

**Norwegian Journal of
development of the
International Science**

№94 2022



NORWEGIAN JOURNAL OF DEVELOPMENT OF THE INTERNATIONAL SCIENCE

№94/2022

Norwegian Journal of development of the International Science

ISSN 3453-9875

It was established in November 2016 with support from the Norwegian Academy of Science.

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1000 copies

Norwegian Journal of development of the International Science

Iduns gate 4A, 0178, Oslo, Norway

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site: <http://www.njd-iscience.com>

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BIOLOGICAL SCIENCES

EXPERIMENTAL METHODS IN EDUCATION: EXPERIMENTS ON PREGNANT MICE FOR THE TREATMENT OF ALCOHOLISM

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<https://doi.org/10.5281/zenodo.7197634>

Abstract

The article discusses the inhumanity of alcohol and other experiments on pregnant mice in biological education. Use of "indicator" animals with known microbiological status. Animals are placed in the same environment as the population being tested and periodically sacrificed and examined. Naked (athymic) mice are excellent indicators because they are immunodeficient and especially susceptible to pathogens. But these mice are not suitable for detecting changes in serological titer, which may indicate the presence of viruses, since there is no antigenic response in nude mice. To determine the serological titer, it is necessary to use animals with the appropriate immune status.

Keywords: pregnant mice, experience, humanism, blood test, alcoholism, ethyl alcohol

Introduction. The World Health Organization has identified six criteria for diagnosing alcohol dependence. The main and first criterion is a person's inability to control alcohol intake. According to the second criterion, a person feels the urge to drink. This desire can manifest itself both openly and under the pretext of relieving tension and relaxation. As a result of this desire, a person forgets his family, laws and norms of social behavior. The third symptom is that the body easily "tolerates" alcohol. If a person drinks three glasses of vodka and brags that he is not drunk, it is a dangerous syndrome. The problem is that the body tries to process ethyl alcohol into the bloodstream to the best of its ability. But sooner or later the final stage is reached and the mechanism is broken. As a result, alcohol causes mental weakness. That is, the person can greet you and forget about it after a few seconds.

The fourth symptom is abstinence syndrome. This means that a person feels tired, depressed, and his hands swell the day after drinking. Such people look forward to the end of the working day to drink again, even if they do not drink early in the morning. However, those who feel unwell after drinking are also divided into two groups, and those who are poisoned by alcohol can not be considered alcoholics. They simply feel bad the next day because they have been poisoned and do not want to drink again to improve their condition. Alcoholics, on the other hand, feel the need to drink again. However, alcohol poisoning is also directly related to the culture of alcohol consumption. If a person drinks two bottles of vodka, he receives 400 milliliters of ethyl alcohol. This is a lethal dose for a person weighing 70 kilograms. The average person is resuscitated with this dose. This does not happen in alcoholics. Therefore, for drinkers, alcoholism and heroism are synonymous. The fifth symptom is various diseases. That is, a person's laboratory tests are negative or his family breaks up as a result of drinking. He can't stop drinking and can't stop drinking alcohol. The last criterion is that alcohol plays a key role in human life. In other words, according to this criterion, a person's life and personal life are

built around alcohol. Other non-alcoholic interests take second place.

Alcohol is one of the drinks that contains ethyl alcohol, and when drunk, it gives a person temporary pleasure and intoxication, as well as a harmful effect on the body, which has become a habit in many people. Those who are unable to abstain from alcohol are called alcoholics if they consume alcohol to the extent that it impairs their physical and mental health, family, social, and work life. Alcoholism is a disease that occurs as a result of regular consumption of alcohol and is addictive. This disease negatively affects a person's reputation by causing physical and mental disorders. Alcohol is mainly toxic to brain cells. A drunk person celebrates for the first moments, enjoys himself and so on. but as the effects of alcohol increase, all of this can be replaced by irritability, obscenity, irritability, and rudeness. Alcoholism causes dystrophic changes in the vascular system, the development of hypertension, serous liver, impaired renal function, as well as profound mental and somatic disorders. The disease results in mental retardation, alcoholic epilepsy, and sometimes alcohol psychosis. The patient is frightened, sleep is disturbed, hallucinations are observed. Accidents often occur among alcoholics, their ability to work is weakened. Alcoholism has a negative effect on the female psyche. Alcohol consumption during pregnancy is especially unacceptable. Thus, the alcohol consumed in this case has a very negative impact not only on the mother's body, but also on the health of the unborn child. It is more common for women with alcoholism to give birth to children with physical or mental disabilities.

Unfortunately, both in education and in science, have to experiment on animals in order to treat alcoholism and measure the scale of harm in general. Acute alcohol toxicity should be studied in several animal species, and it is imperative to use the species in which the therapeutic effect of the pharmacological substance has been shown and in which long-term toxicity was studied. Usually 2-3 species of rodents and non-rodents (mice, rats.) are used. Groups of male and female ex-

perimental animals are formed separately. For small rodents, each group should contain at least 5-6 females and the same number of males.

An experiment carried out on several lines often shows different susceptibility of the lines. The assessment of nanosafety should be based on the most sensitive line, but in some cases it is necessary to find the gene for such susceptibility. This will help clarify mechanism of nanotoxicity and obtain data for innovative drugs in the future. Unfortunately, toxicologists have never attempted such a design. If mice are used instead of rats, then more radical changes will be needed. According to foreign data, it was mice (91.4%) that were the most commonly used species for gene modification, and only then were rats (3.6%), zebrafish (2.3%), and other species, including chickens, sheep and cows (1.3%). The most frequently used for gene modification of mouse lines C57BL/6 (48.1%), 129Sv (11.1%), Balb/c (4.3%), CD1 (2.5%) and FVB (0.3%). The advantage in using mice is the wide availability of different strains and an extensive database of mouse genetics, mouse/human gene matching, and the relative ease of mouse genetic manipulation. Genetic modifications may include the "insertion" of the necessary gene that gives a response to nanosubstances.

The similarity constants show how many times faster (or slower) intoxication can develop in an animal compared to humans due to a higher (or lower) intensity of biological processes and, according to our calculations, if a person is taken as a unit: for a mouse ~9.7, rats ~5.2, guinea pig, ~4.3, rabbit, ~2.5, dogs, ~1.7, sheep, ~1.4, pigs, ~0.83 and horses ~0.75.

When switching to real time, this means that, for example, intoxication or an adverse drug reaction that develops in a rat in 3 months will manifest itself in a mouse after 1.5 months, in a rabbit - after 6 months, in a dog - after 1 month, in humans - 16 months, and in the horse only after 22 months of exposure to the substance. The existence of allometric dependencies of time for the development of the effects of intoxication is necessary take into account when assessing the adequacy of the duration of pharmacological and toxicological experiments when extrapolating data from animals to humans.

Genetic analysis has shown that the number of newly acquired genes per neuron in the human brain is greater than in the chimpanzee brain. In addition, the adult human brain contains significantly more copies of mobile genetic L1 elements than the liver and heart, which is due to the adaptation of the nervous system to the constantly changing environment and the individual's lifelong learning. In 2006, it was found that the human genome contains 212 copies of the MGC8902 gene, which is expressed only in brain neurons and encodes the DUF1220 protein with unknown functions. At the same time, in the genome only 37 copies of this gene were found in chimpanzees, and one copy each in mouse and rat genomes. Hence, it was suggested that the MGC8902 gene may be involved in evolutionary changes in the brain. It is also assumed that the formation of a more complex neural network and, accordingly, a more complex structure of the human brain is responsible for the so-called extended transcription of

the human genome. About 20% of brain neurons normally regenerate, while at the same time, with age, up to 30 g of neurons are irretrievably lost every year.

It has been established that mice infected with toxoplasmosis "run badly" from cats and, most importantly, the parasite is transmitted to cats with great success. It is also believed that toxoplasmas "redistribute" and affect the psyche of the infected person. This is one of them examples of an amazing biological phenomenon when a parasite can be managed by a host.

In real time it has not been possible to create yet human hybrids and to obtain therapeutic antibodies are used only mouse hybrids. Imaging monoclonal antibodies represent their own powerful immunogens, which are formed in the body of patients with HAMA (from the English "human anti-mouse antibodies" -

antimyszynye antibodies of man). To reduce the immunogenicity of such antibodies are carried out with the help of different and sufficiently labor-intensive ways of their "embodiment", transferring mouse sites, determining complementarity (CDR, from English. "Complementarity determininiges" regions). Protein NR2B was found that the process of training and blood pressure are regulated by one and the same biochemical mechanism, in particular, with the participation of protein NR2B. This protein has a beneficial effect on the process of memory and training in mice. Transgenic mice with an additional copy of the NR2B protein gene instantly learned the details of the LEGO designer. This line of mice was called "Arc", in honor of the hero of the TV series "Arc Hauser - Doctor of Medicine." It is assumed that the transfer of the gene NR2B protein in human offspring will allow to create the future "wunderkinds to order". However, the addition of "smart protein" sharply increases the likelihood of stroke in the carrier of an additional copy of the gene.

In view of all this, scientists are studying the effects of alcoholism on pregnancy through various experiments. As mentioned earlier, mice, the gene closest to the human gene, are used for this purpose. Scientists keep pregnant mice in a cotton cell impregnated with ethyl alcohol and its derivatives. Some even drink ethyl alcohol to pregnant mice. Blood tests and other tests of these pregnant mice are then performed.

Let's clarify right away: the main component of any alcoholic beverage is ethyl alcohol (or ethanol). It is he who is responsible for all the changes that occur to our body after drinking alcohol. After swallowing, ethyl alcohol enters the stomach, where approximately 20% of its volume is absorbed into the blood. Most (80%) a little later enters the bloodstream already from the intestines. Once in the blood, ethanol begins to act on the body. The fact is that ethyl alcohol has a different effect on different types of nerve cells, upsetting the balance of the processes of excitation and inhibition.

All alcoholic products necessarily contain ethyl alcohol. For example, what is beer? 100 grams of beer is 6-12 grams of poison (ethyl alcohol), "dressed" in hops, rye, yeast and other ingredients.

What is wine? 100 g of wine is 20 g of poison (ethyl alcohol), "dressed" in grape, apple and other must (juices). Different varieties of grapes, apples -

these are different varieties of wine, but the main component of them is poison - ethyl alcohol, one for all. 100 g of champagne is 17 g of poison, and the rest is various extracts.

What is vodka? 100 g of vodka is 40 g of poison (ethyl alcohol) "dressed" in 60 g of water and various extracts.

What is cognac? 100 g of cognac is 40 g of poison, "dressed" in color, which is drawn from an oak tree and 60 g of water and various extracts.

What is moonshine? 100 g of moonshine is from 20 to 70 g of poison, "dressed" in water and fusel oils.

Once in the body of a mouse, ethyl alcohol is absorbed through the walls of the stomach and intestines, quickly reaches the liver and appears in the blood. The state of intoxication depends on the concentration of alcohol in the blood. The content of alcohol in the blood up to 0.5 g / l usually does not cause immediately noticeable changes. At an alcohol concentration of 0.5-1 g / l, there is no noticeable intoxication observed, but the nerve centers cease to function normally. This is a very dangerous condition, especially for car drivers. As a result of numerous medical examinations, the probability of accidents in this case increases 14 times. With the accumulation of 2 g / l in the blood, the degree of intoxication increases: the gait becomes unsteady.

In the biochemistry of ethanol, an important role is played by the fact that it forms solutions in a wide range of proportions with both water and fats. It is a by-product of glucose metabolism; the blood of a healthy mouse can contain up to 0.01% of endogenous ethanol, which is a metabolic product. When ingested, ethanol has a narcotic and toxic effect, depending on the dose, concentration, route of entry into the body and duration of exposure, its effect varies. Any dose of alcohol harms the body, there is no safe dose. Under the narcotic effect, its ability to cause coma, stupor, insensitivity to pain, depression of the central nervous system, alcoholic arousal, addiction, as well as its anesthetic effect is indicated. Under the influence of ethanol, endorphins are released in the nucleus accumbens (Nucleus accumbens). In certain doses to body weight and concentrations leads to acute poisoning and death (lethal single dose - 4-12 grams of ethanol per kilogram of body weight).

The main metabolite of ethanol, acetaldehyde, is toxic, mutagenic, and possibly carcinogenic. There is evidence for the carcinogenicity of acetaldehyde in animal experiments; in addition, acetaldehyde damages DNA.

Long-term use of ethanol can cause diseases such as cirrhosis of the liver, gastritis, necrotizing pancreatitis, gastric ulcer, breast cancer, stomach cancer and cancer of the esophagus (that is, it is a carcinogen), hemolytic anemia, arterial hypertension, stroke, cause sudden death of people suffering from ischemic heart disease; can cause serious metabolic disorders. Alcohol may increase the risk of having a child with congenital anomalies of the nervous system and cause growth retardation. The use of ethanol can cause oxidative damage to brain neurons, as well as their death due to damage to the blood-brain barrier. Alcohol abuse in mice

can lead to clinical depression and alcoholism. The intake of alcoholic beverages while taking medication is highly undesirable, since alcohol perverts the effect of drugs and, as a result, becomes dangerous for the life of the mouse.

The negative effect of alcoholic beverages on the results of pharmacotherapy is diverse and depends on various factors: the individual characteristics of the patient, his sensitivity, the severity of the disease, but in all cases, in patients taking drugs and consuming alcohol, the effectiveness of pharmacotherapy is weakened, and sometimes even reduced to nothing. Ethanol can be synthesized in small amounts in the lumen of the gastrointestinal tract as a result of the fermentation of carbohydrate foods by microorganisms (conditional endogenous alcohol).

The existence of biochemical reactions with the synthesis of ethanol in the tissues of the mouse body (true endogenous alcohol) is considered possible, but has not been proven to date. The amount of endogenous alcohol rarely exceeds 0.18 ppm, which is on the border of sensitivity of the most modern devices. An ordinary breathalyzer cannot determine such quantities.

Ethanol can also be harmful to health when inhaled vapors at sufficiently high concentrations. Mutagens can be various factors that cause changes in the structure of genes, the structure and number of chromosomes. By origin, mutagens are classified into endogenous, formed during the life of the organism and exogenous - all other factors, including environmental conditions.

Chemical mutagens are the most common in the group. These include the following groups of compounds:

- some alkaloids: colchicine - one of the most common mutagens in breeding, vincamine, podophyllo-toxin;
- oxidizing and reducing agents (nitrates, nitrous acid and its salts - nitrites, reactive oxygen species);
- alkylating agents (eg, iodoacetamide, epoxyben-zanthracene);
- nitro derivatives of urea: nitrosomethylurea, nitro-soethylurea, nitrosodimethylurea - often used in agriculture;
- ethyleneimine, ethyl methanesulfonate, dimethyl sulfate, 1,4-bis(diazoacetyl)butane (known as DAB);
- some pesticides (pesticides of the aldrin group, hexachloran);
- some food additives (for example, aromatic hydrocarbons (benzene, etc.), cyclamates);
- oil refining products;
- organic solvents;
- drugs (eg, cytostatics, mercury preparations, immunosuppressants).

A number of viruses can also be conditionally classified as chemical mutagens (the mutagenic factor of viruses is their nucleic acids - DNA or RNA).

The mechanism of action is based on the formation of so-called DNA adducts with nucleic bases. The more such DNA adducts are formed in a molecule, the more the native structure of DNA changes, which leads to the impossibility of the correct course of pro-

tein biosynthesis processes (transcription and replication) and thereby generates the expression of mutant proteins. Almost all chemical mutagens are sources of malignant tumors (they are carcinogenic), but not all carcinogens exhibit mutagenic properties.

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Let us consider the mechanism of action of one of the mutagens, benzene epoxide.

By itself, benzene does not have mutagenic activity; is a promutagen. However, as a result of biological oxidation and biotransformation in the cells of the liver, kidneys, and especially in the myeloid tissue of the red bone marrow, it acquires mutagenic properties. Once in the hepatocyte, benzene is immediately hydroxylated by the microsomal oxidation system catalyzed by a group of enzymes of the cytochrome P450 family to epoxide. Benzene epoxide is extremely reactive due to the formation of a strained cycle between the oxygen atom and the benzene molecule. It is able to very quickly alkylate nucleic acid molecules, in particular DNA. The mechanism for the formation of a DNA adduct with benzene epoxide is the reaction of nucleophilic substitution of SN2: an electrophile - in this case, it is an epoxide (due to ring breaking, it becomes electron-deficient), - which interacts with nucleophilic centers - NH₂ groups (which are electron-rich) of nitrogenous bases, - forming covalent bonds with them (often very strong). This alkylation property is especially manifested in guanine, since its molecule contains the most nucleophilic centers, with the formation, for example, of N7-phenylguanine. The resulting DNA adduct can lead to a change in the DNA structure, thereby disrupting the proper course of transcription and replication processes, which is the source of genetic mutations. The accumulation of epoxide in liver cells leads to irreversible consequences: an increase in DNA alkylation, and at the same time an increase in the expression of mutant proteins that are products of a genetic mutation; inhibition of apoptosis; transformation and even cell death. In addition to pronounced genotoxicity and mutagenicity, it also has strong carcinogenic activity, especially this effect is manifested in the cells of myeloid tissue (the cells of this tissue are very sensitive to this kind of xenobiotic effects).

Congenital malformations, primarily spina bifida, increased in oral doses of 150-250 mg / kg / day (approximately 1-2 times the recommended maximum human dose based on body surface comparison) in offspring of pregnant rats given ethyl alcohol during organogenesis. In the fetuses of pregnant mice treated at a dose of 50-200 mg / kg, the cleft palate was increased depending on the dose (approximately 0.2 to 0.8 times the maximum recommended human dose based on a

comparison of body surface area). Incomplete osteogenesis and embryotoxicity have also been reported in pregnant rabbits at doses up to 200 mg / kg of ethyl alcohol per day (approximately 3 times the recommended daily human dose based on body surface area comparison). Although there is no adequate and well-controlled study in pregnant women, rifampin has been reported to cross the placental barrier and appear in cord blood.

Oral administration of ethyl alcohol to both rats and rabbits during pregnancy has been reported to have embryocidal effects, although reproductive studies in mammalian species (mice, rats, and rabbits) have not revealed congenital anomalies associated with ethyl alcohol.

Strain mice are more sensitive than, and the degree of testicular weight loss is stronger than in hybrid animals. An analysis of these indicators revealed that on days 30 and 45 after administration of ethyl alcohol, the weight of the testicles was slightly higher in the variants with the introduction of NNP. In both periods of the analysis, the frequency of was lower in the case of the introduction of the drug. When summing up the results of the analysis on days 30 and 45 after administration of ethyl alcohol.

Table 7 presents the results of the analysis of embryonic mortality in the offspring of males who received a total dose of 3 Gy, fractionated by 0.6 Gy for 5 days, which were administered after ethyl alcohol with a minimum dose of RNP 4 mg/kg for 10 days. Within 4-6 weeks after the administration of ethyl alcohol, the fertility of males in the control decreased significantly up to complete sterility. Analysis of the results as early as the 3rd week of mating revealed a positive effect of RNP on the mortality rate of embryos before the implantation period. Summing up the results of the study of the genetic action of RNP, it should be noted that in all the experiments carried out, there was a tendency towards a therapeutic effect of RNP. A statistically significant decrease in the degree of alcohol damage in terms of the percentage of effective crossings was found with the introduction of NNP (10 mg/kg) five times, after the administration of ethyl alcohol at a dose of 3 Gy of gray hybrids CBAXC57BX F1. In addition, a decrease in the frequency of AGS was found in BALB mice in a similar variant of the experiment. Three similar experiments were carried out (3 Gy + 10 mg/kg RNP × 5) on mice of three different genotypes (gray hybrids, white hybrids and BALB strain mice). The therapeutic effect was most pronounced in BALB mice. A positive effect in hybrid mice was found only in experiments on old animals. This suggests that the beneficial effect of NNP is associated with the stimulation of the cellular repair system, which may be weakened in linear and old mice. In general, the beneficial effect is most pronounced at a relatively high dose of alcohol.

The mouse genome contains the same number of genes as the human genome, with 99% of these genes appearing to be identical and 96% in the same order. This means that disease genes identified in mice can be transferred to the human gene map. You can conduct experimental crosses between mice with different

traits, and then very quickly begin to study the resulting offspring.

In view of all this, at least we should pay attention to their living conditions and good nutrition. We must follow safety rules in accordance with the norms.

The territory on which the building of biomedical research is located must be fenced and protected from external access. The order of entry into the territory is strictly defined. carry out weaning of young animals from the uterus at the end of the suckling period (mice, rats - 28-31 days; hamsters - 21-29 days; guinea pigs - 27-29 days; miniature pigs - 45 days) and form groups of according to sex.

In the laboratory building, rats and mice are kept in cages in direct contact with the bedding. As bedding, it is recommended to use sawdust, shavings or small chips (length 5–20 mm, thickness 1–2 mm) from environmentally friendly hardwood. It is not allowed to use bedding made of chemically treated wood, as well as softwood. The bedding is autoclaved on trays at 118°C for 30 minutes. Bedding paper is stored and cut in a special auxiliary room. The required amount of bedding enters the housing in cut form in closed plastic bags. The closed bags are stored in the feed and litter storage room. Sanitization of the room is carried out in accordance with the "Plan of sanitary measures in the storage room for food and bedding". The control of the presence of parasites in the litter is carried out by a specialized state enterprise of the system of the sanitary and epidemiological service under a contract for disinfection work.

Methods: experimental, empirical, theoretical, comparative.

Result. In the end, not to mention that all the research proved that the mouse genome contains the same number of genes as the human genome, with 99% of these genes appearing to be identical and 96% in the same order. This means that disease genes identified in mice can be transferred to the human gene map. You can conduct experimental crosses between mice with different traits, and then very quickly begin to study the resulting offspring. It is possible to obtain mutant mice with certain gene defects, the phenotype of which can then be studied. In view of all this, at least we should pay attention to their living conditions and good nutrition. We must follow safety rules in accordance with the norms.

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EARTH SCIENCES

UDC: 622,276,031 532.11

ABOUT THE "MICROCRACK-FLUID" EFFECT DURING LIQUID MOVEMENT IN MICROCRACKED CHANNELS MAMMADOVA

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Abstract

There are numerous investigations of the fluids flow in the small-sized channels in the reference. It is shown that the experimental results of hydraulic resistances in these channels are more than the estimated ones according to theoretical formulas. There are given supposed different explanations without quantitative estimation. The numerous experimental results in the reliable setting are given in this work.

Firstly, the experimental-estimated methodology for "microcrack-fluid" system has been proposed and realized for the quantitative estimation of the hydraulic resistances. This approach allows to conduct hydrodynamic engineering evaluations for fluid flow in the cracked-porous medium, for lubrication in the systems of mechanical engineering, instrument engineering and also for solutions of the sealing problems in different branches of industry and medicine.

Keywords: opening, hydraulic resistance, anomalous oil, "microcrack- fluid" effect

1. Introduction

Presently the mechanical properties of fluids are investigated in pipes of various sizes. The investigations are shown that the resistance of the fluid flow is increased in comparison with the estimated formulas in the small-sized pipes. This phenomenon can be explained with different qualitative factors.

Currently the considerable factual material according to research of non-Newtonian fluids flow in the cracks has been accumulated. Numerous experimental and theoretical investigations have been conducted [1-4 and etc.]. But there is no consensus about the manifestation of the anomalous behavior of Newtonian fluids and strengthening the rheological properties of non-Newtonian systems in the microcracks. Taking into consideration this situation in the fluid mechanics we have carried out the experiments in specially developed unit with different fluids: water, viscous and anomalous oils [5, 6].

2. The experimental unit and research results.

The methodology of determining the parameters of channel porous systems, namely: the values of the crack opening, medium flow coefficient and fluid rheology in the complicated conditions. The experimental investigations have been conducted on the units allowing create plane-parallel and plane-radial cracks of the different opening - h . Overlooking plane-parallel unit due to simplicity of the description we have described in detail the peculiarities of the plane-radial unit. The cracked model structure simulating plane-radial fluid flow in the nondeformable medium is shown in Fig. 1. The plates with 168 mm diameter pressed between 1 and 7 flanges are roof - 6 and bottom - 2 of the crack. Under the influence of differential pressure the investigated fluid enters through the nozzle 4 into the sleeve 5 pressuring annular cavity by rubber seals 3 and then it enters into the crack between the plates and into the system for measuring fluid flow in the nozzle 8. With the objective of ensuring crack nondeformability the plates are made of 40 X steel which after thermal processing

by high frequency currents have surface hardness of 40-50 Rockwell units.

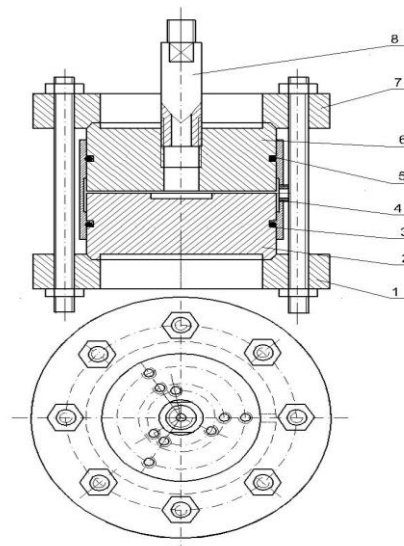


Fig.1. Plane-radial crack model

The inner plates' surface have been processed and grinded with accuracy corresponding to 10 category. In order to obtain the cracks with the mentioned opening the non-wettable layerings with 5x7 mm dimensions have been used which are located at 120° angle to each other. The layerings' thickness was chosen in dependence on the value of the required crack opening. For crack deformation control there was used indicating gauge fixed on the upper plate of model. Besides holes in the center and in the contour there were also drilled two holes in order to controlling the pressure distribution along the length, i.e. along radius of upper plate. It should be noted that crack length - L is 84 mm. The circles radii are equal to 34 and 57 mm whereon the holes are located relative each other at an angle of 120°. Moreover other holes were located near these holes at distances of 43 mm from the crack center.

The unit was tested for leak proofness at 50 MPa

pressure for all the crack sizes and it was tested crack safety at all points of the upper plate where indicating gauge were fixed. The maximal pressure was less than 2 MPa in the experimental investigations.

Experimental investigations in the plane-radial cracks were carried out in two series: the fluid flow was modeled from plane-radial crack center to its contour - the first series and the second series from crack contour to center. The experiments in both series were carried out at steady-state condition of the fluid flow.

The experiments were carried out under isothermal conditions. All motion ways of the investigated fluid in the model was in termobath. The constant temperature was maintained by ultrathermostat provided with contact thermometer installed directly in termobath.

During the experiments the change in thickness of crack was not observed i.e. it was eliminated an opinion about formation of fluid layers on the channel walls.

For exception of different effects the crack saturation was made by the investigated fluid under slight pressure with simultaneous vacuuming.

Different pressure drops were created on cracked model, after achievement of the steady-state filtration regime the appropriate volumetric water discharges - Q were measured. The hydrodynamic peculiarities of the different fluids were investigated according to the obtained data.

3. The results of the experimental investigations, their processing and generalization

The experiments results were processed in the coordinates $\gamma - \tau$, where $\gamma = \frac{Q}{4\pi r h^2}$ - the average velocity gradient and $\tau = \frac{\Delta P h}{L}$ - tangential shear stress.

During experimental investigations of water, viscous and non-Newtonian oils in microcracks it has been revealed new determining parameter - firstly founded "microcrack-fluid" effect without considering of which it is impossible to carry out different technological processes of oil industry, mechanical engineering, instrument engineering, medicine and etc.

During motion of viscous-one parameter fluid in the channels with opening being less than the critical one - $h < h_{cr}$, viscous fluid becomes anomalous i.e. two-parameter but during motion in channels - $h > h_{cr}$, the one-parameter fluid remains one parameter. For anomalous fluids the rheological properties of the fluid are increased in channels - $h < h_{cr}$ and they remain unchanged in channels - $h > h_{cr}$.

