understanding of states, moods and emotions of others, benevolent-critical perception of the strengths and weaknesses of others, the ability to prevent and overcome personal conflicts, culture of emotional expression. This, in turn, determines moral development of an individual, provides guidance in the moral standards, assimilation of ethics [2, 6].

It should be noted that art therapy provides the child with mental retardation the opportunity to express feelings of different modalities, including feelings such as aggression, anger, temper, hostility, irritability in free socially acceptable form. Sculpture, painting, sewing, drawing, playing are constructive ways of transformation of psychological stress, frustration and feelings of interpersonal conflicts of a child.

In addition, art therapy promotes the development of the child's attention to his or her feelings, sensations, desires, thoughts and actions, as it allow to experiment, explore and reflect at some symbolic level that is a peculiar safe form of self-expression and self-discovery. During the art therapy process, the child acquires the skills to overcome difficulties of choice and decision-making,

adequate perception and attitude to failure, difficult life circumstances, which generally improves self-esteem and success of social adaptation of children of primary school-age with mental retardation.

Thus, art therapy allows a child with mental retardation in adaptive form to actualize a traumatic situation or experience for him or her, and based on that recognize their own feelings and emotional experiences and work them through verbally, to analyze the reasons for their actions and behavior and, therefore, to design the divergent ways and forms that contribute to a constructive solution of a problem.

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## SELF-MANAGEMENT AND THE QUALITY OF EDUCATION

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The problem of quality education in university is one of the most relevant in the modern world. The article examines the impact of technologies of self-management on the implementation of the quality management system at the Institute of social education.

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**Keywords:** quality of education, self-management, factors of quality education, correction, corrective actions, preventive actions

“Quality of education” is not only the results of studies, but also a system, model, organization and procedures to ensure that students receive comprehensive personal and social development, giving them the opportunity to meet their needs and enable them to contribute to the progress and improvement of society [5].

Today, the quality of education is characterized not only by necessary knowledge, skills and abilities. Demands of modern life are much richer and broader, more diverse and more complex. In many situations of professional activity effect is not the amount of knowledge and skills but their composition and structure, not the use of skills but creative approach to problem solving. In this regard in the modern conditions of development it is insufficient to get just some qualification as the result of education. It is necessary not only to provide the level of training, but also the nature of social existence in professional life.

The main parameters of the quality of education reflect the totality of the factors that have a significant impact on the formation of quality, as well as determine the extent and characteristics of these factors and their interaction with each other.

Y.B. Vasenev identifies several key factors that determine the quality of education: the quality of the content of education, i.e. quality of Federal State Educational Standard of Higher Professional Education and quality of specific educational programs, based on these data, the quality of applicants and students; positive motivation of students enrolled, the quality of methodological and material and technical support of the educational process, the quality of the teaching staff and support staff; positive motivation of staff, the quality of learning technologies etc. [1].

In addition to the above factors there are some others that influence the quality of education, including student learning and success in

higher education establishments: financial situation, health status, age, marital status of students, their level of pre-university training, possession of skills of self-organization, planning and supervision of their activities (especially studying) motives in choice of high school, the adequacy of the initial ideas about the specifics of high school training, mode of study (full-time students, part-time, distance, etc.), availability of tuition fees and amount of payment, the organization of the educational process in high school, the school's prestige, and finally, individual psychological characteristics of students.

One may ask why some students are diligent and learn well, while others are less successful? Such differences can be observed in the same environmental conditions of training activities. In explaining this phenomenon psychologists and educators often appeal to such individual psychological characteristics of students as intelligence, creativity, learning motivation, providing strong positive experiences in achieving educational goals, high self-esteem, leading to the formation of high level of aspiration, etc. But none of these qualities alone or even a combination of them is not sufficient to ensure students' focus on everyday stubborn and hard work on mastering knowledge and professional skills in fairly frequent or long-term setbacks that are inevitable in any complex activity.

In higher educational establishment the effectiveness of quality management system can be traced back through the interaction with the educational sector of the student council and with teaching staff for the effective organization of the educational process, by informing students about the features and requirements for the quality of their training, by making a survey of students and parents, by providing a wide range of educational literature (main, extra, special and electronic books), through the analysis of the outcomes of sessions and interim certification.



The work of the internal support system for the quality of education of universities is carried out by deans' offices. They are a key element in the educational process, carrying out immediate feedback to students, organizing psycho-educational support for students at all times during training at the university. The main purpose of the deans' offices is organization of the process of improvement of the educational system as a whole and its individual components, it assumes not ascertaining of the level of quality but constant search for ways to improve it. In actual practice, improving the quality of education can only be a gradual process of approximation to the ideal notions of stakeholders [4]. In their work deans' offices can systematically collect information on student academic performance and quality of student learning, taking into account their attitudes to learning, meaningful incentives in learning activities, motives to enter university.

At the first and second years of studying the main areas of work of deans' offices may include: the formation of students' knowledge about the features of university studies, forms and methods of control, creating the conditions for self-realization and optimization of learning activities, formation of students' culture of self-education, self-organization and self-control.

At the senior courses of studying dean's office may pay special attention to the formation of the students' motivation to self-development, self-improvement, active lifestyle and professional positions, the development of students' culture of self-education and self-control.

The second factor in the direction of the dean's offices work may be the analysis of students' participation in extracurricular activities in the following areas: mass sports, cultural and recreational, as well as participation in research work of students. Cooperation of deans' offices with student government and student activists affects the quality of education.

Another factor affecting the quality of education in high school is self management, which is regarded as the most natural tool for teaching the skills of self-organization (time management), understood not simply as a set of techniques of planning, but also as a technique to control personal activities (self-management).

In his book, "If you hurry – do not hurry: new time-management in accelerated world: seven steps to the effectiveness and independence in the use of time", Lothar J. Seiwert gives this definition: "Time-management is

self-management and active formation of personal behavior or leadership" [3].

Thus, self-management of a student is consistent and purposeful use of proven techniques of organization of personal and training activities in daily practice, in order to make the best use of time.

The introduced method of self-management to the work of dean's office and learning activities of students could be one of the biggest factors that can be used to develop the skills of self-organization, planning and supervision of students' activities. However, before you form students' self-management skills, any activity of a dean's office should be organized according to the method of self-management: first of all it should be planned for a year, a quarter, a month, a week or a day. The advantage of the plan is that even in the event of unforeseen circumstances, the scheduled tasks will not remain forgotten. In addition, self-management involves setting priorities for each day. This will help distribute the time and avoid the crisis at the end, when the work is to be completed, and the time is gone.

On the other hand, a student who does not have the skills of organization of personal time will not be able to become a full-fledged specialist and member of the labor market as well as learn effectively. A student, studying at university, should organize his or her work, plan studies, and distribute workloads. Finally, a student who does not master self-management and have no clear strategy of life is unable to grasp what is given in a university.

After analyzing the activities of the dean's office for a year at the Institute of social education in Ural state pedagogical university, there were identified the following potential inconsistencies that arise in the course of providing services of higher education:

#### 1. Poor progress of students.

There were identified the following reasons for poor progress of students: non-attendance of training sessions by students and untimely working off debts, lack of motivation to learn, the lack of normal conditions in family, and in this regard, the combination of study and work.

On the identified discrepancies there was scheduled such correction: interviews with students to identify the reasons for failure and the organization of additional consultations with students who have academic debts, but having the right to liquidate them within two weeks, scheduling elimination of tests and examinations.

In addition to these measures there were planned some corrective actions: conducting interviews with parents, holding organizational meetings with students, conducting the so called "parent meetings".

There were conceived the following preventive actions: to introduce students to the "Regulations for interim certification", including in working curricula of the first course of studying such elective course as "Culture of learning activities", clear indication of the order of evaluation and criteria of the discipline in working curricula, conducting ongoing assessment of students in the subjects studied, the development of the system of admission of students to the session.

2. The instability of the initial composition of the students.

The reasons: academic underachievement of students as a result of which they are subject to expulsion, the student's own desire.

Analysis of the reasons allowed to plan for corrective interviews with students and their parents, as well as with the teaching staff to identify the causes of deductions.

There were scheduled the following corrective and preventive actions: to introduce students to an excerpt from the Charter of USPU and the "Regulations for interim certification", systematic work with faculty members by dean's office, discussion of problems in the departments.

Based on the identified gaps, we can isolate the effect of self-management techniques to the dean's office and student activities, as only systematic, planned correction, conducting corrective and preventive actions will improve the quality of education at university. The result of the introduction of self-management tech-

niques into the work of dean's offices allowed to systematize the work of the internal support system for the quality of education at university and in addition allowed the students to develop professional competences in the field of:

- control of personal time;
- the implementation of self-examination and the level of self-organizing of their own activities;
- rationalization of their own personal and educational activities;
- goal-setting and planning;
- decision-making.

Thus, it can be concluded that the implemented method of self-management to the work of dean's office allows to talk about the creation of the necessary conditions for the successful implementation and deployment of an effective system of quality management education and, ultimately, ensures long-term success of the university in the education and working force market.

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*Short Reports*

**THE VIRTUAL REALITY,  
PERSREFERENCES ON-ORIENTED  
TECHNIQUES AND INTERACTIVE  
EDUCATION TECHNOLOGIES**

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This article analyses the innovative ideas published authors for development of interactive educational technologies and person-oriented methods in virtual reality.

In terms of total virtualization of Russian society, when the images dominate reality or pretend reality, preserving centuries of accumulated tradition of education is one of the semantic elements of human consciousness and the axiological measure of activity. The problem of sup-actualization in contemporary culture should be considered as the emergence of a new kind of reality – real virtually, which was the consequence of the introduction of new flexible communication technologies in all spheres of social production for network-society. On the one hand, the process of formation of the network-society is the loss of autonomy of many elements of the traditional system of social relations. On the other hand, it opens the possibility of a critical review of traditions, historical assessment criteria values and the formation of a new world. Due to the loss of traditional benchmarks are under the pressure of new experiences in the communications environment to the fore the need for the construction of new social meanings and relationships. Thus, we can say the emergence of a new culture, a culture of real virtually. Real Virtually – a system in which reality itself is fully immersed in the virtual images, and the external world is not just displayed on the screen, but the experience becomes. The information society – a society of knowledge, produces intelligent products using the digital form submission sites. Due to the transformation of information into digital form, the nature of the virtual objects will inevitably come to replace the physical.

**Background**

The content of modern education requires significant changes in the training facilities. Today it is necessary to use person-oriented educational techniques that contribute to the development of the necessary in modern society values and activity-related and research competence in students. One of the main tasks of education is not simply the sum of the mastery of knowledge by students, and the development of creative, independent thinking students, formation of abilities and skills of independent research, analysis and evaluation of informa-

tion. As evidenced by our study of self-organizing technology can be viewed as a process and as a phenomenon. As a self-organization process technology consists in forming, maintaining or eliminating a set of actions leading to the creation of stable, productive and interpersonal relations on the basis of free choice of the adopted rules and procedures. As a phenomenon of self-organization technology is a set of elements that are used to implement the program or purpose. These elements include the management structure, the participants of the process, resources, etc. And the introduction in 2010 by Professor V.S. Mkrttchian [1, p. 9] in the educational process of the concept of intellectual agent – avatars trainee and the training it provided an opportunity to significantly improve the efficiency of the learning process and to achieve 100% absorption of each participant of the process regardless of their individual abilities. Intellectual Agents – an adaptive computer program simulating a particular process participant implementation of educational technology for learning – a learning process for the learner – this process of assimilation. A participant in implementing this educational technology has in addition to the teacher and the learners are their intelligent agents, virtual environments have a bunch of teacher, his avatar, a bunch of students with their avatars. At the same time build their own avatars network self-adapting to the specific conditions of the learning process. So there is a teacher network through your avatar associated with the avatars of each student.

**Issues, Controversies, Problems**

We have under the adaptability of the educational system is considered from three main perspectives:

– Adaptability of the educational system to the constantly changing level of student's knowledge.

– Adaptability of the educational system to the changing material within the individual training courses.

– Adaptability of the educational system to the changing requirements of employers and labor markets.

Offered in the works of V.S. Mkrttchian [2, p. 69] avatar technology allows to solve adaptive problems completely. In particular, the avatar, the intelligent agent being an end user, serves as an additional means of unification. Putting Course modules made by different standards, the avatar makes transparent to the end user of their structural and technical differences. Trained by itself configures the interface of the avatar, which will determine the appearance, which will be rendered material of the course. Similarly, the teacher's picture abstracts the technical details of certain standards and specifications. The teacher sets the

interface part of the avatar, in which it is convenient to make the material of the training course. The functional part of the avatar, hidden from the user, allows to adjust the injected material to the requirements of specific standards and specifications, with no longer exists common understanding of the concept of the life cycle of electronic modules, courses and educational systems. Based on the analysis of the current profile of the student, are select the optimal configuration of the avatar. After that, the student avatar configuration change occurs upload the following content sections and the interface sets its visualization. If the course is fully passed, it can pass on to the next course with the load in the student's picture of the new model variability. The convenience of the proposed approach is that the modular structure of the training courses has a typical hierarchical structure and allow insertion of special tags (system administrator or teacher), delimiting the course subject areas and levels of complexity. The presence of such tag allows further build models of variability for each course in automatic mode without the participation of the teacher. Building such an environment opens a new phase of e-learning (E-Learning 3.0), in which the leading role will be played by the distributed computer systems, cloud computing, mobile personal devices, systems, artificial intelligence and virtual reality tools. Technology E-Learning 3.0 is ideal for learning the academic discipline of "Project Management", which now has earned recognition as a self-management discipline, the use of which increases the reliability of achieving the goals as scheduled, with the required quality and within budget. Implementation of projects is an integral component of business processes present in any organization, and particularly in research and in education. While such projects may vary in type, scope, complexity, but from a management point of view, they are the same. Our research revealed the following statistics: participation in projects takes between 30 to 70 % of the time. This is especially clear in the highly competitive industry, what are the education and isslednovaniya, where the effective implementation of development projects is becoming a key factor in the success of teaching and research for middle and senior managers (depending on the position and type of business). Administrative knowledge and job training system is conducted teacher (software technical administrations in this article are not considered). All issued assignments, the work of students and teacher trainees' activity recorded in the database.

### Solutions and Recommendations

In the works of V.S. Mkrttchian [3, p. 219] he is analysed all known digital objects of different management techniques. We propose a path for management purposes of teaching and research use control algorithm using a sliding mode and controls theory. Control method with intentional introduction into the sliding mode is characterized by simplicity and high reliability, as it involves forcing the management, causes the process to proceed in a certain trajectory specified by the developer. Such management methods allow you to build arbitrarily complex algorithms, tuning them specifically under the control object is of the process of learning and research in the virtual education system. The trajectory of learning in a virtual reality begins with the definition for the student a set of modules corresponding to the curriculum of the academic discipline of "Project Management for a particular specialty. For each discipline there is a set of modules (eg, each lecture consists of a set of themes, and the theme is divided into sections) that define the structure of the discipline. Next comes the study material according to the specified schedule in the environment and the implementation of monitoring in the form of passing the tests corresponding to this module. Test results allow, to a certain extent, to evaluate the student's level of knowledge and to invite him to continue their education or to repeat previously learned material. The analysis of student learning activities allows us to formulate recommendations, which it can use to improve their knowledge. This procedure is performed for each discipline. When learning the system state is determined by the level of quality and pace of acquired knowledge to students. In different situations, when training becomes necessary to adjust the learning process that occurs when a fast or slow digestion, increase or decrease the complexity of tasks and so on.

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## EMOTIONAL BURN-OUT OF THE YOUNG PSYCHOLOGIST WHILE PERFORMING JOB FUNCTIONS

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The authors present the results of their study of the factors of professional environment, which transform the young psychologist's emotional sphere. While performing job functions, the consulting psychologist undergoes informative and emotional attack of negative assessments or facts of the client's life and unintentionally projects them on the world around. The concepts of the values and meanings idealized by the young people are destroyed, leading in some cases to emotional burn-out and in 12 per cent of the latter to abandoning the profession.

