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Dear Colleagues,

I address you, on the occasion of the International scientific and technical conference “Innovative development of resource-saving technologies and sustainable use of natural resources”, a collegial greeting and warm congratulations for all the accomplishments in your activity.

It is a great pleasure, for me and my colleagues, that the University of Petrosani, still in this year, is co-organizer of your well known and appreciated conference. Friendly appreciation and solidarity feelings binds me with the National University of Water and Environmental Engineering in this one difficult period of war in Ukraine. The Conference became more and more important for both our universities due to the quality of scientific papers and of course due to the Scientific committee of the conference which includes scholars and manufacturers from more and more countries of Europe, Asia, Australia and Africa.

A lot of specialists from your University, in the field of bachelor's and master's studies, recognized in the academic and scientific circles in Ukraine and Europe, and having an orientation of scientific research towards the top problems of the theory and practice of economic and social life. The fact that the University always expands its horizon of studies related to the dynamics of modern public life, provides the country with a reservoir of human resources with high qualifications and various competences.

We are happy to observe the participants from Poland, Kazakhstan, Ukraine, Nigeria, Uzbekistan, Ghana, Albania, Zambia, Vietnam, Germany, Azerbaijan, Algeria, Kyrgyzstan, Republic of Guinea, Mongolia, Slovakia, and of course from Romania and Ukraine.

Every year makes the National University of Water and Environmental Engineering a more powerful center of scientific and cultural irradiation, well integrated in the circuit of international cooperation.

I wish you the best of health, luck and happiness being convinced that the collaborative relations between our universities will be fruitful.

Sincerely yours,
Professor Ph.D.Eng. Sorin Mihai RADU
Rector of the University of Petrosani, Romania

Dear friends, colleagues, organizers and participants of the V International Scientific and Technical Conference “Innovative Development of Resource-Saving Technologies and Sustainable Use of Natural Resources”.

The world has greatly changed since the previous conference. For eight months, Ukraine has been waging a liberation war with an insidious invader – the russian federation wishing to destroy our country that has turned to democracy and recognition of European values. Our University is doing everything it can to help hasten our victory. It has initiated creation of a volunteer formation of the territorial community; students and employees are actively engaged in volunteering and defending our state by joining the Armed Forces of Ukraine.

We are pleased to hear words of support from our colleagues – lecturers of the University of Petroşani. And we dedicate this conference to our victory.

Our University is constantly developing. At present, there are 129 educational programs for the bachelor's and master's degrees and PhD, for full-time and part-time as well as formal and non-formal education. Intense scientific and pedagogical activities of the University, cooperation with foreign partners have contributed to the growth of its rating in the “Top 200 Ukraine 2022” and the increase in publications indexed in the international database Scopus.

The geography of the conference participants is constantly expanding. In 2022, leading scientists from 34 countries of Europe, Asia, Africa, Australia, South America have agreed to join the Scientific Committee of the conference. And this is the international recognition of our conference.

We thank Rector of the University of Petroşani, Professor Sorin-Mihai RADU and his colleagues for their cooperation. Special thanks to the members of the Scientific Committee and all participants of the conference.

The conference proceedings highlight advanced technologies used in different countries of the world. And this allows us to expand the horizons of international cooperation and establish research and production relations with scientists and practitioners from other countries.

More than 100 abstracts of reports from 48 scientific institutions of 14 countries are presented in four sections of the conference.

We are pleased to welcome participants from Poland, Romania, Kazakhstan, Ukraine, Ghana, Zambia, Vietnam, Germany, Azerbaijan, Algeria, Kyrgyzstan, Moldova, Tajikistan, Armenia.

I wish peace, health and creative inspiration to the participants of the conference!

Respectfully,
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DUST BINDING SUBSTANCE

Introduction

In the city of Kryvyi Rih, 93,4% of the total volume of industrial production is made up of the mining and metallurgical industry. At the same time, the intensive extraction of minerals in Kryvyi Rih, their processing and waste storage have led to the formation of anthropogenic relief, which causes constant pressure on the city's natural environment. Thus, the dynamics of dust emissions during 2018-2020 amounted to 34,90, 33,24 and 29,06 thousand tons, respectively. One of the main unorganized sources of dust emissions are tailings of mining and beneficiation enterprises. With the wet tailings storage method, the hydromix of the tailings pulp is pumped into special hydrotechnical facilities - tailings storage facilities. The tailings, which are placed in the maps of the dam, on the slope areas quickly give off moisture, dry out and, at wind speeds of more than 3 m/s, subject to wind erosion, become the sources of dust emission into the atmosphere. The vast majority of tailings, by their fractional composition, belong to erosive and hazardous dust. The release of dust into the air from the dry surfaces of tailings storage facilities leads to the development of occupational lung diseases among workers of industrial enterprises and the deterioration of the general ecological situation in the area where the industrial object is located as a result of the release of pollutants into the air.

Working hypothesis

In order to theoretically substantiate the expediency of using selected reagents for dust suppression on the surfaces of tailings, a study of industrial adsorbents was conducted, where the main ones are activated carbon and its modifications. The use of a humate reagent, which production is carried out in accordance with, in the composition of a working mixture as a filler for the sleeves of the external hydraulic hammer during mass explosions in the quarry of PJSC "InGZK" showed its ability to sorb gases and dust (Fig. 1). The humate reagent is a product, including the processing of lignite, the main active ingredients are sodium and potassium salts of humic acids and gelatinous substances, which are finely dispersed carbon-humic complexes. Common to humic acids of various origins is the presence of an aromatic core and peripheral open chains consisting of carboxyl, carbonyl groups, hydroxyls of an alcoholic and phenolic nature, and residues of nitrogen-containing

amino acids. This structure of humic acids explains their adsorption properties. It is inserted that the process of adsorption of carbon monoxide (ll) of the carbon-alkaline reagent, which is a component of the humate reagent, is an exothermic process and has a significant value of ΔH. It is equal to -179 kJ/mol, which allows to conclude about the presence of chemisorption (not only physical, but also chemical sorption).

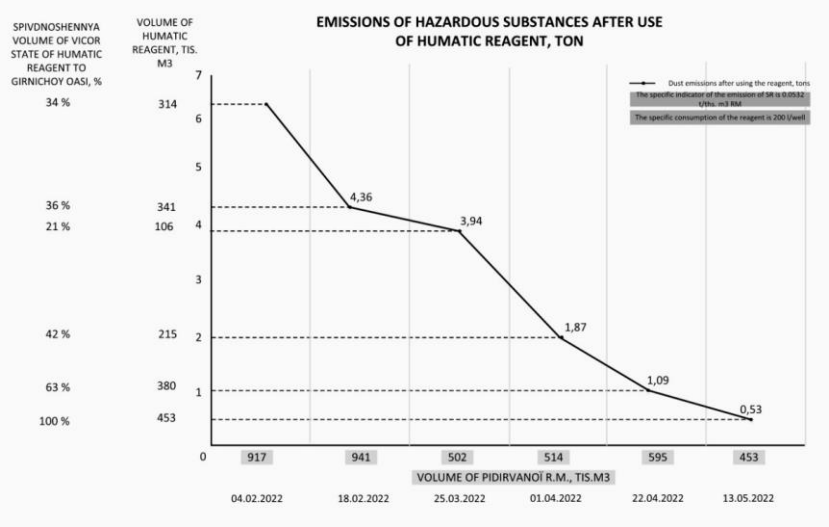

Fig. 1. Results of industrial tests of an external hydrohammer with a humate reagent on mass explosions in the quarry of PJSC "InGZK"

Effective neutralizers of carbon monoxide are potassium permanganate $KMnO_4$ and hydrogen peroxide H_2O_2, which oxidize CO carbon monoxide to CO_2 dioxide. It was proved by employees of the Research Mining Institute and Research Institute of Mining and Ore [4-7] that physical sorption of gases occurs on activated carbon, while its ability to absorb carbon monoxide and nitrogen oxides, regardless of their chemical nature, and to form a stable protective layer (crust) from fine dust particles upon evaporation of moisture was experimentally confirmed.

Conclusions

1. In order to determine the special properties of reagents for fixing the surfaces of tailings storage facilities, the following indicators are proposed: stability of the protective layer; dust emission intensity; strength of the protective layer (ultrasonic method); the thickness of the protective layer; water absorption of the surface;

2. According to the conducted studies and taking into account the comprehensive efficiency indicator, the best properties are determined for the reagents: Liquid organic fertilizers; Humate reagent (aqueous solution 30%); Enviro Binder (Enviro Binder/water ratio - 1:19).