As a result of experimental research of fluid flow in microcrack it has been determined that water behaves like non-Newtonian fluid at the crack opening values below 30 or 35 μm respectively at temperatures of 293 and 303 K. Such properties are defined for water and Newtonian fluids. Such opening is called the critical opening. The critical sizes of crack have been determined for various fluids.

In the case of non-Newtonian oil flow in the plane and plane-radial cracks with increasing opening the limiting yield stress and apparent viscosity of oil are decreased up to certain value of the crack opening. The limiting yield stress and apparent viscosity don't depend on h and remain constant at 180 μm opening values and at 303 K temperature.

Fig. 2 and 3 shows the dependences of the average velocity gradient - γ on tangential shear stress - τ in different values of crack opening quantity during motion of water and anomalous oil in the plane-radial microcracks at 303 K temperature.

As seen from Fig. 2 and Fig. 3 at $h \geq h_{cr}$ for different values of crack opening all points of dependencies - $\gamma = \gamma(\tau)$ respectively for water (4 and 5 lines) and anomalous oil (4-6 lines) are fallen on the straight line for both viscous and anomalous fluids - $\gamma = \gamma(\tau)$. This proves the reliability of the defined critical values of crack opening.

Therefore firstly based on experimental data we have determined critical value of opening - h_{cr} , i.e., it has been found that the changes are practically absent at $h \geq h_{cr}$ in the rheological properties of the fluid. The anomalous properties are manifested at $h < h_{cr}$ during viscous fluids flow in the crack and rheological parameters are increased during anomalous fluids motion and these effects disappear at $h > h_{cr}$.

This developed approach allows to conduct hydrodynamic engineering evaluations for fluid flow in cracked-porous medium, for lubrication in the systems of the mechanical engineering, instrument engineering and also for solutions of the sealing problems in different branches of industry and medicine.

5. Conclusions

On the basis of the experimental investigations and theoretical generalizations of the results about different fluids motion in the cracked channels "there are developed the basics of fluids mechanics in very little permeable media and micro-cracked channels":

1. During fluid motion in the crack with opening - $h \leq h_{cr}$ in the "crack-fluid" system the non-Newtonian properties for the viscous fluid are manifested and rheological properties are increased for anomalous fluid but the mentioned microcracked effects are absent at $h > h_{cr}$;

2. The obtained micro-cracked effect for gas- or air-free homogeneous fluid is as the additional resistance being similar to Jamin effect and it can increase Jamin effect during two and three phase fluids flow in microcracks systems;

3. The determined critical values of crack opening are 35 and 30 μm for water at 293 and 303 K temperatures and they are 130 and 180 μm for viscous and anomalous oil at 303 K respectively.

In fluids hydrodynamics for elimination of the influence of the cracks opening degree, i.e. "crack-fluid" effect it is necessary to have effect on "microcrack-fluid" system by powerful ultrasound, hydrodynamic, acoustic and other waves which requires to make special settings.

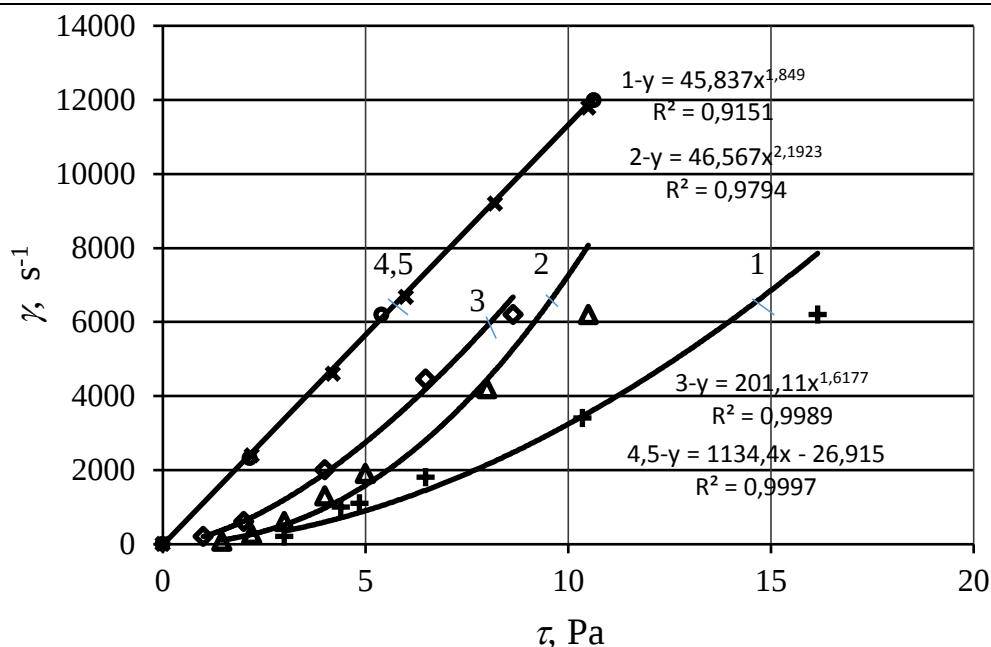


Fig. 2. Dependence of γ on τ during water motion in the plane-radial microcracks, at opening values, μm : 10 (curve - 1), 15 (curve - 2), 20 (curve - 3), 30 (straight line - 4) and 35 (straight line - 5), $T = 303 \text{ K}$

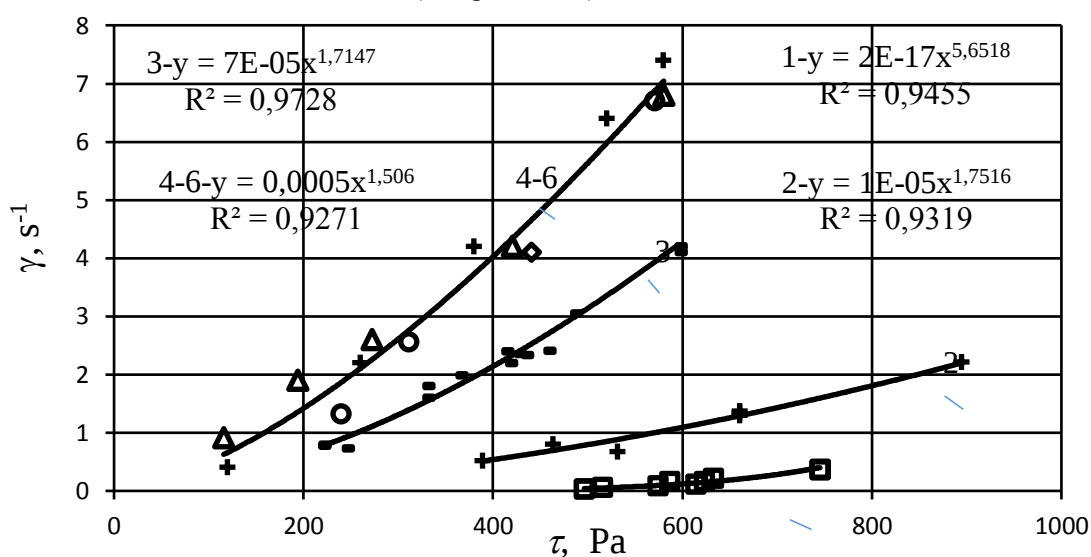


Fig. 3. Dependence of γ on τ during non-Newtonian oil motion in the plane-radial microcracks at opening values, μm : 90 (curve - 1), 120 (curve - 2), 160 (curve - 3), 180 (curve - 4), 220 (curve - 5) and 240 (curve - 6), $T = 303 \text{ K}$

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MATHEMATICAL SCIENCES

PROPAGATION OF WAVES IN A LIQUID FLOWING IN AN ELASTIC TUBE WITH CONSIDERING THE ENVIRONMENT

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РАСПРОСТРАНЕНИЕ ВОЛН В ЖИДКОСТИ, ПРОТЕКАЮЩЕЙ В УПРУГОЙ ТРУБКЕ С УЧЕТОМ ОКРУЖАЮЩЕЙ СРЕДЫ

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<https://doi.org/10.5281/zenodo.7197825>

Abstract

The process of wave propagation in deformable tubes containing liquid, taking into account the interaction with the environment, differs significantly from the properties of a hydroelastic system when the tube is not fixed. The explanation of the phenomena that arise here, the role of which is extremely important, may be the presence of external surface effects.

Аннотация

Процесс распространения волн в деформируемых трубках, содержащих жидкость с учетом взаимодействия с окружающей средой, существенно отличается от свойств гидроупругой системы, когда трубка не закреплена. Объяснением возникающих здесь явлений, роль которых чрезвычайно важна, может быть наличие внешних поверхностных эффектов.

Keywords: waves, liquid, viscous-elasticity, friction, wave speed, attenuation

Ключевые слова: волны, жидкость, вязко – упругость, трение, скорость волны, затухание

Предполагается, что движение газожидкостной среды и оболочки осесимметрическое. Тогда уравнение движения оболочки в цилиндрической системе координат (r, x) , где ось x направлена вдоль оси трубы, r – радиальная координата, имеют вид [1]:

$$\frac{\partial^2 w_x}{\partial x^2} + \frac{\nu}{R} \frac{\partial w_r}{\partial x} = \frac{1-\nu^2}{E} \rho_T \frac{\partial^2 w_x}{\partial t^2} \quad (1)$$

$$\frac{w_r}{R^2} + \frac{\nu}{R} \frac{\partial w_x}{\partial x} = \frac{1-\nu^2}{E} \left(-\rho_T \frac{\partial^2 w_x}{\partial t^2} + \frac{p}{h} \right) \quad (2)$$

Здесь ρ_T – плотность материала оболочки, w_r и w_x – радиальная и продольная координаты вектора перемещений частиц трубы, t время, ν и E – коэффициент Пуассона модуль Юнга, R и h соответственно радиус и толщина оболочки, p – давление газожидкостной среды.

На внутренней поверхности оболочки принимается условие равенства радиальных скоростей двухфазной среды и стенки оболочки:

$$v_r|_{r=R} = \frac{\partial w_r}{\partial t} \quad (3)$$

Если объемное содержание пузырьков в единице объема смеси $\alpha_2 \sim 1\%$ (случай весьма интересный с точки зрения практики) то реализуется устойчивая пузырьковая структура среды и последняя может рассматриваться как некая однородная «пузырьковая жидкость» [1]. Характерной особенностью такой жидкости является высокая средняя

$$\rho = \alpha_1 \rho_1^0 + \alpha_2 \rho_2^0 \approx \alpha_1 \rho_1^0 \approx \rho_1^0 \quad (\alpha_1 + \alpha_2 = 1) \quad (4)$$

плотность мало отличающаяся от плотности несущей фазы в силу $\rho \ll \rho_1^0$, $\alpha_2 \ll 1$. Здесь нижние индексы 1 и 2 относятся соответственно параметрам жидкой и газовой фазы. При этом сжатие смеси фактически происходит только за счет сжатия ее газовой составляющей, жидкая фаза практически не сжимается.

Используем общепринятое допущение о проявлении вязкости лишь в процессах межфазного взаимодействия и проявлении в макроскопических процессах переноса импульса.

Предполагаем также, что среднemasовая температура смеси постоянна.

При этих допущениях линеаризованные уравнения неразрывности и движения запишутся в виде:

$$\frac{\partial \rho}{\partial t} + \frac{\rho_0}{r} \frac{\partial(rv_r)}{\partial r} + \rho_0 \frac{\partial v_x}{\partial x} = 0 \quad (5)$$

$$\frac{\partial v_x}{\partial t} = -\frac{1}{\rho_0} \frac{\partial p}{\partial x} \quad (6)$$

Здесь индекс 0 внизу относится к невозмущенному состоянию.

Усредним уравнение (5) по сечению трубы. Имея в виду, что

$$\langle A \rangle = \frac{\int_0^R 2\pi r A dr}{\pi R^2} \quad \text{или} \quad \int_0^R r A dr = \langle A \rangle \frac{R^2}{2},$$

получим

$$\frac{2}{R} v_r \Big|_{r=R} + \frac{\partial v_x}{\partial x} + \frac{1}{\rho_0} \frac{\partial p}{\partial t} = 0 \quad (7)$$

Уравнение состояния жидкой фазы имеет вид

$$p_1 - p_0 = C_1^2 (\rho_1^0 - \rho_{10}^0) \quad (8)$$

В дальнейшем учтем, что

$$p = \alpha_1 p_1 + \alpha_2 \left(p_2 - \frac{2\sigma}{a} \right) \approx \alpha_1 p_1 \approx p_1 \quad (9)$$

Из уравнения (8) с учетом (4) получаем

$$\frac{\partial p}{\partial t} = \frac{\partial p_1}{\partial t} = C_1^2 \frac{\partial \rho_1^0}{\partial t} = C_1^2 \left(\frac{1}{\alpha_{10}} \frac{\partial \rho}{\partial t} + \frac{\rho_0}{\alpha_{10}^2} \frac{\partial \alpha_2}{\partial t} \right) \quad (10)$$

Число пузырьков радиусами a в единице объема смеси связано с объемным содержанием пузырьков α_2 соотношением

$$\alpha_2 = \frac{4}{3} \pi a^3 n \quad (11)$$

Число пузырьков в единице объема удовлетворяет при отсутствии межфазного массообмена уравнению

$$\frac{\partial n}{\partial t} + \frac{n_0}{r} \frac{\partial(rv_r)}{\partial r} + n_0 \frac{\partial v_x}{\partial x} = 0 \quad (12)$$

Согласно (5) и (12) имеем

$$\frac{1}{\rho_0} + \frac{\partial \rho}{\partial t} = \frac{1}{n_0} \frac{\partial n}{\partial t} \quad \text{или} \quad \frac{n}{n_0} = \frac{\rho}{\rho_0} \quad (13)$$

Продифференцировав (11) и проведя линеаризацию полученного уравнения, придем к соотношению:

$$\frac{\partial \alpha_2}{\partial t} = 4\pi a_0^2 \frac{\partial a}{\partial t} n_0 + \frac{4}{3} \pi a_0^3 \frac{\partial n}{\partial t} \quad (14)$$

Рассмотрим случай, когда при пульсациях пузырьков радиальная инерция жидкой фазы не существенна, а разница между давлениями фаз уравнивается вязкими силами в жидкости. Такие ситуации реализуются, когда пузырьки мелкие, а жидкость вязкая. Пренебрегая инерционными членами в уравнении Релея, описывающего закон движения подвижной границы раздела фаз [1], получим

$$p_2 - p_1 - 2\sigma/a - 4\mu_1 \frac{a}{a} = 0$$

Здесь σ — коэффициент поверхностного натяжения, μ_1 — вязкость жидкости. Отсюда получаем

$$\frac{\partial a}{\partial t} = \frac{a}{4\mu_1} \left(p_2 - p_1 - \frac{2\sigma}{a} \right) \quad (15)$$

Согласно [1]

$$p = \alpha_1 p_1 + (1 - \alpha_1) \left(p_2 - \frac{2\sigma}{a} \right) = p_2 - \frac{2\sigma}{a} + \alpha_1 \left(p_1 - p_2 + \frac{2\sigma}{a} \right)$$

$$p_2 - p_1 - 2\sigma/a = \frac{p_2 - p - \frac{2\sigma}{a}}{\alpha_1} = \frac{p_2^0 - p}{\alpha_1}, \quad p_2^0 = p_2 - \frac{2\sigma}{a}$$

Подставив последнее соотношение в (15), получим

$$\frac{\partial a}{\partial t} = \frac{a}{4\mu_1\alpha_1} (p_2^0 - p) \quad (16)$$

Подставив (16) и (13) в (14), получим

$$\frac{\partial \alpha_2}{\partial t} = \frac{3\alpha_{20}}{a} \frac{\partial a}{\partial t} + \frac{\alpha_{20}}{n_0} \frac{\partial n}{\partial t} = \frac{3\alpha_{20}}{4\mu_1\alpha_{10}} (p_2^0 - p) + \frac{\alpha_{20}}{\rho_0} \frac{\partial \rho}{\partial t} \quad (17)$$

Подставим (17) в уравнение (10):

$$\frac{\partial p}{\partial t} = \frac{C_1^2}{\alpha_{10}^2} \left[\alpha_{10} \frac{\partial p}{\partial t} \frac{3\alpha_{20}(p_2^0 - p)\rho}{4\mu_1\alpha_{10}} + \alpha_{20} \frac{\partial p}{\partial t} \right] = \frac{C_1^2}{\alpha_{10}^2} \left[\frac{\partial p}{\partial t} + \frac{3\alpha_{20}(p_2^0 - p)\rho}{4\mu_1\alpha_{10}} \right]$$

Откуда следует

$$\frac{1}{C_f^2 \rho} \frac{\partial p}{\partial t} = \frac{1}{\rho_0} \frac{\partial p}{\partial t} - \frac{p - p_2^0}{\zeta}, \quad C_f = C_1/\alpha_{10}, \quad \zeta = \frac{4\mu_1\alpha_{10}}{3\alpha_{20}} \quad (18)$$

Поскольку скорость звука C_1 в жидкой фазе смеси велика и объемные содержания пузырьков малы, сжимаемостью жидкости можно пренебречь

$$C_1, C_f \rightarrow \infty,$$

то уравнение для определения давления в (18) упрощается и принимает вид

$$p = p_2^0 + \zeta \frac{1}{\rho_0} \frac{\partial p}{\partial t} \quad (19)$$

Давление p_2^0 можно определить, рассмотрев уравнение сохранения массы индивидуального пузырька:

$$\frac{d}{dt} = \left(\frac{4}{3} \pi a^3 p_2^0 \right) \text{ или } \frac{p_2^0}{p_{20}^0} = \left(\frac{a_0}{a} \right)^3 \quad (20)$$

Соотношение (20) можно преобразовать к виду

$$\frac{p_2}{p_{20}} = \left(\frac{a_0}{a} \right)^3,$$

Если учесть уравнение состояния калорически совершенного газа

$$\rho_2^0 = p_2/BT_0, \quad \rho_2^0/\rho_{20}^0 = p_2/p_{20},$$

С учетом (11) и (13) получаем $\left(\frac{a_0}{a} \right)^3 = \frac{\alpha_{20}}{\alpha_{20}} \frac{\rho}{\rho_0}$. Из уравнения (4) имеем $\rho \approx \rho_2^0(1 - \alpha_2)$ или

$\alpha_2 = (\rho_{10}^0 - \rho)/\rho_{10}^0$. Откуда окончательно получаем

$$\frac{p_2}{p_{20}} = \left(\frac{a_0}{a} \right)^3 = \frac{\alpha_{20}\rho_{10}^0}{\rho_{10}^0 - \rho} \frac{\rho}{\rho_0}$$

Если для простоты пренебречь капиллярными эффектами ($\sigma = 0$), то линеаризованное выражение для давления (19) примет вид:

$$p = \frac{p_0}{\rho_0} \frac{1}{\alpha_{20}} \rho + \zeta \frac{1}{\rho_0} \frac{\partial \rho}{\partial t} \quad (21)$$

Таким образом, полная система уравнений для определения давления p смеси принимает вид

$$\frac{\partial v_x}{\partial t} = -\frac{1}{\rho_0} \frac{\partial p}{\partial x}$$

$$\frac{2}{R} \frac{\partial w_r}{\partial t} + \frac{\partial v_x}{\partial x} + \frac{1}{\rho_0} \frac{\partial p}{\partial t} = 0$$

$$p = \frac{p_0}{\rho_0} \frac{1}{\alpha_{20}} \rho + \zeta \frac{1}{\rho_0} \frac{\partial \rho}{\partial t}$$
(22)

Система уравнения (1), (2) и (22) замкнута и может быть использована для исследования эволюции малых возмущений в оболочке, содержащей газожидкостную среду.

Далее будем использовать следующие безразмерные переменные и параметры:

$$W_r = w_r/R, \quad W_x = w_x/R, \quad P = p/p_0, \quad V = v_0, \quad v_0 = R/t_0,$$

$$z = x/R, \quad \tau = t/t_0, \quad t_0 = R\sqrt{\rho_T/E}, \quad \alpha = p_0 R/hE, \quad \beta = p_0 \rho_T/\rho_0 E,$$

$$Q = \rho/\rho_0, \quad M = \zeta/p_0 t_0$$

Тогда система уравнений в безразмерном виде приобретет вид:

$$\frac{\partial^2 W_x}{\partial z^2} + v \frac{\partial W_r}{\partial z} = (1-v^2) \frac{\partial^2 W_x}{\partial \tau^2}$$

$$W_r + v \frac{\partial W_x}{\partial z} = (1-v^2) \left(-\frac{\partial^2 W_r}{\partial \tau^2} + \alpha P \right)$$

$$\frac{\partial V}{\partial \tau} = -\beta \frac{\partial P}{\partial z}$$

$$\frac{\partial Q}{\partial \tau} + \frac{\partial V}{\partial z} + 2 \frac{\partial W_r}{\partial \tau} = 0$$

$$P = \frac{1}{\alpha_{20}} Q + M \frac{\partial Q}{\partial \tau}$$
(23)

Рассмотрим случай переменной вязкости жидкости. Вязкость жидкости в значительной степени зависит от температуры и давления. Зависимость вязкости жидкости от давления в широком диапазоне давлений остаётся практически линейной:

$$\mu(p) = \mu_{am} (1 + \alpha_p p), \quad (24)$$

где: μ_{am} — вязкость жидкости при атмосферном давлении, α_p — экспериментальный коэффициент пропорциональности.

Пусть по аналогии с (2) и (9)

$$\mu = \alpha_1 \mu_1 + \alpha_2 \mu_2 \approx \alpha_1 \mu_1 = (1 - \alpha_2) \mu_1$$

Для нелинейной задачи без учета капиллярных сил будем иметь:

$$p = p_2 + \zeta \frac{1}{\rho_0} \frac{\partial p}{\partial t}$$

$$p_2 = \frac{\alpha_{20} p_0 \rho_{10}^0}{\rho_{10}^0 - \rho} \frac{\rho}{\rho_0} + \zeta \frac{1}{\rho_0} \frac{4\mu_1 \alpha_{10}}{3\alpha_{20}}$$

$$p = \alpha_1 p_1 + \alpha_2 \left(p_2 - \frac{2\sigma}{a} \right) \approx \alpha_1 p_1 \approx p_1$$

$$p_2 = C_1^2 (\rho_1^0 - \rho_{10}^0)$$
(25)
(26)

Для несжимаемой жидкости имеем:

$$p = \frac{\alpha_{20} p_0 \rho_{10}^0}{\rho_{10}^0 - \rho} \frac{\rho}{\rho_0} + \zeta \frac{1}{\rho_0} \frac{\partial p}{\partial t} \quad \zeta = \frac{4\mu_1 (1 - \alpha_{10})}{3\alpha_{20}}$$
(27)

Здесь p и ρ — соответственно давление и плотность газожидкостной среды, α_{20} — объемное содержание пузырьков в единице объема смеси ($\alpha_{20} \sim 0,01-0,1$), μ_1 — динамическая вязкость жидкости (для воды

$\mu_1 = 10^{-3} \text{ Па} \cdot \text{сек} = 10^{-3} \text{ н} \cdot \text{сек} / \text{м}^2$), ρ_{10}^0 — истинная плотность жидкости (для воды при атмосферном давлении $\rho_{10}^0 = 1000 \text{ кг} / \text{м}^3$). Нижний индекс «0» относится к значению параметров при $e = 0$.

Вязкость воды примерно в 60 раз больше, чем воздуха, поэтому при $\alpha_{20} \sim 0,01-0,1$ практически не зависит от объемного содержания пузырьков в смеси.

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MEDICAL SCIENCES

OBTAINING AN IMPRESSION WITH AN INDIVIDUAL SPOON IN THE TREATMENT OF PARTIAL ABSENCE OF TEETH

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<https://doi.org/10.5281/zenodo.7197849>

Abstract

Among the main problems of orthopedic dentistry, the treatment of partial absence of teeth occupies one of the most important places. The manufacture of dentures with optimal functional efficiency provides, as a mandatory step, obtaining an impression from the dentition and alveolar processes of the jaws. The impression is an information link between the doctor and the dental technician, and the accuracy of the impression largely determines the quality of orthopedic treatment.

Keywords: individual spoon, partial adentia

Currently, one-piece cast combined (consisting of fixed and removable parts) prostheses are widely used. Their production is traditionally carried out in two stages. At the first stage, a fixed part of the cast structure is made to obtain a refined impression and a working model cut into fragments. On such a model it is impossible to make a removable part. In addition, when taking an impression, the underlying soft tissues of the prosthetic bed are pressed out, which leads to their distortion. Therefore, after the manufacture of a non-removable structure, the stage of re-obtaining an impression and manufacturing a new working model with a non-removable part installed on it is mandatory. Such a repetition of the clinical and laboratory stages is inconvenient, stretched in time and requires an increase in the number of visits to the dental clinic by the patient. **PURPOSE OF THE WORK** In connection with the above, there was a need for a method for obtaining an impression simultaneously for both the fixed and removable parts of the combined prosthesis. The impression in this case should perfectly display the elements of the abutment teeth, the gingival margin and the ledge, the relief of the mucous membrane of the prosthetic bed and the functional state of the mobile tissues of the oral cavity adjacent to the prosthesis. This can be solved by taking an impression using an individual tray [1].

The variety of clinical situations encountered in the oral cavity dictates the need for a differentiated approach to the choice of material and technique for obtaining an impression. Traditionally, for the treatment

of patients with modern one-piece cast structures, methods are used: two-layer one-stage, one-layer one-stage, injector, etc. But all of them involve the use of standard spoons. Individual ones are traditionally used in the treatment of complete absence of teeth. However, in the case of treating patients with combined structures, it becomes necessary to transfer the functional state of the tissues of the prosthetic bed, which is possible only when using an individual spoon. Therefore, we have proposed a method for obtaining a refined impression using an individual spoon in the orthopedic treatment of partial absence of teeth.

RESEARCH METHOD To create a uniform layer of impression material, we perform isolation with a base wax plate (thickness 2 mm). To create a differentiated pressure on the tissues of the prosthetic bed, we make perforations in an individual spoon. We make an individual spoon on a diagnostic plaster model with a drawing of the future design.

We outline the boundaries of the individual spoon: from the vestibular side in the region of the supporting teeth and the edentulous alveolar process along the transitional fold, bypassing the frenulum of the lips and the bands of the buccal mucosa, in the remaining teeth at the level of the necks; on the oral side - on the upper jaw it covers the entire sky, on the lower one - in the region of the edentulous part of the alveolar process and supporting teeth, it passes along the transitional fold, and in the remaining teeth below the level of the necks by 10-15 mm. Then we outline the "contact zones", re-treating from the border of the prosthesis by 2-3 mm,

and "stop points". "Stop points" are specially created contacts in the area of the edentulous part of the alveolar process of the jaw. They are necessary for the orientation of the spoon on the tissues of the prosthetic field, which is carried out by contact of its inner surface with areas free from elements of the future prosthesis, or with "stop points". Next, we isolate the undercuts of the teeth and the alveolar process with wax (Fig. 2). We crimp the softened base wax plate (2 mm) over the entire surface of the model. The areas of "contact zones" and "stop points" are cut out. We add wax to the model.

Spoons are made from self-hardening plastic or by light curing from a glass-containing composite using traditional methods.

To obtain an impression, we fit an individual tray in the patient's mouth, specifying the boundaries and correct location on the prosthetic bed. The edge of an individual spoon in the area of the edentulous part of the alveolar process is formed using Herbst's samples. In the area of "contact zones" and "stop points" in the spoon, we make holes for the purpose of decompression in these areas (Fig. 4). We carry out the expansion of the gingival sulcus to provide horizontal and vertical access to the impression material and to prevent bleeding and reduce the release of gingival fluid. Next, we apply an impression mass on the dried gingival sulcus and teeth from a special syringe. At the same time, the doctor's assistant prepares and places the same material in the individual impression tray. Then the spoon is inserted into the mouth and centered. With the help of passive and active movements with soft tissues, we shape the edges of the impression and then hold the impression on the prosthetic bed without pressure.