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**Keywords:** emotional burn-out, young psychologist, mental states, transformation of emotions

The importance of stabilization of mental states in the young psychologist's professional development cannot be overestimated. Some scientists associate this process with self-regulation of mental states, with satisfaction of job requirements [5]. It has been established that social behavior of the young psychologist and the nature of his interpersonal relationships depend on the general social situation and, in particular, on the emotional comfort and stability of his mental states [4]. According to A.A. Tsahaeva, "applied psychologist himself needs two consulting psychologists" [7].

The psychologist's emotional sphere undergoes constant overpressure due to specific consulting situations or projection of individual consciousness on the client's problems, which are similar to mental states. Mental state is one of the forms of conscious reflection of the real world, the response to dangers and difficulties of adaptation. However, these mental states are often destabilized and differ from the norm. In this case some cognitive processes, be it memory, imagination, intuition, feeling or others, will not reflect the state of the real world fully and it will adversely affect the young psychologist's professional activity.

The work of mental states depends on the emotional and volitional sphere and its stability. And on the whole, it is an essential aspect of the development of the young psychologist's personality. The problems of emotional and volitional regulation and stabilization are especially acute both while doing important professional tasks and in the everyday life of the young psychologist. Without targeted stabilization of the young psychologist's emotional and volitional sphere, in stress conditions of the current society psychologists turn out to be unable to regulate their professional activities. One of the levels of manifestation of mental states is emotion. Emotions are dynamic and they are subject to burn-out in case of stressful situations in the professional activity.

## Materials and methods of research

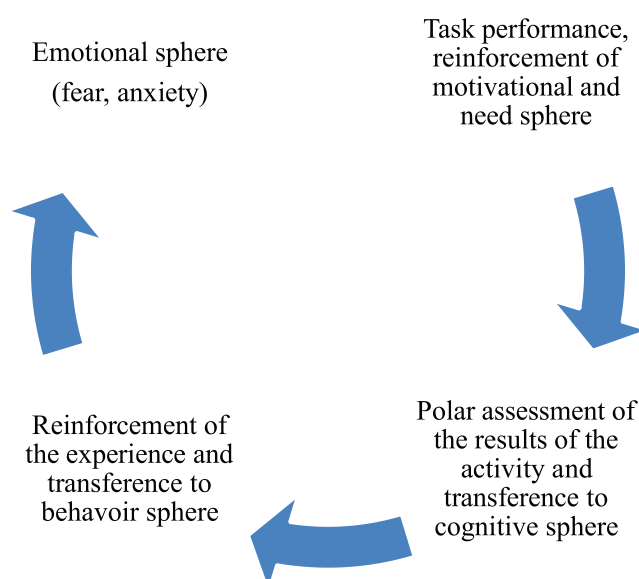
The problem of identification and stabilization of mental states during the young psychologist's study at the institution of higher professional education falls under competence of diagnostics and subsequent correction, into which we have included the complex method of overcoming of mental states adversely affecting the professional activity (A.Yu. Fedotov, I.N. Medvedev [2]), auto-training, Jacobson's progressive muscular relaxation, modified questionnaire of method of sequential dynamic assessment (MSDA) allowing to identify the determinants of mental states.

We understand that such emotions as feelings cannot last long and they consistently transform into activity aggressive register, which allows to utilize previously needed resources and start targeted expansive activity of implementation of situational task and realization of the need linked with it. And the only effective mechanism for neutralization of aggression is a tolerant worldview [9].

After passing this stage of situational activity, the interest in accomplished situation is gradually weakened, it is already worked out and stored internally as an element of life or professional experience and, therefore, is no longer able to activate the consciousness. This leads to transformation of cognitive emotional register to standby register, search for changes, and opens the subject for active entrance to a new situation. This register can be identified as boredom, sadness, etc. Thus, the cycle is closed and a new situation will again begin with switching on the fear register. For better visualization see the following Figure.

But emotions cannot experience this cycle endlessly. In accordance with the laws of the space-world, they spend part of their energy biological potential, i.e. they grow weak. This is what we call emotional burn-out. In respect to the concept of the emotional burn-out syndrome, introduced into psychological science by the American scholar, psychiatrist Freudenberg (1974), the experts consider it to be usual overfatigue [3]. The characteristic growing indifference to himself, professional and domestic duties, facts of life, the presence of negativity in relationships with patients or clients, as well as the members of the family and professional community, strengthen the person's illusion of professional minimalism, dissatisfaction with his professional level. Some depersonalization takes place and it subsequently leads to the development of neurotic disorders and destructive psychosomatic states.





Implementation of the cycling principle of transformation of emotions

To cope with the task, which professional education gives to practical psychology, of avoiding the transformation of the young psychologist's emotional register and the mechanism of emotional burn-out, and to achieve the goals we used three groups of methods in our research:

- theoretical methods: study and analysis of the literature, comparison, description and schematization of theoretical approaches;

- empirical methods: *diagnostic* methods – the author's version of the form of MSDA retrospective interviewing/individual, L.N. Sobchik's individual typological questionnaire, questionnaire for mental status examination and questionnaire of vital capacity, Boiko's technique of identification of emotional burn-out, data collection and analysis, observation and talks; *correctional* methods: A.Yu. Fedotov and I.N. Medvedev's "Complex method of overcoming of mental states adversely affecting the professional activity", auto-training, Jacobson's progressive muscular relaxation;

- statistical methods. Forms of the techniques were processed on the hardware-software psychodiagnostic system "Multipsychometer" and percentage of indexes was calculated.

Theoretical and statistical methods are well-known, so we will not elaborate on them and will analyze the use of empirical methods and their validity. Complex method of overcoming of mental states was used by A.Yu. Fedotov and I.N. Medvedev to identify mental states adversely affecting the professional activity of psychologists [2, p. 65–72]. Basing on the criteria for determining stability of the psychologists' emotional sphere and permissible variations from the norm, we have constructed the diagnostic process consisting of several stages:

1. Revealing of stable personality traits, which point at the certain employee's predisposition to particular ways of emotional response in the future professional activity.

2. Determination of actual peculiarities of the employee's emotional response in various situations of professional activity. During the study we used system-situational analysis of activity (SSAA) – a complex method of research of professional activity, based on the formation of a data bank on the situations in the "client-psychologist" system and its psychological interpretation in order to obtain reliable information about psychological determinants of its effectiveness. For the purpose the system-situational analysis of activity was used as a basic method, it involves the integral study of activity by generalization of information about a large number of typical situations of professional activity. SSAA is based on the analysis of situations, and introduction of the concept 'situation' requires some explanations. SSAA includes the method of sequential dynamic assessment (MSDA). The authors' version of the form of MSDA retrospective interviewing/individual includes six units:

1. Task.
2. Subject.
3. Objective conditions.
4. Situation in the narrow sense.
5. Situational activity.
6. Result.

The content of each unit depends on the specifics of individual psychological data of the respondents. There are several modifications of the MSDA and they differ in the following criteria:

- the subject of activity – an individual and a group. The MSDA for the analysis of group and individual activities differ in the content of the studied features (individual psychological qualities);

- the type of analysis: retrospective. Retrospective analysis is studying the situations, which occurred in the past. A retrospective type of analysis is divided into content analysis (printed sources) and retrospective interview (personal experience of the participants or eyewitnesses of the situation).

### Results of research and their discussion

Our study of the presence of the emotional burn-out syndrome in young psychologists (the sample consisted of 118 people with length of service less than 3 years) shows that in 76 per cent of cases the very conditions of realization of professional tasks and job functions give rise to the emotional burn-out syndrome. The level of the young psychologist's professional register comprises of the list of the following features.

The client with this syndrome complains of progressive fatigue; low efficiency; poor tolerance of everyday physical activity; muscle weakness, often accompanied by pain; sleep disorder; amnesia; irritability; weakening of active attention.

In order to understand the details of manifestations of mental states we will focus on the personal data of the respondent A-a G.A., born in 1981. After processing of the obtained data we can state the following in the psychological characteristic of this personality.

High level of mental and behavioral disadaptation. The respondent is characterized by frank anxiety, nervousness, inadequacy of reactions, lack of self-trust, rapid emergence of negative emotions. The subject poorly adjusts to new conditions of life, establishes contacts slowly, as a rule, and does not enjoy authority with the clients. The subject is apt to hypochondria, has a large number of negative feelings, is anxious, irritable, is prone to bad mood, apt to see everything black, and is not satisfied with the profession.

The extent of conflict is increased, the outside world is perceived mainly as a source of threat, and there is vigilance towards the others, rejection of criticism.

Very high level of depression. The respondent is characterized by a high tendency to feel guilty for failing to help the client, increased vulnerability, underestimation of the professional abilities, knowledge and skills. Most of the time the respondent is in alarm, depressed, anxious mood, is prone to various fears and feels bitter about any failures.

The respondent is easily led, feels uneasy and awkward in consulting situations, has modest manners and keeps apart. This complex of symptoms can be, in particular, the result of past traumatic events (post-traumatic stress syndrome, the client's suicide). It needs psychocorrection.

Extremely high values of the scale may indicate a predisposition to abandoning the profession (high level of self-aggression).

In the socially significant situation rigidity may to some extent be softened by focusing on the opinions of others.

Psychosomatic predisposition: conflict multidirectionality of trends allows to compensate some polar features by the others.

The following block of techniques was also processed by multipysychometer and gave the following data.

The respondent believes that people are hostile to him and that any individual and long contact will end in troubles, and, therefore, does not try to make friends and have warm human relations. The respondent works with the clients only in the "client – psychologist" mode and tries not to meet with them again after the professional actions. Thus, actually the respondent has no friends for extraprofessional communication and that is why often feels unwanted and isolated.

Typical is the feeling of helplessness, doubt of the ability to influence the events which happen to him and around him; the belief that everything that happens is the result of external factors (luck, fortuitous combination of circumstances, help of other people, etc.).

Typical is the desire to avoid competition, innovation, changes and other situations connected with uncertainty and risk. Such people prefer stability, regulated activity, are able to do routine work, are rigid and committed to traditional views and rules.

### Conclusions

The young psychologists' emotional states, which, in the respondents' opinion, hindered their work, were anger, perplexity, fear, spite, dreaminess, and panic. Professional reflection acts as an effective mechanism of saving of psychic forces through the extension of transcendental experience of the applied psychologist on the results of activity [6]. But it should be noted that the participants unwillingly answered the question about the hindering emotional states because reflecting the person avoids wrecking of his own value system of self-evaluation [8]. Perhaps, this is due to the peculiarities of general professional competence and unwillingness to admit the existence of emotional states, which can be regarded as a failure of the implementation

of job functions. The index of the personality's individual psychological security works as the factor of preventing wrecking of the professionalization [1]. This supports the idea that the young psychologist's emotional burn-out leads to the transformation of the professional register of the young psychologist's personality.

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## FROM HISTORY OF CONSTRUCTION OF KERCHENSKY BRIDGE IN DAYS OF THE GREAT PATRIOTIC WAR

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Today one of the major Russian infrastructure projects is construction of the Kerch railway and automobile bridge which has to connect the Caucasian coast with the Republic of Crimea. As the Minister of Transport of the Russian Federation Maxim Sokolov at a meeting with the Russian President Vladimir Putin reported on September 5, 2014, works on construction of the bridge to the Crimea through the Strait of Kerch began in August, 2014 and according to the plan schedule will be complete by December 16, 2018. In this regard actually to consider experience and lessons of construction of a crossing, the bridge through the Strait of Kerch in days of the Great Patriotic War.

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**Keywords:** Russian infrastructure projects, construction of the Kerch railway and automobile bridge, Strait of Kerch

From history we know that Cimmerian Bosphorus (ancient Greeks so called the modern Strait of Kerch, at the end of XVIII – the beginning of the XX centuries the passage also called Taurian, Enikalsky, Kerch-Enikalsky) was famous for abundance of banks and islands through which it was passed successfully into antique times. Cimmerians in the VII–III centuries BC occupied northeast Black Sea Coast, even before emergence Scythians here. About two and a half thousand years ago between the capes Panagia and Tuzla on the bank of the Gulf of Taman there was an Ancient Greek city colony of Korokondam. Since then the sea won 2 kilometers from the coast, and the city appeared at the bottom. In droughty years when the rivers Don and Kuban dumped not enough water to the Sea of Azov, from the Crimea to the Caucasus it was possible even to ford (the Ancient Greek playwright Eskhil called the passage “the cow ford”). There are data that the temporary crossing was organized here still by the Pontic tsar Mitrdat of Vievpator in I BC. owning the cities on both sides of the passage. Its bridge was floating: on the boats standing in water imposed logs on which the cavalry could move.

The first the real project of creation of the bridge through the Strait of Kerch was put forward by the Russian naval officer Vladimir Dmitriyevich Mendeleyev in the second half of the XIX century (the son of the great chemist D.I. Mendeleyev). Its plan consisted in a dam construction from Pavlovsky's cape to the spit of Tuzla, and then from it – on Taman. This project was called the bridge from Europe to the Southern Asia. Here once I passed the Great Silk way, the route of the well-known cable line from London to Delhi lay here. At the end of XIX – the beginning of the XX century British managed to lay between the Crimea and the Caucasus on a bottom of the Strait of Kerch a telephone wire for a reliable communication

of the mother country with its colony – India. In 1901 the English government considered even the construction project of a railway line from London to Delhi. At its creation it was planned to build the huge bridge through English Channel and the little the smaller – through the Strait of Kerch. But everything rested as it often happens, for lack of means, and the superproject laid down under cloth.

In 1903 the Russian emperor Nicholas II became interested in idea to build the bridge through the Strait of Kerch. Now design offers on a construction of the bridge were developed by the Russian engineers. But World War I began, then revolution, Civil war burst, they were followed by ruin, and became not to grandiose projects.

Kerchensky Bridge remembered during socialist industrialization. Stalin planned to pave the main railroad from the South of Ukraine from Kherson through the Crimea, further on the bridge through the Strait of Kerch, across Taman Peninsula with an exit to the district of Novorossiysk and then along all Black Sea coast of the Caucasus to Poti. The Soviet plants at that time couldn't cope with implementation of the purchase order of all yet iron designs, necessary for construction of the huge bridge, therefore they before World War II were ordered in Germany.

War began. In 1942 the German troops took the Crimea, there were fights for the Caucasus. Hitler even at the beginning of war showed interest in construction of a huge railway superhighway to India more than once. But, unlike the British project, German began in the Alps, in Munich. From there steel threads of rails had to stretch to the Crimea, step through the Strait of Kerch to the Caucasus, and then through Gulf States to go to Iran, India. Germans decided to use the metalwork made by request of the USSR for the superbridge in the purposes and began to send from Germany to Kerch.

Interesting fact: the Soviet aircraft noticed unusual activity of Germans on the Kerch Peninsula, but forbade to bomb warehouses – Stalin planned to take the Crimea and to finish the construction of the bridge begun by Germans.

In the memoirs Reich Minister Albert Speer wrote war industry of Hitlerite Germany: “In the spring of 1943 Hitler demanded to begin construction of the five-kilometer bridge for motor and railway transport through the Strait of Kerch. Here we already constructed the suspended road which was started up on June 14, (1943) and delivered every day one thousand tons of freight. It was enough for requirements of defense of the 17th army. However Hitler didn't refuse the plan of break to Persia through the Caucasus. Works were conducted continuously, and concerning them, since winter of 1943, one behind another instructions arrived. Last directive: the bridge through the Strait of Kerch has to be finished till August 1, 1944...” (Speer A. Third Reich from within. Memoirs of a Reich Minister of war industry. 1930–1945. – M.: ЛитРес, 2013. – P. 390).