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STATE ENVIRONMENT MONITORING AS A LEGAL INSTRUMENT OF ENVIRONMENTAL MANAGEMENT

In Poland, monitoring of the natural environment began in the early 1990s under the Act of 10 July 1991 on the Environmental Protection Inspection [1]. This act was the basis for the creation of a system consisting of a number of measurements, forecasts and assessments of the condition of the environment.

The development of programs commenced, which were approved by the management of the Ministry of Environmental Protection, Natural Resources and Forestry, and then implemented for the next years. The State Environmental Monitoring has changed along with the amendments to the Act on the Inspection of Environmental Protection. The amendment in 2001 introduced a change in the implementation of environmental monitoring. Long-term voivodeship programs of the State Environmental Monitoring were created. Another amendment to the acts took place in 2018. It changed the implementation of the tasks of the State Environmental Monitoring.

The tasks and resources carried out so far by the voivodeship environmental protection inspectorates have been transferred to the Chief Inspectorate for Environmental Protection and are exclusively carried out by it. The tasks set by the Chief Inspector of Environmental Protection in the long-term strategic programs of the State Environmental Monitoring are then approved by the Minister of Climate. The program for the years 2020-2025 [2] is currently being implemented.

"State Environmental Monitoring, pursuant to Art. 23 sec. 1 of the Act on the Inspection of Environmental Protection is a system for measuring, assessing and forecasting the state of the environment, collecting, processing and disseminating information about the environment"[3].

The main goal of SEM is to provide administrative authorities and the public with information about: meeting environmental quality standards and the condition of its individual elements, places where the standards are exceeded, changes taking place in individual elements of the environment and their causes, the relationship between the emission and the state of the environmental elements.

All information collected by SEM is used by government and local government administration bodies to manage the environment with the use of legal instruments.

The legal instruments include: environmental impact assessment, permission for the introduction of energy or substances into the environment, programs and plans for the protection of the environment as a whole and its individual elements, spatial development plans. The information is used to monitor the effectiveness of activities and their effective planning. The information collected by the SEM is used to service Poland's international obligations, including within the European

Union. SEM provides data that is made available under the Act on the provision of information on the environment and its protection, public participation in environmental protection and on environmental impact assessments. The objectives of the SEM are implemented by performing the following partial tasks: research on indicators characterizing individual elements of the environment, observation of natural elements, collecting and analyzing the results of research and observations, assessing the quality of environmental elements and trends in changes, identification of areas where environmental quality standards are exceeded, cause and effect analyzes, creating reports, statements of messages and making them available via print or the Internet.

Each sub-task is carried out in accordance with the principle of cyclicality and the principle of uniformity of methods in accordance with Art. 23, paragraph 14 of the Act on the Inspection of Environmental Protection [3]. To meet the requirements of the Act, the SEM undertakes various activities, including accreditation of research laboratories, modernization of the measurement infrastructure, training.

Atmospheric air quality is tested under the SEM. The air quality monitoring system is defined for a given region in voivodeship environmental monitoring programs. These programs are prepared by regional environmental monitoring departments.

The system creates a network of measuring stations (most often in cities), which are located in areas with high concentrations of pollutants. The ordinance of the Minister of the Environment of December 11, 2020 on the assessment of the levels of substances in the air contains the criteria for the arrangement of measuring stations [4].

The Chief Inspectorate for Environmental Protection makes a decision on the location of measuring stations and their measurement program. He carries out multi-annual air quality assessments under SEM. On their basis, an assessment is made in a given zone, the number of stations and their measurement range are selected. The collected data can be supplemented with the results of mathematical modeling in order to learn about the spatial distribution of pollutants.

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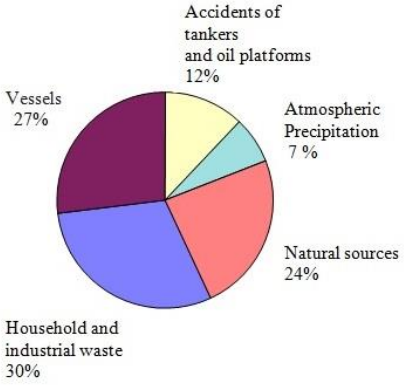
WAYS TO USE SOLID WASTE IN INDUSTRY

The intensive development of industry and construction in recent decades has caused a great demand for the products of the metallurgical industry, and this , in turn, demanded to expand the range of products made on the basis of cheap environmentally friendly raw materials. It should be noted that in terms of the diversity of mineral deposits, the region of the Greater and Lesser Caucasus can be attributed to one of the richest regions in the world. The main resources are oil, gas, alunites, tuff, dolomite, clay and other rocks containing a number of valuable chemical elements such as aluminum, iron, copper, zinc, gold, etc. All this has led to the accelerated development of a number of areas, oil production, oil refining and a number of other industries, including non-ferrous metallurgy.



Sources of environmental pollution with oil products

The specifics of oil and gas development, due to the fact that in the process of oil and gas production, along with oil, highly mineralized water and associated gas are also extracted, create conditions that cause great harm to the environment. Also, in the process of oil production, a large amount of sludge is formed, which is discharged directly into the sea or collected in special dumps, solid waste storage facilities. Such waste causes great damage to the soil. When such wastes, which also contain oil, enter the soil, deep and often irreversible changes in the physical, morphological, physicochemical, microbiological properties of soils take place. Such a composition of waste is capable of forming toxic compounds during transformation, which have carcinogenic properties, are characterized by resistance to microbiological degradation and the ability to pass into plants, which significantly reduces the quality of cultivated crops and poses a certain threat to human health. One-time releases to soil are relatively small, but their constant action creates a significant area of persis-

tent pollution around the source. Currently, there are more than 20-25 thousand hectares of oil-contaminated soils on the Absheron Peninsula, the degree of pollution of which ranges from 1-2 to 50% or more. To prevent the negative impact on the environment during the operation of oilfield equipment, great attention should be paid to the development of process flow diagrams. The creation of modern systems for managing the processes of field development and the introduction of modern technologies and equipment for oil and gas production, allows to reduce the cost of oil by about 20% as well as to reduce their detrimental effect on the ecosphere.

Currently, there is a need for the disposal of man-made waste and, in some cases, the integrated use of processed products. The use of man-made waste as a source of raw materials is the main trend in the development of production in the 21st century, and the involvement of these wastes in the production contributes not only to environmental protection, but also to the creation of waste-free and low-waste industries.

Non-ferrous metallurgy is one of the industries that makes the most significant contribution to environmental degradation. Large non-ferrous metallurgy enterprises are not only powerful pollutants of the air basin, but also of soil cover, both in terms of intensity and variety of pollutants that are accumulated over large areas, removing land from agricultural use.

Aluminum production generates a large amount of waste. Bauxite, the main raw material in the production of aluminum, have a complex mineralogical composition: boehmite, gibbsite , kaolinite, calcite, hematite, pyrite, etc. The chemical composition of bauxite varies widely, both in different deposits and within the same deposit, and this predetermines the general nature of the resulting waste. Aluminum production causes an increase in waste generation.

Thus, the world consumption of aluminum, according to WBMS , increased by 6,7% in 2015.

In the materials of *The Institute* of *International Aluminum* it is reported that global primary aluminum production in the first quarter of 2017 was 30,3 million tonnes.

At the same time, solid wastes from the processing of mineral raw materials (alunites, bauxites, polymetallic ores) are accumulated in large quantities in dumps, which leads to the loss of valuable components, causing significant damage to the state.

Rational use of natural resources and environmental protection is one of the most important problems facing humanity, because it is intimately connected with the whole economic sphere.

There are many elements in the composition of bauxite, the main part of which, during processing, passes into the composition of waste, while the extraction of such valuable components as scandium and titanium from its composition is of particular value. Ultimately, by applying modern technologies, it is possible to obtain rare earth metals and other valuable products that are also used in agriculture in the neutralization of acidified soils.

Due to the detrimental impact and withdrawal of these lands from agricultural use, it is occurred problem especially for enterprises located on the fertile lands of the Ganja region of Azerbaijan. In this complex alunites (Zaglik deposit (Azerbaijan)) serve as the feedstock for aluminum production.

In order to create highly efficient catalysts based on production waste, studies were carried out on the composition of the initial waste. To study the physical and chemical properties, samples of the current production were taken. When studying the composition of waste using modern physical and chemical research methods, it was found that they contain a large amount of aluminum and iron oxides. In the preparation of catalysts by mechanical "dry" mixing of all components, water or various acids were used as a moisturizing agent: sulfuric, nitric, etc., which acted as a plasticizer. To increase the mechanical strength of the granules (diameter 2×2 mm), a binder was used - bentonite clay from Dash-Salakhlinskoe field. In the preparation of catalyst granules available and cheap raw materials were used, as well as a simple and waste-free dry mixing method. Charcoal was used as a blowing agent. The catalytic mass was molded by extrusion with pressing of the mass and obtained granules with a size of 2-5 mm.