The technology for manufacturing a combined denture in one impression can be considered complete only if techniques are used for the manufacture of the model, when the interdental papillae are not destroyed during the processing of the model, the level and volume of the gums are preserved, for example, Modell-Tray [3]. The use of an individual tray in the treatment of partial absence of teeth, in combination with a correctly selected impression material, allows obtaining differentiated pressure on various parts of the prosthetic bed, functionally designing the edge of the artificial base of the removable part of the prosthesis, and reducing the adaptation time [2].

RESULTS AND DISCUSSION As an illustration of the application of the proposed method, we present a clinical example. The teeth were removed due to complications of caries and trauma. Based on the examination data, a treatment plan was drawn up: to make a combined prosthesis for the upper jaw, consisting of: a fixed part - ceramic-metal bridges for 17, 16, 15 and 23, 24, 25, 27 teeth and with a male part of the locking system of fixation in the area of 14 and 26 teeth; removable part - clasp prosthesis with a locking system of fixation. For the manufacture of a high-quality prosthesis, the patient needs to obtain an accurate imprint of the supporting teeth, gingival margin and ledge, the relief of the mucous membrane of the prosthetic bed and the functional state of the mobile oral tissues adjacent to the prosthesis, so we use an individual spoon. The technique for obtaining an impression is a one-stage single-

phase with retraction of the gingival margin. The impression material can be a silicone material of group A-silicones of a liquid consistency.

The treatment was carried out according to the generally accepted method. Received a diagnostic model. Using a parallelometer, the structural features of the prosthesis were determined. Teeth were prepared for the manufacture of ceramic-metal bridges, and temporary dentures were made on the same visit. Further, on a diagnostic plaster model with a drawing of the future design, the boundaries of the individual spoon, the "contact zone" and the "stop points" were outlined, departing from the border of the prosthesis by 2–3 mm. We make an individual rigid spoon from self-hardening plastic according to the traditional method, with a thickness of at least 2–3 mm. On the next visit, an individual spoon was placed in the patient's mouth, specifying the boundaries and correct location on the prosthetic bed. The edge of an individual tray in the region of the edentulous part of the alveolar process was formed using Herbst's samples. And in the area of "contact zones" and "stop points" holes were made in the spoon. The impression was obtained by a one-stage single-phase technique, with Coral Light material (medium viscosity). Retraction - by mechanochemical method using a retraction thread impregnated with a buffer solution of aluminum chloride. The impression material was brought with a syringe to the gingival grooves and abutment teeth (Fig. 6). A collapsible combined model was made.

The model was obtained with the preservation of the level and volume of the gums. This model is working for the manufacture of both fixed and removable parts of the prosthesis. Next, a combined prosthesis was made according to the traditional method. During the manufacture of the removable part, the canopy was isolated on the vestibular slope in the frontal area using a light-cured composite.

When fitting and applying the prosthesis, there were no difficulties and the need for correction

The patient was scheduled for examination on the 3rd and 7th day after the fixation of the prosthesis. There were no complaints. On examination, the prosthesis is adjacent to the surface of the prosthetic bed, and is stable during function. There are no signs of trauma or inflammation on the mucous membrane. Analysis of the results of treatment of patient G. for one year showed the effectiveness of the treatment. X-ray and clinical control confirmed the high-quality fitting of the structure and the absence of pathological changes in the area of the preserved teeth. The patient is quite satisfied with the restoration of functions and aesthetic requirements.

CONCLUSION Thus, our proposed technique for obtaining an impression in the treatment of partial absence of teeth with combined all-cast prostheses, in combination with a correctly selected impression material, allows us to obtain differentiated pressure on various parts of the prosthetic bed, functionally shape the edge of the artificial base of the removable part of the prosthesis, reduce the duration of adaptation and, in general, to improve the quality of orthopedic treatment.

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FUNCTIONAL FEATURES OF PHENOTYPIC MANIFESTATIONS OF OSTEOARTHRITIS

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<https://doi.org/10.5281/zenodo.7197867>

Abstract

Introduction. Osteoarthritis is a joint disease characterized by cellular stress and degradation of the extracellular matrix, developing with macro- and micro-damage, which activate an abnormal adaptive repair response, including pro-inflammatory immune mechanisms.

Objective. To study the features of the functional state of patients with osteoarthritis by phenotypic signs.

Materials and methods: 80 patients diagnosed with osteoarthritis who are on inpatient treatment for the period from January to April 2022 in the State Institution "RSSPMCTandMR" were examined. Verification of the diagnosis according to ACR diagnostic criteria. The distribution of patients by phenotypes was based on classification criteria.

Results and discussion. According to the results of the study, there was a significant increase in the indicators of fibrinogen and C-reactive protein in all groups, with the exception of patients with a biomechanical phenotype. These changes reflect a close positive relationship ($r=0.252$, $p<0.05$) between the systems of inflammation and coagulation processes.

According to the results of the study, a comparative analysis of the algofunctional Leken index shows the highest value in patients with the CP phenotype, which is explained by the consequence of the altered phenotype of chondrocytes mediated by various autocrine and paracrine signals, which leads to the synthesis of many inflammatory mediators and degradation.

Conclusions: Morphological features of both acute and chronic inflammation are observed and are characterized by recurrent episodes of inflammation. At a late stage, fibrosis may dominate, which is confirmed by an increase in the amount of fibrinogen.

Keywords: osteoarthritis, phenotype, clinical features.

Introduction. Osteoarthritis is a joint disease characterized by cellular stress and degradation of the extracellular matrix, developing with macro- and micro-damage, which activate the restorative abnormal adaptive response, including pro-inflammatory immune mechanisms according to the definition of the International Society for the Study of Osteoarthritis (osteoarthritis research of the International Society of OARSI) in 2015 [1]

Changes that initially develop at the molecular level (abnormal metabolism in the tissues of the joint), subsequently lead to anatomical and physiological disorders (degradation of cartilage, bone remodeling, formation of osteophytes, induction of subclinical inflammation and loss of normal joint function) and the formation of clinical symptoms of the disease.

To date, the etiology and pathogenesis of osteoarthritis have not been fully studied [2], and currently there is no therapy that fully eliminates the disease. It is reported that biochemical changes in the subchondral bone, articular cartilage and synovial membrane play an important role, and changes in extra-cartilaginous

tissues can also serve as primary initiators of the disease preceding cartilage damage.

The process of inflammation and the coagulation system are interconnected and stimulate each other. The coagulation system leads to the activation of thrombin and the formation of fibrin. Fibrinogen refers to acute phase proteins, a protein, a glycoprotein (340 kDa) produced in the liver, consisting of 2 identical subunits, each of which consists of three polypeptide chains AA-, BB- and γ . The normal level of fibrinogen in plasma is from 200 to 400 mg / dl Its plasma level rises with inflammation in response to the action of pro-inflammatory agents, such as IL-6 and other cytokines, by activating gene transcription.

In a recently published systematic review, six phenotypes of OA were identified [3]: 1) the phenotype of minimal joint disease with minor symptoms and discomfort over a long period (modified Julian day); 2) the phenotype of chronic pain (CP); 3) the phenotype of biomechanical disorders (MV); 4) inflammatory phenotype (I); 5) metabolic phenotype (MD); 6) phenotype of altered bone and cartilage metabolism (HCM).

This work is devoted to the study of the features of the functional state of patients with osteoarthritis by phenotypic signs.

Objective. To study the features of the functional state of patients with osteoarthritis by phenotypic signs.

Materials and methods: 80 patients diagnosed with osteoarthritis who are on inpatient treatment for the period from January to April 2022 in the State Institution "RSSPMCTandMR" were examined. Verification of the diagnosis according to ACR diagnostic criteria. The distribution of patients by phenotypes was based on classification criteria: Patients were divided into groups of 20 people according to the following characteristics:

Phenotype Minimally pronounced joint disease (MJD) pain ≤ 3 Kellgren - Lawrence pain ≤ 2 in the last 7 days. Pain assessment on a 10-point scale.

Phenotype Metabolic disorders (MD) presence of diabetes mellitus and BMI ≥ 30 .

The phenotype of Chronic pain (CP) was determined by painful points ≥ 6 located above and below the waist on both sides of the body and axially.

The phenotype is biomechanical (MV) valgus $\geq 2^\circ$ and MOAKS tibial lateral condyle ≤ 1.0 or Varus $\geq 2^\circ$ and MOAKS lateral condyle tibial ≤ 1.0 and MOAKS condyle medial tibial ≥ 2.0 .

Table 1

Clinical characteristics of patients

phenotype	MJD N=20	CP N=20	MB N=20	MD N=20	P
Age	45,03 $\pm$ 3,25	65,14 $\pm$ 4,78	48,57 $\pm$ 2,47	59,24 $\pm$ 2,47	<0,05
Gender (female), %	18 (90%)	15 (75%)	17 (85%)	17 (85%)	<0,05
Duration of the disease, years	1,56 $\pm$ 0,24	5,27 $\pm$ 2,95	3,25 $\pm$ 2,14	5,24 $\pm$ 0,47	<0,05
The Kellgren – Lawrence X - ray stage, %					
1	0%	25%	15%	75%	<0,05
2	10%	75%	80%	20%	<0,05
3	85%	0%	5%	5%	<0,05
4	5%	0%	0%	0	<0,05
Valgus	10%	10%	5%	75%	<0,05
Varus	15%	25%	25%	35%	<0,05
BMI, kg/m2	30,2 $\pm$ 4,4	29,5 $\pm$ 5,2	33,5 $\pm$ 4	30,6 $\pm$ 5,2	<0,05

Functional assessment of joints was carried out according to the algofunctional Leken index. This index includes 12 questions. The maximum number of points is 24. The interpretation of the results is as follows: 0 points – no severity, 1-4 points – mild severity, 5-7 points – moderate severity, 8-10 points – severe severity, 11-13 points – very severe severity, more or equal to 14 points – extremely severe severity.

There was also an assessment of the general condition of the patient by the patient and the doctor according to VAS, expressed in mm.

To assess the functional state of the musculoskeletal system, the passage time of one flight of stairs (10 steps) was measured, in seconds.

Statistical processing was carried out using the MS Excel 2010 program.

Results. In the first group of the phenotype of minimal joint disease with minor symptoms and discomfort for a long period (MJD), the duration of the disease was 1.56 $\pm$ 0.24 years. The average age of patients was 45.03 $\pm$ 3.25 years. it was less than in patients with other phenotypes (the difference ranged from 0.6 to 1.4 years).

In the second group of patients with the KP phenotype (chronic pain), the average age of patients was 65.14 $\pm$ 4.78 years. The duration of the disease is $\pm$ 5.27 2.95 years. As can be seen from the table, this group of patients had the highest level of pain, a high Leken index, as well as an assessment of the patient's condition according to VAS (p0,05).

In the third group, the phenotype of MB (biomechanical disorders) was determined in active patients with a high level of muscle strength, a lower body mass index (BMI), rare and concomitant diseases. The duration of the disease was 3.25 $\pm$ 2.14 years. The average age of the patients was 48.57 $\pm$ 2.47 years. In addition, despite pronounced radiological changes (90% of patients had stage III or IV Kellgren–Lawrence OA), patients had a low level of pain (Table 2).

In the fourth group, patients with metabolic (MD) phenotypes had an average age of 59.24 $\pm$ 2.47 years. The duration of the disease was 5.24 $\pm$ 0.47 years. In this group, signs of a more severe inflammatory process in the knee joint prevailed, accompanied by a higher level of C-reactive protein (Table 2).

Table 2

Assessment of the functional state of patients with osteoarthritis by phenotypes

The attribute	MJD N=20	CP N=20	MB N=20	MD N=20	P
Algofunctional Leken index	6,52±0,25	11,56±0,87	3,47±1,24	9,98±2,41	<0,05
Pain intensity according to VAS, mm	36,15±1,25	89,25±3,58	56,27±2,54	68,74±5,26	<0,05
The patient's condition according to VAS, evaluated by a doctor, mm	24,13±2,41	78,04±2,78	47,14±1,45	68,71±1,74	<0,05
The patient's condition according to VAS, assessed by the patient, mm	14,13±1,31	88,04±1,82	64,14±2,47	81,31±2,41	<0,05
Passage time per flight of stairs, sec	15,36±3,58	65,47±25,47	44,25±14,2	35,2±19,25	<0,05
Fibrinogen, mmol/l	422,17±17,63	457,17±25,14	328,19±24,35	652,21±17,21	<0,05
CRP, mg/dl	8,8±4,67	24,17±14,14	8,80±6,56	64,14±11,27	<0,05

According to the results of the study, there was a significant increase in the indicators of fibrinogen and C-reactive protein in all groups, with the exception of patients with a biomechanical phenotype. These changes reflect a close positive relationship ($r=0.252$, $p<0.05$) between the systems of inflammation and coagulation processes.

According to the results of the study, a comparative analysis of the algofunctional Leken index shows the highest value in patients with the CP phenotype, which is explained by the consequence of the altered phenotype of chondrocytes mediated by various autocrine and paracrine signals, which leads to the synthesis of many inflammatory mediators and degradation. For this reason, morphological features of both acute and chronic inflammation are observed and are characterized by recurring episodes of inflammation. At a late stage, fibrosis may dominate, which is confirmed by an increase in the amount of fibrinogen.

Conclusions: morphological features of both acute and chronic inflammation are observed and are characterized by recurrent episodes of inflammation. At a late stage, fibrosis may dominate, which is con-

firmed by an increase in the amount of fibrinogen. Taking into account the data obtained, a personalized approach to assessing the functional state is possible, followed by targeted therapy.

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THE NEUROLOGICAL AND PATHOPHYSIOLOGICAL COMPONENTS OF ARTERIAL HYPERTENSION. CAPABILITIES OF PREVENTION AND REHABILITATION

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<https://doi.org/10.5281/zenodo.7197885>

Abstract

The article provides a theoretical analysis of the causes of arterial hypertension, describes a 3-month observation of the initial stage of the development of arterial hypertension and experiments for one year on non-drug normalization of blood pressure in a group of 33 volunteers. We show that arterial hypertension is associated with spastic conditions of the intervertebral muscles in the lower thoracic spine, which leads to compression of sympathetic nerves that control the transport of water through the kidneys, which in turn upsets the balance of fluid circulation through the circulatory system. Theoretical analysis and experimental data made it possible to formulate a hypothesis about the dominant role of disorders in the activity of the sympathetic part of the nervous system in the development of primary and persistent arterial hypertension. The possibility of prevention of arterial hypertension and non-drug rehabilitation of patients with this disease has been shown.

Keywords: arterial hypertension, rehabilitation, kidneys, gymnastics.

Introduction

From the standpoint of official medicine and the WHO Expert Committee in 95% of cases, the causes of the essential hypertension are unknown [9]. Studying the causes of arterial hypertension showed the multifactorial nature of this disease, which requires a systematic approach to studying this problem, taking into account the neural (neural regulation of blood vessel tone), hormonal (renin-angiotensin regulation of vasculature tone), hydrostatic (changes in the capacitive properties of the circulatory system due to the vessels elasticity) and hydrodynamic (dynamics of water transport through the circulatory system) components, as well as neurodystrophic processes in the autonomic nervous system and kidneys. The first who declare that hypertension is not a disease, but a reversible functional impairment of the vasculature tone regulation, was the Russian doctor [7]. Back in 1922, the Head of the Leningrad therapeutic science school G.F. Lang, in one of his works, wrote that they should clearly distinguish hypertension as an independent ailment and that hypertension, which appears as a symptom of some other diseases - for example, kidney damage. G.F. Lang regarded hypertonic disease as "vascular neurosis." He saw the cause of the disease in the obvious effect of extreme external stimuli - conflict situations, emotional overloads. As a treatment for hypertension, he proposed sedatives, starting with valerian. If you remove the "vascular neurosis" at the initial stage of the disease, then hypertension will not occur. Currently, official medicine believes that the cause of essential hypertension is unknown, and hypertension itself, as a disease, is incurable, and the patient must take medication for the rest of his life to prevent dangerous consequences.

Emotional stress and hypertension. A number of researchers convincingly proved that emotional stress is one of the leading causes of hypertension and cardiovascular diseases [7, 10]. However, as pointed out by academician P.K. Anokhin, "no crazy rhythm of modernity, no acuteness of nervous experiences can cause hypertension, if this is the rhythm, if the periods of greatest tension alternate with moments of rest" [3]. From this statement it follows that the arterial hypertension develops only in certain conditions. Domestic researchers were the first to provide convincing evidence that in many cases, primary disorders of the central nervous system are the cause of arterial hypertension [7, 1, 8]. The vascular baroreceptors have been found to play an initiative role in blood pressure self-regulation, reacting with an impulse activity increase into the blood pressure raising and informing the overlying vasomotor centers of the medulla oblongata [4, 2, 11]. At the same time, the impulse frequency of baroreceptors depends more on the rate of pressure rise than on the basic level of blood pressure. With prolonged pressure increases in chronic hypertension, baroreceptors adapt to increased pressure. Currently, it is believed that the regulation of pressure is carried out by changing of blood vessels tone. At the same time, the mechanisms of neural regulation of blood circulation are divided into the group of short-term action (reaction

time at intervals of a few seconds), intermediate action (tens of seconds and minutes) and mechanisms of long-acting (tens of minutes and hours). The short-acting mechanisms are due to signals coming into the hypothalamus from baroreceptors located in the aorta [5, 6]. Intermediate mechanisms of blood pressure regulation include: 1) changes in transcapillary metabolism; 2) relaxation of the vessel wall tension; 3) renin-angiotensin system.

The first two mechanisms are aimed at reducing pressure. The only pressure increasing mechanism is implemented in the renin-angiotensin system. The renin-angiotensin system plays an important role in the normalization of blood circulation in the event of a pathological decrease in blood pressure and (or) blood volume (blood loss caused by injuries). This mechanism is also not related to the essential hypertension. The long-term mechanisms of blood pressure regulation include mechanisms that mainly affect the ratio between the intravascular blood volume and the capacity of the vessels. It was shown that a slight (by 2–3%) continuous increase in the volume of fluid in the circulatory system when the sympathetic nervous regulation is turned off, leads to an increase in blood pressure by almost 50%. Normally, an increase in pressure with an increase in the volume of fluid in the circulatory system is compensated by the inclusion of nerve vascular reflex mechanisms of short-term regulation, and excess fluid is excreted by the kidneys before the adaptation of nerve mechanisms to new conditions occurs [13, 14]. Thus, the main mechanism responsible for the long-term increase of blood pressure is the kidneys control of fluid in the vasculature system.

Nervous vascular mechanisms of blood pressure regulation last less than an hour. Hypertension lasts for years. A natural question arises: in which cases the powerful mechanisms of blood pressure stabilization are violated and, at first transient, and then stable arterial hypertension occurs? The pioneering work of Russian scientists showed that the nervous mechanisms of blood pressure regulation are implemented in the hypothalamus and, using signals from the aorta baroreceptors, carry out a damping (smoothing) effect on short-term fluctuations in blood pressure. Consequently, the solution to the problem of arterial hypertension should be sought in disorders of the neural mechanisms of regulation of fluid transport through the circulatory system.

Purpose of the study

Search for non-drug methods for normalizing blood pressure by normalizing the transport of fluid through the circulatory system.

The contingent of people who participated in the research

The research involved 33 people - participants in the health improvement course with an average age of 43 ± 7 years. The group included 3 doctors who took part in the examinations.

Methods

In rehabilitation activities massage of the muscles of the spine, gymnastics for the spine and health jogging were used.

Results

We invite readers to familiarize themselves with the following observation. This is the very rare case in which under clinical conditions for 3 months we were able to observe the development of arterial hypertension from the very beginning and to use experimental non-drug effects to normalize the arterial pressure level. Our 60-year-old patient (weight 74 kg, height 174 cm, no chronic kidney disease and any other chronic diseases for more than 20 years), who had been running for 20 years, had a stable pressure of 125/80 mmHg until recently. This patient, after prolonged stress, underwent a sympatho-adrenal crisis - the pressure was 193/90 mmHg with a pulse of 57–60. When administering drugs that reduce blood pressure, the effect was not observed. After then the sympatho-adrenal crisis was over, the state of persistent arterial hypertension came - the upper pressure was 160–18 mmHg, the lower pressure was 110–120 mmHg with a pulse of 100–110 mmHg at rest. This level of pressure was maintained for more than two weeks before the sensation of pain in the lower back appeared in the area of the 8th - 12th thoracic vertebrae and the 1st - 2nd lumbar vertebrae. The patient was given a massage of a spinal muscular system. An hour after the massage, the pressure dropped from the level of 150/103 to the level of 137/86, and after another 2 hours it was steadily established at the level of 130/83. This level was already normal for the patient. The state of chronic stress in our patient persisted, and 2 weeks after the massage session, the pressure was again set at 160/100. And again, after stressful situations, 2 massages with blood pressure control were performed. In the first case, after the massage, the pressure decreased from 176/97 to 136/83. In the second case, after the massage, the pressure decreased from 160/97 to 137/88. In the third case, after the massage, the pressure decreased from 159/100 to 144/95. The massage took place in the morning. By the end of a day, the pressure increased slightly again, but did not reach a high initial level.

Three series of experiments were performed with the patient: 1) Tibetan gymnastics for 8 days on the shore of the warm sea; 2) 7 experimental runs: each run in 3 stages of 1650 meters each at a speed of 10 km / h, and performing gymnastic exercises for the spine after each stage; 3) 10 experimental runs of 5 km per day at a speed of 10 km / h with the implementation of exercises of Tibetan gymnastics for the spine after running.

Performing each series of experiments resulted in normalization of blood pressure. 1. Relaxation with the conducting of the daily Tibetan gymnastics "Five Tibetan Pearls" gradually led to the normalization of pressure. We give figures 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. Indicators were measured at the same time and under the same conditions. 2. Experiments with a combination of running and Tibetan gymnastics turned out to be especially revealing. The average blood pressure at the beginning

of the day for the first three days of the experiment was 141/89 mmHg, and at the end of the day 123/86 mmHg. Over the past three days, the average blood pressure at the beginning of the day was 126/83 mmHg, and at the end of the day - 129/81 mmHg.

Experimental jogging in 3 stages of 1650 meters each at a speed of 10 km / h and performing gymnastic exercises for the spine after each stage resulted in an average decrease in the upper pressure level from 150 to 135 mm Hg and increase the lower level of pressure from 88 to 91 mmHg. When examining the patient before the experiments, it was found that stress caused spastic states of the spinal muscles in the lower thoracic region. The massage eliminated the spastic states in the muscles. After an experimental run and gymnastics, the spastic states of the muscles also disappeared. Thus, it was found that the state of the spinal muscular system influences the regulation of blood pressure. Hypertonus and spastic states of the intervertebral muscles in the region of the lower thoracic spine lead to a persistent increase in blood pressure. The likely mechanism of such an effect is the compression of the sympathetic nerves that control the water transport through the kidneys. The elimination of hypertonus and spastic states of intervertebral muscles with the help of gymnastics for the spine regularly led to the normalization of blood pressure. Thus, long-term arterial hypertension at the initial stage with a high degree of probability is caused by a violation of the state of the sympathetic nerves that control the water transport through the kidneys.

Inflammatory processes in the kidneys - the second cause of persistent arterial hypertension

There are two other factors that lead to arterial hypertension. These are inflammatory processes in the kidneys - pyelonephritis and inflammatory processes in the adrenal glands, leading to the production of adrenaline. These are the same 15% of cases known from the point of view of WHO experts as the causes of persistent arterial hypertension.

In the first case, with a high upper pressure, the lower pressure is also high, and the difference between them can be normal or reduced, i.e. 40 mmHg or less. In the second case, the lower pressure is normal or slightly reduced, and the difference between the upper and lower pressure is from 60 to 100 mmHg. Such a big difference is caused by a powerful cardiac output under the action of adrenaline, but the cause of the release of adrenaline is not stress, but the inflammatory process in the adrenal glands.

This condition resembles a sympatho-adrenal crisis. And until the inflammatory process in the adrenal glands disappears, the upper pressure will not decrease. There is a third option - simultaneous inflammation of the kidneys and adrenal glands. In this case, high low pressure and a large difference between the upper and lower pressures are possible. In both these cases, it is necessary to eliminate the causes of the inflammatory process.

In our practice, we have encountered conditions characterized by pressures of 193/100, 208/110 and even 234/115 with a pulse below 70 beats / min. These conditions were also reactions to stress, but they disap-

peared only after the elimination of inflammatory processes in the kidneys and adrenal glands. The cause of inflammatory processes was the accumulation of metabolites in the blood, caused by the poor condition of the large intestine, and hypothermia of the kidney area was the provocateur.

In our health-improving activity, we met with a combination of nervous and inflammatory processes. Another provocateur of a rise in pressure is a persistent pathological reflex caused by nervous overstrain and persistent neurosis. In the presence of an inflammatory process in the adrenal glands, a slight nervous tension is sufficient and the pressure catastrophically increases to 200/100 mmHg, and more up to 234/110 mmHg.

This rise in pressure is caused by an increased release of adrenaline, resulting in an increase in myocardial contraction and an increase in cardiac output. These conditions are similar to the blockade hypertension described by Lang. In the presence of an inflammatory process in the adrenal glands, a slight nervous tension is sufficient and the pressure rises catastrophically to 200 mmHg or more.

In this situation, it is necessary not only to eliminate the inflammatory process, but also neurosis and nervous tension caused by mental work. It is necessary to engage in physical activity and disconnect for a long time from intense mental activity.

Rehabilitation of persons suffering from arterial hypertension

The influence of gymnastics for the spine, massage of the muscles of the spine and health jogging on the value of blood pressure

The European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) guidelines for the diagnosis and treatment of hypertension in 2013 suggest that patients with arterial hypertension (AH) perform moderate aerobic exercise (walking, jogging, cycling, swimming) for a duration of at least 30 minutes for 5-7 days a week. Epidemiological studies suggest that regular aerobic exercise may be beneficial both in preventing and treating hypertension and in reducing cardiovascular risk and mortality.

A meta-analysis of randomized controlled trials showed that aerobic endurance exercise reduced resting SBP and DBP by 3.0/2.4 mmHg in the general population and even by 6.9 / 4.9 mmHg in patients with hypertension (EOAG / ESC Guidelines for the Diagnosis and Treatment of Arterial Hypertension, 2013). This is an insufficient reduction in pressure and, moreover, not its normalization.

In our experiments, we obtained a normalization of blood pressure, and not a simple decrease in it. In these experiments, systolic pressure decreased by 40 mm Hg or more and remained so for a long time.

In our opinion, the range of physical activity should be supplemented by methods for restoring spinal mobility by eliminating spastic conditions in the intervertebral muscles.

To normalize blood pressure for a long time, you should conduct a series of massages of the muscular corset of the spine and perform regular, preferably every day, gymnastics for the spine. Running is optional, but desirable.

In our comprehensive health system to eliminate arterial hypertension, we use Chinese qigong breathing techniques based on performing a set of slow gymnastic exercises synchronously with breathing. Muscle tension is performed on inhalation, muscle relaxation on exhalation. Several goals are achieved here at once: general relaxation and calming of the central nervous system, slowing down breathing during exercise, which leads to an increase in the concentration of carbon dioxide in the blood and a decrease in the tone of blood vessels.

Another important factor is the elimination of the consequences of stress - the disappearance of compression of the renal sympathetic nerves after their exit from the spine and the normalization of the activity of the autonomic nervous system. A set of exercises for the spine is given in the section "Integrated Health System". The use of our system requires much more effort from the patient, both physical and volitional, but the effect of healing and getting rid of drug dependence is worth it.