The German military engineers developed the project of the bridge through the Strait of Kerch which would allow to pave iron and automobile ways from Kerch to the district of Novorossiysk. Real preparatory work began in the early spring of 1943 construction of the railroad from the Crimean station to Chushka Spit. And from Chushka Spit towards the Crimean settlement of Zhukovka preparation for construction of the bridge, over 3,5 kilometers long began.

But soon construction of the bridge was stopped. Situation on the Caucasian front changed. And in the summer of 1943 the German military engineers were compelled to design and construct in the shortest possible time a suspended ropeway through the Strait of Kerch for transfer of the military freights blocked near Taman Peninsula. Some months the ropeway almost smoothly threw every day on 500–800 tons of freight.

In the fall of 1943, before retreat from Taman Peninsula, Hitlerites blew up a ropeway and part of support, but completely didn't manage to destroy a construction. As soon as Taman was released, and on east part of the Crimea the landing is landed, the Soviet engineers were engaged in connection of two coast of the Strait of Kerch. For restoration of partially destroyed road the equipment from one of the industrial ropeways operating at that time in Georgia was used.

In February, 1944 the rope crossing over the Strait of Kerch started over again to work.

Its extent was about five kilometers, and 150 cargo trolleys worked at it. Daily productivity of the Soviet road made about 300 tons. It was the essential help to the 56<sup>th</sup> army which was on the Crimean coast. On a ropeway arms, ammunition, the food were delivered to the Soviet paratroopers.

During Kerch and Eltingensky operation of 1943. The red Army seized the base to the northeast of Kerch and kept it prior to the Crimean operation of 1944. On a midground between defenders of the base and Hitlerites large reserves of cement and a metalwork – lengthy the shirokopolochnykh the dvutavrovyykh of beams Paine, piles from the tongue and channels were found. Among the taken trophies there were cars of big loading capacity, bulldozers, diesel copras for blockage of piles, mobile power plants, welding machines, etc. They were delivered by Germans for construction of the road bridge through the Strait of Kerch and left at the retreat.

The decision on construction of the railway bridge through the Strait of Kerch was made by the State Committee of Defense by the resolution № 5027 of January 25, 1944. The city of Kerch was freed on April 11, 1944 during the Crimean operation. However design of the bridge crossing, preparatory and construction works on east approach to the bridge and on a platform construction from the Caucasus began even before liberation of Kerch.

Previously two options of the route of transition were considered: Youzhny – from the spit of Tuzla on Kamysh-Burun (the southern suburb of Kerch) and Northern – from Chushka Spit to the settlement Dangerous, to the north of Kerch. On a place the Northern option was chosen. Chushka Spit had length about 16 km, width from 60 to 1 500 m, is separated from the Crimea by the passage from 4,5 to 6 km wide. In its ruslovy part depth of water reached 10 m, from it to coast – 4–6 m. The geology and data on ice drifts in the passage for some tens years were studied. On long-term supervision, ice conditions in the passage were various. In some years of ice was practically not, and in others there was considerable carrying out it from the Sea of Azov to the passage. Complexity of the Strait of Kerch was still that its bottom consisted of mud volcanoes, silt thickness reached 50 meters here. Engineering-geological conditions of transition on materials of researches of 1944 can be divided into three sites. At the west bank throughout about 1 km the dense radical clays (to 13–17 m) covered with a layer of heavy loams, and at a bottom – silty sand superficially lay. The average site (about a half



of length of the bridge crossing) was characterized by a deep bedding of the radical clays covered on tens meters with thickness of weak loams. The site adjacent to east coast, at a deep bedding of radical clays from above was put by dense fine-grained sand and heavy loams.

It should be noted that design decisions were developed and accepted without complete detailed design, on the course of construction works they were approved on a place by the chief engineer of building of Socialist Work I.I. by the Hero. Tsurupy.

For acceleration of opening of train service on transition the main works divided into two turns. Referred blockage of vertical piles of intermediate support, a construction of support of adjustable part, construction of a platform and dam, installation of flying structures, laying of a bridge cloth and way, concreting of metal piles to the first stage; to the second turn – blockage of inclined piles and concreting of grillages of intermediate support, the termination of a dam of the Caucasian coast (a platform zasypka a stone), a construction of 123 ice cutters. The approach construction from the Caucasus from St entered a complex of construction. Hay to the station Caucasus and from the Crimea a site the Crimea – Kerch.

After mine clearing of all route Mostovik began blockage of vertical piles of intermediate support, support of sliding part, construction of a platform and dam. Flying structures from trophy beams and designs from DS steel were mounted on the Crimean coast. Construction of support under adjustable flights took 3 months. Filling of metal piles with concrete and concreting of grillages of intermediate support (about 11 thousand CBM of concrete) made from two concrete plants mounted on sea barges.

Dynamics of construction can be tracked according to operational reports of those of days. The first wooden pile is hammered into a platform of the Caucasian coast on April 24, 1944. The first metal pile is hammered on May 5, the first flying structure is made on May 10. And on November 3, 1944 on the bridge I passed the first train from station the Crimea to station the Caucasus. During this time hammered 2000 wooden and 2341 metal piles, made and mounted about 15 thousand tons of metal designs of flying structures and support, laid more than 5 thousand CBM of concrete, poured out 35 thousand CBM of stone dams. On approaches to the bridge from St. Hay to the station Kerch poured out 400 thousand CBM of a road bed, constructed 21 small artificial constructions, laid 69 km of the main and station ways, prepared and laid more than 40 thousand

CBM of a ballast at way, constructed the communication line 438 long pro-water – km. Efforts of many Crimeans and residents of Krasnodar except the bridge constructed also 18 km of railroad tracks across the Crimea and 46 km across Kuban.

However to winter of 1944 the situation on building considerably became complicated and worsened. The attention to it from the higher organizations weakened, the bridge crossing appeared in the deep back, and military transportations for the front went in other directions. It was reflected and in construction supply with material resources: they went, first of all, to the head, restored after release from the opponent railway directions and objects. Besides strongly weather conditions worsened – storm, disorders on the passage became frequent, came nearer freezing.

The developed conditions didn't allow to conduct successfully work of the second turn, and the bridge was not prepared for an ice drift. Heads of construction to what I.I. Tsurupy's letter in NKPS of December 15, 1944 testifies well understood it. The chief engineer of construction asked to excite the petition before state credit obligations for allocation in the order of construction of 4 ice breakers in it, U-2 squadrons (9–12 planes with air bombs), 3 artillery divisions with stocks of shells for protection of the bridge against an ice drift. The part of planes and artillery pieces was allocated, and ice breakers to the bridge didn't come.

In this difficult situation builders continued to concrete grillages of support, blockage of inclined piles. But the part of grillages wasn't concreted or had still weak concrete. Began a construction of ice cutters – only five managed to make them. On February 11, 1945, when Yalta (Crimean) conference of heads of states of the anti-Hitlerite coalition Stalin, Churchill, Roosevelt terminated, from the Crimea to the Caucasus on Kerchensky Bridge passed especially protected Government train. And on February 18 from the Sea of Azov under the influence of a wind and a current ice fields 0,5–1 m thick began to approach on February 19–20, 1945 there was an accident. Despite broad actions for a ledoborba, attack from tools of ice-rinks from coast, bombardment of ice from planes and throwing on ice from support by special teams of dining rooms of packages – ice in a number of places of the bridge pressed on support and destroyed 15 intermediate flights which majority of flying structures fell in the sea.

After "ice" accident of the bridge some time the question about its further to destiny was discussed. The government commission recommended to sort the temporary bridge, to

design and build the new. Such options of the bridge – in high level and in low with adjustable flight – were designed in 1945–1946 by Transmostproyekt. On the design course on a place, near the Caucasian coast where strong soil deeply lay, built a skilled caisson. Bridge cost in high option was defined about 2 billion rubles (in the prices operating till 31.12.1949). When the project finished in options reported on Stalin, the last argument of the deputy minister of transport I.D. Gotseridze was: “It, t. Stalin, will be “tsar bridge”, on what that answered: “We overthrew the tsar in 1917” (Transport construction. – 1991. – № 6. – P. 33). On it the idea of the constant bridge crossing through the Strait of Kerch quitted the stage.

Still attempts of construction of the constant bridge through the Strait of Kerch are known. Under the leadership of the famous engineer bridge builder Boris Konstantinov, the author of Krymsky Bridge in Moscow, in the late forties – the beginning of the 1950th design of the bridge through the Strait of Kerch was conducted. Groups of builders were already created, from both sides of the passage the construction organizations which were in time to construct the first bull – one of tens intermediate support settled down. But the question of construction was taken out on the Politburo. After the report of the author of the project Stalin asked, will cost how many construction of the bridge and in what construction of a ferry which project was submitted as alternative option will manage. Of course, the cost of a crossing was considerably smaller, and Stalin chose this option. The crossing which works and still, became operational in 1953, and the powerful first bull of not built bridge still sticks out in water near the Crimean coast.

The following attempt was made in the mid-seventies by, it was connected with aspiration of fishermen to improve ecology of the Sea of Azov. It is known that Azov before war gave 30% of all-Union production of valuable fish and caviar. However after reduction almost for 40% of receipt to Azov of fresh waters of Don and Kuban because of introduction of Volga-Don Canal and the Kuban reservoir of a condition for fish breeding in Azov considerably worsened. Water in it became much more solony, and the Azov fish who didn't get used to it simply was lost. It was decided that to construct something in the passage without destiny of the Sea of Azov – this crime.

By request “Azcherryby” Gidroproyekt design institute of S.Ya. Zhuk executed the first stage of project works of the Kerch water-engineering system which limited access of salty

Black Sea water to Azov. The project was agreed with the Crimean regional executive committee and with the government Ukrainian the Soviet Socialist Republic. However the last word, as always, was beyond Moscow. The project was studied in the government and in the State Planning Committee of the USSR, its settlement cost made 480 million rubles. However in parallel the same expensive project of a protective dike of Leningrad which was defended actively by the member of the Politburo V. Romanov came to the State Planning Committee.

The project of the Kerch water-engineering system sustained all examinations, but two such constructions at the same time the country wasn't able to afford. In the Politburo of CPSU it was preferred as the Leningrad dam. The project of the Kerch water-engineering system was postponed “temporarily”.

Remembered the project of the bridge in 1993 when the Crimea appeared as a part of Ukraine. In 2000–2002 the project of tunnel transition through the Strait of Kerch (like a tunnel near English Channel) offered by the CEO of ESPOO scientific and production firm (“Operation and Building of Underground Objects”) Doctor of Engineering Nikolay Glukhov was actively discussed. According to this scheme this tunnel could become an important link of the Great silk way from China to Europe.

At the end of 2013, during visit of the president of Ukraine Yanukovich to Moscow, an issue of construction of the bridge it was finally agreed in a package with the major strategic decisions on providing financial aid to Ukraine. January 30, 2014. The Cabinet of Ministers of Ukraine declared that construction of the “Euroasian” crossing will begin in 2016. However all these plans weren't fated to come true. The Ukrainian Maidan of February, 2014 led to opposition of the Crimea, Donetsk, Lugansk with the new Kiev power which made revolution. On March 18, 2014 thanks to the historical solution of the people of the Crimea the peninsula returned to structure of the Russian Federation. And already on March 19, 2014 the President of Russia V.V. Putin set the task to build Kerchensky Bridge in automobile and railway options for the ministry of transport.

**Thus**, in days of the Great Patriotic War there was an urgent need of construction of Kerchensky Bridge and this project was realized in 1943–1945, but in a peace time managed a ferry. Today, when the Crimea reunited with Russia and journey through the territory of Ukraine became remote, again there was actual a question of construction of modern Kerchensky Bridge.

## LATIN GRAPHIC AND PROBLEMS OF SCIENTIFIC-TECHNICAL TERMS

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Latin inscription (graphics) communication have a priority of the modern worldcommunication. Modern technologies are based on this graphics. This is only one aspect of the problem, it is, i.e., the transition to the Latin script importance in the context of national goals and interests. Area of our country, political, economic, etc. from personal identity and independence, but did not have access to the full range of spiritual independence still. The main reason for our graphics is based on the Russian alphabet. Because of the Kazakh alphabet that has permeated many of the elements of the Russian language. They are lucky to Kazakh language of the twentieth century, many thousands of years, there are still not change the nature of the natural peace and create a change in the national consciousness, national knowledge and understanding of the national tradition, influenced the formation of the national mentality and religion in a different direction. This article is about the formation of the Kazakh language scientific and technical terms. Kazakh language audio feature of the modern Kazakh without spelling analyzes in detail the problem of Kazakh terminology. Kazakh eliminating does not belong to the language of sounds and sound combinations, as well as the Rules of orthographic adjust the legitimacy of the Kazakh language by the elimination of these difficulties will be emphasized.

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**Keywords:** graphics, Latin, spelling, vocabulary about the spelling of foreign

Any terms that play a great role in the development of the field of science known. But still did not find the right solutions to the problem of the term, did not get the full sequence of medicine can not be considered a branch of science. There are many reasons for this. Among them, the most important thing is that the structure of their sound. The structure of the foundation of his sound in any language. To the sound structure of language no differentiation, no quotation, in which the formation of the term, the development of science and huge damages. Unwanted in the walls and roof of the house to the foundation never missing vision is upright. And now the question is what prevents the formation of the Kazakh language terms before moving Kazakh (Turkish) Let's make history writing a few reviews.

Attracted the attention of scientists for the first time in the second half of the XVIII century Orkhon-Yenisey inscriptions key could not be found for a long time. Scientists considers that some of the old Celtic legend, now considered some of the old Gothic writing, even if it was to consider the Finnish legend. "What's left to analyze their key scientist in Denmark V.Thomsen accounted for. He is the first expression of the characters in the monuments of the second characters, and features that do not want to. After V. Thomsen written record referred to in connection with their use of the vowel in the thick and thin noted that there are two different features. Because, in common with the Turkic languages are thoroughly convinced that it is necessary to know the specifics of the law" [1, 21]. Scientist sounds characteristic of the Turkic language dialogue with

each other due to the correct interpretation of the law could read the monument. Turkic languages words evenly and uniformly thick or thin spelling, connected to the vowel harmony with each other. Writers harmony with each other, especially connected with the Kazakh language and stored in the system. If that is the end of the word strictly consonant more strict starts with a consonant, the end of the speech and voice, tone or rough ends with a consonant, in the rough or Indian starts with a consonant. This is not strictly about the rule of law in most of the Turkic peoples. For example, Uzbek or Uighur, Tatar languages at the same time to the voiceless consonant words will connect the sonorant consonants (for example: *ам-лар, ум-лар*, etc.). The reason is the father of knowledge of the Kazakh language A.Baitursynuly can be explained by the following words: "in the absence of writing, the only one who law of nature. Other raped by nature, spell dawn, language ruined" [2, 248].

VIII century Muslim religion spread Kazakh steppe with Arabic writing. Leather Arab origin, religion mullah taught in madrassas and mosques in order to disseminate. Most educational institutions in the Turkic peoples settled, semi-settled Uzbek, Tatar, Nogai, Bashkir, such as peoples. And the spread between the Kazakh Muslim religion is primarily oral. Of course, open the mullah school children in rural areas to teach and opened their literacy, the mass of the population was literate and writing was not in urgent need for the guy. Therefore, included in the spoken language as a result of science, literature, and culture of the Arabic words to obey the laws of the Kazakh language sound

changes. As a result, they each made plans to hear that some version of the above. In fact a lot of different access most of the words, that to the extent that it has a personal meaning to each. For example, only one Arab “хукуматун” [3, 136] the word “үкімет”,

“өкімет” made of two words, one of “the state, the state building”, one of the “means” the executive body of state power in the country are being applied. Other language the word can not be the people who can not. But they say the same words are turning to language difficulty. Say their legislation to make feel their languages. Strange to say the words do not create a special sound-case letters. It is used in all the languages of the world, one of the ways to the development of the vocabulary of the language.