On the basis of the conducted research, it was concluded that during the development of the methods for recycling of production waste, work that aimed at the integrated use of all its components is the most progressive and requires special attention, and addresses respecting natural resources and preserving them for future generations.

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THE IMPROVEMENT OF THE BIOLOGICAL MINELAND RECLAMATION PROCESS USING SOIL AMENDMENTS AND FAST GROWING CROPS

The land cover is significantly damaged in the process of extracting minerals using open-pit mining methods. The technological processes of open field development are accompanied by disturbance of the land cover, changes in hydrogeological and hydrological regimes, formation of

man-made relief, and man-made pollution of the environment. As a result, the territories remaining after the extraction of mineral raw materials are usually wastelands with areas of bare land, loose piles of disturbed soil, and large volumes of overburdened rocks taken to the day surface (Sheoran et al., 2010). The proportion of waste and waste rock is constantly increasing as high-quality ores are exhausted. Most of the mining waste enters into active interaction with the lithosphere, atmosphere, hydrosphere, and biosphere. During storage in depositories or dumps, all mining wastes are subject to changes caused by both internal physicochemical processes and the influence of external conditions. As a result, new ecologically hazardous substances can be formed in the places where these wastes are stored. They can cause a great threat to soil microorganisms by entering the biosphere (Boruvka et al., 2005). Land reclamation is a complex of engineering, mining, reclamation, and biological measures aimed at returning areas disturbed by industry to various uses. It is known that reclamation works take place in several stages. Geo-mining reclamation is considered the most mass-intensive and energy-intensive stage. This is due to the movement and stacking of large masses of rocks and the humus layer of soil removed before development in a certain order. The most difficult are the works related to increasing the fertility of the top layer of dumps, improving its hydro-physical properties (Legwaila et al., 2015). The possibility of migration of acid solutions to the surface of the dump is not excluded if the lower layers consist of particularly toxic rocks. The ultimate goal of the mining stage of reclamation is the creation of an underlying layer of the required capacity on disturbed lands. This process is associated with the creation on the surface of overburden rocks the humus layer of the soil or potentially fertile rocks suitable for biological reclamation. The mining stage of reclamation must be carried out in one cycle with the development of minerals during the technological process of mining. This stage involves restoration and formation of land cover and accumulation of humus and nutrients. Cultivation of the perennial legumes and grasses or their mixtures contributes to the transformation of overburden into "young" soils. Phytostabilization and phytoextraction methods are successfully used for the detoxication and removal of toxic metals from landfills. The introduction of various ameliorants and chelates contributes to a more intensive absorption of heavy metals by plants from technosems (Wong, 2003). Application of bio-based by-products represents a sustainable waste management method and it provides recycling nutrients for energy plants growth, which is in line with the European policy for a circular economy. The high productivity of energetic plant plantations can be provided through the use of sewage sludge and some soil amendments. The use of sewage sludge could not only increase yield but also positive affects biological and physicochemical properties of the soil profile. Recently, biochar has been used as an effective soil amendment for the improvement of soil nutrient management and pollution remediation (Lehmann et al., 2011). Hydrochar is a new type of biochar produced by hydrothermal carbonization. Results showed that hydrochar application could inhibit water evaporation in clayey

soil (Liu et al., 2019). Hydrochar has the advantages of low energy consumption, being environmental-friendly during production, and a high productive rate (Padhye et al., 2022).

It is a peaty but for prevailing amount of existing wastewater treatment plants in Ukraine becomes a problem carrying out stages of sludge stabilization, conditioning, dewatering, thermal drying and sanitation are eliminated. As the rule, all municipal sewage sludge (MSS) management is limited by putting on drying beds without any pre-treatment, where MSS rest for 2-7 years, and disposing cake out of plant territory in a way, which do not meet existing environmental protection and waste management regulatory. According to the state standard of Ukraine (DSTU 7369:2013) it is allowed to introduce MSS for crops growing at a dose of not more than 10 tons/ha for three years. A large rate is possible in the case of land reclamation. Hygienic properties and high content of heavy metals in MSS are the main problems that hinder the application of wastewater sludge for technical crops or biofuels production. Sorption properties of biochar and hydrochar produced from biomass require testing in model experiments as a means of mitigating the negative effects of heavy metals on the soil. Both biochar and hydrochar has the potential to decrease soil CO_2eq emissions (Lange et al, 2015; De Jager et al., 2020). The research hypotheses is assumes that some recycling municipal and agri-waste nutrients (MSS, digestate, ash, biochar and hydrochar) used for energy plants fertilization can be a valuable source of organic matter and minerals (after a special treatment) for plants not intended for consumption, preferably promoting their growth and development. The use of sewage sludge and digestate as a fertilizers makes it possible to keep time to start growing fast-growing energy crops after the end of the mining reclamation stage. It was established that after four years of cultivation in experiments with perennial energy crops, the total yield after the application of sewage sludge at a dose of 10t/ha was equal to the total yield with a single application of $N_{60}P_{60}K_{60}$. The cumulative effect of this fertilizer in the field experiments on low-productivity soils for a period of four years on the harvest of switchgrass and miscanthus at a rate of 20t/ha was greater compared to a one-time application of mineral fertilizer at a dose of $N_{60}P_{60}K_{60}$ by 30% and by 50%, respectively. An increase in the dose of sewage sludge and digestate application is possible due to the mitigation effect of such soil amendments as biochar and hydrochar.

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EXTRACTION OF SILVER FROM TECHNOGENIC WASTES OFMINING AND METALLURGICAL ENTERPRISE

With depletion of reserves of rich and easily extractable gold- and silver-containing ores, as well as the low level of comprehensive use and insufficient depth of ore processing, which reduce the efficiency of field development, the prospects for the industry development are directly linked to the expansion of the raw material base via involvement in processing of poor and off-balance ores, overburden, dumps, tailings of concentration plants and materials of man-made deposits previously that were not processed using highly efficient processing shemes.

It is especially relevant for a number of operating mining enterprises of the Republic of Tajikistan, extracting and processing gold-silver ores (Aprelevka, Kizilcheku, Burgunda) and lead-zinc and lead-silver ores (deposits "Paybulak" and "East Kani-Mansur") [1], since the new strategy of industry development is based on providing sustainable development of metallurgy with a balanced formation of mineral raw material base [2].

Current work contains the results of the study of three technogenic samples of silver-containing raw materials of the Republic of Tajikistan, the composition of which is shown in the table.

Table

Initial chemical composition of man-made waste

Name	Amount of base components, %											Roasting losses, %
	SiO_2	MnO	Fe_2O_3	$S_{gross.}$	Cu	Zn	Pb	As	Sb	Au	Ag	
										g/t		
Takeli cinders	49,71	0,2	12,26	2,82	0,66	1,7	0,06	1,27	0,09	1,4	635	4,37
Old dumps of Kanjol	57,6	1,79	6,14	0,18	n/f.	0,10	0,07	0,07	<0,01	0,1	50	5,52
Old fine-grained tailings of Kanjol	56,3	2,96	7,20	0,22	0,02	0,31	0,36	0,13	0,02	0,4	178	5,83

Concentration of chemical elements in the samples was determined by methods of assaying and X-Ray Fluorescence Analysis (XRF) on a sequential vacuum spectrometer (with wavelength dispersion), model Axios mAX by PANalytical.

Takeli cinders were formed as a result of operations of Takeli arsenic plant, which ceased activity in 1950 due to the ban on arsines usage. Material of the cinders is 35% 1-5 cm splinters and 65% of finer fractions.

Ore minerals are represented by: lead-galenite (PbS), anglesite ($PbSO_4$), and cerussite ($PbCO_3$); zinc-sphalerite (ZnS), smithsonite ($ZnCO_3$), and calamine ($Zn_4(OH)_2[Si_2O_7]xH_2O$; copper-chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4) and covellite (CuS); arsenic-arsenopyrite (FeAsS); silver-prustite (Ag_3AsS_3) and pyrargyrite (Ag_3SbS_3) and a native form. The form of gold contents wasn't determined due to lack of laboratory capacity.

A bottle test was carried out to evaluate the effectiveness of cyanide leaching of gold and silver. The best results were obtained at cyanide concentration of 500 mg/l, S:L=1:1.5, pH-10÷11 and leaching time of 48 hours, i.e. only at relatively high cyanide and lime consumption it is possible to achieve gold and silver recovery of 63% and 45% respectively.

Therefore, in order to find cyanide-free solvents for gold and silver from the Takeli cinders, the effect of sodium thiosulfate was studied [3].

As a result of the study of various methods of processing the Takeli cinders (flotation, cyanidation, thiosulfate leaching), the option of chlorination roasting followed by ammonia-thiosulfate leaching of the cinders was chosen.