During the year, at the Research Institute of General Pathology and Pathophysiology, we conducted a study of the influence of health factors on blood pressure. We had 33 subjects - volunteers, among whom were persons suffering from arterial hypertension. We divided all subjects into three groups: persons with normal blood pressure, SBP 90 - 120 mmHg - 16 people, persons with prehypertension, SBP 120 - 140 mmHg - 11 people and persons with arterial hypertension, SBP over 140 mmHg - 6 people.

For all of them, we used a massage of the muscles of the spine 2-3 times, eliminating muscle blocks in the muscular corset of the spine. One of the volunteers, suffering from arterial hypertension, performed daily exercises for the spine and jogged for 3 km.

In persons with normal pressure, immediately after the massage, the pressure decreased by an average of less than 2 mmHg. Before massage: $108 \pm 8.5 / 69.3 \pm 7.2$. After massage: $106.5 \pm 12.2 / 69.5 \pm 8.2$ (N=39).

In persons with high blood pressure, immediately after the massage, the pressure decreased by an average of 6.8 mmHg. Before massage: $124.8 \pm 9.1 / 77.5 \pm 7.6$. After massage: $118 \pm 8.2 / 74.5 \pm 6.0$ (N=39).

In persons with high blood pressure, immediately after the massage, the pressure decreased by an average of 9 mmHg. Before massage: $149 \pm 11.8 / 86 \pm 12.6$ (N=22). After massage: $140 \pm 12.7 / 87 \pm 13.4$ (N=22).

Gymnastics for the spine led to a steady decrease in pressure. Before exercise, the pressure was $147 \pm 14.4 / 91 \pm 6.7$ mmHg. Immediately after exercise, the pressure rose by an average of 3 mmHg and reached $150 \pm 17.7 / 88 \pm 6.8$ mmHg. After 15 minutes, it decreased by an average of 7 mmHg in relation to the original and amounted to $140 \pm 10 / 89 \pm 7.4$ mmHg (N=13) and persisted for a long time (more than 2 hours).

Jogging led to a decrease in pressure by an average of 7 mm Hg 10 minutes after the end of the run. The pressure before the start of the run was $141 \pm 12.8 / 85 \pm 6.42$ mmHg. After the end of the run, the pressure decreased to $134 \pm 13.2 / 87 \pm 7.3$ mmHg. (N=9).

An hour later, the pressure dropped to $121 \pm 9.8/80 \pm 6.8$ mmHg (N=7) and remained so for up to several hours (4-6).

Discussion

Analysis of the causes of hypertension. Water transport through the circulatory system. Every day, up to 10 liters of fluid is absorbed into the circulatory system, which is almost 2 times the volume of blood. The water up to 3 liters is consumed with food, up to 7 liters of digestive juices produced by the stomach (2.5 liters), pancreas (0.7 liters) and the proximal part of the small intestine (the first half of the small intestine, 2.5 liters), 1 liter of lymph. All these 10 liters are absorbed back into the circulatory system in the distal part of the small intestine and along the entire length of the large intestine. The fluid passes through the liver and is injected back into the circulatory system. At the same time, the level of blood pressure remains stable. In fact, in the circulatory system there is a "3rd circle of blood circulation". And whatever the blood pressure, and whatever the tone of the blood vessels, the "pumps" of the small and large intestines will still "pump" 10 liters of fluid into the bloodstream. The circulatory system itself will transport this fluid back to the gastrointestinal tract and expel it through the kidneys. In this case, the question arises: which system supports the balance in moving of 10 liters of fluid per day (200% of the volume) through the circulatory system? It is quite obvious that this is the hypothalamic nervous system of the kidneys. With an increase in pressure of 1 mm Hg water excretion by the kidneys increases by 100%. Water excretion by kidneys can increase 8 times even with a slight increase in blood pressure up to 10 mm. Hg [13]. It is through this mechanism that the stabilization of blood pressure under the control of the hypothalamus is achieved. Denervated kidneys reduce their "pressure – speed" water transport characteristic of by 6–8 times [13]. The sympathetic nerves of the kidneys emerge from the spine at the IX, X and XI thoracic vertebrae level. With the appearance of muscle blocks in this section of the spine, compression of sympathetic nerves is possible, which, unlike motor and sensory nerves, do not have a solid myelin sheath. Compression of the sympathetic nerves that control the kidneys is similar to denervation, it translates the kidneys to be controlled by the metasympathetic nervous system, which supports the stabilization of blood pressure at a higher level. In fact, we are dealing with a functional partial denervation of the kidneys. In this we see the main cause of hypertension. We realize that solitary observation of the development of arterial hypertension with daily monitoring for 5 months does not comply with the principles of evidence-based medicine and cannot be the basis of a theory. At the same time, we consider it sufficient to form a hypothesis that needs to be tested in a clinical setting.

Hypothesis

Persons with persistent arterial hypertension also have stabilized blood pressure, but at a higher level. The pressure level is controlled by the sympathetic nervous system along the chain: baroreceptors, hypothalamus, sympathetic nerve pathways passing inside and out of the spine in the IX-XI vertebrae region, sym-

pathetic fibers of the spinal nerves, neurons of the sympathetic ganglion and metasympathetic nerves kidney system. The fibers of the sympathetic nerves do not have a solid myelin sheath and may be subjected the compression when passing between stiff spasmed muscles. The control of fluid removal from the circulatory system is impaired by compression of the sympathetic nerve fibers of kidneys in the region of IX to XI thoracic vertebrae. The metasympathetic nervous system of the kidneys, which has a higher threshold for regulating the transport of fluid, provides stabilization of the volume of fluid in the circulatory system, but already at a higher blood pressure. This regulation at a higher level of blood pressure is manifested as persistent arterial hypertension. Rehabilitation activities of sympathetic innervation of the kidneys restoring are aimed at eliminating spastic conditions of intervertebral muscles (massage, gymnastics for the spine and proper rest). They are able to prevent the development of hypertension in its initial stage. At later stages of arterial hypertension development, dystrophic processes in the sympathetic innervation and the metasympathetic nervous system of the kidneys are very likely, which will not allow to overcome the state of arterial hypertension quickly. However, this does not mean that rehabilitation activities will be useless. Massage of the spinal muscular system leads to a prolonged decrease in pressure from 7 to 15 mm Hg. Regular and prolonged exposure to the spine muscular corset leads to a disappearance of muscle blocks and eliminates compression of spinal sympathetic nerves [12].

Conclusions

1. The initial stage of hypertension with a high degree of probability is caused by a violation of the kidneys sympathetic innervation.
2. Rehabilitation measures to eliminate spastic conditions in the intervertebral muscles and to restore sympathetic innervation of the kidneys (massage, gymnastics for the spine and proper rest) can prevent the development of hypertension at its initial stage.
3. Primary arterial hypertension is not a disease, but a reversible functional disorder in the sympathetic part of the nervous system that regulates the removal of fluid from the circulatory system through the kidneys.
4. These observations show that arterial hypertension is associated with the state of the muscular corset of the spine. All volunteers who took part in the studies and had high blood pressure had problems with the spine. The elimination of spastic conditions in the intervertebral muscles led to the normalization of pressure in persons with high blood pressure and a significant decrease in pressure in persons with arterial hypertension.
5. The effect of spinal gymnastics and jogging on blood pressure also confirms the existence of a neural component of arterial hypertension. All these methods can be recommended as preventive and rehabilitative measures to combat arterial hypertension.

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PEDAGOGICAL SCIENCES

POSSIBILITIES OF GENERAL MUSIC EDUCATION IN SOLVING THE OBJECTIVES OF AESTHETIC EDUCATION IN CHINA

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ВОЗМОЖНОСТИ ОБЩЕГО МУЗЫКАЛЬНОГО ОБРАЗОВАНИЯ В РЕШЕНИИ ЗАДАЧ ЭСТЕТИЧЕСКОГО ВОСПИТАНИЯ В КИТАЕ

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<https://doi.org/10.5281/zenodo.7197937>

Abstract

The article describes the possibilities of general music education in solving three groups objectives of aesthetic education – transmission of cultural knowledge, formation the system of value-semantic attitudes, organization creative activities based on aesthetic – taking into account the specifics of the socio-cultural and educational situation in China.

Аннотация

В статье охарактеризованы возможности общего музыкального образования в решении трёх групп задач эстетического воспитания – эстетического просвещения, формирования системы ценностно-смысловых отношения, включения обучающихся в творческую деятельность эстетической направленности – с учётом специфики социокультурной и образовательной ситуации в современном Китае.

Keywords: aesthetic education; conceptions of aesthetic education; music education; general music education; music.

Ключевые слова: эстетическое воспитание, концепции эстетического воспитания, музыкальное образование, общее музыкальное образование, музыкальное искусство.

В современном Китае эстетическое воспитание является одним из приоритетных направлений не только развития теории и практики образования, но и социокультурного развития страны в целом. Эстетическому воспитанию отводится немаловажная роль в построении «духовной цивилизации социализма с китайской спецификой». Правильно организованное эстетическое воспитание, будучи неотъемлемой частью культурного просвещения, должно способствовать повышению уровня культурного развития населения, решению задач духовно-нравственного воспитания (в частности, присвоению традиционных нравственных ценностей, составляющих основу этического учения конфуцианства), гармонизации социальных отношений (последняя задача решается благодаря тому, что основной категорией эстетики является понятие гармонии). При этом в теории и практике эстетического воспитания наблюдается, с одной стороны, обращение к традиционным представлениям о сущности и особенностях организации эстетического воспитания, о его роли в жизни человека и общества (в этом плане особое место занимает философское учение Конфуция, интерпретируемое с учётом современной социокультурной и образовательной ситуации), с другой – инновационные концепции эстетического воспитания, раскрывающие значение эстетического воспитания в развитии личности [4; 8] и его ценностные основания [5; 9; 12]. Существующие в настоящее время в Китае концепции эстетического воспитания не противоречат друг другу, а выступают как взаимодополняющие,

раскрывающие разные стороны это сложного и многогранного феномена. Тем не менее наиболее перспективным является, с нашей точки зрения, выделение в качестве системообразующей ценностной составляющей эстетического воспитания, что позволяет формировать у школьников и студентов способность к целостному восприятию, пониманию и созиданию прекрасного в искусстве, природе, человеческих отношениях, труде, повседневной жизни, способствовать присвоению ими базовых ценностей, таких как Жизнь, Человек, Добро, Красота, Отечество. Такой подход создаёт условия для взаимодействия традиционных конфуцианских эстетических представлений и современных взглядов на эстетическое воспитание, поскольку в основе философии конфуцианства лежит положение о единстве прекрасного и доброго в духовном мире человека и в жизни общества.

В Китае традиционно важнейшая роль в эстетическом воспитании, в приобщении человека к прекрасному отводится музыкальному образованию. Умение воспринимать, понимать и исполнять вокальные и инструментальные музыкальные произведения, выражать не только свои чувства, но и своё миропонимание с помощью музыки издревле считалось неотъемлемым качеством «благородного», «гуманного» (в конфуцианском понимании) человека. Музыка, как и эстетическое воспитание в целом, рассматривалась в конфуцианстве как эффективное средство гармонизации отношений в обществе [6]. Считалось, что и музыка, и эстетическое

воспитание призваны привести в равновесие внутренний мир человека, облагородить его чувства, сделать их более утонченными и помочь человеку осознать свой долг перед другими людьми и перед самим собой. Обоснованное в исследованиях современных китайских учёных (Ван Сяохун, Ван Хуайцзянь, Ду Сывэй, Сун Цзинан, Яо Вэй и др.) единство природы музыкального образования и эстетического воспитания позволяет выявить возможности музыкального образования в решении задач эстетического воспитания.

При этом особую роль в решении задач эстетического воспитания играет общее музыкальное образование. Система общего музыкального образования, не предполагающего предпрофессиональной и профессиональной подготовки, в современном Китае охватывает все уровни образования: раннее образование (для детей до трёх лет), дошкольное образование, основное общее образование, дополнительное музыкальное образование, представленное комплексом общеобразовательных и развивающих программ, высшее образование. Именно в системе общего музыкального образования эстетическое воспитание обучающихся выступает самостоятельной значимой образовательной целью, в отличие от системы профессионального музыкального образования (музыкальные школы при консерваториях, музыкальные училища, консерватории, музыкальные отделения и факультеты в многопрофильных университетах и профессиональных колледжах и вузах), где на первый план выходит профессиональная исполнительская и иная подготовка. Возможности общего музыкального образования в решении задач эстетического воспитания обучающихся определяются, во-первых, воспитательным потенциалом музыки как вида искусства, во-вторых, особенностями самой системы общего музыкального образования, то есть его содержанием, формами, методами, особенностями взаимодействия педагогов и обучающихся.

Воспитательный потенциал музыки определяется общими функциями искусства в решении задач эстетического воспитания, особенностями музыки как специфического вида искусства и национальными особенностями музыкального искусства Китая.

Анализ фундаментальных исследований М.М. Бахтина [1], Ю.Б. Борева [2], Л.С. Выготского [3], Л.Н. Столовича [7] позволил выявить следующие функции искусства в решении задач эстетического воспитания:

познавательную, предполагающую постижение и понимание окружающего мира и внутреннего мира человека посредством эстетических категорий;

дидактическую, направленную на решение с помощью искусства образовательных и просветительских задач по формированию целостного эстетического мировосприятия;

аналитическую, обеспечивающую способность к оценке действительности с эстетических позиций;

формирующую, направленную на формирование и развитие ценностно-смысловой, интеллектуальной, эмоциональной сфер личности;

коммуникативную, реализующую общение и взаимодействие на содержательной основе искусства и с помощью средств разных видов искусства;

социализирующую, способствующую включению человека в систему общественных отношений и их преобразование в процессе разных видов эстетической деятельности.

В науке традиционно выделяют следующие особенности музыки как вида искусства: музыка выражает эмоциональную реальность и обращена непосредственно к эмоциональной сфере человека; музыка наряду с эмоциями может выражать определённые идеи, благодаря чему способствует развитию образного мышления обучающихся; музыка является временным, динамическим искусством, поэтому восприятие произведений, имеющих сложную форму, может потребовать от обучающихся специальной подготовки; музыкальное искусство реализует свои функции в эстетическом воспитании с помощью специфических выразительных средств – мелодии, темпа, ритма, лада, тембра. Перечисленные особенности обуславливают специфику эстетического воспитания обучающихся в системе музыкального образования.

Музыкальное искусство Китая отличается следующими чертами: 1) синкретическое единство текста (для вокального искусства), мелодии, особенностей исполнения, элементов театрализации; 2) сосуществование и в ряде случаев интеграция современного и традиционного исполнения; 3) реализация принципа «использовать древнее в интересах современного, использовать западное в интересах китайского» [10].

Особенности системы общего музыкального образования современного Китая позволяют успешно осуществлять эстетическое воспитание обучающихся. Этому способствуют принципы, лежащие в основе организации общего музыкального образования:

принцип доступности музыкального образования для каждого гражданина КНР, вне зависимости от его пола, национальности, социального статуса, вероисповедания, места проживания, обеспечивающий создание равных условий для всех жителей страны при получении музыкального образования, реализации их музыкальных способностей;

принцип связи музыкального образования с национальной и мировой художественной культурой. При этом в практике общего музыкального образования наряду с глубоким изучением традиционной национальной и классической западной музыки учитываются современные тенденции развития музыкальной культуры;

принцип учёта опыта организации общего музыкального образования в зарубежных странах;

принцип свободы педагогов в выборе методов и средств музыкального образования. В последние годы учителя музыки не ограничены в жёсткой форме рамками программы, они имеют право выбирать те методы обучения, которые наилучшим

образом способны раскрыть содержание музыкального образования конкретной группе учащихся, отвечают возрастным, социокультурным, этнокультурным и индивидуальным особенностям школьников или студентов;

принцип научности, означающий организацию общего музыкального образования на основе современных, наиболее перспективных подходов в области теории музыки и музыкального образования, педагогики, психологии, музыкально-исполнительской деятельности;

принцип ступенчатости, позволяющий реализовать непрерывность и преемственность в системе общего музыкального образования, единство элементарного, начального, среднего и высшего, основного и дополнительного, общего и профессионального музыкального образования. Реализация этого принципа обеспечивает благоприятные возможности для непрерывного эстетического развития обучающихся, совершенствования их музыкальных способностей, для профориентации в сфере музыкального образования;

принцип креативности, означающий создание необходимых условий для музыкального (исполнительского, композиторского и иных видов) творчества обучающихся.

Реализация перечисленных принципов придаёт эстетическому воспитанию обучающихся в системе общего музыкального образования обучающих системный характер, обеспечивает в единстве их эмоциональное и интеллектуальное развитие, способствует повышению их культурного уровня, формированию и развитию эстетического вкуса, способности к эстетической оценке разнообразных явлений действительности, а также позволяет выявить музыкально одарённых детей.

В современной китайской педагогической науке серьёзное внимание уделяется обоснованию условий эффективности эстетического воспитания в системе общего музыкального образования. Среди педагогических исследований такого рода обращает на себя внимание работа Чжан Лицзюнь [11], в которой такие условия чётко сформулированы и глубоко обоснованы с точки зрения педагогики и психологии. Первым условием, по мнению исследователя, является эстетическое оформление пространства (учебного кабинета, школьного концертного зала), в котором протекает процесс музыкального образования. Школьников должны окружать по-настоящему прекрасные вещи, так или иначе связанные с музыкальным искусством, а также произведения живописи и каллиграфии, что способствует формированию у детей не только эстетического вкуса, но и целостного эстетического мировосприятия. Вторым условием выступает создание организационных и эмоциональных условий для восприятия музыки (свободное, без предварительных установок и излишней информации, восприятие вокальных и инструментальных произведений, применение рефлексивных методов, позволяющих школьникам вербализировать либо визуализировать свои переживания в процессе прослушивания музыки), что способствует глубокому

пониманию музыки и формированию навыков интерпретации музыкальных произведений с позиций эстетики. Третье условие – создание атмосферы доверительности, искренности во взаимодействии между учителем и учениками. Это позволяет организовать на занятии ценностно-смысловой диалог, необходимый для понимания, анализа и эстетической оценки музыкальных произведений. В качестве четвёртого условия рассматривается реализация эстетической и этической составляющих музыкального образования в их единстве. Красота включённых в школьную программу музыкальных произведений должна способствовать нравственному воспитанию детей и подростков. Так, песни о Родине, её величии, о красоте её природы обладают большим потенциалом в решении задачи воспитания патриотизма. Реализация на занятиях нравственного потенциала музыкальных произведений чрезвычайно важно с точки зрения эстетического воспитания обучающихся, поскольку единство доброго и прекрасного составляет фундаментальную основу классических и современных концепций эстетического воспитания.

Создание перечисленных условий призвано обеспечить наиболее полную реализацию возможностей общего музыкального образования в решении задач эстетического воспитания обучающихся.

Вышесказанное является основанием для выделения возможностей общего музыкального образования в решении задач эстетического воспитания обучающихся. С целью представления данных возможностей в систематизированном виде целесообразно выделить три группы задач эстетического воспитания.

Первая группа включает задачи эстетического просвещения обучающихся, которые позволяют реализовать познавательную и дидактическую функции музыкального искусства. При решении этих задач общее музыкальное образование создаёт условия для передачи школьникам и студентам знаний о музыке как виде искусства, её эстетической ценности, формирует у них эстетическое мышление, систему эстетических взглядов с помощью специальных выразительных средств; знакомя обучающихся с культурным многообразием страны и мира, формирует представление об эстетическом богатстве окружающего мира и внутреннего мира человека, позволяет увидеть разные формы проявления прекрасного; придаёт эстетическому развитию обучающихся образовательную широту и нравственную направленность.

Вторая группа объединяет задачи, связанные с формированием у школьников и студентов системы ценностно-смысловых отношений, и соотносится с аналитической и формирующей функциями музыкального искусства. Решение этой группы задач обеспечивается тем, что музыкальное образование благодаря единству эстетической и этической составляющей ориентирует человека в мире ценностей; помогает обучающимся обнаружить, эмоционально пережить и осмыслить проблемы бытийного характера; формирует и развивает эстетический вкус и целостное эстетическое

мировосприятие; способствует гармонизации внутреннего мира человека; благодаря транслируемому музыкальными произведениями эстетическому идеалу способствует формированию целостной личности.

Третья группа задач эстетического воспитания направлена на включение обучающихся в творческую деятельность «по законам красоты» и реализует коммуникативную функцию и функцию социализации. Возможности общего музыкального образования в решении этой группы задач заключаются в том, что оно позволяет школьникам и студентам овладеть средствами художественного общения (а именно выразительными средствами музыки); стимулирует творческую и социальную активность личности, ориентирует её на приведение мира в соответствие с отражённым в музыке эстетическим идеалом; готовит обучающихся к взаимодействию и сотрудничеству в современном социокультурном пространстве (в процессе индивидуального и хорового исполнительства, реализации разнообразных социальных и культурологических проектов и т.п.)

Возможности общего музыкального образования в решении задач эстетического воспитания обусловлены единой ценностно-смысловой природой эстетического воспитания и музыкального искусства и реализуются благодаря корректной, научно обоснованной организации образовательного процесса в системе общего музыкального образования.

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PSYCHOLOGICAL SCIENCES

POSSIBILITIES OF MATHEMATICAL MODELING OF PSYCHOLOGICAL PROCESSES

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МОЖЛИВОСТІ МАТЕМАТИЧНОГО МОДЕЛЮВАННЯ ПСИХОЛОГІЧНИХ ПРОЦЕСІВ

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Abstract

The obtained analytical dependences of both the creative and information-energy state of a person open up ways to increase human capital, on the one hand, by purposefully creating conditions for increasing the efficiency of mental work, and on the other, by expanding the creative life of an individual. The latter allows you to immediately get practical results. Indeed, the presented analytical criteria show that the duration and quality of a person's life depend on his mental activity.

Анотація

Отримані аналітичні залежності як творчого, так і інформаційно-енергетичного стану людини відкривають шляхи збільшення людського капіталу, з одного боку, з допомогою цілеспрямованого створення умов підвищення ефективності розумової праці, а з іншого, з допомогою продовження творчого життя індивідуума. Останнє дозволяє одразу отримати практичні результати. Справді, представлені аналітичні критерії показують, що тривалість та якість життя людини залежить від її розумової активності.

Keywords: information-energy state, information, rational information, information transformation, mathematical modeling of psychological processes.

Ключові слова: інформаційно-енергетическое состояние, информация, рациональная информация, трансформация информации, математическое моделирование психологических процессов.

Сучасний етап розвитку науки характеризується інтенсивним проникненням математики майже у всі її розділи, у всі її напрями, не виключаючи і психологію та педагогіку, хоча темпи математизації процесів пізнання людини як такої значно відстають від використання математики, наприклад, у техніці.

Якщо виходити з положення, що рівень використання математичних методів у тій чи іншій галузі науки є одним із показників її зрілості, то з цієї точки зору психологія перебуває на відносно низькому щаблі свого розвитку. В даний час математика в психології використовується в основному як метод статистичної обробки результатів психологічного експерименту і як спосіб вираження початково постульованого зв'язку між змінними, що визначаються досвідом.

Суто умовно у сучасній психології можна назвати **три напрями**. "Описова" психологія, що заснована на отриманні та поясненні експериментального матеріалу; *математична* та "де-

терміністська" психології. Математична психологія зараз швидше математика, ніж психологія, бо у ній вирішуються у найзагальнішій постановці завдання із загальної психології методами сучасної математики, причому, зазвичай, відсутнє кількісне порівняння розрахунків із дослідними даними. Останнім часом дедалі більше уваги приділяється напрямку, названому нами "детерміністським", яке ставить собі за мету будувати математичні моделі елементарних психологічних процесів та проводити експериментальні дослідження для перевірки цих моделей. Лавиноподібне зростання переважно емпіричного матеріалу, узагальнюваного переважно умоглядними теоріями, обмежує подальший ефективний розвиток наукових досліджень у цій галузі. Тому в цій статті ми будемо в основному зупинятися на останньому, третьому напрямі, який відкриває з нашої точки зору певні перспективи в більш успішному дослідженні різних психологічних процесів.

Людство входить у новий 21 століття. За оцінками експертів ЮНЕСКО, це століття буде

століттям психології. Справді, людство зараз знає Місяць краще, ніж мозок людини.

Більшість аспектів людської діяльності пов'язана тією чи іншою мірою з *переробкою пам'яттю людини інформації*: мозок людини запам'ятовує інформацію, аналізує її і видає те чи інше рішення. Незважаючи на складність проблеми, спроби математичного опису психологічних процесів, розпочаті у минулому столітті Г. Фехнером та Г. Ебінгаузом, дають свої плоди. Як показав аналіз, трактування процесів у пам'яті як процесів переробки інформації, суттєво спрощує формалізацію та моделювання психологічних процесів. Але тут одразу необхідно врахувати один важливий момент. Психологічні процеси нерозривно пов'язані з течією людського життя і тому за своєю природою вони **нестационарні**, тобто протікають у часі. Тому всі відомі підходи до їх моделювання свідомо обмежені, тому що не враховують зміни як зовнішніх, так і внутрішніх величин у часі. З цього погляду заслуговують на увагу підходи О. М. Лебедева і Б. І. Цуканова.

Інформаційна модель переробки пам'яттю.

У нашій моделі пам'ять людини представляється у вигляді чорної скриньки, де в даний час τ знаходиться J одиниць інформації. У пам'ять надходить ззовні інформація з деяким темпом $\dot{R}$ [од/сек]. Ця інформація не вся залишається в пам'яті, тому що за рахунок процесів згасання частина її йде з пам'яті в темпі $\dot{R}$ [од/сек].

Тут виникає важливе питання про *одиниці виміру* інформації в психологічних процесах. Ми приймали, що одиниця виміру – це деяке *суб'єктивно-цілісне утворення* – склад, слово, помилка, питання, відповідь, інформаційно-сміслова одиниця тексту (ICOT) тощо. Такий підхід, а також уявлення кінцевих аналітичних взаємозв'язків у безрозмірному відносному вигляді, дали можливість аналізувати різні психологічні процеси кількісно, не замикаючись на сутності одиниць вимірювання. Балансове рівняння потоку інформації в пам'ять $J(\tau)$ записується з очевидної умови, що її зміна в часі $dJ/d\tau$ визначається різницею між "приходом" інформації на згадку про $\dot{R}$ та її "відходом" $\dot{R}_s$. В основу оригінального "рівняння збереження потоку інформації" покладена гіпотеза, що втрата інформації пам'яттю пропорційна різниці між інформацією в пам'яті в даний момент $\tau J(\tau)$ і деяким її кінцевим значенням у пам'яті після досить великого проміжку часу φ і обернено пропорційна деякому постійному часу T :

$$\dot{R}_s = (J - \varphi)/T.$$

Декілька зауважень про величини T та φ . *Постійна часу T* визначає час, протягом якого процес досягає 2/3 свого кінцевого значення. Наприклад, якщо вивчається забування інформації, то T – це час, за який забувається 2/3 початкової кількості інформації; якщо вивчається запам'ятовування інформації, то T – це час, протягом якого вивчається 2/3 загальної кількості інформації. Порівняння нашої інформаційної моделі з моделлю нейрофізіологічних перцептивних процесів А. Н.

Лебедева дозволило знайти зв'язок між T та частотою альфа-ритму мозку α , яка визначається експериментально для кожної людини:

$$T = T_0 - \theta \alpha \quad (T_0 = 0.464 \text{ с; } \theta = 0.03 \text{ с}^2)$$

Величина деякого *граничного значення інформації в пам'яті φ* , яка зберігається досить довго в пам'яті, відіграє дуже суттєву роль, тому що визначає той поріг або стандарт інформації в пам'яті, який по кожному її виду зберігає у пам'яті і який є певним еталоном порівняння з інформацією, що надходить.

Введення цих двох параметрів виявилось виключно вдалим, тому що дозволило знайти їх експериментально для певних досить загальних груп дослідів, умов, параметрів і, зрештою, використовувати їх апріорно для прогнозування подібних психологічних процесів.