The youngest of writing it was kept clean the rest of the Kazakh language as a result of these qualities be lost in the course of it into the language of the target was one of the people A. Baytursynuly. Company, for the development of science understands the importance of a great scholar writing in 1912 on the basis of the Arabic Kazakh alphabet. Arabic script, including defining characteristic of Kazakh language sounds the letters in the spelling of the Kazakh A. Baytursynov formative. In 1913, “Shora” magazine “Kazakh writers” the correct spelling of the game in the article said: “Correct spelling error spell I think he may be deprived me org: tailor language, depending on the nature of the spell? No, tailor the language depending on the type of spell? I do not think, spell – to write something, write something for the language. So do not suit the language, breaking the spell, spell should tailor language. Regardless of the nature of the language, agreed bandaged raped spell, it will be unintelligibly” [2, 247]. Unfortunately the purity of the national language of the Soviet Union, the specificity of the Keeper “conservative routine, nationalists” slandering innocent punished. Finally, in order to A. Baytursynuly alphabet, first in Latin, then moved to the Cyrillic alphabet, “a variety of recording, the elimination of promiscuity” on the grounds that, “Russian language, Russian as the language with English words into Russian with punishment, say” to rule out. It is a little further bottom, Latin, Greek, English, French, and that is the word, but the legislation of the Russian language audio sounds of the words “international terms”, he said, are not translated in terms of the international” invented to rule again. The sound system of the language laws to protect it under the influence of other languages “immunity” effect of the loss of immunity that language would be easy, russianize

a thorough knowledge of the fraud aimed at politicians. Poisoned our minds, in violation of the legality of the language sound script give specific examples to show the imperfections. For example, in our day-to-day use often “test” take the word. Russian language “test” cited in the Kazakh language, some “testing”, others “testing” is written. Kazakh language at the end of a word or phrase at the beginning of the two does not sound hard, but the end of such a combination of sound words appearing in that nouns, verbs (respectively, -la, -le, at the Emirates) suffix can not connect. Kazakh language “friend – дос”, “true-pac” in the words of Persian origin “Friend – дос” and “confirmed – pact” that a lot of people may not know. Not subject to the laws of the language audio sound would have fallen, it became Kazakh According to his own words. Similarly, the “test” to conquer the legality of the Kazakh language “tes – тес” Let’s get this problem would not have arisen, “testeu – тестей – testen”, “the results of the test’s – тестің нәтижелері”, “responsible teacher to the test – теске жауапты оқытушы” would apply. Language embedded by forceв, ф, ц, ч, и, я, ю sound-letters are in the Kazakh language, such as бр, нх, ст, нк, кл, қр, нм, кс, нт, нк there are numerous combinations of sound. In the end or the beginning of the sound is a combination of words such Kazakh language (Turkic languages) or in the middle of the front or back, or will be connected to the voice sounds. One example of such sound effects on epenthese professor K. Akhanov writes: “Two sounds between auxiliary audio sound epenthese phenomenon is called integration. For example, words meters, liters Kazakh will be метір, лумір. Tractors, tram of the words (тырақтыр-tiraktur), tramvay (tirambay) – тырактор (тырақтыр), can serve as an example to refer to the Russian language the word “bed” Uzbeks (карават – karavat) and is pronounced Kazakh (кереует) script combination (кр – kr) is a vowel between” [4, 364–365]. As well as a work of prostheses (two consonant with a vowel at the beginning of the word spellings for example, стакан – ыстақан, шкаф – ышқан), epenthese (to speak with a vowel at the end of the end of the two-consonant words (for example, kiosks, stalls, tanks-tank) as well as phenomena [4, 365]. And now the same medical terms of sound the combination Kazakh Consider how sounded. Kazakh language dentistry, stomatitis, bronchial, words such as thrombosis ыстаматолгоия, ыстоматит, быронхы, тырамбоз. How the rule was enforced addition, she will not comply with the law and



the language of our writing alphabet (orthography) will include the access on the legality of the Kazakh language sounds of words.

Kazakh language is classified as a voice sounds thick and thin, and can be influenced by a vowel consonant sounds completely. For example, the word sounds on both sides of **a** thick sound consonants **b** and **c** is expressed as a thick not labialized, *ḡac* is a thin not labialized the word sounds, the sense of the word *ḡoc* and thick lips, speak the word *ḡec* thin lips. After the thick of the Kazakh language voice can not be subtle vowel pronunciation. Vowel and the Russian language can change the meaning of words to speak as thick or thin, and therefore change the meaning of words in Russian is called a phoneme sounds. As for the Kazakh language, the meaning of the word is pronounced as thick or thin as disabled. Taking into account the specifics of the Kazakh language professor A. Zhunisbek: "Kazakh language (Turkic languages) Indo-European languages, there is no specific phoneme. So that there is no language-specific allofon. Because the Indo-European languages with accents (accent) and Kazakh languages (Turkish) Harmony (synharmonic) language. Turkic (Kazakh) up to the analysis of the languages of the Indo-European languages in the footsteps of previous linguistics Euro-lovers (eurocentric) position is the priority" [5, 45–46], I want to say, and Harmony (synharmonic) languages sinegma to use the term and allosingemabelieves that it should be [5, 47]. An entire generation of the Kazakh language can be thick or thin, thick voice can not be in a thin voice. "Kazakh language descriptor": "The thicker mark the end of the multi-syllable words leave Kazakh language level dialogue is false, that is the last word on the link in the thick thick, thin voice is the sound of the latest generation, thin false: *ла-герь + ге, ла-гер + и, банде-роль + га, фести-валь + га*", as a rule [5, 32]. But this will be connected to the possessive suffixes are thin and in such case, the thicker sign warns [5, 32]. "Such a supersonic, the following additional false, but said the following after the sound false" to write as many notes on our rule disadvantage is that there are a lot of events. The main reason stated above, if a lot of sound is not typical of Kazakh language combinations. For example, "lateral", "Vertical" Kazakh partial to the "lateral", "vertical" is connected to the thin end of the same sound as "Horizontal" word more "horizontal" is connected to the thick

[6, 22]. According to the above provisions, it must be connected to additional bold words. There are many such examples.

If there is not language-specific sounds of the alphabet, not in the non-language-specific sound combinations, i.e., there is no problem and no additional connection such things. In terms of science and education in developed countries and is spreading to other countries, and they in turn will be able to fit it into its own terms. Kazakh intellectuals this issue back in Orenburg in 1924, "Kazakh first Congress experts as" wholesale. Congress words, the term "subject words" E. Omaruly the report said: "The course could not find the word in their language every day, you can get the words used Europe Latin thing. But these words are, it should be changed to the language law. After all, the word document, without prejudice to the bottom of the precious predicted: This is the word of the Kazakh language that does not; The new word is not the law of the Kazakh language, Kazakh suffix, you can not change the endings. Such can not be absorbed by the word of his speech, the Kazakh language, Kazakh, one word remains to be politically incorrect. A foreign word into the Kazakh language originality do not have to be the Kazakh word meaning clear, easy to say, at the ear must not be politically incorrect. This is not a contract can not be the Kazakh word for word, not only is the word book. Book language if the language is not otherwise will not benefit book country", the foreign language word making the best ways [7, 97]. Of course, his views E. Omaruly and A. Baytursynuly "Language is the tool" made on the basis of the textbook. Kazakh legend, the term considerations A. Baytursynuly problem in Baku in 1926, "the first Turkic Congress" to develop further in his report. Speaking of which many of the tactics of the term, science-education focused on the question of the term of the developed European languages. European languages derived from the terms must comply with the laws of the Kazakh language, however, he showed the following principles: "All non-Kazakh words that do not agree with the nature of the Kazakh language, just have to be changed accordingly Kazakh speak. This means, first, that all non-Kazakh words with alien Kazakh language sounds are replaced by the last right sound, and secondly, suffixes non kazakh words are replaced Kazakh, thirdly, double sounds are made in the ordinary form, fourth alien language Kazakh end must change within the desired language ease of pronunciation" [2, 282–283].



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Of course, every year there is no dispute that it improved the quality of spelling dictionaries. However, the Kazakh writing, especially writing words borrowed failure to comply with the law of harmony, breaking the sound of the word Kazakh speaking, write to the many problems can not deny that the price of housing.

So, in other words in the language to conquer the legitimacy of the Kazakh language – is one of the most productive ways to make the term. But based on the laws of the Russian language subscription, you are Kazakh language audio-humor-filled letters in our alphabet and

is not in harmony with the nature of the Kazakh word spellings hindered. Incompatible with the nature of the language of sounds and can be avoided by replacing the alphabetical index to Rules not only limited to the replacement dwelling. But the term has not dealt with the issue of self-selection. Its kind of approach (combining words with different suffixes, Double) could not convey the ability to use language that does not mean that the internal approach is used, and only in this way is the future of Kazakh language clean so that you can let a hostage.

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## RELIGIOUS TOLERANCE

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The article proves the importance and relevance of the study of "tolerance". We give an attempt to uncover the term "tolerance" itself and demonstrate the ability to talk about a fundamentally different cultural condition of the possibility of tolerant consciousness and, consequently, the existence of its various forms.

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**Keywords:** tolerance, religious tolerance, the Buddhist concept of tolerance, the Christian concept of tolerance, the Islamic concept of tolerance

In some ways, the relevant question today is a tolerant attitude to the opposite, a different outlook principles, then clearly the activity of mutual social, political and cultural, religious intransigence various associations. The basis of such intransigence often proclaimed not only the ethnic problems, but also confessional differences. The study and analysis of such problems with modern times is important.

In these circumstances, there is a need to develop new areas of technologies that contribute to the formation of cultural and civilizational contacts, and interfaith dialogue.

Various aspects of the phenomenon of tolerance were considered by foreign researchers: Claude Levi-Strauss, C. Evers, B. Williams, G. Bastide, G.J. Dal-kaurta, P. Garsneya, G. Olporta, T. Aderno, K. Lorentsa, J. Kelly, M. Uoltsera, BE Reardon, P. Markuze, L.J. Skitka, C.W. Bauman, E. Mullena, P. Nicholsona, Y.Ch. Zarka, I.M. Lebedeva, T.G. Stefanenko, A.N. Tatarko, M.P. Mchedlova etc.

In Kazakhstan, the role of religion and faith in the preservation of stability and peace in the unity of the people of Kazakhstan was mentioned by Nursultan Nazarbayev. Kazakh thinkers R.S. Amrenova, B.A. Akhmetov, G.O. Nasimova contributed to the linguistic analysis of the meaning of "tolerance", as well as the culture of peace concept were developed by B.G. Nurzhanov and T.H. Gabitov, M. Sabit, N. Ayupov, G. Yessim, J. Moldabekov, T. Burbaevym, J. Altaeva, A. Balgymbayev, D. Raev, A. Mirzabekova, S. Kenjebayeva, A. Nysanbayeva, S. Kolchigin, E. Drilling, R. Kadyrzhanova etc. But not sufficiently studied is religious tolerance.

The aim of this study is to demonstrate the ability to talk about a fundamentally different cultural condition of the possibility of tolerant consciousness and, consequently, the existence of its various forms, the disclosure of social and philosophical foundations of tolerance in terms of the spiritual, ethical structure.

The concept of "religious tolerance" was studied for over the years, it has come a long

historical path of development. For the first time this term is used in the legislation of the Roman emperor Constantine, who first proclaimed Christianity as the state ideology and vetoed the oppression and the oppression of Christians in the territory of the empire.

The subsequent development of the term occurred only in the XVIII–XX centuries, when it was disbelieved by many people around the globe, that no civilization, no state, no society and no culture is able to fully progress without basic rights: every citizen has the absolute right to religious freedom and to meet their spiritual needs. "The Universal Declaration of Human Rights" (1948), adopted by the UN General Assembly on this evidence, which established the principle of freedom of religion: "Everyone has the right to freedom of thought, conscience and religion; this right includes freedom to change his religion or belief and freedom to manifest his religion or belief, either alone or in community with others and in public or private, in teaching, practice, worship, practice and observance" (Article 18).

Concept of "religious tolerance" term develops in its teachings and religions of the world. These concepts and exercises no hint of exclusivity of one nation in the choice of religion. For example, if we consider one of the world's religions, Buddhism, we can say with certainty about its nonethnicity, since it is composed of all, regardless of any ethnic, linguistic or cultural group they belong to. The doctrine of the Buddha is universal, is close to any person seeking spirituality regardless of ethnic society. This is evidenced by the position of his teachings. Buddhism does not see his own doctrine as the only valid.

Rather, Buddhist practice cultivates personal tolerance. One of its claims to "individual tolerance" practical principles is "the transformation of thinking", "education of the mind". The main purpose and objective of this practice appears bodhisattva's gradual generation of an entity is within the reach of ordinary consciousness as a result of the modification

of regulation: “the awareness that every living creature in the endless chain of previous incarnations ever had your mother, so to every creature should be treated as a mother. It is the basis by which is possible to generate feelings of love and compassion; replacing itself (as an object of care) others, i.e., realization of installations to take care of others more than about himself; the realization of equality of self and others, the fact that all living beings desire happiness and do not want suffering as I” [2].

This practice is an effective means of internalization (the transition from outside to inside) tolerant plants Buddhist teachings [3]. About tolerance, understanding the formation, strengthening intellectual property, limiting personal echoes of the negative thoughts and emotions are reflected in the words of the Dalai Lama: “Religion carries a huge potential benefit for all mankind; it can play an important role in encouraging people to cultivate a sense of responsibility for others” [4]. The Buddhist concept of compassion is the concept of tolerance. Multiple Buddhist canons preach love of humanity, generosity, kindness and other ethical ideals.

The basis of tolerance in the teachings of the early Christian apologists was the concept of the Logos (Word of God) that exists in three major forms: embodied, said seeds. Since the seed logo have the mind of man, and the incarnate Logos (Word of God) is the Christ, the Christian cult and true theology [5].

Christ gives the commandment to love and calls for perfection, to perfection in love. “Christian, as his spiritual perfection, should be exempt from the direct opposition of “I” and not “I”, to get a feeling or consciousness of inside unity” [6].

The essence of the teachings of Christianity is expressed in the unity of mutual love of believers – “that the love wherewith thou hast loved me may be in them, and I in them” (John 17, 26.). It is this love, reaching to the full communion of life and readiness donations it (15, 13), and there is the commandment, the execution of which is caused by our union with Christ (15, 9-15), “- says Metropolitan Anthony [6, p. 17].

The ideological foundations of tolerance in Islam derived from the Qur'an and Sunnah.

Sura 2, verse 265: There is no compulsion in religion, Sura 16: 125: Wanted path to Allah with wisdom and good exhortation. Sura 41: 34 Dejan good from evil cannot be compared.

Pay to evilby goodness – and the one who was your enemy will become your warm friend [6] presented verses and their content shows tolerant attitude of Islam to the other members of the religion, and the unbelievers, they contain an appeal of goodness, justice, compassion for all mankind.

Islam in itself carries higher, spiritual, moral values of peace, good neighborliness. The Qur'an contains the idea of instilling the principles of the Muslim world, goodness, justice, and morality. The believer can experience the fullness of life, happiness, satisfaction only if the belief it was received without violence. One of the basic human rights of preaching and proclaiming Islam is freedom of religion. The verses of the Qur'an are the prohibition of any controversy bearing rudeness, contempt, irreverence to his companion: “Invite to the way of the Lord irrefutable arguments from the Qur'an and good admonition, and strive against them with the dispute soft and well” (sura “An-Nahl”, verse 125).

Even the heathen Muslims patronized and protected. The Holy Qur'an says: “If someone is out of the Gentiles will come and ask for the protection and patronage of the killers, you be his patron as long as he hears the message of Allah, and if you're not confident escorted to a safe place for him” (Sura “Al-Tavba”, verse 9) [8].