The advantage of the two-stage method is the increase of silver recovery from the cinders up to 80-85%, which, in the one-stage leaching process, does not exceed 35%. Besides, preliminary chlorinating roasting makes it possible to increase gold recovery up to 65-70%.

The study has resulted in the technological process mode of cinders processing including chlorinating roasting at temperature 550-600 °C for 2 hours at the rate of chlorine releasing compound at 20% NaCl from mass of cinders, with the subsequent ammonia-thiosulfate leaching in the following mode: S:L=1:2, t=25 °C for 3 hours, $Na_2S_2O_3$ - 25 g/l (overall consumption of 80 kg/t), Na_2SO_3 - 20 g/l (overall consumption of 40 kg/t); $(NH_4)_2SO_4$ - 30 g/l (60 kg/t); pH = 9,5 (NH_4OH - 50 l/t).

Old Kanjol dumps are a mixture of waste rocks and poor ores brought to the surface by ancient miners during the sinking of slotted mining. Old mines are located in chains along ore-bearing cracks hosting vein-like, lenticular and pillar-like accumulations of sulfide ores.

The main components are hydrothermally altered rock and ore minerals: galena, sphalerite, tetrahedrite, pyrargyrite, freybergite, argentite, native silverroo, chalcopyrite, jensonite, boulanjorite, arsenopyrite, pyrite, galena-bismuthite, bismuthite.

The listed primary minerals are substantially oxidized. Gold is rare and is represented by the native form.

Old fine-grained tailings of Kanjola are "tails" of crushed ore enrichment by the method of distillation and washing. Their material is represented by a single-colored brownish-gray fine-clastic (2-3 mm) fraction of hydrothermally altered rocks and ore-forming minerals. Mineralogical composition is as follows: hematite and hydrogetite - 10-15%; sulfides, oxides, carbonates of lead, iron, zinc and copper - 1-2%; sulfides, chlorides, silver sulfosols and native silver - 0,1%; rock-forming and vein-forming minerals - 85-90%.

For these two types of anthropogenic raw materials the principal possibility of using a complexing reagent - sodium or ammonium thiocyanates (rhodanides) was established [3], because they are almost harmless and easily available, and their complexes with silver have sufficient strength in a wide range of pH.

Conducted research shows that silver is easily leached with acidic rhodanide solutions, because the oxidizer (Fe^{3+}) is present in the raw material and passes into the solution at pH=2,5-3 during sulfuric acid stripping.

Eh (redox potential) of acidic solutions from the stripping of both waste dumps and fine-grained tailings of Kanjol ores is 350-400 mv, which is quite sufficient for silver stripping.

As result of the aforementioned research, an optimal mode of leaching silver-containing Kanjol wastes with rhodanide solutions were established, which allows to reach 85-92% of silver recovery: = 20÷30 g/l; pH=2,5-3; Eh=350÷380 mv; t=60°C and τ=4-5 hours.

Also, the process of silver recovery from productive thiosulfate and rhodanide solutions resulting of leaching researched samples was tested via cementation method. Test showed that silver deposition occurs effectively without any corrections to the initial solution. Master solution after the cementation may be sent back to the leaching stage.

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WATER ACCUMULATION CAPACITY OF FOREST ZONE (POLISSIA) OF UKRAINE UNDER GLOBAL WARMING CONDITIONS

Polissia is the main natural reservoir of fresh water in Ukraine, but in modern conditions of global warming, this zone is subject to significant changes in natural conditions and deterioration of the ecological situation, which requires constant scientific research and the development of specific measures to restore the water-regulating capacity of this zone. The set of measures should include not only the formation of the adaptation potential of water ecosystems, the reduction of their risks, and overcoming the predicted negative consequences, but also the use of favorable opportunities arising as a result of changed climatic conditions.

To analyze the general trends and mechanisms of climate change in the studied territory of Ukrainian Polissia, we used archival data of weather observations of the international Spanish weather site Globalclimatemonitor for the last 120 years and analyzed six geographical regions (Volyn Polissia, Male Polissia, Zhytomyr Polissia, Kyiv Polissia, Chernihiv Polissia, and Novgorod-Siversk Polissia). A total of seventeen points were selected, an average of three points in each region. Analyzing the dynamics of the current long-term average air temperature indicators of the Polissia zone, it was found that the trend of their growth was gradually formed during the last decades (since 1998) and began to change intensively at the beginning of the current century, and became most acute in the last decade. Starting from 1991, each subsequent decade was warmer than the previous one: 1991-2000 - by 0,5°C, 2001-2010 - by 1,2°C, 2011-2021 - by 2,3°C. And this indicator continues to grow at an accelerated pace. The precipitation over the years has also increased a bit, but not very essentially - by 3,1-15,3 mm, which is almost completely imperceptible against the background of rising temperatures. The powerful temperature and climate factor not only neutralizes the effect of additional precipitation but also leads to a crisis of moisture supply, which is not inherent in the Polissia zone. The constant and rapid increase in its range and exceeding the temperature norm became stable and confirms that shortly the restoration of the usual type of weather for Polissia is unlikely.

After all, small rivers, lakes, and swamps tend to disappear under such conditions. In large-scale forecasting, it is advisable to assume that the area of swamps, forests, and water bodies in the Polissya zone will decrease significantly in the future, and global natural disasters will increase, which will lead to a crisis state of ecosystems and water resources in all-natural and climatic zones of Ukraine and on the planet as a whole.

It was also established that an important feature of the modern climate of Polissia in Ukraine, which manifests itself in all seasons of the year, is sharp drops in daily air temperatures within the range of 10-15°C for 1-2 days, which are accompanied by spontaneous meteorological phenomena and physiological stresses.

Global and regional climate changes directly affect the water regime of rivers because it is weather conditions that shape the quantitative and qualitative characteristics of river flow.

According to general data, the predicted impact of climate change on water resources by 2080 will cause a decrease in the number of water resources by 30-40%; a reduction in the surface flow of rivers by 10-20%; a reduction in infiltration feeding and lowering the groundwater level; growth of total evaporation from the water surface; reduction in water supply by an average of 15%; expansion of the semi-arid zone; deepening the processes of territory flooding; changing the river regimes and freshwater reserves.

Thus, the main task of adapting water management to climate change is preserving the territorial potential and preventing losses in the volume and quality of water resources. The main priorities in this area are the reduction of the losses of surface water resources due to the reduction of evaporation area and optimization of water use in agriculture; improving monitoring, forecasting, and mapping of hazards associated with the harmful effects of water; updating protection schemes and response plans, optimizing and updating the system of water protection structures; modernizing the water management system, increase in the efficiency coefficients of water management structures, modernizing the rules for the operation of reservoirs, modernizing irrigation systems; preserving the water potential of large rivers, optimizing flow regulation, protection and regulation of water protection zones, forest massifs, wetlands; preserving the quality of water resources; modernizing water drainage and water purification systems, improving and diversification water treatment and water distribution.

It is predicted that in the future we can expect an increase in the frequency of drought events, including extreme ones, due to the uneven precipitation and the increase in temperature during the growing season. In the future, it is expected an increase in the area of water-erosion processes manifestation as a result of an increase in torrential precipitation. Further climate change may cause a shortage of drinking water not only in the Steppe and Forest-Steppe zones of Ukraine but even in the Polissia zone. Taking into account the revealed trends, it is necessary to conduct further scientific research on the improvement of the existing water use regulation mechanisms to preserve the water capacity of the territory and soften the adaptation transition of the water ecosystems of the Polissia of Ukraine to modern climatic conditions.

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THE USE OF AN INNOVATIVE METHOD OF FRAGMENTATION FOR ORE-BEARING ROCKS

The purpose of the work: to study the possibility of using an innovative method of fragmentation for the extraction of useful components of ore-bearing rocks, by improving the conditions for its disclosure, taking into account the environmental safety of processing.

Based on the analysis of numerous literature data, there is an increased interest in the black shale raw materials of the Saryjaz square. Therefore, the search for new methods is based on the relevance and prospects of extracting useful components from them.

In this regard, we were tasked with applying innovative methods, i.e., crushing the mineral of the Black Shale formation of the Saryjaz area with a spark electric charge.

The object of the study is the ore minerals of the black shale formation of the Saryjaz area, brought from three coordinate points.