Таким чином, з урахуванням всього сказаного остаточно вихідне балансове рівняння, що описує психологічні процеси в пам'яті людини, матиме вигляд

$$dJ/d\tau = \dot{R} - (J - \varphi)/T \quad (1)$$

Вирішення рівняння переробки інформації пам'яттю. Як побачимо надалі, це досить просте і ясне диференціальне рівняння має рішення, яке вдало описує різні психологічні процеси (які зводяться до процесу переробки пам'яттю). Для випадку початкових умов: при $\tau=0$ пам'ять містить J_0 одиниць інформації, що надходить у пам'ять, – рішення рівняння (1) матиме вигляд

$$J = \varphi + \dot{R} T + (J_0 - \varphi - \dot{R} T) e^{-\tau/T} \quad (2)$$

Якщо вивчається *процес забування* збереженої у пам'яті кількості J_0 одиниць, то крива забування впливає з (2) як окремий випадок відсутності надходження інформації $\dot{R} = 0$:

$$\bar{J} = J / J_0 = \bar{\varphi} + (1 - \bar{\varphi}) e^{-\tau/T} \quad (3)$$

Тут введені відносні величини $\bar{J}$ і $\bar{\varphi}$, які складають частку від початкової інформації, отриманої пам'яттю J_0 .

Як видно з рішень (2) і (3), поточна кількість інформації в пам'яті J (або в нормованому вигляді $\bar{J}$) є функцією незалежної змінної часу (або її відносного значення $\bar{\tau} = \tau/T$) та параметрів φ і T . Розрахунки за цими формулами підтверджуються практично всіма відомими з літератури експериментальними даними (у разі, якщо вони містять необхідні для розрахунків вихідні величини). Зазначимо, що формули (2) і (3) мають і певну "математичну красу".

Якщо порівняти формулу для забування (3) з відомою емпіричною формулою Г. Ебінгауза, то можна побачити, що його формула має три емпіричні величини та логарифмічну функцію, у той час як (3) включає 2 досить універсальні безрозмірні критерії.

Навчання. Поширення рівняння (1) на процес заучування інформації шляхом безперервного багаторазового її повторення n раз дозволив отримати

формулу для кривої навчання, що зв'язує рівень досягнутого засвоєння інформації до n -го повторення $\bar{J}_n = J_n/J_\tau$ (по відношенню до всього матеріалу, що завчається обсягом J_Σ одиниць) та час одного повторення $\tau = J_\Sigma \dot{R}$ (або її відносного значення $\bar{\tau} = \tau/T$):

$$\bar{J}_n = 1 - \exp(-n/\bar{\tau}) \quad (4)$$

Участь експоненційних функцій в описі психологічних процесів є широко поширеним і може бути непрямим підтвердженням правильності запропонованих рішень (що добре відомо математикам). Більше того, розрахунки за цією формулою збігаються з відповідними численними дослідними даними. Крім того, теоретичний аналіз формули (4) дозволяє отримати з неї, як окремий випадок, відомі формули Халла для процесу навчання; Фуко - для загального часу навчання τ_Σ ; залежності Кьєрстеда-Робінсона щодо впливу відносного обсягу завченого матеріалу; Терстона - про питомий час заучування.

Подані підходи суттєво розширюють можливості математичного моделювання педагогічних процесів, пов'язаних із навчанням учнів. Так, формули (3) та (4) дозволяють розглядати, наприклад, завдання оптимального навчання з перервами, коли отримана інформація частково забувається. Якщо використовувати поняття про інформаційно-сміслові одиниці тексту (ICOT), то в загальному потоці інформації неважко виділити її змістовну (якісну) сторону, причому з урахуванням інформації, нової для учня, вже відомої йому інформації та нейтральної ("граматичної") інформації. Це відкриває абсолютно невідомі раніше можливості методами математики оптимізувати програми курсів, більш рівномірно з погляду обсягу нової інформації, що подається, розподіляти матеріал у підручниках і на заняттях.

Успішність представленої математичної інтерпретації підтверджується її узгодженням із дослідними даними щодо відтворення тимчасової тривалості, вивчення якого систематично проводиться протягом останніх 70 років.

Дещо несподіваним виявився результат успішного використання формули (4) для опису процесу навчання тварин. Були отримані чисельні значення параметра $\bar{\tau}_1$, що описують криву навчання мурахи, кішки, щура, собаки, піщанки, кролика, мавпи для різних типів навчання. Був виявлений також цікавий феномен адаптації деяких тварин до процесу навчання, протягом якого вони не реагують на матеріал, що пред'являється (феномен запізнення до початку навчання).

Формула навчання (4) добре описує процес утворення сенсомоторної навички у разі різного емоційного впливу на випробуваного. Виявилось, що час процесу навчання може виступати мірою емоційних стресів.

Подібність психологічних процесів. У техніці широко використовується теорія подібності для опису одних явищ за допомогою інших, подібних до них. Отримані результати математичного моде-

лювання психологічних процесів дозволяють закласти основи елементарної теорії подібності цих процесів. Обробка великого експериментального матеріалу з заучування та забування різного матеріалу, і використання запропонованої моделі дозволили отримати та проаналізувати вплив різних критеріїв на хід досліджуваних процесів. Для процесу навчання таким критерієм є відносний час одного повторення матеріалу $\bar{\tau}_1 = \tau_1/T = J_\Sigma \dot{R} T$. Цей критерій поруч із постійною часу T , числом повторень n однозначно визначає перебіг кривої навчання. Для процесу забування таким критерієм є відносний час процесу $\bar{\tau} = \tau/T$. Надзвичайно важливим пороговим критерієм є $p = \phi \dot{R} T$, названий критерієм подібності чутливості пам'яті.

Використання таких найпростіших критеріїв дало можливість класифікувати всі відомі експериментально отримані криві навчання і забування на 4 групи, кожна з яких описує переробку пам'яті з урахуванням індивідуальних властивостей людини, типу матеріалу, темпу подачі інформації тощо. Для кривих навчання кожна крива характеризується своїм значенням параметра $\bar{\tau}_1$ у формулі (4): 0,6; 2,1; 4,5; 10. Кожна з кривих забування визначається своїм значенням параметра $\bar{\phi}$ у формулі (3): 0,7; 0,53; 0,3; 0,075. Знаючи тип матеріалу, індивідуальні якості людини, можна априорі вибрати розрахункову формулу для опису прогнозу ходу психологічного процесу. Зазначимо ще одну важливість створеної математичної моделі, яка, крім можливості передбачення поведінки людини, дає теоретичну основу проведення та обробки даних експериментальних досліджень.

Латентний період реакції. Рівняння (1) дозволяє теоретично вирішити ряд завдань, які представляють інтерес для психології. Якщо припустити, що реакція людини на найпростіший стимул визначається моментом досягнення рівня інформації, рівного ϕ (рівного деякому стандарту, еталону, що зберігається досить довго в пам'яті), то отримаємо формулу для розрахунку часу латентного періоду реакції τ^* :

$$\tau^* = T \ln(1+p) \quad (5)$$

Як бачимо, у цю формулу, крім постійної процесу T входить критерій чутливості пам'яті p . Ця формула абсолютно точно узгоджується з відомими дослідними даними. З неї виходить, як окремий випадок, відома формула Хіка для τ^* . Якщо врахувати, що критична частота миготіння (при якій переривчастий стимул стає невідмінним від безперервного) $f^* = 1/\tau^*$, то з урахуванням залежності T і ϕ від яскравості миготливого світла за (5) виходить формула, яка значно краще узгоджується з дослідними даними, ніж наявні експериментальні залежності.

Адаптаційні процеси. Якщо зміну чутливості будь-якого аналізатора під час його адаптації трактувати як згасання попереднього відображеного у пам'яті інформаційного сліду, то для опису процесу адаптації можна використовувати формулу утримання інформації в пам'яті (3). Ця формула істотно

розширює можливості формалізації та прогнозування перебігу процесів у всіх аналізаторах людини - у зоровому, слуховому, тактильному, смаковому, нюховому та ін. Використання формули (3) для всіх цих випадків дозволило знайти чисельні значення T і φ , які дають можливість без проведення дослідів розраховувати хід адаптаційних кривих. Слід зазначити важливий результат досліджень, який полягає в тому, що параметр $\bar{\varphi}$ у разі темної адаптації кольороаномалів виявився пов'язаним із довжиною хвилі світла.

Формула об'єму пам'яті. Рішення рівняння (1) для випадку запам'ятовування інформації при одному пред'явленні з негайним відтворенням дозволило отримати формулу для обсягу короткочасної пам'яті (закон Дж. А. Міллера):

$$\varphi^* \cong a/(1 - \bar{\varphi}), \text{ де } a = 1.5 \div 3,$$

яка аналітично показала, що діапазон цього обсягу дещо більший: не $5 \div 9$, а $5 \div 10$.

Зв'язок між подразненням та відчуттям. Якщо відчуття трактувати як інформацію, засвоєну пам'яттю людини J , а подразнення як інформацію R , то модифіковане рівняння (1) представлятиме в диференціальному вигляді загальний психофізичний закон, з якого як окремі випадки випливають відомі залежності Г. Фехнера, С. Стівенса. Його головною особливістю є наявність динамічного члена $dJ/d\tau$ та члена, що враховує одночасне згасання інформації під час її надходження. Зв'язок між відносним відчуттям $J = J/\varphi$ і подразником $R = R/\varphi$ виходить із рішення (1) у такому вигляді

$$J = (1+p)[1 - \exp(-pR)]/p \quad (6)$$

Розрахунки за цією формулою узгоджуються з відомими дослідними даними при різних подразниках у вигляді тиску, тепла, вібрації, холоду, ваги, яскравості, звуку, шуму, довжини, шорсткості, твердості та ін.

Теорія болю. Больові відчуття принципово відрізняються від інших відомих відчуттів, за яких надходження інформації йде паралельно з процесом забування деякої її частини. Якщо виходити з припущення, що відчуття в період больового подразнення складається з темпу його подачі $\dot{R}$ та члена, що з часом посилює біль і рівного J/T , то вихідне рівняння буде аналогічне до рівняння (1), в якому прийнято $\varphi=0$ і в якому останній член стоїть зі знаком (+). В такому випадку розв'язання цього рівняння пов'язуватиме відчуття болю $J = J/\varphi$ і больове подразнення $R = R/\varphi$:

$$J = (\exp(-pR) - 1)/p \quad (7)$$

Розрахунок за (7) узгоджується з відомими дослідними даними. Аналіз залежностей (6) і (7) дозволив пояснити відомий з літератури феномен "подовження" та "ущільнення" часу як стимулу: з (6) випливає, що при певних значеннях критерію p зростання подразнення не призводить до збільшення відчуття, а з (7) випливає зворотний висновок, що з незначним зростанням больових подразників больові відчуття різко зростають по експоненті.

Чутливість оператора. Якщо темп надходження інформації $\dot{R}$, то за прихований час прийому та переробки інформації τ^* в пам'ять людини надходить її кількість $\dot{R}\tau^*$, що визначає диференціальний поріг відчуття

$$\Delta R_0 = \dot{R}T \ln(1+p) \quad (8)$$

Як добре видно, основними параметрами, що визначають ΔR_0 , є: темп надходження подразника $\dot{R}$, нижній поріг засвоєної інформації φ та постійна часу T . Враховуючи, що широко відома з практики константа Вебера $k = \Delta R/R$, за допомогою (8) неважко знайти аналітичний вираз для неї як верхнього k_L , так і нижнього порога k чутливості:

$$k_L = [1 + (1+p)/\ln(1+p)]^{-1} \quad (9)$$

$$k = [1 + p/\ln(1+p)]^{-1}$$

Розрахунки за цими залежностями підтверджуються численними експериментами. Для відомих сенсорних систем людини було визначено значення параметрів p , T і $\dot{R}$, що дозволяє використовувати аналітичні залежності для прогнозування ходу відповідних характеристик людини.

Моделювання процесу ймовірного прогнозування як основа вибору "одиниці відчуття". Якщо людина приймає рішення в умовах появи декількох сигналів, то формули (2) і (5) дозволяють отримати зв'язок між часом реакції вибору

$$\tau_{\delta} = \tau_{\delta} / \tau^* \text{ та ймовірністю їх появи } W:$$

$$\tau_{\delta} = 1 + \ln[1 + p(1/W - 1)] / \ln(1+p) \quad (10)$$

Порівняння розрахунків за цією формулою з дослідними даними О. М. Лебедева - Б. Г. Бовіна дозволили зв'язати порогову величину φ з частотою α -ритму мозку f , яка може бути визначена для кожної людини за допомогою електроенцефалограми потиличної ділянки людини:

$$\varphi = 5\dot{R}(T_0 - \alpha\theta), (T_0 = 0,32 \text{ сек}; \theta = 0,0175 \text{ сек}^2) \quad (11)$$

У формулах (6) та (7) φ є нормуючим параметром для відчуттів та подразнень, тобто ця величина ідентична елементарній одиниці їхнього виміру. Визначення можливості її розрахунку за (11) вирішує певною мірою питання ікалювання відчуттів і подразнень. Цікава особливість в тому, що такий підхід полягає у виборі індивідуальної одиниці виміру (хоча у відносному вигляді всі отримані нами залежності придатні для всіх випадків).

Моделювання почуттів людини. Розвиток почуттів людини можна формалізувати та описати за допомогою деяких представлених співвідношень. Так процес розвитку почуття любові можна уявити як утворення різниці між інформацією про ідеал людини протилежної статі Q^I , сформованої в пам'яті людини вихованням, літературою, на генному рівні і тією, що надходить на згадку позитивною U і негативною E інформацією про конкретну людину (з урахуванням домислюваної інформації про людину Z). Якщо ввести в розгляд коефіцієнт кохання L як обернену величину зазначеної інформаційної різниці

$$L=1/Q^I-U-Z+E,$$

а потім використати формули (2) і (3) для визначення накопичення інформації в пам'яті і для її втрати, то можна отримати кількісну формулу для L . Ця формула після нормування параметрів, що входять до неї, залежить від безрозмірних величин, що визначають ступінь позитивності (ідеальності) і негативності (негативності) людини (яке можна визначити методом тестування), а також від поточного часу. Досить громіздкі вирази, проте, дозволяють знайти деякі цікаві розрахункові точки L і порівняти їх з експериментальними (статистичними) даними. Якщо припустити, що мінімум коефіцієнта кохання відповідає максимуму розлучень сімей, можна кількісно визначити найбільш небезпечні з погляду стійкості сім'ї тимчасові точки. Відповідні розрахунки та аналіз статистичних даних з розлучень показали їх близькі значення: перша, небезпечна точка з погляду розлучення, відповідає 1 року після весілля, друга - через 3,5 року. Максимальна кількість розлучень і за розрахунками, і за статистикою припадає через період 8,7 року. Надалі "небезпечні" точки з'являються з тим же періодом 3,5 року (нещодавно професор Елен Фішер з американського університету Rutgers виявила явище зміни хімічного складу крові, що впливає на сексуальність, у жінок з періодом 3, а чоловіків 4 роки, що підтверджує та пояснює одержану нами цифру). Таким чином досить абстрактна формалізована модель такого складного почуття як кохання дає можливість отримувати практично цікаві результати.

Аналогічний підхід можна використовувати для отримання *формули страху*. Якщо коефіцієнт страху F трактувати як величину, зворотну різниці інформації між деяким "стандартом" закладеної на згадку небезпеки Q і реальною що надійшла U і уявної Z , можна методами математики аналізувати поведінку людини за умов загрози його існування.

В авіації широко використовуються криві навчання льотчиків щодо виконання вправ в умовах різних емоційних впливів, що визначаються наявністю небезпечних ситуацій у повітрі. У цьому випадку критерій τ_1 (або постійна часу T) може бути кількісною мірою *страху*.

Моделювання діяльності людини-оператора. Узагальнення поданих підходів на випадок

діяльності людини як оператора людино-машинних систем дозволяє скласти математичну модель його діяльності, отримати її передатну функцію та дослідити її поведінку в системі «людина-машина» добре відомими з техніки методами теорії автоматичного регулювання. Наші розрахунки, наприклад, частотних характеристик одного з космонавтів (як оператора космічного корабля) добре узгоджуються з експериментальними даними. У зв'язку з цим несподівані можливості відкрилися для моделювання та прогнозу поведінки льотчиків та космонавтів в умовах дії на них гравітаційних полів, відмінних від земного. Обробка дослідних даних показала суттєвий вплив перевантажень і невагомості на ключові параметри представленої теорії - ϕ , T та τ .

Представлені результати демонструють успішні можливості математичного моделювання різних психологічних процесів - від навчання до емоційних станів людини - і можуть бути основою моделювання інших цікавих явищ, можуть бути основою прогнозу поведінки людини в різних ситуаціях, коли не можна використовувати інші методи дослідження, як, наприклад, тестування.

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SOCIAL SCIENCES

УДК 316.34

SOCIAL ASPECTS OF THE FORMATION OF ATTITUDES TO HEALTH AMONG ADOLESCENTS IN THE FRAMEWORK OF SCHOOL EDUCATION

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СОЦИАЛЬНЫЕ АСПЕКТЫ ФОРМИРОВАНИЯ ОТНОШЕНИЯ К ЗДОРОВЬЮ У ПОДРОСТКОВ В РАМКАХ ШКОЛЬНОГО ОБРАЗОВАНИЯ

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Abstract

The health of adolescents - is tomorrow's health of adults, but the incidence trends in this category are characterized by the most negative indicators. Although strengthening the health of children and adolescents is recognized in Russia as a national task that requires an interdepartmental approach and actions of all ministries and departments, the actual situation is different. Schools do not systematically teach schoolchildren about health care. Three reasons for the absence of the subject "Health" in the school curriculum and the features of the formation of the need for health care, including with the help of the media, are considered. A list of social policy measures aimed at changing the current situation is proposed.

Аннотация

Здоровье подростков - это завтрашнее здоровье взрослых людей, но тенденции по заболеваемости данной категории характеризуются самыми негативными показателями. Хотя укрепление здоровья детей и подростков признано в России общегосударственной задачей, требующей межведомственного подхода и действий всех министерств и ведомств, но фактически положение иное. В школах не ведется планомерное обучение школьников заботе о здоровье. Рассматриваются три причины отсутствия предмета «Здоровье» в школьной программе и особенности формирования потребности в заботе о здоровье, в том числе с помощью средств массовой информации. Предлагается перечень мер социальной политики, направленных на изменение сложившейся ситуации.

Keywords: adolescent health, health education, the role of schools in shaping attitudes towards health

Ключевые слова: здоровье подростков, образование в сфере здоровья, роль школы в формировании отношения к здоровью

Значимость проблемы здоровья подростков - потенциала трудового и популяционного ресурсов страны - обусловлена тем, что здоровье данной категории населения характеризуется негативными тенденциями уже несколько десятилетий. За 2000-2020 годы показатели заболеваемости подростков 15-17 лет ухудшились в 1,3 раза, в том числе по новообразованиям - в 2,3 раза, болезням органов дыхания и нервной системы - в 1,5 раза, но больше всего по болезням эндокринной системы: сахарному диабету - в 2,3 раза, ожирению - в 4,4 раза [6], [7].

Самосохранительное поведение и состояние здоровья подростков являются следствием низкой санитарно-гигиенической культуры, которая обусловлена существующей социальной политикой в сфере здоровья. Она ориентирована, главным обра-

зом, на улучшение качества медицинского обслуживания преимущественно больных людей. Здоровые люди находятся фактически вне зоны ответственности сферы здравоохранения. В последние годы были реализованы значительные меры по совершенствованию сферы здравоохранения, но некоторые аспекты не получили должного развития. Один из важнейших - формирование отношения к здоровью в рамках школьного образования.

Внимание к здоровью подростков в нашей стране никогда не было в числе приоритетов, в то время, как в других странах здоровье подростков изучают уже многие годы. Под управлением ВОЗ каждые 4 года, начиная с 1983, проводится исследование «Поведение детей школьного возраста в отношении здоровья» (Health Behaviour in School-Aged Children - HBSC) в более чем 50 странах среди школьников 11, 13 и 15 лет. Россия участвует

в исследовании с 1993 года. Примечательно, что во всех «волнах» исследования состояние здоровья и психологического состояния российских подростков характеризуется преимущественно негативными показателями по сравнению с их зарубежными ровесниками [13].

Отечественные исследования подтверждают неблагоприятные тенденции здоровья школьников. Многолетние исследования НИИ гигиены и охраны здоровья детей и подростков ГУ НЦЗД РАМН свидетельствуют, что за время обучения в школе распространенность хронических заболеваний среди учащихся возрастает более, чем на 50%. В течение 15 лет используются унифицированные методики при обследовании одних и тех же учащихся на протяжении всех лет обучения в школе. Это позволяет выявить особенности формирования здоровья детей и подростков на разных возрастных этапах. Так, у подростков 15-17 лет (опрошено 2,5 тысячи человек) распространенность функциональных отклонений у юношей увеличилась на 89%, у девушек – на 51,6%. [11 с.26-30].

Идея о введении предмета, связанного со здоровьем, в структуру школьной программы вот уже несколько десятилетий является объектом дискуссий. Были предприняты попытки преподавания «Этики и психологии семейной жизни», валеологии, повсеместно введен предмет «Основы безопасности жизнедеятельности». Но все они не отвечают задачам, которые решает именно предмет «Здоровье»: он не только дает знания по жизненно важным вопросам, но еще формирует установки и потребности в ведении здорового образа жизни, которые трансформируются в необходимое самосохранительное поведение. Важность введения в школьную программу предмета «Здоровье» детерминирована еще и менталитетом россиян, который исторически не был соотнесен с заботой, как о собственном здоровье, так и общественном. Этому содействовал и патерналистский характер советского здравоохранения, который формировал пассивное отношение россиян к здоровью. Со временем изменился тип патологии – доминировать в структуре заболеваний и смертности стали неинфекционные хронические заболевания - но стратегия здравоохранения сохранилась. Современная социальная политика в данной сфере сконцентрирована на заболеваниях и больных людях, намерение уменьшить их число не обозначено как практическая задача.

Очевидно наличие позитивных результатов формирования здравоохранения, но пропаганда здорового образа жизни и активная профилактика не ведутся в требуемых масштабах, тогда как менталитет россиян требует значительной популяризаторской динамичности в сфере здоровья с целью коррекции пассивного отношения россиян к собственному здоровью. Важность данного направления деятельности отмечается в качестве одной из основных задач – «формирование навыков здорового образа жизни и культуры здоровья семьи как базовой ценности» - в «Плане основных мероприятий, проводимых в рамках Десятилетия детства, на

период до 2027 года» с привлечением к этой работе основных министерств и ведомств [10].

По мнению ведущих ученых в области детского здоровья (Баранова А.А., Кучмы В.Р., Рапопорт И.К., Сухаревой Л.М., Соколовой С.Б.), изменение сложившейся ситуации возможно только в рамках такой стабильной, многокомпонентной структуры, как школьная система, на которую должна быть возложена функция формирования культуры здоровья. Включение в школьную программу специального предмета «Здоровье», который профессионально разработан для всех классов, начиная с первого, будет способствовать изменению сложившейся ситуации со здоровьем детей и подростков. Кстати, вопрос о его введении обсуждается уже не первый год [4].

Назовем три причины, которые существенно тормозят этот процесс. Первая - это распространенное мнение о перегруженности школьной программы, в которую, тем не менее, вводятся, такие предметы как, например, Астрономия или Основы религиозных культур. Вторая причина связана с тем, что вопросы здоровья формально считаются включенными в ряд школьных предметов (русский, литература, биология, основы безопасности жизнедеятельности, химия и др.). Но в обязанности педагогов стандартных школьных предметов не входит формирование культуры здоровья у школьников, так как для них это не является отчетным показателем работы. Третья причина отсылает сторонников введения предмета «Здоровье» к семье, как источнику знаний о здоровье. Отдавая должное роли родителей в вопросах заботы о здоровье, нельзя не признать, что они не подготовлены к подобной работе.

Следует также учесть, что достижение позитивных результатов в ведущейся сейчас борьбе с распространенностью 4 основных поведенческих факторов риска (курения, употребления алкоголя, нездорового питания, низкой физической активности), которые влияют на рост числа неинфекционных заболеваний (главной причины смертности в России), также напрямую зависит от сформированной ориентации на здоровый образ жизни.

Наиболее сложной проблемой в сфере здоровья является формирование у человека потребности в заботе о нем, повышение ценности здоровья, за которое каждый индивид лично ответственен. Сложность заключается в необходимости ломать психологические стереотипы в сознании людей, которым десятилетиями внушалась мысль о том, что об их здоровье заботится государство. Ситуация изменилась. Сегодня необходимо создавать систему воспитания и обучения навыкам заботы о здоровье с первых лет жизни человека. Сложность и длительность этого процесса предполагает систематическое, научно обоснованное информационное воздействие на население, формирующее соответствующие социальные нормы поведения. Результаты этой работы будут достигнуты, когда полученные в детстве знания о здоровье превратятся в установки, убеждения, потребности и сформируют поведение на уровне привычки. Осуществить это

возможно в процессе всех лет обучения в школе, как считает Сухарев А.Г и его коллеги [12 с.32-35].

Но сегодня обучение заботе о здоровье ведется в ограниченном числе школ. О наличии в школе предмета, связанного со здоровьем, в ходе исследования «Здоровье подростков и окружающая среда», проведенного Институтом социологии РАН в 2017 году в 4 регионах страны (N=974), указали только 19% респондентов [5 с.147].

При отсутствии школьного образования в данной сфере необходимая мотивация может эффективно формироваться средствами массовой информации. Но, по мнению члена-корреспондента РАН Кучмы В.Р. «им не уделяется должного внимания в субъектах Российской Федерации, не учитываются интересы, ожидания, проблемы, наиболее эффективные каналы коммуникаций для различных групп детского населения. Для этой работы не выделяются необходимые ресурсы, практически все средства здравоохранения вкладываются в высокотехнологичную медицину в ущерб первичной помощи. В результате система формирования здорового образа жизни детей и подростков в должной мере не функционирует ни на уровне образовательных учреждений, ни на уровне муниципалитетов» [8 с.23-24].

Изменить сложившуюся ситуацию, по мнению ряда специалистов, может:

- введение в школьную образовательную программу предмета «Здоровье»;
- подготовка в вузах профильных педагогов для ведения предмета «Здоровье»;
- обеспечение финансирования пропаганды здорового образа жизни средствами массовой информации, включая цифровую сферу.

Данные проблемы обсуждались еще в 2012 при создании единой профилактической среды, системы формирования здорового образа жизни на основе межсекторального подхода при участии всех министерств и ведомств. Именно тогда была образована Правительственная комиссия по охране здоровья граждан, к сожалению, в 2016 году прекратившая свою деятельность. Сегодня систематическая работа по формированию у учащихся ответственного отношения к здоровью не осуществляется ни педагогами, ни медиками, ни психологами.

Однако в ряде регионов силами энтузиастов успешно реализуется ряд перспективных проектов, ориентированных на интеграцию указанных сфер влияния на здоровье.

В Тюменской области осуществляется профилактический проект «Здоровая школа», который разрабатывает новые игровые методики просветительской работы среди школьников, направленные на профилактику заболеваний и формирование здорового образа жизни детей и подростков. Тысячи школьников приняли участие в проекте, начиная с 2010 года. Обучаются также учителя, медицинские работники и волонтеры с использованием нового интерактивного формата принципам здорового образа жизни, правилам полезного питания, умениям оказать первую медицинскую помощь, основам ухода за собой [1 с.26-28].

Акцент на межсекторальное взаимодействие в области образования и здоровья в студенческом возрасте является доминантой спортивно-оздоровительного проекта федерального уровня «Здоровое поколение — сильный регион», который успешно реализуется в Республике Башкортостан с 2015 года. Основной целью проекта является создание системы вовлечения детей, подростков и молодежи в массовые виды спорта [2 с.35-37].