Thus, all the world's religions (Christianity, Islam, and Buddhism) have common values on tolerance, each of these religions state tolerance. The best way of formation of tolerance – a dialogue between different cultures, creature tolerance, including in the field of religion and ethnicity.

Also it can play a vital role to encourage people in the formation of a sense of responsibility, care, attention for others.

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## THE PHILOSOPHICAL ASPECTS OF SECULAR ASCETICISM

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The ideas of secular asceticism are based on the conception of “the world coordinate system on the basis of the extreme dynamical balances”. The last represents natural or cultural formations where all its interactions (power, information, spiritual) counterbalance each other. The formation of “the conjoint substance” can take place being guided by three fundamental limits and represent the fastening within a certain cultural sphere (subsystem) in whole. The questions of the identification and the integration of all cultures can be examined in relation to their asceticism which can become a core ingredient during the initiation of the dialogue between cultures. Such asceticism is able to become the base of the synthetic panhuman culture, so all unique and specific of different people will be already a superstructure over it.

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**Keywords:** world coordinate system, extreme dynamical balance, balance-web, conjoint substance, cultural asceticism, identification, integration, dialogue, synthetic, the basement of panhuman culture

The ideas of secular asceticism are based on the conception of “the world coordinate system on the basis of the extreme dynamical balances”. This concept is developed by the authors and the main idea of developing our approach is formulated in the following way. The world around us is viewed as consisting of two unequal parts. On the one hand chains and structures of interrelated limit dynamic equilibriums in the formations at various levels of organization of the world are the same. On the other hand it is the rest of the world, covering nonequilibrium processes and phenomena [4, p. 702]. The main idea of the natural coordinate system of the world is that all the natural and cultural formations and their structures can be connected to the ultimate fundamental equilibriums of three types. These limits are mapped to the coordinate axis, which are associated with the fundamental limits [Ibid].

All natural and cultural formations strive to the three types of ultimate fundamental equilibriums.

1. Any natural formation from the spheres of non-living, living, spiritual (elementary particles, molecules, gaseous nebulae, living organisms, individuals, personalities) tend to self-identification – *I-limit*.

2. All these formations strive to communication-network limit – *S-limit*, that is, they tend toward completeness and a stable equilibrium with environment. An individual is defined by their communications; cultures exist through dialogues within and outside themselves.

3. The existence of all natural and cultural formations is limited to the full time of their existence – *F-limit*, which can be determined only from the point of view of the neighbouring structural levels and unattainable from within these formations. The overwhelming majority of these limits remain unattainable,

due to opposite tendencies; therefore natural formations reach only some intermediate dynamical equilibriums. Any natural and cultural formation can be arbitrarily connected to these limits by the three coordinate axes.

The coordinate system is based on the equilibriums of dynamical chaos, created by specific natural or cultural formations, through that part of the energy that can be balanced. The result is a cell of dynamic equilibrium (“cell interconnection”) the system of coordinates and this formations simultaneously. The coordinate system has no location or any spatial-temporal constraints; it exists in every part of the world, at all levels of its organization. The coordinate system interacts only with open natural or cultural formations, with a tendency towards self-development or dialogue.

Intermediate dynamic equilibrium, in which the fixed nature of formation have not met their self-organization identification and systematic communication of limits will remain stable only if they will be in the “calibration” (space-time) nodes, which are separated from each other by intervals corresponding to the frequency oscillations of these fundamental limits. They can be considered fundamental rhythms of the world. Calibration originating from full-time existence of natural and cultural formation reveals optimality and stability of these “steps” and rhythms. The combination of all three types of “steps” and rhythms that conform to these limits, build sustainable natural formations, and these “steps” and rhythms define the parameters of the spatial-temporal cells coordinate system on the basis of “deterministic chaos” [9, p. 77]. In their development, these “steps”, rhythms and cells are sent coordinate system and can exist in the world, millions and billions of years, as for example, galaxies, planetary systems, the atmosphere,



the hydrosphere of the Earth, philosophical and religious concepts. In case of deviation from these rhythms are all natural or cultural formations destroyed.

Calibration of the above-mentioned limits means that they can be used as the basis of scales, and the units for these scales are obtained by multiplying the values of these bases on the corresponding coefficients. The cell is made up of these fundamental limits will be the largest of all. The corresponding coefficients for these limits (identification, systematic communication, full-time existence of natural or cultural formation) let  $k_1, k_2, k_3$ . Then units scale respectively will be  $k_1 I, k_2 S, k_3 F$ . The cell formed by the fundamental limits can be defined as the  $ISF$ , and large-scale cell at a certain stage of development of natural or cultural formations as " $k_1 I k_2 S k_3 F$ ". These cells are unusually stable. They have a minimum of energy, information, spirituality, and other similar settings, and their main characteristic is becoming "connected substance" and its specific values connected energy, information, spirituality.

#### The Foundation of approaches

Besides the coordinate system on the basis of the extreme dynamical equilibriums, the conception of "emptiness", the web-balances and also the notion of "conjoint substance" can refer to the ideas underlying the secular asceticism. These notions and conceptions have been rather carefully analyzed in Taoism, Buddhism, Zen Buddhism and Christianity. "The Path" – "pada" is the main notion in Buddhism, in Taoism this is the notion of "the Central Path" – "tao". They are accessible from any place and time and represent the harmony or the connection with the beginning of the world coordinate system, its original state. When the nature, the society or a human finds this path, they find their harmony of development, stability and the optimality of their existence, as they have interrelation with all limits of fundamental balances mentioned before.

"The emptiness" is one of the central notions of Taoism. "Tao is empty but thank to it everything exists and doesn't overfill" [10, p. 13]. "Thirty spokes in the wheel converge to hub, which middle is empty, thank to it it's possible to use the wheel. When the loam is being potted to make the vessel, it's done so that the middle is empty, thank to it's possible to use the vessel. When the house is being built, the holes for windows and doors are made, the middle is left empty, thank to it, it's possible to use the house. That's why the filling it's what brings a return, the devastation it's what does

well" [Ibid, p. 23]. The ascetics' experience, which matters a lot almost in all religions, also proves the fundamental meaning of "the emptiness" as the guide of the cancellation of interactions with three limits mentioned above. In Christianity a special emphasis is laid on the poverty of spirit.

This contradiction may be solved through the development of the notions about the types of balances, which ideas were elaborated in the XX century. Web-balances represent the next stage of development of dynamical equilibriums which are present in all spheres of nature, society, human. All nature and cultural systems tend to them. Such equilibriums are studied in the thermodynamics of information processes, the synergetic, the tectology and in other sciences. "The balance-web" is the most spread among web-balances; it is formed on the basis of chaotic processes (exchange processes of different kinds) during the formation of the planetary cultural webs. The balance-web needs the multiple layers, deepness and the entwinement of the culture, as the interactions web itself is more important than their sources, so the main resources of information, spirituality are contained in the web of interactions itself forming this balance.

The balance-web provides mutual complementarity of the difficulty and simplicity, of the natural and human sciences, in spite the fact that natural science interacts with one range of the extreme culture foundation, and human sciences do it with the other range, and the conceptual frameworks of the organization of these schemes are different. The balance-web encourages the revelation of stable correlation relations between these ranges and extreme culture foundations. The conception of universal planetary being and its formation can be realized by means of such mutual complementary relations.

"The conjoint substance" represents natural or cultural formation where all its interactions (power, information, spiritual) counter-balance each other. So this element, covering all existent interactions of natural education with its environment, characterizes the entirety of these interactions, and as a result it also characterizes the connection of this formation with the fundamental balance. The conjoint substance (power, information, spirituality) is the main characteristics of the construction of extreme relational equilibriums, providing their existence and being the main internal characteristics of this construction. "The conjoint substance" hasn't been examined or studied in Philosophy, although the examples



of the use of conjoint power or information as a constitutive parameter in number of sciences provided the formation of the top-to-bottom view in many examined natural processes.

### Features of secular asceticism

“All religions suppose anyway ascetical practice as a mean of spiritual and moral purification and also of transformation of daily activities...As a moral principle the asceticism requires ascesis, abstention from the sensual pleasures and strengthening of the will for perfect duty performance. A human should turn away from carnal in his mind and attain the self-control in the ascetical effort – restraint from food, drinking, carnal infatuations, negotiation of the weaknesses (e.g. voluptuousness), control of physical state and of the state of mind. A pray is an important mean if the asceticism” [2, p. 188]. In the religious asceticism the body resources help during the process of human’s spiritual perfection, his ascension to the God, the rupture to Him. “The ascetics represented a special class of more faithful people than the other ordinary people at the First Church” [3, p. 35].

Cultural and secular variety of asceticism can lay upon religious experience in its development, but there are some considerable differences. The cynicism elaborated the approaches focused on the ideals of the asceticism during the antiquity. “All kinds of physical or spiritual poverty were more preferable than the richness for cynics: it’s better to be a barbarian than an Hellen, it’s better to be an animal than a human. The life simplification was completed with intellectual simplification” [1, p. 245]. The notion of “epoché” is not less significant for the development of ideas of cultural and secular asceticism. “It goes up to the antique skepticism and it was revived by E. Husserl in the XX century. He defined it as a complex of preparative procedure-phenomenal methods which function is “sidelining” or withholding, or “parenthesizing” or “suspending” of “naive and realistic” assumptions of science and philosophy about the world, the human, and his conscious... “Parenthesizing” itself has got only methodic nature: it’s only a thought, only methodic “counteraction modification” which doesn’t concern the state of the facts in the world itself” [7, p. 452].

In Modern age the ideas of asceticism were scarified, especially in the works of P. Holbach and F. Nietzsche. P. Holbach wrote that, the ascetics “consider in their delirious the hate, self contempt, voluntary slavery, melancholy, indolence and self-torture – in short,

continuous insult of their nature which does real good neither to them, nor for society – to be a virtue”. Moreover “according to Baron d’ Holbach, raising the suffering to religious cult was the absolute evidence that the religion prescribes the human “to refuse everything that can make him happy”, as the real morality “tells the human to work for real happiness” [5, p. 267–268]. F. Nietzsche considered that the asceticism contradicted the human’s aspiration to health, beauty perfection and taste. The ascetical ideal rises from protecting and treating instinct of degenerating life falling over itself to resist and fighting for its existence; he points at a partial physiological detention (of some functions) and the fatigue with which the deepest remained untouched life instincts fight... the ascetical ideal is a trick for saving a life” [8, p. 165].

The cultural and secular asceticism represents the combined state of individuals’ intelligence and intellectual activities within the context of their ethnic differences. The protestant ethic of M. Weber correlates with it. His ethic avoid superfluity and to lead austere life. According to the authors, the estimations of the asceticism within the context of sociology, political science or religion science issue from the fact that they are beyond the current research. Dogmatic ideology widely used by all theorists of collectivism was elaborated on the ground of the asceticism. It’s possible to study pros and cons of the asceticism, but it’s not interesting for us as a system of axes, relatively to which different cultural and social processes take place.

The formation of “conjoint substance” can take place being guided by three fundamental limits and represent the fastening within a certain cultural sphere (subsystem) in whole. In some cases it’s enough to lean on two of these limits. Orientation to “identification limit” allows distinguishing a core of definite kind of cultural activity or such several cores. Art styles can be considered as such cores in Art as for literature they can be chronotopes. In modern culture the stress is laid on memes which can also be considered as such cores. In many cases polysemy takes place in the designation of such cores, and their interaction with each other.

The aspiration to the system and communication limit supposes the formation of stable and optimal system covering the cores within an activity or the whole cultural sphere. If a separate core is often distinguished with some ambiguity, then the complex of these cores forms stable structures within the system.

In culture and its main subsystems the core systems are used in the first place. Cultural code uniting the cores of all main kinds of activities of examined culture is the brightest example.

The conjoint substance can appear as coherent information, coherent spirituality, coherent intellect. These are dead simple constructions, where all phenomena correspond to fundamental zero balances connected in a single whole. The process providing bigger and bigger simplification in comparison with spontaneous structures corresponds to them. Coherent spirituality and intellect have got the essential meaning for the provision of coherence during the formation.

There are some bright examples of conjoint substances in culture, arts, linguistics and in other sciences. In cultural sciences the conjoint substance can be considered as “zero cultural code”, which should be understood as culture elements which absence can result in the distortion of the whole culture. There are some examples of the most simple style in art, for example the paintings “Red square”, “Black square”, “White square” by K.S. Malevich, about which the author himself gave a comment “Suprematic three squares are the establishment of a definite world view... black as a sign of the economy, red as a revolution signal and white as a pure action” [6, p. 187–188]. The atomic propositions of L. Wittgenstein and his “Logic-Philosophical Tractates” should be mentioned in linguistics and its philosophical understanding. There is nothing superfluous in this tractate, only the necessary for the expression of main ideas, so this approach can be also used to prove the ideas developed by us.

#### **Features of secular asceticism**

In modern global world there are two main tendencies to which the majority of cultures is subject. From one hand everyone aspires to self-identification, in other words to distinct determination of own borders, typical features and to maximum transparence for there presentatives of other cultures. The problem is that many cultures still haven't established yet, they stayed somewhere on the half-way of their development. From the other hand they have to contribute to the integration of the humankind. So nowadays the weakening of economical, political and state borders combines with much bigger cultural isolation (cultural diversification).

Moreover, in recent times, the culture relevant to modern human needs tends to become network and traditional cultures can be a part of it as some elements. Cultural nets

should be formed on the ground of systems and subsystems made of these elements. The diversity is the cornerstone of sustainability in the nature, human and social spheres aren't exceptions. The tighter and the more active the cultures will be connected with each other, the better for humankind. Of course, they all should be tolerating, humanity-oriented and unique. Every modern human should interact actively with several cultures, contributing to their closing in united energetic and information cycle.

The questions, mentioned above, connected with the identification and integration of all cultures can be examined from the point of view of their own asceticism, which can become a key-element during the formation of the dialogue between cultures. What's more, the asceticism as a localized state of the spirituality within its ethnic and individual demonstration can become a base of synthetic panhuman culture, so everything unique and specific of different nations will be already a superstructure above it.

In the frame of developed approach, all cultures in modern conditions should tend to the state of stable synchronic and diachronic fluctuations. In the first case (named for our purpose horizontal) it happens between the cores of self-identification of traditional cultures and forming invariants of panhuman culture. In the second case (named for our purpose vertical) it happens between two best examples of the world cultural heritage and corresponding milestones of information society. As a result, there is a two-dimensional dynamic balance within the interaction of traditional cultures with economical, financial, technological, informational subsystems of modern world is possible. It's so much important, that over whelming number of culture in the human history were traditional and two great “mutations” which formed antique and Christian cultures took place among them. In all interactions mentioned above it's possible to distinguish extreme dynamic balances and to connect them thereby with natural system of axes on all levels of the formation of cultural super-system. Every nation is able to make its own unique contribution to the formation of natural system of axes and the more contribution they make, the more stable this system will be. At that, the ascetic parts of traditional cultures will be formed as their invariants, determining the web of the main worldview universals able to provide further possible human development. Nowadays, there is no alternative to such development.

If all cultures will tend to the identification of their own asceticism, the formation of intercultural dialogue will happen due to universal rules, contributing to the establishment of the world communicative reality changing gradually into the world being. The revelation of the rules mentioned above considerably depends on new educational approaches.

Firstly, the education should expose the particularities of two kinds of asceticism: self-identification asceticism and web asceticism. During the personality formation it necessary to choose carefully everything that will be part of the “self-identification structure”, where from the one hand there shouldn’t be anything superfluous, but from the other there should be all necessary elements for self-identification. The web-structure also rejects everything superfluous, that hinders its formation in the optimal way, otherwise, it becomes unstable and easy to destroy. The web self-organization aspires to provide their formation with optimum speed of complementary unification of synchronic and diachronic cultural subsystems, in other words, of the elements of national and mass culture, and also of the best samples of world culture and information society.