Table 1

Coordinates of points

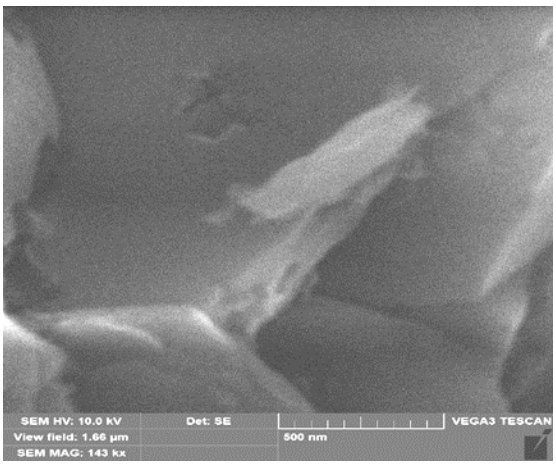
Point 1. ChSJ-1 (19)	*Point* 2. ChSJ -2(19)	*Point* 3. ChSJ -3 (19)
x-14344641	*x*-14344943	*x*-14337830
Y-4678073	*Y*-4679611	*Y*-4683314
h-2731	*h*-2738	*h*-2927
Geographical coordinates		
x-42º, 13', 19,6”	*x*-42º, 14', 9,6”	*x*-42º, 16', 4,4”
Y-79º, 7'.4 3”	Y-79º, 7'.16”	*Y*-79º, 2'.2,2”

First, the initial samples of the mineral are subjected to electrical conductivity testing, of the three samples taken, the ChSJ -3(0) sample, possesses the electrical conductivity. Therefore, this sample is subjected to fragmentation by a spark electric charge in an aqueous medium. The resulting product consists of two phases:

1. The solid phase is the particles of the mineral ChSJ -3(1) crushed by an electric spark charge;

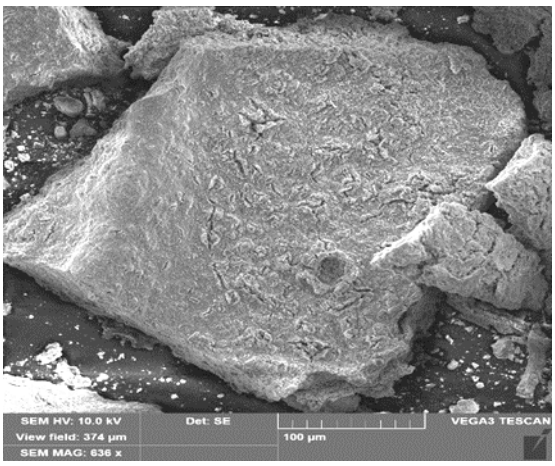
2. The liquid phase is water, there are also small crushed mineral particles in it, which is why it has a dark color of ChSJ -3 (2).

After phase separation, we determined the size of the fragmented samples (using a scanning electron microscope (SEM) Fig. 1,2,3), and their elemental composition (using spectral, atomic absorption, *X*-ray phase and optical emission analysis).



In 143*x* magnification

Fig.1. The ChSJ -3 (0) fragile sample



In 638*x* magnification

Fig.2. Samples of ChSJ -3 (1)

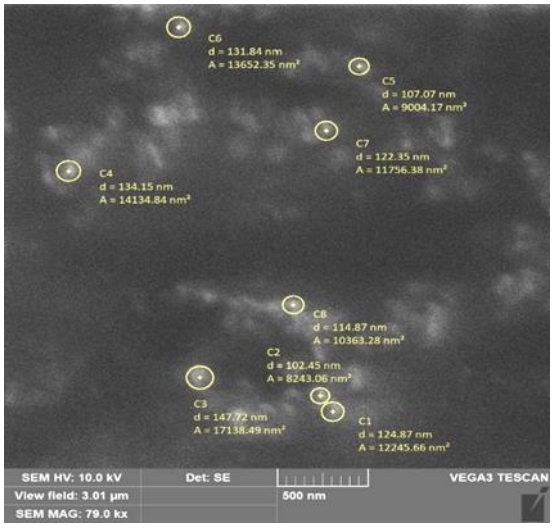


Fig.3. Particle sizes in the liquid phase

At the same time, the size of solid particles crushed by a spark electric charge in an aqueous medium, according to SEM, averages 270,69 µm; and the size of particles in the liquid phase ranges from 123,165- 172,92 µm. When studying the initial sample and the particle in the liquid phase by atomic absorption and *X*-ray phase analysis, the presence of the following elements was established: Au, Ag,AL,Cu,Fe,K,Ca,Sg,Mg,Mn,Mo,Ni,Sb,Pb,Ti, V,W, Zn,Zr,Se,Sr, etc. in various Weight quantities, including uranium (U), and when studying the elemental composition of a small Dispersed particles in the liquid phase quantities, including uranium (U), and when studying the elemental composition of a small Dispersed particles in the liquid phase obtained according to ICP-AAS and ICP-MS data, the presence of the following elements was established: Ag, AL, As, B, Va, Ca, etc.

Conclusions

1. Using an innovative method of dispersing ore-bearing rocks with a spark electric charge in an aqueous medium, two phases can be obtained: dispersions of solid and liquid phases with the smallest particles;

2. During spark electrical fragmentation, some metals remain in the composition of the liquid phase Mn, Cr, Cu, Pb, Ag, Zn;

3.When the black shale formation of Saryjaz is crushed by a spark electric charge, it is possible to enrich the amount of useful components such as (Cu, Ag, Mn, Pb, Ti, Zn, etc.) in the composition of ore-bearing rocks, including up to the maximum quantitative content of Cu -84,23%

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OBTAINMENT OF MICROPOROUS ZEOLITES AND ZEOLITE-LIKE COMPOUNDS FROM NATURAL AND EXPANDED PERLITE

The synthesis of industrially important zeolites from natural raw materials, such as volcanic glasses, perlite, obsidian, kaolin clays, smectites, has advantages over other production methods due to the low cost and availability of starting reagents. Zeolites are solid granular materials with a very porous structure and a large specific absorbing surface. Zeolite crystals are permeated with a system of channels, cavities and windows of various input sizes. This structure allows zeolites to play the role of molecular sieves to selectively adsorb harmful components of waste and drinking water, such as alcohols, phenol, hydrogen sulfide, heavy metal nuclides, etc. Natural zeolites are increasingly being used as filter media in wastewater treatment plants [1-3].

This paper presents the results of experiments on the hydrothermal transformation of perlite from the Dashsalakhli deposit of the Republic of Azerbaijan. The chemical composition, the percentage ratio of the main oxides (SiO_2-71,5; Al_2O_3-11,31; Fe_2O_3-0,42; CaO-1,28; Na_2O-2,02%) makes perlites a suitable raw material for obtaining low silica zeolites.

Considering that the industrial production of zeolites is not cost-effective to carry out above 100°C, a series of experiments on the hydrothermal processing of perlite was carried out in the temperature range of 92-96°C.

Perlite, taken in a certain amount, after fine grinding was mixed with sodium hydroxide solutions of various concentrations. The reagents placed in the flask were kept at a temperature of 95°C for 5 to 96 hours. The chemical composition of the initial, intermediate and final products was determined by X-ray, thermographic and infrared spectroscopic methods of analysis.

In a series of experiments, 5 g of crushed perlite powder were mixed in a flask with NaOH solutions (the concentration of the solution was changed from 0,5 N to 5 N) and kept for 5 hours at a temperature of 95°C. X-ray analysis showed that the products of hydrothermal treatment consisted of a mixture of NaX zeolite and hydrosodalite. With an increase in the crystallization period, the reflections corresponding to the NaX phase gradually disappear from the X-ray diffraction patterns. Starting from the 72 h period, the reaction product consists of highly crystalline pure hydrosodalite.

Considering that the direction of the zeolite formation process changes depending on the state of the initial material, in a series of experiments perlite was melted with the participation of Na_2CO_3 at a temperature of 950°C in muffle furnaces. The melt was dissolved in 50 ml of distilled water, the resulting product was homogenized for 12 hours in polyethylene vessels. After 24 hours of crystallization, the NaA phase appears in the results of the experiments together with hydrosodalite. The optimal conditions for the synthesis of crystalline pure NaA zeolite were found. Zeolite NaA is of great industrial importance, is one of the main components of detergents, due to its ion-exchange properties it is used to soften water. The results of the experiments show that the melting of perlite with alkaline carbonate fluxes increases the reactivity of perlite and reduces the nucleation time of zeolite phases.

Perlite swelling was carried out in special muffle furnaces at a temperature of 750°C for two hours. The transformation of perlites into zeolites was studied in alkaline media with concentrations of NaOH and KOH solutions from 0,5 N to 5 N, at temperatures of 90-150°C. The experiments lasted from 2 to 5 days. Hydrothermal experiments were carried out in “Mori” type autoclaves with a self-sealing shutter. Zeolites ZK-19, P (phillipsite), W (merlionite), chabasite and edigtonite were obtained in a series of experiments with KOH solutions of various concentrations and durations. Pure ZK-19 and W zeolites with a high yield were obtained from the original perlite without the participation of an additional aluminum source. The introduction of additional aluminum into the initial mixture leads the reaction in the direction of crystallization of chabazite and erionite. In hydrothermal crystallizations, in NaOH media, analsim, gismondine, hydrosodalite, and zeolite of the NaA type are formed. The output of NaA zeolite is carried out only with the addition of an additional amount of aluminum to the reaction mixture.