С целью создания единого пространства между педагогическим, медицинским коллективами и семьями учеников для формирования здорового образа жизни и профилактики поведенческих рисков школьников в Самаре предприняты действия по разработке Национальной программы «Здоровье школьников». Для этого организована учёба для педагогов школ силами медицинских сотрудников Центра здоровья, который с целью привлечения родителей к популяризации здорового образа жизни реорганизован в Семейный Центр [9 с.122-123]. Подобных примеров множество, но они, к сожалению, не способны обеспечить систематизированное формирование грамотного отношения к здоровью и мотивации по заботе о нем.

Некоторый оптимизм вызывает информация 2019 года о том, «Министерство здравоохранения разработало учебник по охране здоровья для школьников», по которому дети начнут учиться в 2020 году [3]. До сих пор этого не случилось. Определенные ожидания связываются и с Планами Десятилетия детства, где во всех пунктах плана, относящихся к здоровью (раздел I п.2, п.5, п.16, п.21, раздел VI), используется многозначный термин «совершенствование» [10]. Предлагаемое введение в школьную структуру образовательного направления, связанного планомерным обучением заботе о здоровье, должно трактоваться, как один из путей совершенствования данной сферы жизни.

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THE “AMERICAN DREAM” PROPAGANDA IN HOLLYWOOD MOVIES

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<https://doi.org/10.5281/zenodo.7198163>

Abstract

In 1895, the French Lumière brothers presented a new type of art to the world by creating the cinematograph. Over the course of one hundred years, cinema managed to become an integral part of cultural and daily life. Cinema shows real life using its unique means of expression, thus communicating different ideas, worldviews, values, and lifestyles. This article focuses on how the “American Dream” is propagandized in Hollywood movies. It examines the cinematographic tools used to convey a value system and shape social behavior through Hollywood movies representing the “American Dream” to trigger immigration. The article presents the visual, verbal, and audio propaganda tools used to communicate the terminal and instrumental values of the “American Dream” in Hollywood movies.

Keywords: “American Dream”, propaganda, communication, terminal values, instrumental values, visual means, audial means, verbal means

Introduction

Until the 16th century, the term propaganda was used only in biology to define the propagation of animals and plants. In 1622, Pope Gregory XV created a holy brotherhood called the Congregation for the Propagation of the Faith. It provided a library for research and a school for training priests and missionaries, assigned territories, and directed ecclesiastical matters overseas [16]. In English, the word “propaganda” started being used in 1718, in a religious context, and was used mainly in that sense until the middle of the 19th century. Then the word “propaganda” began to be

used in the political context as well. It became very popular during the First World War (1914-1918).

In 1928, in his book “Propaganda”, Edward Bernays stated that propaganda explored the psychology behind manipulating the masses, and the ability to use symbolic action and propaganda to influence politics, affect social change, and lobby for gender and racial equality [3, p. 37]. During that period, propaganda did not have a negative connotation. Nevertheless, during World War II, it became associated with fascist Germany.

All mass media - books, television, music, newspapers, radio, Internet, and cinema - can be used for propaganda purposes as communication tools that are widely distributed among the target audience [13, p. 50-52]. Movies are uniquely powerful as a propaganda tool, and by virtue of having its own expressive language, editing, cinematography, actors, etc, cinema went from a technical means of reproducing reality to a new means of its artistic presentation [24, p.175]. It can have an intense emotional impact on the audience. It creates a perfectly controlled imaginary world, affecting human desires, feelings, attitudes, and behavior in an indirect way, beyond the control of consciousness [7, p. 257].

Propaganda in Movies

The first most famous propaganda silent short movies were made by Vitagraph Studios in 1898, during the Spanish-American War. In 1915, the silent film "The Birth of a Nation" directed by David Griffith also had propaganda purposes. The film portrays Lincoln as a friend of the South, black people (many of whom are played by white actors in black makeup (blackface)) as unintelligent barbarians, and the Ku Klux Klan (KKK) as a heroic force necessary to preserve American values, protect white women and maintain white supremacy [7, p. 203]. Soviet cinematography was also developing rapidly in the 1920s. Sergei Eisenstein's "Battleship Potemkin" (1925) glorifies communist ideology [26, p. 183], and by portraying the 1905 revolution in the film, Eisenstein made an attempt to create a new history for Russia - to be led by those who were oppressed before.

The years 1930-1940, on the eve of World War II, were called "the golden age of propaganda". German film production was used as a means of Nazi propaganda [23, p. 411]. In 1940, Charlie Chaplin directed the film "The Great Dictator" in which he played Adenoid Hinkel with a clear reference to Adolf Hitler's image [30].

The American film industry had a great role in the development of cinema. Gomery, a film historian, argues that contemporary Hollywood is more powerful than it has ever been [10, p. 248]. The largest number of films is produced in the USA each year with an average of 700 films [19].

American cinema is very successful in spreading values and changing social behavior. In the context of the "soft power" developed by Joseph Nye, movies can be characterized as one of the main tools to make the USA attractive to immigrants. "Soft power" allows the state to achieve the desired outcomes by making other states want the same [21, p. 35]. Due to American movies, certain ideas have been formed all around the world about the value system in American society and about life in the United States.

The formation of social values and value systems by movies is considered in the context of social identity theories. The audience discovers its own interests and needs, while subconsciously using movies for reference. For this purpose, cinema uses many mechanisms of socio-psychological and socio-cultural persuasion [28, p. 109].

Persuasion Mechanisms in Movies

Every person interprets a film in his or her own way. What is shown and what conclusions the audience draws from the film depends on the knowledge and experience [2, p. 128]. Bourdieu states that the act of decoding an artwork, as well as a spontaneous and adequate understanding of it, is possible and effective only when the cultural code is fully assimilated by the viewer. The cultural code of the work must match the cultural code of the perceiver. When these unique conditions are not possible, a misunderstanding arises [4, p. 194]. Throughout its long history, American cinema has mastered the art of effectively influencing audiences. It knows what the audience needs, and is able to effectively convey to the audience the ideas of directors and screenwriters that contribute to the spread of American cultural values all around the world. Hollywood directors and producers try to focus on what is close and understandable for a person living anywhere in the world [22, p. 217-219].

The audience admires James Cameron's "Titanic", considering it a love story, and does not even assume that the film actually glorifies the United States and American values [17, p. 32-34]. The events, characters, and relationships presented in the movie become associated with the image of the United States in the mind of the audience, forming a general image of the country that most moviegoers have not actually seen.

George Gerbner's and Larry Gross's studies were instrumental for understanding audience behavior change. According to the theory of cultivation developed by them, television and screen violence have an effect on human behavior. Cultivation theory can be discussed not only in the context of violence but also in terms of reproducing certain values and social behavior [8, p. 178]. The influence of the movies can also be seen in the field of fashion. For example, in the 1960s, women borrowed the hairstyles of famous actresses: Audrey Hepburn's hairstyle from the "Breakfast at Tiffany's", Marilyn Monroe's hairstyle from "Some Like It Hot", Jennifer Aniston's hairstyle from the cult TV series "Friends" in the 1990s.

An ordinary moviegoer, watching movies about success stories, peaceful and beautiful life in American suburbs, will tend to adopt the behavior of the characters of that movie and will try to have a similar lifestyle. Gerbner compares television to a Trojan horse that hides a certain ideology under simple entertainment and then secretly infiltrates the consciousness of the audience [9, p. 358]. Thus, behind its beautiful images and stories, cinema can hide ideas that contribute to the spread of certain social behaviors and values.

To ensure the impact of cinema on the audience, a number of technical tricks are used: editing, color theory, sound design, music, dynamic video sequences, close-ups, and visual effects. They directly affect the audience, convey the emotional saturation of the film's events and strengthen the impact of the visual images, contributing to the emergence of desired impressions and feelings [2, p. 136].

"American Dream" as a Value System

The first narratives about the "American Dream" can be found in the book "A General History of

Virginia, New England and the Summer Islands” by the English writer and sailor John Smith. Due to him, America was first described as an *“open space where every person, regardless of his social status, wealth and quality of education, can achieve happiness, independence, a certain social status and can establish himself as an individual only through hard work and virtue”* [25].

The “American Dream” is also discussed in the Declaration of Independence of the United States *“We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.”* [14].

Although the term “American Dream” had been used earlier, it is usually attributed to the historian James Truslow Adams, who first coined the term “American Dream” in 1931 in his book “The Epic of America” and called it *“that dream of a land in which life should be better and richer and fuller for everyone, with opportunity for each according to ability or achievement.”* Adams believes that anyone can succeed if he/she works hard, and it does not matter who they are or what social class they belong to [1, p. 214-215].

In 1930, F. Scott Fitzgerald was working on a story about a girl named Fifi. Fifi appears on her birthday in a “dazzling black dress” and charms a young Hungarian count, who describes Fifi as *“my American dream girl”* [6, p. 70].

According to the Merriam-Webster dictionary, *“the American dream is an American social ideal that stresses egalitarianism and especially material prosperity.”* [18].

The “American Dream” played an important role in ensuring the large flow of immigration to the United States. In the years 1820-1999, more than 65 million people arrived in the territory of the United States from different countries of the world (Neimer 2003). For example, from January 2021 to April 2022, the largest increase in the total foreign-born population are California (up 527,000), Florida (up 390,000), Pennsylvania (up 375,000), Michigan (up 247,000), Georgia (up 152,000), Arizona (up 148,000), New York (up 145,000), Tennessee (up 130,000), and South Carolina (up 128,000) [5]. In the context of the “Push-Pull” theory of migration in this process, the “American Dream” is a significant pull factor for U.S. immigrants. People from all over the world migrate to live in a more attractive country than their homeland. The desire to live in a free society and have a better life as a result of one's own work is the driving force behind achieving the “American Dream”.

M. Hofman says that within the concept of the “American Dream”, the dream may be at odds with life experience, but the dream is not abstract, it embodies societal values, and the most important among these is respect for others. Society decides what it respects a person for and why one is to be despised. In the ancient world, the value of a person was determined not by wealth but by personal qualities. In the new world, a person's worth is determined by the size of their bank account. One has to become a “millionaire” to gain the

respect of society. Hofman considers that the “American Dream” is a dream about the material success of a person [11]. For this reason, the 19th century became a period of mass migration of daring people from the Old World to the New World in search of success.

Methodology

This study focused on the verbal, visual, and audial representation of the “American Dream” in Hollywood films of the 1940s-2010s. The study has centered on understanding how the concept of the “American Dream” is communicated in the movies. For this purpose, the content analysis of Hollywood movies about the American dream was conducted. The study was approved by the Scientific Board of the Faculty of Sociology and the American Studies Center at Yerevan State University.

Data Collection

In 2022, the authors confirmed the study topic with the Faculty of Sociology and the American Studies Centre at Yerevan State University. The research was conducted in 7 major steps: 1) identification of the goal and objectives of the research; 2) watching Hollywood movies and sampling them; 3) identification of critical variables; 4) design of the instrument for the content analyses; 5) coding the content; 6) data collection, watching the sampled movies and filling in the codebook; 6) systematization of the information; 7) analysis and presentation of study results.

Instrument

The codebook was developed during the initial research preparation and after a thorough literature review. The researchers studied different approaches to the content analysis of video documents and particularly movies in order to compile questions that would cover the concept of the “American Dream” in the movies. The purpose of the codebook was to provide enough structure to guide the researchers while allowing flexibility for taking notes on the unique story and techniques used in a particular movie. The codebook included chapters about the audial, verbal, and visual representation of the components of the “American Dream”.

Procedure

Each movie was watched first to make sure that the concept of the “American Dream” was present there. During the second viewing of the movie, the notes were taken to capture the appropriate verbal, visual, and audial tools used by the film creators to depict and stress the components of the “American Dream” concept. The notes were transferred into the instrument for further analysis, comparison, and interpretation.

Sample

A purposive sampling of Hollywood films promoting the ‘American Dream’ produced between 1940 and 2010 was made. Then, the most viewed films, which were approved by critics and audiences alike and grossed the highest, were selected from each period. Thus, the following 10 Hollywood movies from the 1940s-2010s were subjected to content analysis: “Citizen Kane” (1941), “East of Eden” (1955), “A Raisin in the Sun” (1961), “America America” (1963), “Stay Hungry” (1976), “Ragtime” (1981), “Wall Street” (1987), “Forrest Gump” (1994), “There will be blood”

(2007), and “The Social Network” (2010). The sampling let the researchers observe the dynamic of the representation of the “American Dream” in Hollywood movies.

Data Analysis

The compiled codebooks and the notes were analyzed using an interpretative approach. Emerging themes were documented based on the outcome of coding. Key verbal, visual, and audial information was organized and reviewed closely by the researchers. Conclusions were incorporated into this article.

Findings

As a result of the content analysis of Hollywood movies, an interesting dynamic was observed in the change of communication of the terminal and instrumental values of the “American Dream” in films over time. Movies of the 1940s are famous for their plots about the American upper class, and Orson Welles' “*Citizen Kane*” is no exception. The communication of the “American Dream” in this film was mainly carried out through wealth as a terminal value, and hard work as an instrumental value. Every frame of the film shows Kane's possessions and his luxurious life. He earned that property on his own with honest work. The communication of that idea is carried out through both visual and verbal means, which are very often juxtaposed in the film. The film presents the media mogul Kane's property, parties and celebrations, his and his wives' clothes and jewelry. Kane's high-paying job is visually communicated through his estate Xanadu, radio station, restaurants, residential buildings, luxury cars, factories, and ships. The same communication is also carried out verbally: the voice from the background talks about Kane's possessions. Every scene of the film is accompanied by Bernard Herrmann's music. The sound in the film is as innovative as the visual solutions. In the scene about the estate Xanadu built by Kane, the music further emphasizes the impact of the scene [39].

Unlike Hollywood films of the 1940s, which were by rags-to-riches plots or stories about bourgeois society, Hollywood films of the 1950s portrayed the American working class with its goals and dreams, one of which was Elia Kazan's “*East of Eden*” filmed in 1955. The movie is based on the eponymous novel by the American writer John Steinbeck. The film tells about the “lost generation”, which is trying to live a normal life during a difficult time for the whole world (in 1917). The communication of the “American Dream” in this film is also carried out through wealth as a terminal value, and hard work and overcoming difficulties as instrumental values. However, more screen time has been devoted to the communication of hard work and overcoming difficulties than in other films. Unlike “*Citizen Kane*”, the communication of wealth in this film is much more restrained [35].

In the 1960s, Hollywood cinema became more diverse, stories about refugees came to the fore, and the first steps were taken in making films about people of color. Elia Kazan's 1963 epic drama “*America America*” is a story about refugees, and it differs dramatically from the films discussed above. Most of the events take place in Turkish-occupied Anatolia and Constantinople, the ancient land of Armenians and

Greeks. Only at the end of the film do the spectators see America, when the main character, Stavros (played by Greek actor Stathis Giallelis), finally appears in coveted America. He works hard as a shoe shiner and becomes rich. Later he was able to bring his family from Anatolia to the United States. In this film, the communication of the “American Dream” is carried out mainly through the instrumental values of hard work and overcoming difficulties. Only because of those two, it was possible to reach America from Anatolia in the late 19th and early 20th centuries [34].

In the film “*A Raisin in the Sun*” (1961), the “American Dream” is mainly communicated through a happy family life and overcoming difficulties. Communication of happy family life plays a significant role in this movie. And the overcoming of difficulties is largely related to the most common problem of the time - racial discrimination, which the main characters of the film face but still achieve their “American Dream”. The visual and verbal communication of a happy family life is conveyed through the positive interactions between family members. The slogan of the film - “*The Prize-Winning Drama That Warms the Screen with Its People and Its Passions!...*” - claims that the film is mainly about human relationships [36].

One of the films about the “American Dream” made in the 1970s is the comedy-drama “*Stay Hungry*” by Bob Rafelson. The characters of this film are representatives of different social classes. The main character Blake (played by Jeff Bridges) is from a rich family. The film shows how Blake and his friends spend their weekends in entertainment complexes and in the suburbs, while practicing water skiing. They drive a Cadillac DeVille Convertible luxury car (1965) to the suburbs. During the film, we see how carefree and happy their life in America is. However, the words of another character, Joe Santo (played by Arnold Schwarzenegger), “*...You get used to good things quickly, then it's hard to give up, I prefer to stay hungry...*”, become a turning point for the main character. Blake got used to his carefree life, with the property inherited from his parents and a luxurious mansion where he felt like a guest. He wanted to deserve such a life through his own work, but being accustomed to a carefree life prevented him from making his dream come true. Santo's words motivated Blake to achieve on his own what his parents had once achieved. The calm soundtrack created by the film composer Richard Portman conveys the carelessness of the life of rich Americans. In some parts of the film, country music is played, which proves that everything will be fine with Blake, who is already striving for the “American Dream” with his own work [37].

In “*Ragtime*” (1981) by Miloš Forman, wealth is communicated through lavish mansions and cars. A happy family life is conveyed as follows: the family sits at the dining table and talks about the good events that happened to them during the week, and the relationship between a caring father and daughter is presented. The freedom in the film is communicated by the U.S. flag. Near the very end of the film, Harry Houdini demonstrates his famous trick of escaping from shackles while hanging from a building with an American flag waving behind him. Just as Harry Houdini was freed from his

shackles, American citizens and refugees have the opportunity to live a free and independent life in the United States. Music plays an important role in the film. Ragtime is a genre of American music that was popular in the years 1900-1918. It is considered the prototype of jazz. The main melody of ragtime music is syncopated, with the emphasis moving from the strong half of the measure to the weak, with some interruptions. The compositions of the ragtime genre are composed of 4 main themes, and this is where interesting parallels are drawn with the screenplay, which is composed of 4 stories, which differ from one another, but at the same time are strongly interconnected, and the transition from one story to another is linked to a broken rhythm of syncopation. The film presents 4 stories about the "American Dream": (a) the storyline about an American family, which mainly communicates a happy family life, (b) the plotline about Elizabeth Nesbit, which mainly communicates wealth, (c) the plot of Jewish refugee Tateh, which communicates hard work, wealth, and a happy family life, and (d) the story of black pianist Coalhouse Walker, which communicates hard work and overcoming difficulties [33]. The syncopated ragtime beat composed by Randy Newman waxes and wanes outlining the main theme of each plotline.

In Oliver Stone's *"Wall Street"* (1987), wealth is mainly conveyed by luxurious mansions, apartments, cars, and famous artworks. Pablo Picasso's "Le Matorador", Joan Miro's "Paysage", and Robert Birmelin's "The Twenty Dollar Bill" hang in the office of the main character. The communication of wealth is present throughout the whole film. All the conversations of the characters of the film are about transactions of several million and even billion dollars and living a financially secure life. To stress the wealth, such attributes as Davidoff Cuban cigars and a gold Cartier Santos watch, the value of which is around \$35,700, are demonstrated in the movie [38].

The 1990s are known for many films about the "American Dream", one of which is the Oscar-winning *"Forrest Gump"* (1994) directed by Robert Zemeckis. The film shows that in the USA, everyone has equal opportunities and the "American Dream" can be real for everyone. Forrest has mental problems, but this problem does not prevent him from achieving great success. Freedom is conveyed by the scenes where the Statue of Liberty, the US flag, and the roads are demonstrated. These are well-known symbols of freedom and the "American Dream". In one of the scenes, an American political and social activist who fought for freedom and peace, Abbie Hoffman, wears a shirt with the U.S. flag printed on it. Music plays an important role in this movie. Composer Alan Silvestri's Oscar-winning soundtrack for *"Forrest Gump"* manages the emotions of the audience, describes the image of every character in the film, and expresses the shifts in times. For example, when Forrest tells the story of his life and success to strangers, a soft piano piece is played that characterizes Forrest's kindness and simplicity. Forrest does not even imagine what an impressive life story he has, which inspired the whole of America and thanks to which he became an exemplary American [40].

"There will be blood" (2007) directed by Paul Thomas Anderson is an epic drama based on the novel "Oil!" by the American writer Upton Sinclair. Oil stands for wealth in this film. Wealth is communicated verbally when the main character of the film, Daniel Plainview (played by Daniel Day-Lewis), talks to the local residents in order to buy a new place for oil extraction: *"Ladies and gentlemen, I've traveled over half our state to be here tonight. I couldn't get away sooner because my new well was coming in at Coyote Hills, and I had to see about it. That well is now flowing at 2000 barrels; it's paying me an income of 5000 dollars a week."* The soundtrack written for this film by Jonny Greenwood, the lead guitarist of the British rock band Radiohead, makes every frame of the film even more expressive. The soundtrack is performed by the BBC Concert Orchestra, and the main theme is very heavy, which emphasizes all the hard work that Daniel is doing. The drums playing hard along with the music of the string orchestra accompany the scene of the oil extraction to impress the spectators with the imminent danger [29].

In David Fincher's *"The Social Network"* (2010) wealth is communicated through high-paying jobs. For the visual communication of wealth, expensive cars and private houses are used which are the result of highly paid work. When we learn through the subtitles at the end of the film that Mark is the youngest billionaire in the world, the song "Baby, You're a Rich Man" by The Beatles is played. The idea of overcoming difficulties is communicated in the trial episodes presented regularly during the movie. Mark Zuckerberg had simultaneous trials with his close friend Eduardo Saverin and brothers Tyler and Cameron Winklevoss. Despite the difficulties, Mark managed to maintain his organization and even become the youngest billionaire in the world. The soundtrack written by Trent Reznor and Atticus Ross that plays throughout the film is effectively combined with the scenes representing the creation of Facebook; it adds tension to the scenes and emphasizes the challenges of Mark's work. The choice of music called "3:14 Every Night" is very fitting, it creates the impression of keyboard work. The soundtrack with electronic musical effects is consistent with Mark's work, and the music played in the trial scenes heightens the tension and emphasizes the complexity of the situation, thus also implementing an audio communication of overcoming difficulties in the film [31].

Conclusion

The "American Dream" is communicated in Hollywood films by presenting the terminal values of wealth, freedom, and a happy family life. Diligence and overcoming difficulties are communicated as instrumental values necessary to achieve the realization of the above-mentioned terminal values.

A study of films from the 1940s to 2010s revealed that over time, Hollywood films used a variety of verbal, visual, and audial means to communicate the terminal and instrumental values of the "American Dream". An interesting dynamic is observed with the change of time in connection with the technical development of Hollywood cinema, the change of plot characteristics, and the improvement of video and sound.

Despite the change of the times, the terminal and instrumental values communicated in the films about the “American Dream” remain unchanged. It is due to the communication of repeated ideas that Hollywood cinema effectively carries out the propaganda of the “American Dream”. In those films, we see that the U.S. citizen is proud to be an American, he lives in a free and independent country, and foreigners dream of living in such a country, where everyone has equal opportunities to live a prosperous life. During the communication and propaganda of the “American Dream” in Hollywood films, no comparisons are made with other countries; instead, a country is presented where, due to hard work, it is possible to live prosperously, happily, and carefree.

In this way, Hollywood films create both Americans' and foreigners' perceptions of the “American Dream”, enhancing the country's attractiveness to immigrants, and shaping audience aspirations, attitudes, and behavior.

Funding Information This research was funded through a Department of State Public Affairs Section grant, and the opinions, findings, and conclusions or recommendations expressed herein are those of the Author(s) and do not necessarily reflect those of the Department of State.

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TECHNICAL SCIENCES

STRUCTURAL DRAFTING OF CONVERTIPLANE-TYPE UNMANNED AERIAL VEHICLE

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Abstract

The article gives a structural draft of a convertiplane-type unmanned aerial vehicle and the purpose of its components and depending on the location the effect of the selected elements on its aerodynamic properties is based on theoretical and practical knowledge. Also, the main parameters of the convertiplane have been optimized in the context of observation of strategic objects and the probability of its detection by visual, acoustic and radar detection means has been determined.

Keywords: unmanned aerial vehicles, convertiplane, flight controllers, flying wing, aerodynamic features, accumulator batteries.

It is well known that in a globalizing world it is necessary to have quality information to assess critical risks for effective management, rational planning, optimal use of resources and a high level of security.

Timely detection of threats to the security of oil and gas export pipelines, ensuring the security of air, water and land borders throughout the country by taking preventive and adequate measures in this direction is of national importance. It is possible to carry out research, inventory, planning, environmental monitoring or operational control of the infrastructure of onshore and offshore oil and gas production facilities using UAVs [1]. One of the main applications of UAVs is their use in mapping and aerial photography. By performing mapping and aerial photography in the most dangerous places, it is possible to prepare topographic maps, as well as to observe strategic objects using UAV, which minimizes the risks to human life and health. The efficiency of using the latest generation UAVs is irreplaceable, which are very hard to be detected by visual, acoustic and radar detection in the observation and protection of strategic objects. The UAV's autonomous flight function on a given route significantly reduces the cost and time spent on piloting aircraft and real-time on-board imaging, allows you to monitor the terrain in real time and make decisions on the spot.

The purpose of the work: Consists of determining the optimal structural draft of a convertiplane-type unmanned aerial vehicle (UAV) designed for mapping, monitoring of oil and gas

industry facilities, observation of strategic facilities and aerial reconnaissance and combining the flight and technical characteristics of both the helicopter and the aircraft.

Structure and working principle of components of convertiplane-type UAV. Description and main parameters of the components that make up the internal parts of the convertiplane [2, 3], designed by us and having the necessary technical characteristics, are described in Table 1.

The structure of a convertiplane has been designed based on the *"Skywalker X8 Flying Wing 2120mm"* stationary wing glider using the propulsion engine directly installed on the rear of the fuselage, electronic equipment attached on the body and lifting motors fixed to glider through two carrier arms made of carbon tubes installed parallel to each other on the top of the wings. Carbon tubes with a diameter of 20 mm, wall thickness of 1 mm and a length of 1 m have been used as carrier arms. The front and bottom view of a convertiplane is described in Figure 1a and 1b.

When installing lifting engines, the structural, aerodynamic and following requirements for the purpose of the UAV must be observed.

1) The distance between the centers of the motors on the axis of rotation should be as small as possible.

2) During propellers rotation the area of the circles they draw must be outside the area occupied by the glider.

3) The location of the engines must allow the UAV to be used for its intended purpose.

Table 1.
Onboard components included in the structure of the convertiplane.

Nº	Name and (or) brand of the product	Description	Operating principles or features
1.	Here 2 GHSS		GPS module
2.	PIXHAWK 2.1- Cube		The flight controller consists of a microprocessor, 3-axis gyroscope, magnetometer and 2 barometers. Frequency: - 168 MHz; RAM: - 256 kB;
3.	Carbon tubes		Composite carbon tubes
4.	Batteries		LiPo battery 6S 5000 mAh
5.	P15x5 Prop-2PCS/PAIR		- Maximum rotation speed - 3500 rot/min; - It is lightweight, has a large carrying capacity and a long flight time. - Number of wings - 2;
6.	Non-collector electrical motor (lift), T -Motor MT4008 KV600		- Internal resistance - 132 mΩ; - Stator diameter - 40 mm and length-8 mm; - Shaft diameter - 4 mm; - Weight - 100 g;
7.	ESC- electronic speed controller T-Motor 40A		- Current - 40 A - Frequency - 400 Hz - Battery - 2-6S - Weight - 26 g - Dimensions - 55.6×25.2×11.3 mm
8.	Master Airscrew 12×6 K-Series Propeller		Drag (thrust) propeller
9.	Non-collector electrical motor (thrust), U7-V2.0 KV490		Thrust engine
10.	ESC - electronic speed controller T-Motor 80A FLAME LV		Operates with 400 Hz ESC 4-6S. - Current - 80 A - Dimensions: 30,6×72,2×17,3 mm - Weight - 110 g
11.	Foxtech Map-02		- Number of pixels (effective): 24.3 mp - Shooting speed: 30-1/4000 sec. - Image format: jpeg, raw, - Operating voltage - 8.4 V
12.	MinimOSD		- Operating voltage - 5 V, - FTDI input
13.	Radio telemetry module CUAV SX Radio CUAV SX Radio		- 900MHz Wireless Data Transmission Module TX RX - Weight - 39 g
14.	FPV 5,8 GHz Wireless Video Link 48CH Transmitter TS832		- Power - 600 mW; - Weight - 25 g



Fig. 1. View of the front and bottom of the convertiplane

The first requirement is to reduce the moment of forces acting on the carrier arms, and consequently their load, and it's a structural requirement. When fulfilling this requirement, it should be taken into account that the

minimum distance between the centers of rotation of the rear engines serving vertical lift is limited by the length of the propeller shaft.