Secondly, continuous human education on the ground of “the balance-web” should be developed. The main point of this education is the creation of communication web by a human during all his life. This web con-

nects him with other people deeper and more tightly, unites the people of different cultures. This web is focused on the only system of the world axes. It allows to overcome the social isolation in whole through the development of new communication forms, the conservation of these best forms and restores integrity of separate “I” which was disturbed by nonlinearity and unpredictability of the world around us, by too fast rate of its development.

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## SOCIO-PHILOSOPHICAL ANALYSIS OF SELF-ACTUALIZATION PROCESS IN THE CONTEXT OF POST-NONCLASSICAL PARADIGM

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The article is an attempt to socio-philosophical analysis of the phenomenon of self-actualization in terms of the main provisions of postnonclassical paradigm. It is suggested synergistic nature of self-actualization process, the special role of chaos and order. Man is regarded as a dynamic system capable of self-organization and striving to realize their inner potentials through the interaction of its subsystems – individuality and lichnosti. Obe subsystems are responsible for the process of human self-actualization of its development, which is understood as the alternation of order and chaos. As chaos is the set of individual acts of communication activities and that human individuality impact on society through his personality, and it, in turn, affects the personality.

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**Keywords:** self-actualization, postnonclassical paradigm, synergetic, individuality, personality, self-organization

Modern scientific and philosophical understanding of the socio-cultural, economic and biological processes finds its expression in the post non-classical paradigm, which is the result of the synthesis of post-nonclassical science, global studies and post-modern image of reality that is characteristic of the late XX – early XXI centuries.

Postnonclassical science tends to principles of probability, stochastics, polyvariance, instability. It is a kind of “third stage” of the world in the study. In comparison with the “classical” science of Newton-Laplace type “post-nonclassical” renounces rigid linear determination of all processes and the principle of “classical rationality” XVII–XVIII centuries. Understanding the truth as a process of passive reflection characteristics of the object is replaced by “non-classical rationality” Einstein-Bohr postulates the dynamic nature of external reality, dependent on the reference system, the position of the subject and its properties. In the post-nonclassical knowledge of this principle is reinforced ideas of self-organization and self-development in complex systems of various nature – from the biophysical to the socio-economic. Thus, “post-nonclassical” – is qualitatively new, interactive state of human knowledge, specific interdisciplinary methodology which is based on the synergetic foundation “non-linearity”, proposed by I. Prigogine – H. Haken.

A new type of knowledge is different from non-classical science for two main parameters: the object / subject and the type of rationality. On the first post-nonclassical science it differs in that explores not only complexly, but also extremely complex system, open and capable of self-organization. Its object and becomes “human-dimension” natural systems, which are an integral component of a person stands for. In the second param-

eter postnonclassical science differs from the previous in that the object of knowledge correlates not only with the means of knowledge, as it was inherent in the non-classical science, but also with the values and structures of targeted operations [8].

The subject of the study of contemporary globalism is the integrity of the world. Investigating the problems of the human race and the approval of the global civilization, it merges with the creation of the model of development of human society and the prospects for post-industrial world. The images of the future in a globalized concepts remove all the features of modern culture; age, defined as “post-modern”: the connection of rational and irrational way of knowing the truth; the synthesis of Eastern and Western philosophies; the growing integration of the scientific, philosophical, artistic pictures of the world; gradually sharpens interest in the individual consciousness.

This interest is based on the fact that, together with the change of the general scientific and philosophical paradigm there is a need of paradigm shift or a model of human life, its vital and creative and personal growth in the Russian society. Previously, the reference model is characterized by the subject The correlation representations about his life with the ideas of the social group of society with which he identifies himself, no longer corresponds to the changing demands of life and the needs of the subject. The principles underlying the basis of this model, do not meet the new life situations in which a person cannot, as before, to rely on social support and protection when they receive different benefits, but “have to take into account all the” cruel and isolating alienation of the real world” [6, 202]. Now it is impossible to plan and organize their vital functions in



the social space, taking advantage of a familiar, well-established living standards, rules and regulations which are suitable for the regulation of single-line life events.

In this case, more emphasis on self-referential model of life, which gives a person more opportunities for self-creation and self-realization. This means that he relates his ideas about themselves with their real existence, with those events, which constitute his real life. And based on the result The correlation data are updated by a particular potential creates your life. After all, human identity is not permanently installed, it must be created. Therefore, the process of designing their livelihoods strategy that involves long-term stability and long-term consistency of the medium, is gradually replaced by a process of self-creation, self-development.

Self-creation is performed in the process of life by means of symbolically generalized means – ideals, authoritative evidence and expert assessments. In contrast to the group norms, they do not regulate and control human activity, and suggests freedom of subject choice of certain characters that are oriented and positioned its “Me” and give a general idea of the direction and its fulfillment.

However, the changes and the nature of the resources that attracts and employs people in life. Instead of the usual self-representation in the form of benefits and achieve certain success, social status, there is a more complex and multifaceted its definition, taking into account the increasing role of knowledge and information. Indicators of such a definition could be: knowledge of the authority of the news, human culture, the implementation of their intellectual and creative potential, making it possible to become a carrier of effective knowledge that allows you to continue your creation and act as a mediator in the process of self-creation and self-realization of others. To update these indicators need to form a “system attractive and persuasive character” [6, 203], contributing to the process of human self-creation and self-organization.

As already noted, the man is a dynamically developing biopsychosocial system, the highest in the level of self-organization and self-regulation. The same system, but only a psychosocial identity of the person, the idea of nature and that activities in the form of self-organization allows you to use the methodology of non-linearity and social synergy. Synergetics considers the self-organization as a development process, which is a binary opposition of order and chaos, organization and self-organization, integration and differentiation. Their synthesis creates such a thing as a dissipative structure, which

features inherent in the person represented. In contrast to the equilibrium structure, a person, as a dissipative structure can exist only if the constant exchange of energy with the environment, information and product performance. Through this exchange, it maintains its individuality, balances the internal “self” at the expense of strengthening and expanding their livelihoods, variety and diversity of social ties.

Thus, the synthesis of ordered internal organization and the chaotic multitude of individual acts of activity and communication are two aspects to the individual:

- Internal stable organization, “self” of the personality, there is due to the “chaos” of various activities and communication as person contributed to society, and the society contributed to the structure of the individual.

- Due to its integrity and orderliness, the person is able to adequately respond to the impact of the chaotic society and that maintain its stability, individuality. In its orderly conduct appear “chaotic” features that have become “a necessary condition for its orderly existence” [2, 118].

Considering the many individual acts of activity and communication that make up our understanding of the essence of the chaotic component of self-organization process of the individual, it is necessary to point to a new understanding of reality. In contrast to the classical one-dimensional understanding of reality in post-nonclassical knowledge is multidimensional, multi-directional, non-linear. Today, “there is not one but many different realities” [7, 32], such as the scientific, subjective reality of everyday life and the ideal of cultural objects. Among them is the reality of inter-individual relations and communications, which in turn breaks down into a number of separate acts.

According to L.P. Karsavin, “there can be no identity and sets out its moments” [4, 19]. This set does not exclude, but presupposes the unity of the person: each moment with all the originality and The correlation with other such moments must be “with all the personality – and all its other aspects. At any time, it carries out the whole entire personality” [4, 77]. The man in every moment is influenced by a number of updated relations and motives that make up the field of motivation. The latter determines the purposes and means of achieving them, associated with subjectively experienced reality way, the activity as a manifestation of self-realization process.

Making a single act of his activities, the person does not use the entire “field” picture of social reality, it focuses your mind on its fragment, which at the moment is for her the greatest



value and meaning, it is “centers” his focus on a particular line of conduct. In a separate act, it “breaks” the integrity of public relations. A search for an objective form of action through the production of a particular combination of assets and performance targets, its conditions and regulations, a person indirectly through related objective embeds communication into the logic of their behavior.

This fragmentation, and unique one-act all life situations, opening experience and activity, have a certain value for the person. The diversity of these provisions creates a full human life. The more differentiated and individualized is a sense of the value of the person, being in a certain fragment of his being, the more significant is its participation in a variety of its values. The collection of personal existence fragments potencies of its implementation – this field of human activity. Their diversity and forms the entire spectrum of the content of its existence. The versatility of interests intertwined in communication and self-acts, is the key to a sense of personal value. The potency of being a fragment makes a person act, but it depends on the person – this is his freedom. However, in the same and complete and profound responsibility that marked JP Sartre. In choosing myself, the individual in the process of self-realization is the legislator, along with himself elects all mankind.

Personality gives the effect of a complete design, combining various fragments of his personal and social life in the related combination and movement. Resolution of social forms, it is hidden in the personality as time and creates the possibility of its inclusion as a “missing link” in the various social chain. Person, including in them, closes the loop of social forms, off – the ability to create other combinations of skills and social relationships. This inclusion of the person is essential for expression and reproduction of the social form. It emphasizes the dynamic nature of the individual being. Connection elements of the social process is only possible on the move, during which found their inherence to the whole organization of the process and this move provides self-actualization.

To identify the causes of subjective human self-actualization, please refer to the concept of self-organization and reveal its mechanism. It is necessary to understand the reasons that determine the formation of the person in the world of subjective phenomena, taking over the functions of reflection, and the regulation of its activity. What are the causes of self-qualities, emotions, motives, playing the role

of the causative link in the overall chain of self-organization?

Due to the complexity and diversity of the reflective capacity, the person is capable of reflecting a result of their own actions, to realize itself, the “Me”, which acts as the mechanism of formation of the integrity of the human person, the basis of its self-creation. At the same time, forms the “I”, as a result of self-esteem, will inevitably starts to correct, modify his behavior, control its activity, ultimately, to improve and update. Formed above the level of activity, it is “Me”, through such influence and ends in this activity and behavior, improving and developing them already. Therefore, there is reason to speak about self-organization cycle. Personality as a self-organizing system, shaped, refined and implemented, if it works this cycle.

The quality of “Me”, forming, creating opportunities for a variety of areas of self-regulation. Realizing itself, a person can ask themselves the questions: Who am I? what is the meaning of my existence? In accordance with these questions, he builds and sells himself to find out whether self-awareness turned into self-education, as far as he is whole as a person. At the same time, combining the differences displayed form, the “Me” becomes a carrier of the transformative power which it can be used for transformation of the environment – creation and self – self-creation. An important role in convertering human activity plays its ability to abstraction, generalization, which is the basis of self-actualization.

Through this ability of all varieties and chaotic reality, combining the elements singled out and summarizes the most significant, repetitive communication, knowledge of which provides reliable guidance and gives the process of self-sustainability. No less important in the formation of human integrity are his emotions – a reflection of the subjective importance of certain objects, actions and acts of communication.

Under the pressure of emotional evaluations person forced to enter something or put out of its composition, existing, of being self-modifying, update its work. As a result, it created an integrative quality of self-reflection and evaluation, activating any manifestation of human capabilities. Such emotionally colored “Me” is always something you need, so involved and transforming capabilities, and establishing a common feature, and just the actions themselves. There is a single self-regulatory complex, the core of which is the synthesis of reflection and motivation, joined cognition and locomotion.

Thus, quite clearly visible link between the processes of self-organization of the human person and his self-actualization, which not only preceded by self-organization, but it is based on mechanisms depends on their effectiveness. Therefore, the application of the provisions of social synergy and nonlinear methods to the analysis of the essence of self-actualization and its implementation strategy is justified and heuristically justified.

By identifying the internal determinants of self-actualization process, you also need to show their correlation with objective factors of the social environment. First, it should be noted that the fundamental incompleteness of human life, the creative aspect of its activity involves the openness of his personality as an external objective world, and openness in the sense of constant criticality in relation to itself, its position, recognizing that any position – it is only a certain position. Therefore, in contrast to the classical understanding of rationality in postnonclassical paradigm of “openness it is a necessary element of rationality, its permanent, necessary moment” [7, 21]. According B.C. Stepin, open rationality is a necessary characteristic postnonclassical paradigm in understanding human-dimension self-developing system [8]. It follows that there is decentration attributive sign of any human activity, communication and self-actualization in particular, as a person, as much as possible using the creative potential of its specific, subjective, personal understanding of the world, should have the ability to look at this position from the outside.

Therefore, the person must be understood as an open system, which is to preserve internal order violates a dynamic equilibrium with the environment, seeking to actualize themselves. According synergy, under certain conditions, in such a system necessarily arise streamline processes and self-organization, or, conversely, disruption.

According to the law of increasing entropy, the closure of any of the system leads to its disorganization. For example, the closure of the social system inevitably gives rise to processes of social tension, and systemic quality of society disintegrates. By the degree of openness of the system and the level of its organization there is one correspondence. To increase the order in the system, it is necessary to increase the degree of openness, the new value that will correspond to the new, higher level of organization, with the result that the system will dominate the processes, organize it to a new level. To disorganize the system, reduce the degree of its openness, at the same time decreases the level of the organization, which will cause the predominance of processes disrupt the system to its new value.

So as a person is the subject of activity, it interacts with the environment and at the same time become an open system. Openness means a person's ability to perceive the diversity of social relations and transform them, bringing a new level of its internal organization and realizing itself. However, this ability is itself determined by the quality of the internal organization of the personality, its self, identity, motivational and volitional complex. On the other hand, the openness of the individual is determined by the ability and willingness of society to accept this openness, that is, to be open and create a variety of social relations. Only in this case, sufficient openness of society and the poor organization of the inner “Me” of the person, there may be processes of self-raising “self” to the level of openness of society. Otherwise, the person may be entitled to in the process of transformation of social reality only in its emotional motivational and volitional complex, which regulates its activities by means of self-evaluation system, self, self-creation.

Transforming the world and creating in it a new social environment, a person becomes an open-increasing variety of social communications, activities and individual acts of communication. In this case, we cannot forget about the appropriate level of their education, culture, needs, motives, goals, want to raise the level of its openness. Otherwise there will be time disruption, and opening level decreases, which may result in regression and degradation of the individual. And in this context it is necessary to address the problem of human identity.

The main driving force behind the formation of identity becomes a desire to relate the inner world with the outside, which implemented the development and operation of information and knowledge. Social trends include the correlation of his own life and the universal time, processes of individualization and pluralization of life strategies. A. Giddens in “Modern and self-identity”, notes that daily life has become based on the dialectics of local and global, and in individuals widened perspective in choosing life strategies. Giddens suggests that the traditional ties are replaced by more abstract, among which it is necessary to look for his place, and identity is formed in the reflective activities of daily living [3]. However, simply increasing the number of choices is not contributes to the quality of development of the person and its actualization. The problem is the person that would be based on their identity, the identity of an individual to update these options, transform them into creative activities. M. Castells, in this context, under the identity understand

the process by which the individual expresses himself and creates his essence. The most powerful force in the ever-changing world is the identity of the person, of her personality. It is becoming a major center of culture in the social structure, forming a person's behavior, and thus new social institutions [1]. Individuality people really exist in its assembled, independent and specific as a Process, which allows the person to keep the unity of decay in space and time points of activity.

Individuality implies uniqueness, originality and non-linearity, since any individualized existence has nonlinear properties: unpredictability, independence, self-organization. The uniqueness of the nonlinear systemology – condition for the preservation of the individualized system and its environment that is highly organized and is stable in the presence of the same properties of the systems that structure it. In the language of non-linearity, individuality appears as a “living, unique, self-deterministic, complexly, moving and evolving” [5, 23]. It is a special integrity, endowed with specific properties are always some process, not a state, first of all an act of creativity itself and the world. The creation individuality proves its ability to organize itself: at every moment of its existence, the “Me” recreates their base, while maintaining identity with each other. At the same time, making changes in the world, personality changes itself, improving and developing.

Personality as a social quality of a person and the subject of activity is a dissipative system, because it is constantly interacting with the environment, exchanging energy and information and products activities, in spite of the dissipative nature of its existence, it is not destroyed due to its individuality, non-linearity which supports dynamic integrity of the individual, its ability to self-organize and self-creation.