In order to study the effect of the nature and size of cations on the direction of crystallization, some transformations were carried out in bicationic NaOH and KOH media. At low concentrations of alkali solutions (up to 1 N), only potassium feldspars crystallize. Under these conditions, large potassium cations create steric hindrances for the formation of Na zeolites. In relatively concentrated solutions, both cations are present during the formation of frameworks, which is associated with the formation of highly polymerized and silicon-oxygen associates. The formation of associates with pores of various sizes and shapes creates favorable conditions for the incorporation of both templates into the structure.

Within the field of zeolite crystallization, in the absence of a potassium cation, type P zeolite crystallizes, and in the absence of a sodium cation type zeolite W.

The formation and transformation of frameworks in the series ZK-19→An→W→ KF in mono- and bication systems during perlite crystallization can be explained by the structural origin of these phases. In all structures, secondary structural units are composed of four-membered rings. Condensations of the indicated units with different orientations around the templates lead to the formation of aluminosilicates, which are energetically more favorable under the indicated conditions.

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RESULTS OF BIOLOGICAL RECULTIVATE OF THE SLUDGE STORAGE

During the summer period, the surface of depleted tailings is heats up to 80 °C, while the thickness of the dry layer reaches 30-50 mm.

The surface of the tailings is a loose pulverulent material, between the particles of which there are no stable bonds, so such dust is easily blown away by the wind.

Are known methods of fixing dusty surfaces of tailings, such as aerodynamic, hydro technical, technological, mechanical and biological [1-3].

The aerodynamic method is based on reducing of wind speed by installing protective screens around the perimeter of the tailings. Due to the high cost and low efficiency, this method is not used on large areas of tailings.

The hydro technical method involves moistening of the beach surface with water or aqueous solutions, as well as maintaining the water level above the surface of the tailings.

The technological method involves the addition of binders to the pulp. Both of the methods are used only in the operation of existing tailings.

The mechanical method, based on the covering surface of the tailing dump with dump rocks and clay, securely fixes the tailings, but limits the further use of the land.

The biological method (reclamation) involves the sowing of grasses and shrubs on the surface of the tailing dump with or without the use of plant soil. This method is the most efficient, fast, non-toxic and economical. As suitable plant species for fixing the surface of existing tailings, southern reed, Black Sea

grate, racemosus grate, Siberian couch grass, elongated couch grass, etc. are suggested, which are recommended to be sown on tailings treated with mineral and organic fertilizers. [4-7].

Natural overgrowth of tailings occurs within 10-30 years. Plant shoots are observed in wet places, meadows, cracks, where areas with a low content of the silt-colloidal fraction are formed. The lack of mineral nutrients, the absence of humus, the degree of salinity, and the high level mineralization of water make the tailings unsuitable for plant germination. Therefore, the aim of the work is to develop a technology for accelerated biological reclamation of tailings, which including the preparation of soils for sowing, the choice type of seed and monitoring their growth during industrial research.

Industrial researches were carried out at the tailing dump of PJSC YuGOK on the areas covered with chernozem, clay and uncoated. Initially, seeds of broom cochia, seed clover and common alfalfa were sown on all plots. Artificial irrigation was not carried out. Observations of plant development were carried out annually from May to October during five years, with the following results [7,8].

In the first year, crops of Kochia skoparia showed themselves [5]. It should be noted that the density of Kochia skoparia plants is such that it prevent the development of other weed species at 80-90% coverage.

The next year, Kochia skoparia was replaced by Descurani Sophia L. Webb ex Prantl [5], which significantly replaced Kochia skoparia plants, providing 70-80% coverage [8].

Two years after the start of the experiment, thickets of Melilotus officinalis (L) appeared on the surface. Pal [5]. The successions of this plant covered the experimental area with a continuous cover (70-80% coverage), taking space from other plant species [9].

Three years after the beginning of the experiment, Lotus comicalatus klok [5] joined the struggle for the surface of the experimental area, providing a coverage of 7-80%.

And, finally, after four years from the beginning of the experiment, Grindelia squarrosa (Pursh) Dun became the leader among plants. [5]. It should be noted that this plant grows everywhere outside of the experimental area, forming a mass distribution. The presence of a plant in such volumes can be explained by anemochory (spread with the help of wind), the abundance of seeds in a plant, and large expanses [9, 10].

So, the certain conclusions can be drawn. The chernozem cover is an elementary necessary base for carrying out an operation for the introduction of plants. The chernozem contains a significant amount of seeds in order to give a sufficiently dense coverage of the area with plants and be a source of seeds for the environment. The development of grass cover took place through successions, which eventually lead to the establishment of a natural steppe cover.

Analysis of plant species in the territories adjacent to the territory of PJSC "Southern Mining Plant" showed the identity of plants, which growing in the experimental plots. But, under experimental conditions, overgrowing of the tailings surface is observed for 5 years, and under natural

conditions, overgrowing of the surface occurs within 25-30 years, which reduces the term for dust suppression on the surface of depleted tailings by 5-6 times.

In the areas of the tailing dump covered with clay, during the first year of experimental observations, no seedlings of plants were observed. In subsequent years, more and more plant species grew on it, mainly weeds, introduced by anemochory from the side of the area, which covered with chernozem. Clay is a potentially fertile soil, but with a slow overgrowing process, which at a certain stage is compared with the chernozem area [9,10,11].

Particular attention should be paid to sludge storages, the surface of which is not covered with a layer of chernozem or clay. For 5 years, they have not been covered with vegetation, with the exception of some plants.

In addition to the reclamation of sites with help of the plants, an equally important event is observed - the development of woody plants. First of all, Ulmus carpinifolia Ruppex G. Suckow has become widespread. Populus deltoids Marsh also grows well [11]. These trees germinate well in open spaces, in particular in sludge storages, where there is a lot of calcium and iron, are very unpretentious in conditions of high temperatures and reproduce well with the help of seeds.

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INFLUENCE OF BIOGAS CONTENT ON THE EMISSION OF HARMFUL IMPURITIES

Environmental characteristics of biogas combustion products, natural gas, and their mixtures can be determined based on the results of mathematical modeling of the dynamics of decay and formation of various components that affect the appearance of harmful substances.

The formation of harmful impurities in the combustion products of biogas, natural gas, and their mixtures was studied using a mathematical model. According to computer calculations, it was established that the amount of carbon monoxide during the combustion of biogas is an order of magnitude lower than in the products of natural gas combustion, and is $1{,}28 \cdot 10^{-3}$ %.

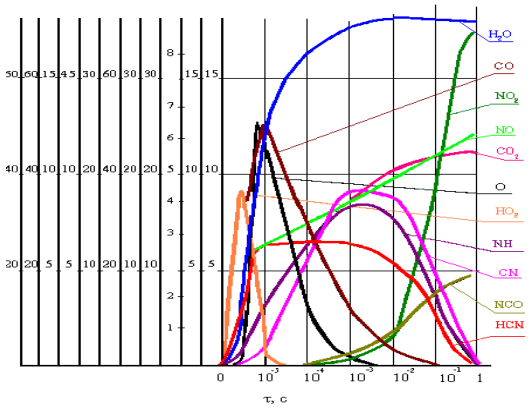

Fig. 1. Results of the computer calculation of the kinetics of the natural gas combustion process

The main harmful components of gaseous fuel combustion products are nitrogen oxides. Calculations have established that the content of nitrogen oxides in the products of biogas combustion is 1,5-2 times lower than in the products of natural gas combustion, due to a decrease in the combustion temperature, the presence of CO_2 and H_2O in biogas. Addition of biogas to natural gas in proportion БГ:ПГ=1:1 results in a reduction of NO by 45% and NO_2 by 22%. Even for biogas containing impurities HH3 and NO, which is typical for biogas of agricultural BGUs, the yield of nitrogen oxides is lower than that of natural gas, by 36% NO and 17,5% NO_2.