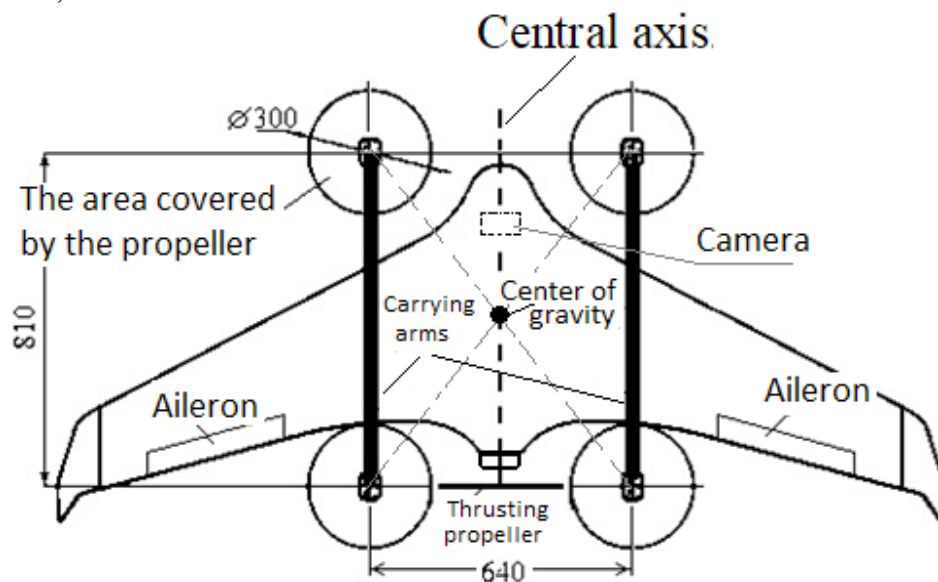


Fig. 2. Upper view of the convertiplane.

Second, the maximum use of the lifting force of the engines is ensured when fulfilling the aerodynamic requirement. Otherwise, the lift force of the engine will decrease as a result of the downward flow of air in the vertical direction of the propeller in proportion to the extent to which the wing covers the area of the circle covered during rotation.

For the purpose of mapping, as well as electron-optical reconnaissance of strategic objects, the UAV is equipped with a video camera mounted to the bottom of the fuselage front side. During rotation, the blades may enter the field of view of the video camera's lens and adversely affect image quality. Thus, in order to meet the third requirement, as well as to ensure a stable balance of UAV in the air, the engines are mounted to the upper side of wings. In such a design, the center of gravity of the PUA is below the flatness of the lifting motors, which ensures that the steady balance condition is met in any situation.

The on glider installation place of the propulsion engine, which provides horizontal flight, is provided by the manufacturer at the rear of the fuselage. Under the same conditions, the front-mounted traction motor has two known disadvantages compared to the rear-

mounted thrust motor. First, the front part of the glider sharply reduces the speed of the air flow going back from the propeller mounted on the front, resulting in a significant reduction in the speed of the aircraft. Second, the vortex air flow created by the front-mounted propeller tries to rotate the aircraft around the main axis by affecting one of the wings from below and the other from above and in aviation terms, to disturb its horizontal balance on the roll. In order to maintain horizontal balance, it is necessary to create a different lifting force on the wings by changing the position of the small moving parts on the back of the wings - the ailerons. This increases the aircraft's air resistance and power consumption and reduces flight time. The top view of the engine layout on the glider is described in Figure 2.

Propulsion system. The power system of the convertiplane includes five non-collector electric motors and their electronic speed controllers and two servomechanisms. As is well known, a propeller, a non-collector electric motor and its electronic speed controller together form the propeller-motor group (PMG). The vertical take-off and landing is provided by four and the horizontal flight by one PMG.

Servomechanisms are used to control two movable ailerons installed to the right and left wings. Ailerons maintain the air balance of the convertiplane by regulating the up-down, right-left and rotational movements in horizontal flight mode. The principles of

aircraft power system construction have been extensively analyzed in the literature [2, 3]. For this specific design, the functional block diagram of the convertiplane's electrical circuits is described in Figure 3.

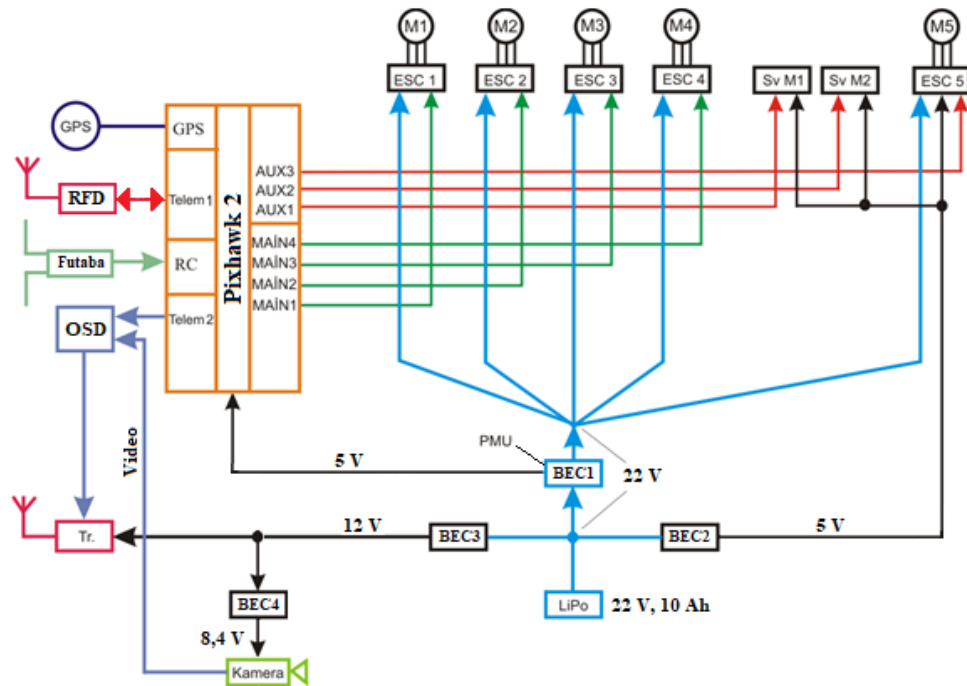


Fig. 3. Functional block diagram of the electrical circuits of the convertiplane

ESC (Electronic speed controller) forms the power circuit, schematically located between battery and motor, connected to them by two and three wires, respectively. The size of the cross-sectional area of the five power wires is proportional to the value of the current flowing through them and their diameters are also larger than those of the signal wires due to the large current flow.

Conflicting issues need to be solved during the placing of ESCs. For example, electromagnetic fields around power cables can interfere the operation of

sensitive, mainly MEMS-type inertial navigation devices and GPS receivers, as well as flight controllers. To reduce the impact of electromagnetic interference and losses, it is advisable to shorten the length of power cables. On the other hand, in order to reduce the temperature, it is advisable to place the ESCs in the air flow created by the blades, for example, at a distance equal to half the radius of the blades from the center of the lifting motors. Thus, as an optimal solution, it was decided to place the ESCs on the bottom side of the motors. In this case, two power cables

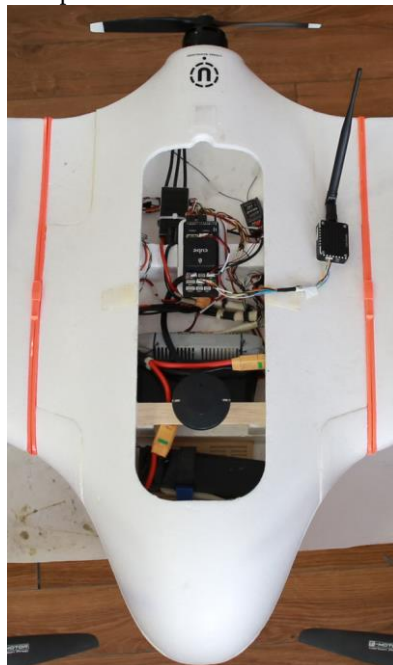


Fig 4. View of the convertiplane's fuselage

connecting battery and ESC pass through the carbon tube, and the following advantages are obtained.

First, due to the electrical conductivity of carbon, the impact of electromagnetic interference coming from the wires to the surrounding devices is significantly reduced. Second, the lengths of power cables connecting engine and ESC are minimal. Finally, by choosing the same dimensions of the trays on which they are fastened, it is possible to install

engine and its ESC in a multi-layered way at the end of the carbon tube, resulting in a relatively simple design [4].

The place and direction of the propulsion motor on the glider requires its ESC to be located inside the fuselage. In this case, in order to improve the temperature regime, it is advisable to select a relatively large ESC power reserve factor or to provide air flow that provides heat transfer through the fuselage [12-14].

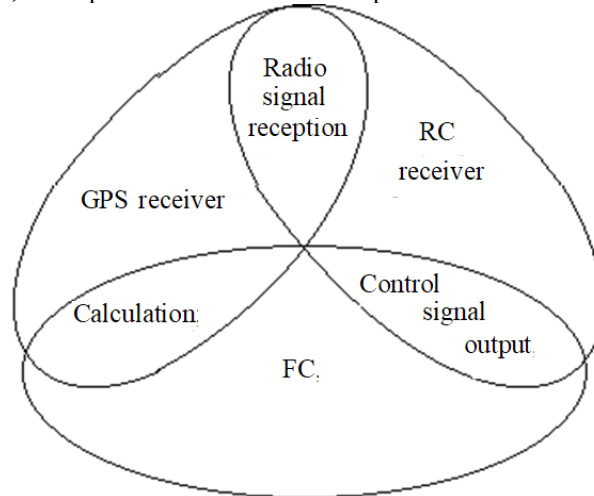


Fig 5. Functions of FC, RC and GPS devices.

Power system. The power system of the convertiplane consists of two LiPo batteries (AB) connected in parallel and four voltage converters with stabilized output voltages. The operating voltage of each battery used as a power source is 22.2 V, power capacity is 5000 mAh. Voltage converters convert the relatively high voltage of batteries into the required low-value and stable voltages. The first supplies 5 V power to flight controller, the second 5 V to servomechanisms and the low-voltage circuit of the electronic speed controller of the thrust motor, the third 12 V to video transmitter and the fourth 8.4 V to camera. Except the voltage converters included in the components of flight controllers, the other voltage converters are assembled in one block and placed symmetrically to the central axis, between battery and flight controllers inside the fuselage.

The power system of the convertiplane is powered directly from the battery. Aircraft weighing up to 20 kg usually use one or more Li-Po batteries to provide the required power and flight time. The battery weighs more than the electrical equipment used in the convertiplane and has a significant effect on the equal distribution of the load on the motors. To maintain the transverse balance of aircraft, the batteries are placed symmetrically on the right and left sides relative to the center axis of a glider. To achieve the longitudinal balance of the aircraft, it must be taken into account that the propulsion engine is unmovably fixed to the rear of the glider. Therefore, it is possible to change the center of gravity of the aircraft by sliding the place of the batteries in the direction of the central axis, thus achieving an equal distribution of the load on the motors. In this case, the center of gravity of the aircraft falls on the point of intersection of the diagonal lines connecting the lifting engines diagonally (Fig. 2).

In general, the coordinates of the center of gravity of the glider can be calculated using the following known formulas:

$$X_t = \frac{\sum G_i x_i}{G}, Y_t = \frac{\sum G_i y_i}{G} \quad (1)$$

here:

- X_t and Y_t - coordinates of the aircraft's center of gravity;
- x_i and y_i - coordinates of the centers of gravity of the separate parts of aircraft;
- G_i - weight of the separate parts of aircraft;
- G - total weight of aircraft.

Figure 4 describes the location of UAV elements in fuselage from the top view.

Control and navigation system. The navigation system of the convertiplane consists of navigation devices, including GPS receiver, 3-axis gyroscope, 3-axis accelerometer, magnetometer and barometer. GPS is global positioning system, gyroscope and accelerometer are inertial navigation devices, magnetometer is used as an electronic compass, barometer - used to determine the relative flight altitude based on atmospheric pressure. The combined use of these systems improves the quality of the flight.

As mentioned above (Fig. 2), the center of gravity affects the stability of the aircraft. To increase the horizontal stability, it is advisable to place the center of gravity of the multi-rotor aircraft below the flatness of rotation of the blades, for example, at the level of the engines [5].

It is possible to ignore the weight of the flight controllers, GPS and radio control receivers used to control the convertiplane in the equal distribution of weights relative to the center of gravity of aircraft. In order to determine the installation place on glider, let's look at a diagram describing the relationship between

all three electronic devices in terms of similarities and differences in their functions (Fig. 5).

Performing the calculation operation as described in Figure 5 is a similar function of flight controller and GPS receiver. Two reports or coordinate systems are used to perform these operations, which include the processing of navigation data and the calculation of flight parameters that determine the position of the aircraft in space. The locations of both flight controller and GPS centers relative to the center of gravity of the aircraft must be known in the moving coordinate system at the center of gravity in order to properly assess their position in space.

Flight controllers can be located in the center of gravity of a multi-rotor aircraft or near the center of gravity. Problems that can occur when the flight controller is placed away from the center of gravity of the aircraft have not yet been observed [6].

GPS receiver is a navigation device that processes the received navigation data and its antenna and receiver are usually installed in the same case. The followings should be taken into account when placing GPS receiver on the aircraft:

1) GPS antenna should be aimed at the open sky by placing it on top of the aircraft to receive satellite signals carrying navigation information without impediment;

2) The GPS antenna should be as far away as possible from the aircraft's electromagnetic interference power supplies and wires.

GPS receiver can be placed on the flight controller installed in the center of gravity of the multi-rotor aircraft. However, due to the limited height of the fuselage of the convertiplane, installing the GPS receiver at a certain height above the flight controller by keeping the centers aligned on the vertical axis is both structurally difficult and reduces the aerodynamic quality of the glider. For this reason, it is not advisable to install a GPS receiver above the fuselage.

In order to solve the above-mentioned issues, GPS receiver was slid to the front in the direction of the central axis of the developed convertiplane and the upper surfaces of the receiver and the fuselage have been placed in the same flatness. At the same time, the distance measurements of the center of the GPS receiver on the x, y, z axes relative to the center of the flight controller are included in the coordinate section of the flight controller program. In this case, depending on the direction of sliding, a positive or negative sign is written in front of the measurement values in accordance with the operating instructions.

RC receiver. The location of RC receiver is not decisive relative e.g to center of gravity of the aircraft, because it does not perform calculation operations and the weight does not have a significant effect on the equal distribution of the load. During the installation of RC receiver, it's tried to ensure that the conductive elements of the aircraft structure do not interfere with its antenna in the direction of the ground. Also two directional antennas mounted at an angle of 90 degrees to each other are used to improve signal reception reliability. Thus, taking into account the small geometric dimensions, light weight and the fact that the

glider is made of radio-transparent material, it has been decided to place RC receiver in a section created

inside fuselage. During the convertiplane test flights, radio control at a distance of 500 m was reliably performed [6].

Camera. As mentioned earlier, convertiplane is designed for mapping, and the video camera used for this purpose is fixed from the front to the bottom of fuselage. The body of video camera is located inside fuselage to ensure equal weight distribution of aircraft relative to the center of gravity and to reduce impact on the aerodynamic quality of the glider. In this case, its lens come out of the fuselage and are directed to the ground during a horizontal flight.

OSD (on-screen display) – Provides telemetry data view on display image. The weight of OSD is very small and does not affect the balance conditions of aircraft. Due to the shortness of the input and output cables connected to video camera, flight controller and video transmitter, it is advisable to place it close to all three devices inside fuselage.

VideoLink - (video transmitter). Video transmitter provides image and telemetry data transmission to the ground, because its temperature is relatively high in the operating mode, it is advisable to place it outside fuselage. Thus, video transmitter is placed behind camera and installed to the bottom of fuselage.

DataLink - is a telemetry device for transmitting digital data over long distances. Two identical devices are used to create two-way "ground-to-air" communication. Due to the similar operating modes, the requirements for the location of video transmitter can also be applied to the on-board telemetry device. Because it works with longer-wavelength (lower-frequency) radio signals than a video transmitter and a GPS receiver, the location of telemetry device at the bottom or top of fuselage is not decisive. Taking into account that its weight affects the balance conditions and above mentioned issues, the telemetry device is placed close to the center axis of glider and installed on the top of fuselage.

One of the main requirements for the selection and development of components has been the optimization of the main parameters of the convertiplane-type UAV in the context of observation of strategic objects. For this purpose, the detection features of the developed convertiplane-type UAV by visual, acoustic and radar type detection means have been determined.

Surface reflection. The possibility of detecting the aircraft by various technical means during the flight remains a topical issue at the present time. The main parameter characterizing the probability of detection, used as a technical-confidential indicator, is the coefficient of surface reflection. Surface reflection depends on the overall dimensions of the aircraft and the parameters of the radar (generator) that generates the electromagnetic waves directed at it. According to the report and survey books, the value of the surface reflection coefficient of small aircraft is 0.1-0.01 m² (-10 ...- 20 dB). In medium-sized aircraft, the surface reflection is 30 m² and higher. Taking into consideration that UAV is made of a dielectric-based

polymer-composite material, the electromagnetic waves generated by radar are absorbed by the surface of the aircraft and are not reflected. This feature reduces the chance of UAVs being detected by radars [7-8].

Acoustic detection. Due to the low volume of non-collector electric motors used in these aircrafts, the probability of detection of UAV by acoustic detection means is very low [9].

The **visual detection** coefficient depends on the illumination level of the aircraft and is calculated by the following formula (2).

$$\rho = \frac{\Phi_r}{\Phi_0} \quad (2)$$

Here: Φ_r - a stream of light reflected from the surface; Φ_0 - stream of light falling on a surface.

The brightness range of light, which can be absorbed by the human visual system, is very large ($10^6 \dots 10^6 \text{ kd} \cdot \text{m}^2$). Design of the UAV in light blue (sky) color reduces the probability of its visual detection at low altitudes (200-300 m) [10-11].

The "ARAN-4" unmanned aerial vehicle, which has such positive qualities as vertical take-off and landing, long stay in the air and simplicity of design, as well as mapping, monitoring and observation of oil and gas industry facilities to ensure the safety of strategic assets are designed and developed at the National Aviation Academy of The Republic of Azerbaijan.

CONCLUSION

The balance conditions, aerodynamic and electromagnetic compatibility requirements have been met during structural emplacement of the elements in the convertiplane type UAV. Static and dynamic balance conditions are achieved

by equal distribution of mass and forces relative to the center of gravity of the glider. In order to meet the aerodynamic requirements, the protrusions on the surface of the glider, which create the opposite aerodynamic forces, have been minimized and for meeting the requirements of electromagnetic compatibility, both electronic devices with sharply different operating frequencies were used and sensitive and power devices were placed at a certain distance and in a certain position. The insulation layer is made of electrical wires that are resistant to both high temperatures and mechanical impact.

The coordinates of the control and navigation devices relative to the center of gravity of the aircraft are taken into account in the program uploaded on the control unit. The directional diagrams of the antennas of radio-electronic devices are directed in the direction of the communication channel as much as possible. Because RC receiver is made of radio-transparent composite material, it allows to place it inside the fuselage.

Making of composite material has caused the surface reflection coefficient and weight of convertiplane-type UAV to be low and equipping it with radar devices, as well as non-collector electric

motors and making the glider in air color significantly reduced the probability of detection of the aircraft by acoustic and visual detection means.

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DEVELOPING PRINCIPLE OF MEASURING FLUIDS LINEAR AND VOLUMETRIC VELOCITY IN HORIZONTAL WELLS

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<https://doi.org/10.5281/zenodo.7198449>

Abstract

Potential global growing energy demand to be a realistic script for the coming decades. Sources have emerged as an alternative, oil has continued to be the most important source of energy so far (32.9% of the total; World Energy Council, 2016) and may remain the main option in the long term. Recent major oil discoveries are in offshore fields where oil production is still difficult. Although new technologies have been developed, the lack of a clear understanding of the multiphase flow has imposed restrictions on projecting the directional wells.

Keywords: multiphase flow, flow velocity, horizontal well, updraft, downdraft

One of the actual tasks of modern field geophysics in operating horizontal wells is the determination of phase flow rates with an assessment of the interval production rate. Currently, mechanical flowmeters are traditionally used to measure the flow rate in the well. Unfortunately, the method has significant limitations, especially in multiphase flow conditions. A mechanical turbine is critical to the fluid composition, and phase separation in an inclined or horizontal well adds uncertainty due to its uncontrolled position relative to the interface [1].

Issue partially resolved through the use of distributed mechanical flowmeters that provide layer measurement of the local flow velocity in operating horizontal wells in combination with composition sensors [2]. However, under the conditions of water intrusion and low flow rates, it's typical for horizontal wells in most fields in Russian Federation.

The technology of operating inclined-directional and horizontal wells is widely used in every oil field in this country and abroad, along with constantly improving technology for drilling inclined-directional wells and well completions [1-3]. Compared to a vertical well, the underground environment of a highly deviated well and a horizontal well is undervalued [4-5]. Basically the following facts were shown:

1) the well gravity direction is perpendicular to the well axis direction, and the space around the well is asymmetric.

2) Stratified flow is common in multi-phase flow for gravity differentiation, and the flow modes are very complex due to the change in angle of the wellbore inclination.

3) There are three types due to wavy wellbore, including horizontal flow (inclination angle $(\alpha=0^\circ)$, updraft $(\alpha > 0^\circ)$, and liquid flows upwards), and downdraft $(\alpha < 0^\circ)$, liquid flows downwards). Thus, the traditional

multiphase flow interpretation model in a vertical well can't be effectively used to interpret well GIS data in highly inclined-directional and horizontal wells.

In this article, based on the theory of similarity, using a combination of instruments for production logging from SONDEX, experiments were carried out in a plexiglass pipe to simulate two-phase oil-water and gas-water phases in updraft, horizontal and downdraft flow, with an inner diameter of 124 mm. Based on the analysis conclusions of experimental data and considering such factors of influence, as the angle of inclination, models for correcting the well curves for the slippage velocity in inclined-directional and horizontal wells are created and preliminary verified.

Qualitative Analysis is estimated for the flow characteristics of two-phase oil-water and gas-water systems, so this article uses the example of two-phase oil-water system to analyze the slippage velocity of flow characteristics at different inclination angles [6-8]. Figure 1 shows a diagram of oil-water two-phase flow distributions and velocity profile in a wave-like well. Assuming that the fluid flow is from right to left;

1) updraft ($c > b$), accumulation of oil in the upper part of the pipe, and the buoyancy component of the oil takes away the bottom water with updraft, as well as the velocity of oil more than water. When moving into position, the buoyancy component of oil is equal to or less than the gravitational component of water, the water stops or sinks down, thereby forming a circulating water flow (or regurgitation), the oil velocity is positive, the water velocity is close to 0 or has a negative value.

2) When the wellbore is located horizontally, oil is at the top, water is at the bottom, and the difference in the rates of oil and water is low.

3) Downdraft ($b > a$), since the density of water is higher than that of oil, the velocity of downward water is higher than that of oil.

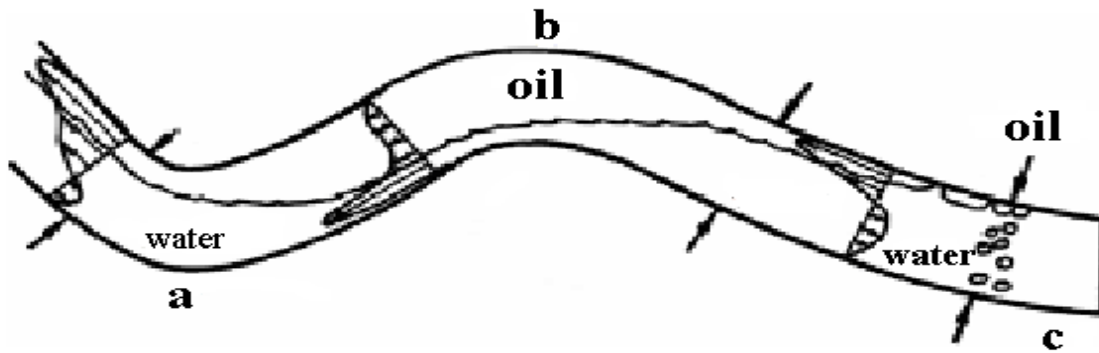


Figure 1– Oil and water distribution

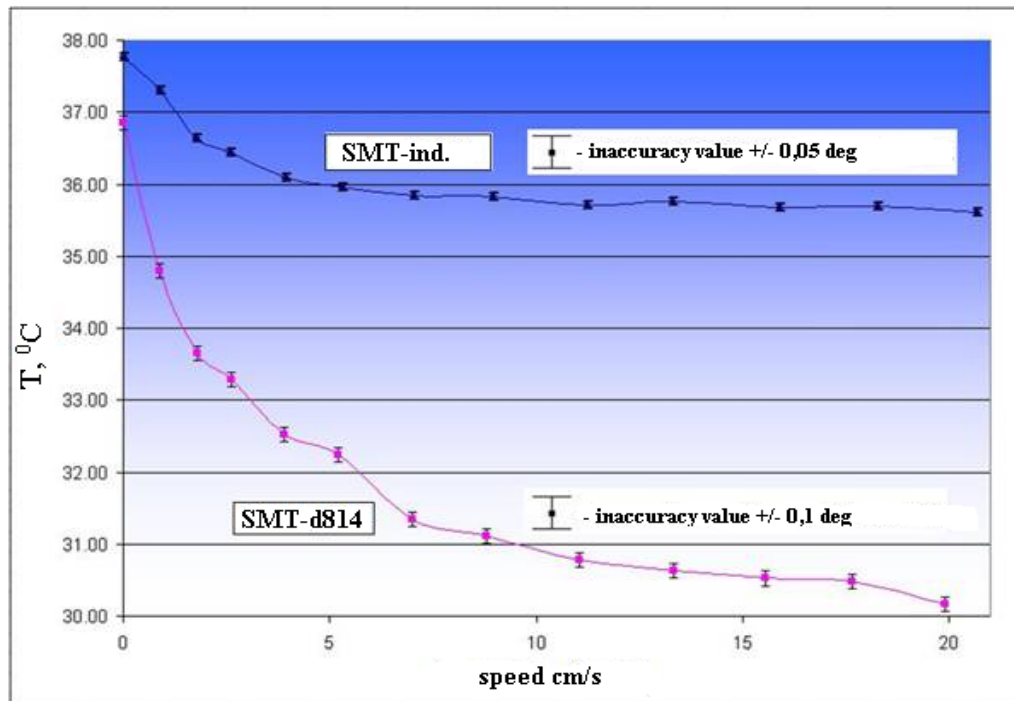


Figure 2– Values depending on the water flow velocity

In a vertical well, the traditional calculation formula for the slippage velocity in a two-phase oil-water mixture is:

$$V_{SV} = 12.013 (p_W - p_O)^{0.25} \exp \left\{ -0.788 \ln \left[\frac{1.85}{p_W - p_O} \right] \times (1 - Y_W) \right\}, (1)$$

In a highly inclined well, the slippage rate is affected by differences in the density of each phase and the gravity component. In other words, the larger the angle of inclination, the more obvious the effect of gravity, so the sliding velocity can be corrected using the angle of inclination.

$$V_S = V_{SV} + V_{SC} = V_{SV} + f(\theta)$$

$$V_S = 12.013 (p_W - p_O)^{0.25} \exp \left\{ -0.788 \ln \left[\frac{1.85}{p_W - p_O} \right] \times (1 - Y_W) \right\} (1 + \lambda \theta), (2)$$

Where SV and SC are the corrected slippage velocity and correction value, m/min.