Thus, considering the process of human self-actualization in the context of post-nonclassical paradigm can be identified as follows.

According to the principle of self-organization, in the subjective world of the individual there is a coherent interaction between its aspirations, motives and goals, which is not always predictable result. This position is an immediate consequence of such a general principle of self-organization, as is the occurrence of bifurcation or branching in the moments of transition from the old to the new structure. Fluctuations or random deviations that may occur at this point, fundamentally affect the nature of human personality self-actualization. The role of fluctuations in this case, can one act play and a lot of moments of activity and communica-

tion. They contribute to the emergence of new structures of subjective identity. However, in turn, affects the process actualization cumulative activity-human field, including the process for its communication. This effect has a control character, aimed just at the very acts of activity and communication that make up the chaotic, potentially creative atmosphere of the process of self-actualization of man.

Man is regarded as a dynamic system capable of self-organization and striving to realize their inner potential. For in the process of activity and communication could people self-actualization is needed is a clear relationship between its subsystems – individuality and personality. Individuality is regarded as non-linear and internally grounded reality, with the properties of self-development and self-creation. Personality – is an open system with a dissipative nature of development in the exchange of information and the exchange of products of activities with the community. Quantitative and qualitative characteristics of this exchange depends on the degree of openness of the personality, the ability to perceive the variety of social relationships, create and transform them, thus expanding the boundaries of their subjectivity. Both subsystems, each in its own way, the person responsible for the process of self-organization, its development, which is understood as the alternation of order and chaos. As chaos is the set of individual acts of communication activities and that human individuality impact on society through his personality, and it, in turn, affects the personality. It converts them to embed in its structure and, thus, reaches a new quality level. Thus, the alternating opening and closing of an individual personal-systems create the preconditions for self-creation and self-actualization, the formation of individual identification strategies.

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## ALIENATING AND ASSIMILATING KNOWLEDGE: PRAVDA AND TRUTH

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The authors aim to determine the differences between the categories of truth and Pravda. It is shown in this article that truth and Pravda are differently bound with each other, and contradictions between them are frequent. It is proposed to apply in gnosiology such new concepts, as “alienating cognition” and “assimilating cognition”, “epistemic truth” and “existential truth”. Technical and natural-science cognition are examples of knowledge with a dominant of the alienating beginning. On the contrary, religious and philosophical cognition – are mainly “assimilating cognition”; they are interfaced not so much with the search of epistemic truth, but, first and foremost, they try to find the ontological truth of life.

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**Keywords:** truth, Pravda, alienating cognition, assimilating cognition, epistemic truth, existential truth

Hegel has somehow told that “truth” is a great word and a greater subject; if spirit and soul of the person are still healthy, his breast should be raised above at it at sounds of this word. But what is truth? There is no unequivocal answer to this question, and the term “truth” is initially multiple-valued.

Plato speaks in his dialogue “Theaetetus”, that it is possible to own some truth, not owning knowledge. Not being cognized, this truth somehow is present at thinking. But knowledge is impossible without Logos, without any reasonable-verbal report. Limited truths should be such truths which are realized and designated by names. According to Plato, the uttered ideas are incomplete and false, and the maximum truths about life are inexpressible. Nevertheless, it is necessary to think about life, even if it is incomprehensible. On Descartes, clear truths – from the God; on Spinoza, the unconditional truth is how the God sees the world; from here, the original truth is an attribute of full and exact knowledge.

Some philosophers-pragmatists approved: “Even if the God actually is not present, but the person requires Him very much and trusts, that He is, then the God by all means will appear as a real force”. Utopian function of philosophy justifies itself when force of uniform belief substantiates a Utopia, inhaling a life into it. We shall recollect that in Russia in XX century, in this range of Utopias, the communistic ideal has found the form of the Soviet authority has generated rich culture and has existed more than half of a century. So, concept of utopian illusion is quite compatible to the concept of real practicability.

Not only the epistemic-true knowledge is capable to be materialized, but subjective-illusory knowledge, which maintenance does not possess objectivity and which is not adequate to the external world, can be materialized as

well. Atheists-materialists are inclined to consider religion only as one of forms of powerless utopian error. But whether it is fair to recognize as illusions and errors such embodiments of faith in the Absolute, as cultures of Buddhism, Christianity and Islam?! Whether the difference between the substantiated ideas of science and religion is so great?

Generally speaking, it is not too important, whether the initial idea is adequate or inadequate to laws of the protogenic nature (whether such portrait, type of furniture, a facade of this house “is realistic”, etc.?). Ability of idea to be materialized, to find separate real existence to satisfy human needs, to develop society is much more important. Philosophers-pragmatists have revealed an enormous role of will and belief in the process of materialization of ideas which are thought up by consciousness: the more the will and belief will be stronger, the sooner and more successfully the imagined world becomes the valid world.

Two types of philosophy always compete among themselves in the West-European philosophy: theoretical and practical. The first is guided by concept of truth, and the world of truths rather reminds the transcendent area of Plato’s ideas, opposite to the sphere of the fluid material phenomena. M. Heidegger has named such type of philosophizing “an eidetic discourse”. On the contrary, the practical philosophy is aimed at concept of the Good, on human needs and consequently prefers other – an axiological – method of analysis.

In the beginning of XX century theoretical philosophy has rigidly demanded to release the knowledge, which declares itself as truth, from any sort of axiological formulations. In turn, philosophers-axiologists have forbidden building their reasoning as an image and similarity of theoretical scientific knowledge. Unlike theoretical and practical versions of philosophy,



the religious discourse, as a rule, aspires to harmonization of truth and the good – in conformity with the standard of kalokagathia of divine essence.

In eastern doctrines (Hinduism, Buddhism, Taoism, Confucianism) truth is understood as saving knowledge:

1) as the word of the Teacher specifying the true way to rescue;

2) as overcoming of illusion in favor of an original image of reality;

3) as a way of restoration of world harmony (for example, through reverence of traditions in Confucianism, laws of Empire in Legalism).

In theistic doctrines truth is defined as conformity of some statement to divine revelation. So, in Judaism and Islam truth is a saving Law, fidelity to precepts of the God, transferred to people through Moses or Mohammad. For Christians truth is not a certain universal abstraction, but it is the alive and saving person – Jesus Christ – who has uttered: “I am the way, truth and life” (John. 14, 6).

Lie is an antipode of truth, Pravda and honesty. In formal logic the term “lie” designate “not-true” in the most abstract sense. In philosophical and religious texts a lie and slyness are distinguished from mistakes and errors and are defined as the going distortion of fact of the matter. From the religious point of view, a lie is a sin, a moral harm, a vain attempt to deceive the God. First of all a man who tells a lie harms to himself because he spoils his relations with the God.

A lie can have different scales and degrees of danger, possesses destructive force and causes sharp conflicts between people. Christians consider Devil as “the father of any lie” and as the most unmitigated liar who tempts people and induces to lie those who have weak spirit. Jean Baudrillard has regarded our modern civilization as a product of total simulation (conscious or not realized); our life is filled by simulacrum – by crafty fakes of lie under truth, disgraces under beauty.

As it is known, in classical philosophy there were three different interpretations of truth in which truth was understood as coincidence of knowledge with objective reality (in Latin: *veritas est adaequatio rei et intellectus*):

- theory of correspondence starts with a principle of conformity of knowledge to a piece of material world (Aristotle writes in “Metaphysics”: “To speak about real, that it is not present, or about not real, that it is, means to speak false. And to speak, that there is real and not real is not, means to speak true”);

- Essentialist doctrine leans on a principle of conformity of things to its non-material originals – to transcendent ideas (Plato, Neoplatonists, etc.) or immanent essences (Hegel);

- Coherence theory of truth is based on a principle of conformity of knowledge to some form of human consciousness.

Any theory of “conformity” stumbles at a question “conformity to that?”. It cannot express exactly in an obvious form that object to which knowledge presumably is put in conformity. For example, to what object the statement “My hand hurts” corresponds? In fact the pain is subjective. It is not registered by devices, and an actor is able to simulate it on a stage quite plausibly.

Irrationalism in understanding of truth amplifies in philosophy since XX century. Nietzsche connects truth with ideas of eternal returning and reassessment of values. Existentialism contrasts the objective truth and representation about personal truth as intuitive appearance of original being to some individual. Sartre sees essence of truth in freedom. J. Maritain and N. Hartmann declare that truth is a special ideal object in structure of transcendental being. Theorists of Postmodernism speak about knowledge as about a process of eternal and unsuccessful “quest” for truth.

Whether truth is objective really? Sometimes this question should be answered with aphorism: “We tolerantly concern to other’s opinions, until we have no our own opinion”.

According to Heidegger, who continues the ancient tradition, in order to find out truth, it is necessary to use *pro-duc-tivity*, that is to withdraw truth from its hidden place using technology; and technique itself is a kind of truth-making. Attribute of objectivity is no longer ascribed to truth in non-classical philosophy; truth is identified either with specific conditions of soul (Kierkegaard), or with value (Rickert), or with linguistic interpretation (Gadamer).

The truth and value become more and more closely connected. The concept of value began to affirm in gnosiology in the second half of XIX century. Lotze introduced it to philosophy. He believed that value occurs exclusively in situations of its significance to a subject, but it is not the product of personal arbitrariness and freedom of will. Value is objective because it is a mutual intersubjective form of volition and human behavior. In postnonclassical philosophy the problem of truth turns to be one of aspects of a game subordinated to those rules, which are randomly chosen by that or other subject (Foucault).



Russian language marks the ontological moment in the word “truth” – the existing, original, real. Two sorts of truths are distinguished in Russian spiritually-academic philosophy of XIX century: ontological truth (it has objective character and it is stored in the very being) and logical truth (it is subordinated to ontological truth, and it is subjective and expressed in human judgments about being).

In particular, Kudryavtsev-Platonov (1828–1891) proved, that there are two opposite parts in any cognizable thing –

- 1) ideal, possessing more true life;
- 2) phenomenal, caused by accidental modifications.

The ideal world is the objective maintenance of truth. Top of hierarchy of ideas – the absolute idea summarizing in all of property of ideal life and possessing absolute truth. This idea is perfect, and the form of its being is individually-concrete. It is inexhaustible. The God possesses it only, it is not allowed to a human being to learn it completely. On Kudryavtsev-Platonov, the establishment of truth of a thing is tied with reference of this thing to values-samples: it is necessary to compare the empirical aspect of a thing with what this thing should be (Kudryavtsev-Platonov, 1892–1894).

It is proved by Kant: in order to learn a thing it is necessary to operate with this thing and our operations change cognizable objects. As a result, a human being learns not that originally exists as primordial nature, but that is recreated by him under schemes of his concepts and creative imagination. On Hegel, there, where there is mutual reflection of the subject and object, measurement of force of creativity needs a special notion of truth as a measure of conformity real with ideal (that is as a degree of coordination emergent (new quality) with the original-essence). Therefore Hegel often defined truth as harmonization (conformity) of a thing with its notion. So, the constructed house is evaluated as “true” when there is adequacy between this house and previously approved architectural project. It is logical to apply non-classical notion of truth of Plato and Hegel to processes of mastering knowledge. We shall name this notion “existential truth” (in Russian – “Pravda”).

The existential truth is some correspondence between the human existence and a proper ideal of being. Criterion of justification of ideas and ideals of a person is completeness of assimilation of vital space and a degree of satisfaction with this assimilation. It is not necessary to search, with persistence of a naive realist, only epistemic truth in the knowledge

displaying the world together with human relationship to the external world.

Knowledge by all means includes individual understanding. To “understand” means:

- 1) to express cognizable objects in concepts;
- 2) to imagine these objects with a help of evident models – in forms of secondary sensuality;

3) to allocate the comprehended object with the sense contained in a personal semantic context of the subject.

Sense-meaning, which an individual attributes to the cognizable object, either is creatively invented, or taken from already old habitual senses. To understand the physical world in religious sense means to imagine this world as:

- 1) a product of divine creation;
- 2) object of Providence;
- 3) the medium among people and the Absolute.

It is necessary to consider virtual division in spiritual processes of two maintenances of an ideal image-emergent: one of them is consciousness, and the second – self-consciousness. Consciousness is not able to distinguish fully, what in emergent was exclusively “mine”, and what was put into it from outside, from «alien being». At least, it demands great existential efforts and theoretical reflections.

The classical notion of truth does not measure adequacy of images of consciousness and self-consciousness in their entirety. Is it possible to estimate our subjective experience of assimilation of external world as true or false? Whether the predicate “true” is applied to images of self-consciousness and what are the images of self-consciousness in general – what is a proportion of “picturesqueness” (imitation) and “expressiveness” in such images? I think that there are no unequivocal answers on such questions.

The concept of vital truth (existential truth) is applicable not so much to designation of the objective maintenance of natural, social and mental processes (though it assumes partial reproduction of such maintenance in the removed kind), how many it is interfaced to uniqueness of personal experience of internalization of the world – to harmony of individual relationship to objective world. Generally speaking, how many people there are, so much, there are vital truths. Collision of mutually exclusive vital truths can be fine and ugly, tragic and comical, ennobled or low.

Unsurprisingly, philosophy of pragmatism has identified truth with property of idea to give the constructive character to our activity, to lead to practical successes, to bring vital advantage. Philosophers-pragmatists, debunking

the claims of Marxists in the possession of the absolute epistemic criterion of truth (the criterion of practice), have turned philosophical thinking to a theme of vital truth. The vital truth is a syncretic alloy of the removed objective contents (it makes it related with an objective truth) and of subjective-personal moments in worldview (this distinguishes it from epistemic truth). Often similarity is taken for its criterion: to prove Pravda means to establish subjectively the similarity between discussed situations and previously estimated circumstances.

When the person, painfully solving his conflict with the world, searches new milestones of own sense of life – he searches a new Pravda for himself. Having found this Pravda, he subjectively accepts it for universal epistemic truth, true for all people, and sometimes is indignant, why others do not accept his vital position. The conflict of different vital Pravda's (both inside of a person and between people) is always inevitable. There is a close communication between Pravda and belief (for example, some people say: "To be faithful to his own Pravda"). The typical vital Pravda, the basis for the allocation of which common human moments of outlook serve, is the criterion for comparison and an estimation of diverse vital Pravda's [5].

Classical rationalism started with the firm belief that:

- 1) the external world is one and continuous;
- 2) there is only one truth about this world, and all people have the same uniform truth;
- 3) the scientific truth is universal and general for all of us; it is necessary, uncontradictory, self-evident.

Irrationalism and critical rationalism expose to this opinion its radical doubt. If to believe, that the God is capable to create any possible world, and a human being is similar to the God, then the world surrounding us is not one and uniform at all, and people are able to create any original worlds and images-theories of these worlds.

For example, the sphere of fine arts is made by the sum of alternative art worlds and consists of "strange" art truths competing among themselves. Science and technics have skillfully created set of different new realities which are subordinated to the special independent laws which have been thought up by scientists and engineers. Hence, it is logically true to match against classical principles of uniqueness, universality and uncontradiction of scientific truth the non-classical concept of pluralism of paradoxical scientific truths about the possible worlds.

Considering pluralism of representations about notion of truth, it is expedient to enter two new terms into the general theory of knowledge: "assimilating cognition" and "alienating cognition" [2, p. 30–38].

The term "assimilation" (also "internalization"; in Russian – "освоение", "усвоение", etc.) designates the process of receiving new facts or of responding to new situations in conformity with what is already available to consciousness. Internalization is also often associated with learning ideas or skills and making use of it generally. Internalization is the long-term process of consolidation and embedding one's own beliefs, attitudes, and values, when it comes to moral behavior.

The opposite of "assimilation" is the term "alienation" (in Russian – "отчуждение") translates two distinct German terms: "Entfremdung" ("estrangement") and Entaußerung ("externalization"). Both terms originated in Hegel's philosophy, specifically in his *Phenomenology of Spirit* (1807). "Externalization" (also – embodiment, incarnation, manifestation, materialization, objectification, substantiation, etc.) means to put something outside of its original borders. Alienation is often a harmful separation, disruption or fragmentation which sunders things that properly belong together. To be alienated is to be separated from one's own essence or nature.