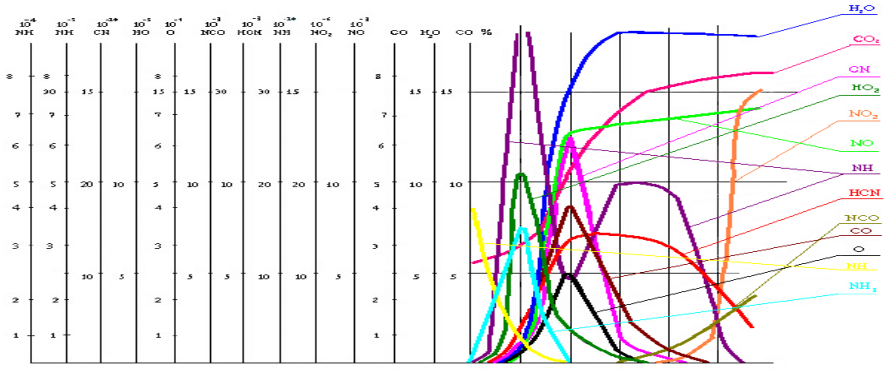

Fig. 2. Results of a computer calculation of the kinetics of the biogas combustion process with an admixture of 0,004% NH_3

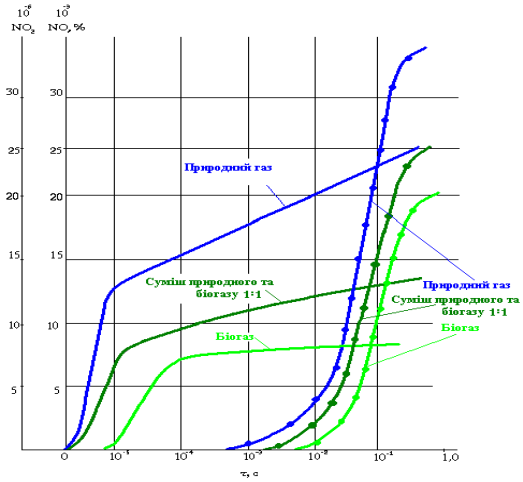

Fig. 3. The content of nitrogen oxides in the combustion products of natural gas, biogas and their mixture of NO and NO_2

Therefore, the addition of biogas to natural gas can be recommended as one of the ways to reduce the output of nitrogen oxides when burning gaseous fuel, i.e. nitrogen oxide.

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CONVENTIONS FOR THE PROTECTION OF THE MARINE ENVIRONMENT OF THE BALTIC SEA AREA

Pursuant to the Environmental Protection Law [1], environmental protection is understood as taking or abandoning actions that enable the preservation or restoration of natural balance. This protection consists in rational shaping of the environment and management of environmental resources in accordance with the principle of sustainable development, counteracting pollution, restoring natural elements to their proper condition [2,3].

In order to define the concept of protection of the marine environment, one should refer to the intra-Community and international regulations binding on the Republic of Poland. One should refer, inter alia, to to Chapter 17 of the Agenda 21 Global Program of Action, which states that the marine environment is made up of the oceans, all seas and their adjacent coastal zones, and inland water resources, forming an

integrated whole [4]. The marine environment is also defined by Directive 2008/56/EC of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy. “The marine environment is a valuable heritage that must be protected, preserved and, where possible, restored, ultimately maintaining biodiversity and preserving the diverse and dynamic nature of the oceans and seas that are clean, healthy and fertile”[4]. Directive 2008/56/EC also indicates that "pollution means the direct or indirect release of substances or energy into the marine environment by human activities, including submarine noise caused by human activities, which causes or is likely to cause adverse effects such as in living resources and marine ecosystems, including loss of biodiversity, threats to human health, impediments to maritime activities, including fishing, tourism and recreation, and other legitimate uses of the sea, as well as deterioration in the quality of seawater used and reduction of aesthetic values”[5]. The definition of the marine environment recognizes human interference as an integral part of its shaping.

Another important document is the Convention on the Protection of the Marine Environment of the Baltic Sea Area, drawn up in Helsinki on April 9, 1992, ratified by the Republic of Poland on October 8, 1999 [6]. The Convention applies to the protection of the marine environment of the Baltic Sea Area, which includes the water and the seabed together with their living resources and other forms of marine life [7]. Art. 15 of the Convention, which delegates taking appropriate forms of protection of the Baltic Sea area and its coastal ecosystems affected by the Baltic Sea, in order to preserve natural environments and biodiversity and to protect ecological processes, to the states parties to the convention and individually to the states concerned by the convention. This regulation indicates that the marine environment covers not only marine waters, but also coastal ecosystems.

The land-sea areas are also covered by the regulation of the Act of 6 July 2001 "on the preservation of the national character of the country's strategic natural resources"[2]. Waters of Polish sea areas together with the coastal belt and their natural living and mineral resources, as well as natural resources of the bottom and interior of the earth located within these areas within the meaning of the Act of March 21, 1991 "on the maritime areas of the Republic of Poland and maritime administration", are the country's strategic natural resources. "Competent public administration bodies and other entities managing natural resources on the basis of separate regulations are obliged to maintain, increase and improve renewable resources, use mineral deposits in accordance with the principle of sustainable development"[4].

One of the tools of the European Union, which is to sustain the loss of natural values in the EU, is the NATURA 2000 network. It is based on two pillars: the Birds Directive and the Habitats Directive. Marine NATURA 2000 areas are those that are at least partially located in marine waters. Virtually the entire coastal strip, 200 km from the base of the Hel Peninsula to the border with the Pomeranian Bay refuge, is included in the Natura 2000 area "Coastal waters of the Baltic Sea". The area of 212 ha covers a strip of coastal waters of the Baltic Sea, 15 km wide and up to 20 m deep [8].

Solving the problems of protecting the marine environment is complex and very costly. The costs increase exponentially with its deterioration.

In Poland, the problem of sea coast protection is covered by the Act, a long-term program of sea coast protection for the years 2004-2023.

The aim of the program is to stabilize the coastline and protect sea shores from the destruction and disappearance of beaches. Particularly many investments were carried out in the period 2007-2013 under the Operational Program Infrastructure and Environment [9].

Protection of sea shores, in particular protection against the disappearance of beaches and flood protection from the sea, is also a vital interest of local self-governments and municipalities located in the coastal area. To a large extent, it is the beaches that determine the attractiveness of coastal towns, including their financial condition.

According to data presented by the Polish maritime administration - specifically by maritime offices - almost 70% of Poland's coastline is subject to constant erosion as a result of the activity of sea currents.

Violent storms destroy the beach every year and cause the Baltic Sea to burst into land more and more.

Forecasts of sea level changes predict an increase in the water level on the southern shores of the Baltic Sea by 500 cm in the next 100 years, which may cause the coastline to recede by 150-400 m [10].

At the same time, an increase in the frequency of severe storms is forecasted. We have had several confirmation of such assumptions in recent years, incl. during such weather anomalies as "Xaver" (December 2013) or "Axel" (January 2017).

In recent years, there has also been a very intense discussion on the close relationship between the protection of sea coasts and the protection of the marine environment.

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ENVIRONMENTAL MONITORING BY THE DIFFERENTIAL ITN-METRY METHOD

There are a number of classical methods for determining the transfer numbers of ions (ITN) in solutions. Of interest is also the determination of the transfer numbers in proton-conducting ion exchange membranes (IEMs). Such membranes based on stable perfluorinated polymers of the Nafion117 type are used in powerful electrolyzers for the synthesis of pure alkalis (NaCl electrolysis), electrolysis of H_2O for the synthesis of pure hydrogen, in the production and operation of liquid fuel cells (electrochemical generators, ECG). This line of work is of particular importance due to the fact that chemists have recently synthesized new promising materials - ionic liquids that have unipolar conductivity and are capable of forming new directions of technology.

The simplest method for determining transfer numbers is two-chamber electrolysis of a simple electrolyte with the determination of changes in electrolyte concentrations in the chambers. According to the results of electrolysis, transfer numbers can be determined by formulas

$$n_+^* = \frac{(C_0 - C_1)\cdot V_T}{((I\cdot\tau)/26{,}8)}\quad , \tag{1}$$

$$n_+^{**} = 1 - \frac{(C_\tau - C_0)}{C_\tau}, \tag{2}$$

where expressions (1) and (2) denote conditions with variable (1), $dV/d\tau \neq 0$, and constant $dV/d\tau = 0$ chamber volume.

One of the most effective water treatment technologies in modern industry and energy is water desalination using ionic filters filled with ion exchange materials-ionites. The use of ionites makes it possible to fundamentally improve production processes. Obtaining deeply demineralized water, which is widely used at nuclear power plants (NPP) and nuclear fuel cycle (NFC) plants, is of particular importance. Monitoring of the operation of ion exchange systems is carried out using chemical analysis, which is difficult to perform for automatic monitoring. Therefore, increasing the efficiency of ion exchange resins and developing non-chemical (reagent-free) control methods for water purification systems is an urgent task.