$f(\theta)$ is the correction of inclination angle,
 θ is inclination correction factor,
 Y_W is zero dimensions of water,
 $p_W - p_O$ are densities of water and oil,

Conclusion

1. There is still a slippage velocity between two-phase oil-water and gas-water mixtures in a highly inclined and horizontal well. The slippage velocity is strongly influenced by the well trajectory. In updraft, the slippage velocity is often positive. In horizontal flow, the sliding velocity is over 0, but close 0. In downdraft, the slippage velocity is negative.

2. Based on the analysis of the flow characteristics in the simulated experiments and theoretical multiphase flow models, with the introduction of the concept of well deviation correction, models are determined for adding and multiplying the well deviation correction by the slippage velocity. And the multiplier correction model has been proven correct and feasible in highly inclined and horizontal wells by verification two-phase oil-water experimental data.

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RESEARCH OF THE RANDOM PROCESS LOAD CURRENT OF THE TRANSFORMER SUBSTATION

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ДОСЛІДЖЕННЯ ВИПАДКОВОГО ПРОЦЕСУ СТРУМУ НАВАНТАЖЕННЯ ТРАНСФОРМАТОРНОЇ ПІДСТАНЦІЇ

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Abstract

In article the technique of the analysis of electrical loads of consumers as non-stationary casual processes with hidden periodicities is submitted. The estimation of outcomes of decomposition of casual process in a trigonometrical series happens on the basis of inspection of statistical hypotheses. The obtained performances of investigated casual process can be used for prediction of his extremes, and also for the purposes of optimum control.

Аннотация

В статье представлена методика анализа электрических нагрузок потребителей как нестационарных случайных процессов со скрытыми периодичностями. Оценивание результатов разложения случайного

процесса в тригонометрический ряд происходит на основании проверки статистических гипотез. Полученные характеристики исследуемого случайного процесса могут быть использованы для прогнозирования его экстремальных значений, а также для целей оптимального управления.

Keywords: load current as a random process, hidden periodicities, trigonometric series, statistical hypothesis, agreement criterion, correlation function.

Ключевые слова: ток нагрузки как случайный процесс, скрытые периодичности, тригонометрический ряд, статистическая гипотеза, критерий согласия, корреляционная функция.

Вступ. Відоме, що існуючі методи дослідження і прогнозування випадкових стаціонарних процесів не застосовні безпосередньо до процесів нестационарних. Однак в енергопостачанні побутових і промислових навантажень, навантажень приміських залізниць і т.д. часто приходится зіштовхуватися з нестационарністю випадкових процесів струму споживання. Як правило, гістограми, отримані в таких випадках, мають декілька вершин і не апроксимуються нормальним розподілом. Бажано з такого нестационарного випадкового процесу виділити, якщо це можливо, детерміновану складову, залежну від часу, і випадковий стаціонарний процес, до якого можуть бути застосовані в залежності від конкретної мети різноманітні методи дослідження.

Мета роботи складається у викладенні і практичному застосуванні методики аналізу нестационарних випадкових процесів зі схованими періодичностями.

Матеріали і результати досліджень. У загальному випадку нестационарного випадкового процесу не існує статистичних методів його дослідження. Однак випадкові процеси в електропостачанні мають добову, тижневу, річну й іншу періодичність у силу періодичності роботи підприємств і транспорту, побутових навантажень. Труднощі обробки нестационарного випадкового процесу можна уникнути, якщо як математичну модель прийняти наступне його представлення [1]:

$$x(t) = m(t) + \varepsilon(t), \quad (1)$$

де $x(t)$ – досліджуваний процес; $m(t)$ – математичне очікування, яке залежить від часу; $\varepsilon(t)$ – стаціонарний нормальний процес з параметрами $N(0, \sigma)$.

Передбачається, що нестационарність випадкового процесу $x(t)$ обумовлена тільки змінним математичним очікуванням, яке у свою чергу є детермінованою функцією. Тоді центрований випадковий процес $\varepsilon(t) = x(t) - m(t)$ має властивість стаціонарності. Якщо припущення відносно $\varepsilon(t)$ вірні, то при достатньо представницькій вибірці з процесу $x(t)$ середнє значення $\bar{\varepsilon}(t)$ наблизиться до нуля і залишиться тільки детермінована функція $m(t)$. Математичне очікування $m(t)$ в силу періодичності випадкового процесу $x(t)$ може бути

представлене у вигляді ряду Фур'є, коефіцієнти якого визначаються методом найменших квадратів [2].

Таким чином, представимо функцію $m(t)$ відрізком ряду Фур'є:

$$m(t) = \frac{a_0}{2} + \sum_{i=1}^r (a_i \cos \omega_i t + b_i \sin \omega_i t), \quad (2)$$

де $\omega_i = \frac{2\pi}{T} i$; $i = 1, \dots, r$; T – період першої

гармоніки.

Процес збору експериментальних даних припускає здійснення операції дискретизації за часом безперервних реалізацій випадкового процесу. Ця операція звичайно проводиться через рівні проміжки часу $\Delta(t)$. Причому величина інтервалу дискретності $\Delta(t)$ повинна бути такою, щоб значення випадкового процесу на кінцях інтервалу $x(t_j)$ і $x(t_{j+1})$ були некорельовані. Вибір величини $\Delta(t)$ відповідно до зазначеної умови забезпечує, з одного боку, незалежність вибіркового значення процесу $x(t)$, що уможливорює застосування для їх обробки розвинених методів математичної статистики; з іншого боку, можна чекати швидку збіжності ряду Фур'є, тобто таку, коли число членів у розкладанні (2) не перевищить максимального, котре можливо визначити при такому кроці квантування. Загальна кількість вихідних даних при m реалізаціях випадкового процесу буде дорівнювати $n = ml$ і повинне бути парним. Зареєстровані значення $x(t)$ зручно заносити в таблицю, кожен рядок якої відповідає визначеній реалізації, а число стовпців дорівнює числу значень випадкового процесу l в одній реалізації.

Виразивши відхилення випадкової величини від її математичного очікування, одержимо:

$$\varepsilon(t_j) = x(t_j) - \frac{a_0}{2} - \sum_{i=1}^r (a_i \cos \omega_i t_j + b_i \sin \omega_i t_j), \quad (3)$$

де $j = 1, \dots, n$.

Для оцінки невідомих коефіцієнтів a_0, a_i, b_i вимагатимемо відповідно до методу найменших квадратів [2], щоб

$$S = \sum_{j=1}^n \varepsilon^2(t_j) = \sum_{j=1}^n \left[x(t_j) - \frac{a_0}{2} - \sum_{i=1}^r (a_i \cos \omega_i t_j + b_i \sin \omega_i t_j) \right]^2 \rightarrow \min \quad (4)$$

по змінним a_0, a_i, b_i .

Екстремальне значення виразу (4) виходить у результаті розв'язання системи рівнянь:

$$\frac{\partial S}{\partial a_0} = 0; \frac{\partial S}{\partial a_i} = 0; \frac{\partial S}{\partial b_i} = 0. \quad (5)$$

Розв'язання системи (5) істотно спрощується при використанні матричної алгебри. Введемо матрицю:

$$A = \begin{pmatrix} \frac{1}{2} & \cos \omega_1 t_1 & \sin \omega_1 t_1 & \dots & \cos \omega_r t_1 & \sin \omega_r t_1 \\ \frac{1}{2} & \cos \omega_1 t_2 & \sin \omega_1 t_2 & \dots & \cos \omega_r t_2 & \sin \omega_r t_2 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \frac{1}{2} & \cos \omega_1 t_n & \sin \omega_1 t_n & \dots & \cos \omega_r t_n & \sin \omega_r t_n \end{pmatrix}, \quad (6)$$

яка має n рядків і $2r+1$ стовпців. Далі позначимо

$$c_0 = a_0, c_1 = a_1, c_2 = b_1, \dots,$$

$$c_{2r-1} = a_r, c_{2r} = b_r.$$

Тоді транспонована матриця-стовпець C' запишеться у вигляді:

$$C' = (c_0, c_1, c_2, \dots, c_i, \dots, c_{2r-1}, c_{2r}). \quad (7)$$

У такому випадку рівняння (3) переписуться в такий спосіб:

$$E = X - AC. \quad (8)$$

Вираз (4) у матричній формі запису прийме вигляд:

$$S = E' E = (X - AC)' (X - AC) = X' X - 2C' A' X + C' A' A C, \quad (9)$$

$$\text{де } E' = (\varepsilon(t_1), \varepsilon(t_2), \dots, \varepsilon(t_n)),$$

$$X' = (x_1(t_1), \dots, x_1(t_1),$$

$$x_2(t_1), \dots, x_2(t_1), \dots, x_i(t_1), \dots, x_i(t_1), \dots, x_m(t_1), \dots, x_m(t_1)), \quad (10)$$

– вектори-стовпці розмірністю $(n \times 1)$.

Диференціюючи (9) по кожному коефіцієнту c_i , одержимо систему рівнянь:

$$-2A'X + 2A'AC = 0, \quad (10)$$

відкіля оцінки коефіцієнтів $\hat{c}_i$ визначаються з розв'язання системи:

$$\hat{C} = (A' A)^{-1} A' X \quad (11)$$

за умови, що матриця $B = A' A$ – не вироджена. Матриця B з урахуванням властивостей тригонометричних функцій виходить квадратною, діагональною, розміром $(2r+1) \times (2r+1)$.

Як показано в [2], отримані оцінки $\hat{c}_i$ ($i = \overline{0, 2r}$) володіють наступними важливими властивостями: величини $\hat{c}_i$ є незміщеними оцінками коефіцієнтів c_i і не залежать від вигляду розподілу $\varepsilon(t)$; отримані оцінки є найкращими з усіх можливих інших,

$$D[\hat{C}] = D[FX] = F D[X] F' = (A' A)^{-1} A' \sigma^2 E A (A' A)^{-1} = \sigma^2 (A' A)^{-1} = \sigma^2 B^{-1}. \quad (16)$$

Таким чином, за формулою (16) можуть бути визначені дисперсії оцінок коефіцієнтів $\hat{c}_i$, $i = \overline{0, 1, \dots, 2r}$. Варто підкреслити незалежність цих оцінок, що впливає з діагонального виду матриці B .

отриманих у вигляді лінійної комбінації вихідних даних $x(t_j)$ ($j = \overline{1, n}$). Питання про кількість членів ряду Фур'є, яке потрібно зберегти в розкладанні, визначається перевіркою на значимість оцінок коефіцієнтів за критерієм Стюдента.

Перш ніж застосувати критерій Стюдента, необхідно знайти дисперсії оцінок $\hat{C}$ коефіцієнтів C . Вони повинні виражатися через дисперсії вимірюваної величини $x(t_j)$ за допомогою деякої лінійної комбінації, тому що самі оцінки є лінійними комбінаціями результатів виміру $x(t_j)$. У загальному випадку дисперсії є елементами головної діагоналі матриці коваріацій. Зі сказаного вище про відсутність кореляції між сусідніми значеннями випадкового процесу $x(t_j)$ і $x(t_{j+1})$, впливає умова:

$$\text{cov} \left[x(t_j), x(t_{j+1}) \right] = 0. \quad (12)$$

Випадковий процес $x(t)$ відрізняється від стаціонарного процесу $\varepsilon(t)$ з параметрами $N(0, \sigma)$ на величину не випадкової функції $m(t)$, тому розглянуті перетини цього процесу мають однакові дисперсії σ^2 . Тоді з урахуванням (12) впливає вираз для дисперсій $D(X)$ результатів вимірів $x(t_j)$:

$$D(X) = \sigma^2 E, \quad (13)$$

де E – одинична матриця.

Далі визначимо дисперсії оцінок коефіцієнтів $\hat{c}_i$. Позначимо матрицю

$$(A' A)^{-1} A' = F. \quad (14)$$

Тоді (11) можна записати у вигляді:

$$\hat{C} = F X \quad (15)$$

і матриця дисперсій оцінок визначиться як результат наступних перетворень:

Тому що σ^2 – величина невідома, то вона замінюється на оцінку S^2 дисперсій у перетинах випадкового процесу $x(t)$, обумовлену за формулою [3]:

$$S^2 = \frac{(X - \widehat{AC})(X - \widehat{AC})}{v}, \quad (17)$$

де $v = n - 2r - 1$ - число ступенів свободи.

Якщо матриця дисперсій оцінок коефіцієнтів ряду Фур'є визначається виразом

$$D[\widehat{C}] = S^2 B^{-1}, \quad (18)$$

то погрішність оцінок коефіцієнтів

$$t_{i,v} = \frac{|\widehat{c}_i - c_i|}{\sqrt{D\widehat{c}_i}} \quad (19)$$

має розподіл Стюдента зі $v = n - 2r - 1$ ступенями свободи.

Гіпотеза H_0 , що перевіряється, полягає в тому, що $c_i = 0$. При цьому, якщо значення $t_{i,v}$, обчислено за (19), виявляється більше критичного $t_{кр}$ для даного рівня значимості $q\%$, то гіпотеза H_0 відкидається, і оцінка приймається значимою [4]: $\widehat{c}_i \neq 0$. У випадку, якщо виконується зворотна умова, то оцінка коефіцієнта $\widehat{c}_i$ вважається незначущою, і даний член розкладання відкидається.

Варто підкреслити, що якщо досліджуваний процес $x(t)$ у дійсності є стаціонарним, то всі коефіцієнти в розкладанні (2) виявляються статистично незначущими за винятком коефіцієнта a_0 [5].

Після того як виконана апроксимація функції $m(t)$ рядом Фур'є, по отриманих величинах $\varepsilon(t_j)$ будуємо гістограму і перевіряємо нормальність розподілу за критерієм хі-квадрат χ^2 .

Для перевірки гіпотези H_0 про рівність дисперсій процесу в різні моменти часу можна застосувати критерій Кокрена. У кожному перетині випадкового процесу $\varepsilon(t_k)$ ($k = \overline{1, l}$) обчислюється оцінка дисперсії S_k^2 . З l дисперсій S_k^2 вибирається максимальна:

$$S_{\max}^2 = \max(S_1^2, S_2^2, \dots, S_l^2). \quad (20)$$

Якщо значення статистики

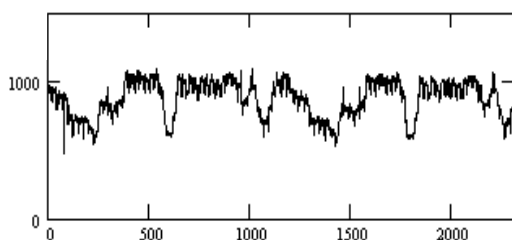


Рисунок 1 Графік навантаження силового трансформатора

$$G = \frac{S_{\max}^2}{S_1^2 + S_2^2 + \dots + S_l^2} \quad (21)$$

виявиться менше $G_{кр}$, знайденого по таблицях [4] для $v = m - 1$ ступенів свободи, l дисперсій і заданого рівня значимості, то гіпотеза про рівність дисперсій приймається.

Подальше дослідження укладається в рамки методів, застосовуваних для стаціонарних процесів. Спектральна щільність і кореляційна функція виражаються взаємно одна через іншу перетвореннями Фур'є:

$$R(\tau) = \int_0^{\infty} S(f) \cos 2\pi f \tau df, \quad (22)$$

$$S(f) = 4 \int_0^{\infty} R(\tau) \cos 2\pi f \tau d\tau,$$

а нормована кореляційна функція і нормована спектральна щільність запишуться у вигляді:

$$\rho(\tau) = \frac{R(\tau)}{D}, \quad s(f) = \frac{S(f)}{D}, \quad (23)$$

де D — дисперсія обчислена по одній реалізації процесу $\varepsilon(t)$ утвореної як сума m реалізацій такої ж загальної тривалості.

Функції $\rho(\tau)$ й $s(f)$ аналогічно зв'язані перетвореннями Фур'є:

$$\rho(\tau) = \int_0^{\infty} s(f) \cos 2\pi f \tau df,$$

$$s(f) = 4 \int_0^{\infty} \rho(\tau) \cos 2\pi f \tau d\tau. \quad (24)$$

Для перевірки ефективності викладеної вище розрахункової методики був здійснений аналіз результатів виміру випадкового процесу зміни діючого значення струму в одній з фаз вторинної обмотки трансформатора тиристорного перетворювача одного з прокатних цехів Криворізького металургійного комбінату. Усього було зроблено 2320 вимірів струму з інтервалом між вимірами в одну секунду. У такий спосіб був отриманий вихідний випадковий процес, який наведений на рисунку 1.

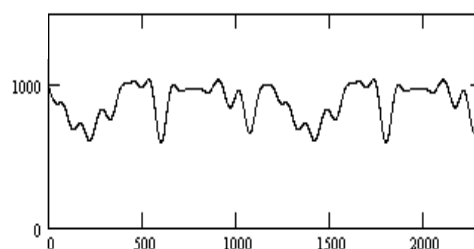


Рисунок 2 Математичне очікування випадкового процесу зміни навантаження силового трансформатора

Після того, як були узяті перші п'ятнадцять гармонік ряду ($r = 15$), програма, написана мовою

програмування середовища Matlab, здійснила розрахунок оцінок коефіцієнтів ряду Фур'є за формулою (11). При цьому отримані наступні результати:

- оцінка постійної складової ряду $\hat{a}_0 = 1758$;
- значення амплітуд косинусоїдальних складових $\hat{a}_1, \dots, \hat{a}_{15}$: -52.6, 6.5, 101.7, 2.2, 57.1, -19.3, 24.1, -23.3, 19.2, -55.6, -4.1, -5.9, 33.9, -2.2, 9.1;
- значення амплітуд синусоїдальних складових $\hat{b}_1, \dots, \hat{b}_{15}$: 62.1, -42.7, 29.1, 11.5, -17.7, -6.5, -16.8, -26.6, -14.1, 14.9, 7.2, 0.73, -7.7, -1.3, -5.4.

Оцінка дисперсії випадкового процесу, визначена за формулою (17), $S^2 = 1908$ і $S = 43.68$.

Величини дисперсій оцінок коефіцієнтів $\hat{a}_0, \hat{a}_i, \hat{b}_i$ відповідно до (18) дорівнюють: $D\hat{a}_0 = 3.37$, $D\hat{a}_i = D\hat{b}_i = 1.72$, $i = 1, \dots, r$.

Далі за формулою (19) обчислені значення t – статистики Стюдента, записані в наступному порядку $t_{\hat{a}_0}, t_{\hat{a}_1}, t_{\hat{b}_1}, t_{\hat{a}_2}, t_{\hat{b}_2}, \dots, t_{\hat{a}_r}, t_{\hat{b}_r}$: 956.4, 39.4, 49.1, 4.9, 33.4, 77.6, 22.6, 1.7, 8.8, 44.2, 13.1, 14.9, 4.9, 18.6, 12.9, 17.9, 20.5, 14.7, 10.9, 42.8, 11.5, 3.2, 5.5, 4.6, 0.57, 26.3, 5.97, 1.67, 1.04, 7.03, 4.16.

Критичне значення для $\nu = 2289$ і рівні значимості $q = 5\%$ по таблицях [4] дорівнює 1.97. Після перевірки значимості оцінок коефіцієнтів a_i і

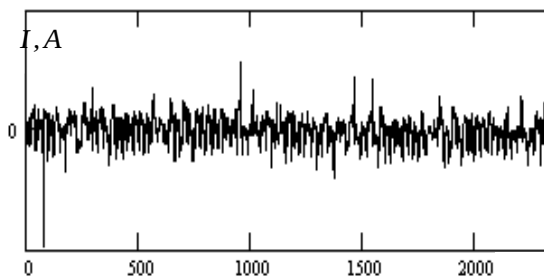


Рисунок 3 - Стаціонарний процес змінення навантаження силового трансформатора, який накладається на періодичну складову

По (21) обчислюється значення статистики Кокрена $G = 0.0464$. Табличне значення для довірчої імовірності 0.95, кількості порівнюваних дисперсій 29 і ступенів свободи $\nu = 79$ дорівнює $G_{кр} = 0.0545$. З нерівності $G < G_{кр}$ випливає, що дані вибірки з імовірністю 0.95 не суперечать гіпотезі про рівність дисперсій. Таким чином, центрований випадковий процес є стаціонарним і його графік наведений на рисунку 3.

Після визначення статистичної кореляційної функції процесу $\varepsilon(t)$ і побудови її графіка виникає необхідність апроксимації кореляційної функції аналітичним виразом, зручним при подальшому дослідженні. Для згладжування залежності $\rho^*(\tau)$, використовуємо функцію виду:

$$\rho(\tau) = e^{-a|\tau|}. \quad (25)$$

b_i за критерієм Стюдента отримані наступні результати: статистично незначущими виявилися оцінки $\hat{a}_4, \hat{b}_{12}, \hat{a}_{14}, \hat{b}_{14}$ і їхні значення приймаються рівними нулю. Графік детермінованої періодичної складової досліджуваного процесу наведений на рисунку 2.

Для стаціонарності центрованого процесу $\varepsilon(t)$ необхідне виконання умови сталості дисперсії. Для цього визначається оцінка дисперсії S_k^2 в кожному перетині випадкового процесу $\varepsilon(t)$.

Нижче наведені результати обчислень у порядку $S_1^2, S_2^2, \dots, S_{29}^2$: 2405.4, 1762.1, 1703.9, 2007.4, 2101.1, 1499.7, 2148.2, 1650.3, 1559.7, 1210.8, 1479.8, 2087.7, 1600.9, 1582.8, 1852.1, 1748.8, 2563.3, 1563.1, 1621.9, 1882.7, 1825.7, 2130, 2305.4, 1846.5, 1780.4, 2001.1, 1701.3, 1812.7, 2438.4.

Визначається максимальне значення і сума дисперсій: $S_{\max}^2 = S_{17}^2 = 2563.3$, $\sum_{i=1}^{29} S_i^2 = 55203$.

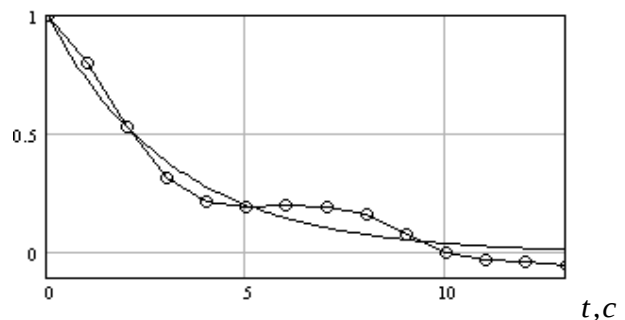


Рисунок 4 Графіки функції $\rho^*(\tau)$ та залежності $\rho(\tau)$, яка її апроксимує

Для визначення параметра a використовується метод найменших квадратів. Застосовуючи даний підхід, складається наступне нелінійне рівняння відносно параметра a :

$$\sum_{i=1}^l \tau_i \rho^*(\tau_i) e^{-a\tau_i} - \sum_{i=1}^l \tau_i e^{-2a\tau_i} = 0, \quad (26)$$

де $\rho^*(\tau_i)$ – значення емпіричної нормованої кореляційної функції в моменти часу τ_i .

Вирішуючи рівняння (26) методом бісекції, знаходимо $a = 0.318$. Тоді аналітичний вираз нормованої кореляційної функції має вигляд:

$$\rho(\tau) = e^{-0.318|\tau|}. \quad (27)$$

Згладжена функція $\rho(\tau)$ і емпірична функція $\rho^*(\tau)$ показані на рисунку 4.

Кореляційна функція характеризує взаємозв'язок ординат графіка навантаження, визначає порядки частот, їх співвідношення і тим самим однозначно зв'язана з функцією розподілу енергії процесу по частотах, тобто спектральною щільністю.

$$s(f) = 4 \int_0^{\infty} e^{-a\tau} \cos 2\pi f \tau d\tau = \frac{4a}{a^2 + 4\pi^2 f^2} = \frac{15.88}{15.76 + 4\pi^2 f^2} \quad (28)$$

Графік функції $s(f)$ наведений на рисунку 5.

Спектральна щільність показує питому потужність випадкового процесу струму навантаження, що приходить на одиничні інтервали частоти.

Висновки. У даній роботі викладається загальний підхід до аналізу нестационарних випадкових процесів із прихованими періодичностями, які визначаються режимом електроспоживання промислових підприємств. Пропонується у якості матема-

тичної моделі прийняти представлення досліджуваного випадкового процесу у виді суми детермінованої функції із змінним математичним очікуванням і стаціонарного нормального процесу з нульовим математичним очікуванням. Віднімаючи із нестационарного випадкового процесу змінне математичне очікування, отримаємо центрований випадковий процес, середнє значення якого при досить представницькій вибірці наблизиться до нуля і залишиться тільки детермінована функція.

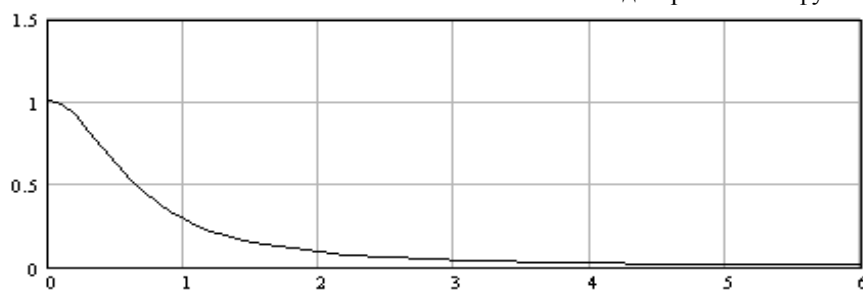


Рисунок 5 – Графік однобічної нормованої спектральної щільності випадкового процесу $x(t)$

У силу періодичності досліджуваного випадкового процесу математичне очікування може бути представлено у вигляді ряду Фур'є, коефіцієнти якого визначаються методом найменших квадратів за умовою мінімізації суми ординат центрованого випадкового процесу.

Питання щодо кількості членів ряду Фур'є, які необхідно зберегти у розкладенні, розв'язується перевіркою на значимість оцінок коефіцієнтів за критерієм Стюдента із попереднім визначенням величини дисперсії оцінок коефіцієнтів. Перевірка гіпотези про рівність дисперсії у різні моменти часу розраховується на основі критерію Кокрена. У розрахунках коефіцієнтів Фур'є взяті перші п'ятнадцять гармонік з визначенням оцінки постійної складової та значень амплітуд синусних і косинусних складових.

Як відомо для стаціонарної випадкової функції, окрім сталості математичного очікування, необхідно мати сталість дисперсії. За даними вибірки із центрованого випадкового процесу побудована імпірична функція щільності розподілу. Узгодження імпіричного і теоретичного розподілів перевіря-

лося за критерієм Пірсона, у результаті чого з вірогідністю 0,95 немає підстав відкидати гіпотезу щодо нормальності розподілу. Кореляційна функція детермінованого процесу визначена через кореляційні моменти. Апроксимація виконана стандартною експоненціальною залежністю.

Отримані характеристики досліджуваного випадкового процесу можуть бути використанні для прогнозування його екстремальних значень а також для цілей оптимального керування.

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№94/2022

Norwegian Journal of development of the International Science

ISSN 3453-9875

It was established in November 2016 with support from the Norwegian Academy of Science.

DESCRIPTION

The Scientific journal “Norwegian Journal of development of the International Science” is issued 24 times a year and is a scientific publication on topical problems of science.

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