Assimilating cognition (gnosis) unites the subject and object so, that cognizable thing becomes subjective and vitally valuable to the learning person. Thus, object can be not only external (even transcendent) in relation to his subject, but also immanent (sometimes transcendental); therefore it is necessary to allocate in assimilating knowledge, in turn, its externally-transcendent and immanently-transcendental versions.

Alienating cognition (ἐπιστήμη, episteme), on the contrary, separates learning and cognizable, transforms the subject into the discharged, passionless and objective observer, and object – into something "absolutely other". Not only external (including transcendent) things but also immanent (sometimes transcendental) things can be objects of such cognition; therefore alienating cognition can be subdivided on exterior and interior alienating cognition.

In Ancient Russia almost all fields of human activity were defined by Pravda and Non-Pravda. "A man could live under "Pravda", because it is the Divine precepts and church rules. Also he can be judged in accordance with it, because "Pravda" is the court, as well as court trials and even the fee for appeal of the witness in the court".

I.S. Peresvetov, the original Russian thinker of XVI century, wrote that Pravda is a set of the God's commandments which have the status of laws both for sovereign, and for its citizens. Being norm of a life, Pravda results from a unique divine source – from Bible. The orthodox belief helps people to execute and understand Pravda, but spiritual persons have the fullest knowledge of divine precepts.

Truth and Pravda are differently weaved with each other, just as interrelations of objective knowledge with subjective belief are various. Contradictions between them (truth and Pravda, belief and knowledge) are frequent. There are: true Pravda and false Pravda; Pravda-lie and Non-Pravda-truth; rescue lie and murderous Pravda. For example, our national fairy tales express the deep truth of life, but contradicts truth of facts (Russian proverb says: "This fairy tale is a lie, but there is a hint in it – it's a lesson for a good guy!").

Certainly, the named kinds of cognition – assimilating and alienating – are abstractions torn off from each other. In objective reality (in everyone separate cognitive action) they are jointed in this or that proportion, and contradictions between them are possible. Finally assimilating and alienating kinds of cognition grow from the same roots, namely from the process of interaction among "mine" and "alien" – from controversial experience of assimilation and alienation.

Examples of cognition with a dominant of the alienating beginning are technical and natural-science cognition. On the contrary, religious and philosophical cognition are examples of assimilating cognition mainly; they are associated not so much with the search for epistemic truth, as with the search for ontological Pravda of life. For this reason religious and philosophical systems continue to render powerful influence on minds of people even then when "rational-scientific criticism" rejects its by means of objective criteria of epistemic truth.

Any of great philosophical doctrines, unlike scientific theories, never becomes outdated, and this fact probably reflects the fundamental difference of wisdom (*sapientia*) from scientific quality (*scientia*). "Revelation

is a display of the basis of Being in human knowledge" (P. Tillich).

Sometimes researchers (in particular in Christianity) prefer to designate religion using the term "faith", and in other cases religion is defined as a special "saving knowledge". Many atheists, confusing Pravda and truth, estimate religion as the "blind" and empty belief which does not have its objective analogue in reality, and they oppose religion with cold educated reason. Theologians argue amongst themselves trying to describe human cognition of the Absolute through faith. For example, pantheists believe that direct faith is sufficient to know the God. Theists demand to add empirical evidences of the Epiphany and logical proofs of being of the God to religious faith.

It is much told by Apostle Paul, Tertullian, Pascal, Kierkegaard, Karl Barth etc. about an incommensurability of belief and reason. Religious belief is often directed on transcendent, physically impossible, wonderful, therefore its truths seem to our reason paradoxical, senseless and even absurd.

The contradiction between absurdity of belief and logicity of understanding is reflected in Kierkegaard's formula: "to trust, means do not understand". It is impossible to prove belief, but it is possible to clarify it. As a rule, it is impossible to force someone to believe, – faith can be found only through our free choice; "slave is not the one who prays to God". If the truth, via its own light, is not able to attract someone's mind, then external force will not help to do this" (J. Lock). The true belief is spread in heart by the God (R. Niebuhr). At the dawn of Christianity philosophers-Gnostics have identified the specificity of assimilating cognition with the term "gnosis".

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*Materials of Conferences***CONCEPTUAL SCHEME OF INTERACTION  
“MAN – ENVIRONMENT” AS THE BASIS  
OF PARADIGMS FOR THE ANALYSIS  
AND MANAGEMENT OF PUBLIC HEALTH**<sup>1</sup>Artemenko M.V., <sup>2</sup>Teplova V.V.<sup>1</sup>FSEI HE “South-West State University”, Kursk,  
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The article discusses the basic stages of the decision-making components of the system “man-environment” and their respective different four conceptual schemes of interaction of subsystems other than the autonomous management subsystem and the formation of functional, allowing to analyze the status and to carry out simulations of “man” and states “environment”, as well as to synthesize appropriate decision rules for state correction based on past experience, the current situation and forecast the future. These conceptual frameworks allow forming different paradigm for research in the field of study of the effect of habitat as a separate human body, and the population of a specific region as a whole through various aggregators functional, reflecting the relationship between the observed and controlled characterize the state of subsystems informative recorded indicators certain points in time. The above arrangements make it possible to systematize the study in the study of human responses to changes in the habitat of various levels of the organization biosystem.

The World Health Organization as indicators of public health in the implementation of the strategy “Health for all in the XXI century” stand [6]: the availability of primary health care, % of GNP (gross national product) in public health, public safety water supply, % vaccinated against infectious diseases of persons, nutritional status children born with low birth weight, infant mortality rates, mortality in general, fertility, life expectancy, literacy rate of the adult population, the share of GNP per capita. These figures are observed and controlled in terms of management theory.

Meanwhile, in the planning of economic costs requires an analysis of their expenses for specific recreational activities in a given region depending on the prevailing therein incidence of individual nosological groups. Adequate and reliable analysis of short-term and long-term forecasts of the impact of certain environmental factors, endogenous and exogenous characters (including man-made and rhythmological) allow you to control the above indicators.

Research in this direction are carried out continuously and the various mathematical methods (eg, represented in works devoted to fundamental and specific issues [1–4, 7, 8, 12]).

Studies show that the information sources the analysis of regression (linear) relationship be-

tween environmental performance and levels of certain nosological groups of morbidity and demographic variables considered, or the current time and-or considering the cumulative effect and, or, taking into account correlations to the time shift in the “past”. Meanwhile, any living open system responds to the current point in time based on the experience of its interaction with the environment in the past and forecast the future. Decision-making process in this case is described, for example [13].

According to [9] The basic steps:

1) the functioning of a healthy person is a sequence – update structures with the expenditure of matter and energy, education, and power consumption based on information influence the autonomous control system (ACS), regulation of energy processes using ACS temporary coordination structure and functioning of the energy-information levels;

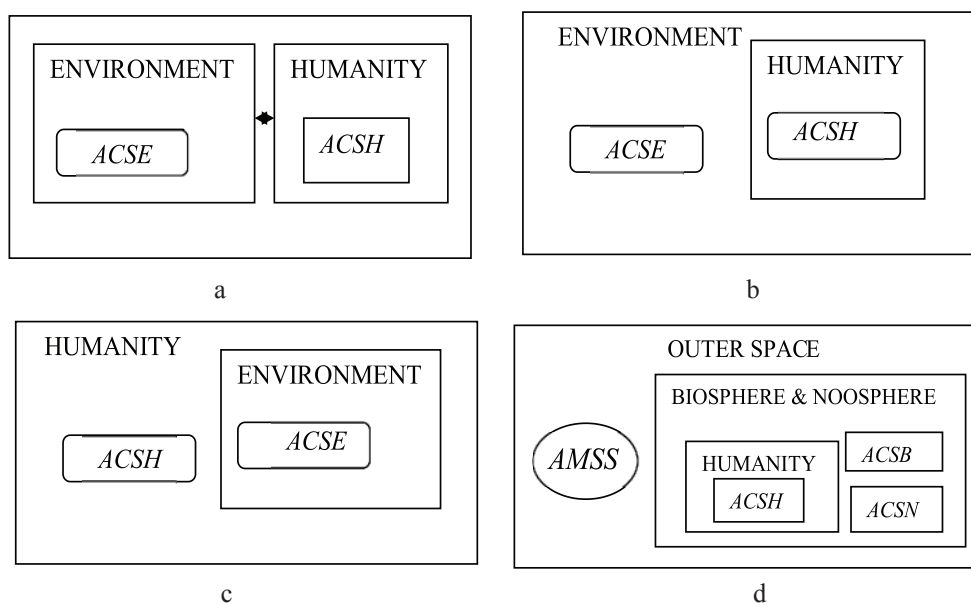
2) the development of the pathological process – a temporary mismatch functioning at various levels of biosystem, violation of information flow in the body, the violation of energy metabolism, metabolism and organ destruction and-or the functional systems of the body.

These steps occur in view of the interaction of internal and external body fluids, both in time and in space. Because living systems have the ability of self-regulation and self-organization (including the maintenance of homeostasis), based on the positive feedback and it is necessary to take into account the factor of whether they are stand-alone control, the functioning of the basic foundations of which are discussed in [5].

To solve these problems is offered before the beginning of the identification process and functional-and-or logic or semantic relationships between speakers of different indicators of health medical and preventive character of the human population and environmental factors will be determined with the paradigm of the forthcoming investigations. In particular, we have a conceptual scheme “man – environment”, presented in Figure.

The following symbols and terms are used Figure: humanity – “people, the population” in the region; environment – “nature, environment, habitat”; OUTER SPACE – “kosmosfera”; ACSE -autonomous control system environment – autonomous ENVIRONMENT management system; ACSH – a utonomous control system of the human – HUMANITY autonomous control system; AMSS – autonomous management system space – OUTER SPACE autonomous control SYSTEM; biosphere & noosphere – the biosphere and the noosphere; ACSB – autonomous control system of the biosphere – biosphere autonomous control system; ACSN – autonomous control system of the noosphere – an autonomous control system of the noosphere.





Conceptual scheme of interaction “man – Wednesday habitat”

The results in Figure 1 form the conceptual schemes allow different paradigm for research in the field of study of the effect on the environment as a separate human body, and the population of a given region as a whole.

The circuit of Figure 1 – subsystem HUMANITY and ENVIRONMENT are functioning according to its own laws defining the ACSE and ACSH, respectively, the interaction of states that can be described by systems of differential and-or regression equations reflecting the dynamic and static recording parameters determining the state of the subsystems and components and relationships defining their intended function. Here are four possible situations that determine the functioning of the ACSE and ACSH:  $\text{dom}(\text{ACSE}) \& \text{ACSH}$ ;  $\text{ACSE} \& \text{ACSH}$ ;  $\text{ACSE} \& \text{dom}(\text{ACSH})$ ;  $\text{not}(\text{ACSE}) \& \text{not}(\text{ACSH})$ . In the first case – it is dominated by the ACSE, in the third – ACSH, in the second – control systems are equivalent, in the fourth – almost absent (the values observed and controlled parameters chaotic subsystems).

The paradigm is based on the scheme shown in Figure 1, a is the largest application (including in [2, 7, 8, 11]), since in this case and ACSE ACSH autonomous control systems do not include one an-

other, greatly simplifies modeling, reducing it essentially to the analysis of statistically significant, represented by registered during the monitoring of the observed values and adjustable parameters describing the state of the respective systems.

In this case, it carried out structural and parametric identification of functional models for the species:

$$\{\text{Shum}_j\} = \{\text{Facsh}(\{\text{Senv}\})\},$$

$$\{\text{Senv}_k\} = \{\text{Facse}(\{\text{Shum}\})\}. \quad (1)$$

I.e., each possible state of HUMANITY  $\text{Shum}_j$  ( $j = 1, \text{Nhum}$ ;  $\text{Nhum}$  – the number of States of the system) is functionally associated with the set of States of the ENVIRONMENT  $\{\text{Senv}\}$ , and the condition of may be associated inverse functions with the set  $\{\text{Shum}\}$ . Simulation in this case is “playback” of occurrence of possible States of the subsystem HUMANITY depending on the predicted state of the environment and the reaction of relevant systems of autonomous control.

In contrast to the previously used the work proposed as elements of a set of states to consider the state in a variety of positive and negative time offsets relative to the current moment:

$$\{S\} = \{\{S\}_{t-k}, \{S\}_{t-k+1}, \dots, \{S\}_{t-1}, \{S\}_t, \{S\}_{t+1}, \dots, \{S\}_{t+l}\}.$$

For example, in the simplest case when the current state of the system is based on the preceding and following situations formula applies:

$$\{\text{Shum}_j\}_t = \{\text{Fuz}_j(f_1(\{\text{Shum}\}_{t-1}), f_2(\{\text{Shum}\}_{t+1}), f_3(\{\text{Senv}\}_{t-1}), f_4(\{\text{Senv}\}_{t+1}), f_0(\{\text{Shum}\}_{t-1}), f_0(\{\text{Senv}\}_t))\},$$

where  $\text{Fuz}_j()$  – aggregator for the state  $\text{Shum}_j$  of the function  $f$  with fuzzy model indexes dependence on the previous situation, the odd – on the future, a zero – the current (for ENVIRONMENT only).



(Note that the pilot simulation for the indicator “birth rate” and the characteristics of the water pollution in the Kursk region has shown to increase the accuracy of mathematical models constructed on the basis of the following formula and linear aggregator 15–20% better than the models are not considered “forecast”).

As reaction to the various components of systems in which members have the greatest correlation for different time shifts, it is recommended to initially assess the value of these changes either visually (by analyzing the dynamics of indicators) or by analysis of coherence.

The paradigm of scheme Figure, b suggests that HUMANITY is a subsystem of the ENVIRONMENT subsystem and, consequently, its autonomous status defined ACSH control system according to the multitude of its states and state ENVIRONMENT subsystems, variable functioning standalone ACSH system. In this case, it is necessary to identify and analyze patterns according functional types:

$$\{Shum_j\} = \{Facsh(Senv, Facse(\{Shum_j\})), \{Senv_k\} = \\ = \{Facse(\{Senv\})\}. \quad (2)$$

Paradigm simulations presented of scheme fig.1c, suggests that the ENVIRONMENT is completely determined by the states and transitions between them (hence the operation) HUMANITY subsystem (and ACSH). In this case, the functional models are defined:

$$\{Shum_j\} = \{Facsh(Senv, Facse(\{Shum_j\})), \{Senv_k\} = \\ = \{Facse(\{Senv\})\}. \quad (3)$$

Substantially different is the modeling and study of the state of HUMANITY is the situation represented by the diagram shown in Fig.1d, because it is an element of the hierarchical control at the level of “man – habitat”, providing for the dependence (observability and control) on the part of some “space” – the OUTER SPACE –, which by acting on the biosphere and the noosphere [10, 14, 15]. In this case, the basic paradigm is defined by the formula:

$$\{Shum_j\} = Famss(Facsb(Shum, \\ Facsh(Shum)), Facsn(Shum, Facsh(Shum))). \quad (4)$$

In fact, in this case, we considered a hypothetical situation of complete controllability (controlled) state (and transitions) HUMANITY subsystem on external factors of the biosphere and the noosphere, which change under the influence of its own autonomous control systems (control) on the basis of the fundamental “space” laws of the cosmos. (The simplest option may be, for example, outbreaks of

viral diseases, depending on the passage of comets, or “lunar cycle” of a number of mental illnesses.)

Thus, the presented diagrams of different paradigms of research of human conditions (as an element of “population”), allow to systematize the study in the study of human responses to changes in the habitat of various hierarchical levels and environmental changes (including human nature), which certainly should contribute to the concentration of research potential in certain areas, depending on the research objectives and the resources available.

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