The full set of the IER properties is obtained in laboratories at enterprises by long and costly physicochemical methods. To determine ion transfer numbers in heterogeneous and multiphase ion exchangers, we have created the method of differential ITN-metry. The method was developed for a simplified assessment of the properties of ion exchange resins (IER) used in industrial water purification and water treatment technologies at industrial enterprises. Transfer numbers give an indirect characteristic of the ion exchangers' quality, but the differential ITN-metry method gives a result in

a short experiment on the electrolysis of NaOH or NaCl solution in a three-chamber electrolyzer reactor. The middle chamber of the reactor is located between two cellophane membranes and is filled with the studied ion exchanger.

The initial data of the experiments were the readings of the flow conductometric sensors developed by us [2], which were converted into concentration. Based on the results of the experiment, the functions of the concentration dependences of the electrolyte $C(\tau)$ in the cathode and anode chambers of the electrolyzer were calculated. The transfer number itn^* was determined by software data processing using a system of approximation functions. The primary electrolysis data were in the form of numerical lines with significant fluctuations in readings, so they were unsuitable for subsequent mathematical processing.

The aim of the differential ITN-metry method was precisely to replace discrete unordered lines of experimental data with simple mathematical expressions in the form of simple parabolic equations $y=a_0+a_1x+a_2x^2$.

The final result of the differential *itn*-metric method is the construction of a special $\Psi_\tau(\tau)$-function of the transfer number differential , where itn^* is the value of the transfer number, calculated by the differential ITN-metry method, $\psi_\tau = itn^*\left(\frac{\Delta itn^*}{\Delta\tau}\right)$ which depends on the experimental conditions. In contrast to it, the $\Psi_\tau(\tau)$-function when extrapolated to the beginning of the process $\tau\to 0$ gives a condition-independent value of the transfer number.

Fig. 1 shows the function $\Psi_\tau(\tau)$-graphs for homogeneous membranes made of cellophane, MA-40, and Nafion.

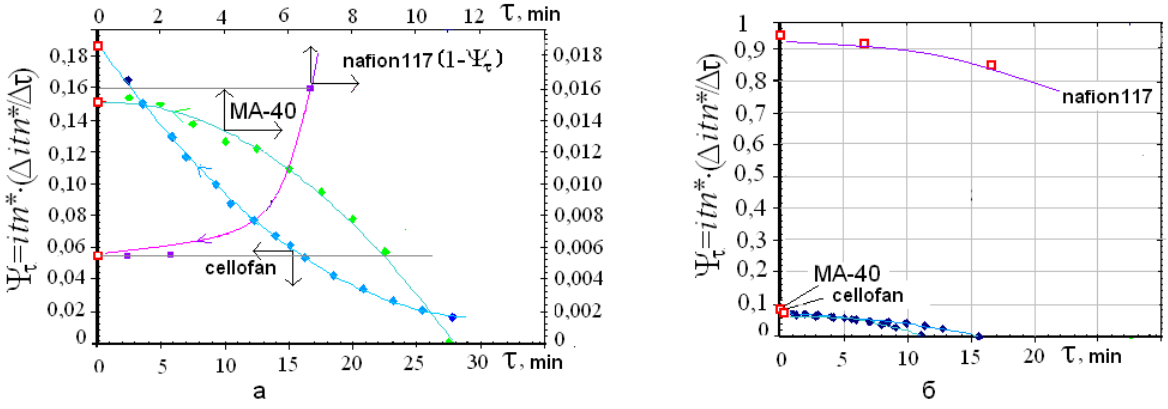

Fig. 1. Ψ_τ -functions of the transfer number differential itn^* in small (*a*) and large (*b*) scales for homogeneous membranes made of cellophane, MA-40, and Nafion

As can be seen from the graphs, the numbers extrapolated to the $\tau\to 0$ point give exact values of transfer numbers for known materials.

Fig. 1*a* uses a scale with the maximum value $(1-\Psi_\tau)=0{,}2$ for convenience.

Electrolysis of NaOH and NaCl solutions was performed with a layer of cationites KU-2-8 and A400-purolite and anionite resin MA-40 in the middle chamber of the electrolyzer.

The calculated numbers of cation transfer in KU-2-8 resin n^{Na}=0,924-0,910, in MA-40 anionite n^{OH}=0,952-1,081, A 400 n^{Na}=0,95-1,08 correspond to the properties of these resins as strong ion exchangers, which confirms the correctness of the differential ITN-metry method for determining the transport properties of dispersed ion exchange resins.

It can be concluded that the use of the differential ITN-metry method will be effective for other resins with amphoteric properties.

The use of the method of differential ITN-metry may be appropriate in researching a wide range of problems of environmental monitoring and management of environmental projects.

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ARTISANAL SMALL-SCALE MINING AND THE DEPLETION OF THE FOREST AND THE POLLUTION OF WATER BODIES IN GHANA

From the earliest times, forests have been preserved for the protection of herbal plants, trees and animal parts for the practice of traditional medicine in Ghana.

Drawing on archival documents, interviews, newspaper reports and a review of secondary sources, this study reveals that the regularisation and the facilitation of Artisans Small-scale Gold Mining (ASGM) in Ghana in 1989 has resulted in the depletion of the forest and the pollution of water bodies in Ghana. This has been a threat to national security.

This problem has been exacerbated by the corrupt activities of individuals within Ghanaian society.

This study argues that the limited capacity of government along with a long-standing trend of bad implementation of the country's small-scale mining politics, have contributed to the magnitude of the problem.

Based on the findings and discussions arising from this study I recommend rigorous education and orientation programmes towards the protection and sustaining of the forest environment.

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ASSESSMENT OF SUITABILITY OF ROCKS FROM SINKING THE IRON ORE MINES AT DEEP HORIZONS AS A SUBSTRATE FOR PLANT GROWTH

Modern iron ore mines in Kryvyi Rih mainly mine "rich" iron ore at the horizons of more than 1000 m. The waste rocks, which are mined during primary, secondary and subordinate development workings by drilling and blasting, are usually stored in dumps on the ground surface. These embankments, in addition to destroying the landscape, create an environmental hazard, as they are sources of intense dust formation. Over time, herbaceous plants, bushes and even trees from seeds accidentally brought in by the wind, birds or animals, which is commonly called "self-organized vegetation", can settle on the slopes of "old" dumps (age more than 20-30 years) in places where a small fraction is concentrated. To speed up and improve the process of greening the surface of dumps, there are also many methods of their biological reclamation by artificial planting of plants with or without surface grounding [1;2]. The latter indicates a certain suitability of the waste rocks from sinking the mine shaft and relatively shallow horizons of iron ore mines for plant settlement and growth, which contain up to 9-15% of the fine fraction of rocks of sedimentary cover and weathered rocks of the VI-V schist horizons. As the mine workings deepen, it is natural to expect changes in the mineralogical and chemical composition of waste rocks from sinking operations.

The purpose of this work is to assess the granulometric, mineralogical and chemical composition of enclosing rocks of deep horizons of iron ore mines, which are stored in external dumps, with a forecast of their suitability for plant growth.

The research was carried out at one of typical mines of the central part of Kryvyi Rih iron ore deposits (Pokrovska mine), where, as of 2021, cleaning works are being carried out at the level of 1190-1265 m, subordinate and secondary development workings – at the level of 1190-1340 m, and primary development workings - at the level of 1340-1490 m.

Based on the geological structure of Kryvyi Rih series of rocks, secondary and subordinate development workings at the surveyed mine are carried out within the productive Saksahanskyi and, partly, Inhuletskyi suites, including quartzites of the IV ferruginous and schists of the V-IV schist horizons. The lithological composition of enclosing rocks of these horizons includes chlorite, sericite-chlorite, graphite-sericite, graphite-biotite and paint-chlorite schists, non-ore and sericite-magnetite hornstones, quartzites and martite jespilites. The ore-containing rocks, namely hematite-martite and hematite ore, can be mixed with the waste rocks from sinking operations [3].

Primary and deeper sinking is carried out in the rocks of the Archean basement of Novokryvorizkyi and lower parts of Saksahanskyi suites of Kryvyi Rih series, which contain granites and quartzites of the IV ferruginous and schists of the III schist horizons. Novokryvorizkyi suite is mainly composed of chlorite-biotite, chlorite-amphibole, and biotite-quartz schists with a subordinate number of metasandstones on chlorite cement and schist metaconglomerates [4].

The material composition of the waste rock mass, which is stored in modern dump of Pokrovska mine, is constantly changing depending on the ratio of volumes of the above types of sinking operations and the type of rocks being mined. On average, there is the following ratio of rocks and minerals in the composition of dump rocks from sinking at deep horizons:

- *up to* 37% of ferruginous quartzites, quartzites and martite jespilites containing minerals of quartz, magnetite, martite, mica, silicates, chlorite, sericite, goethite, graphite, biotite and hornblende; fine and usual hematite, limonite (hydrohematite), plagioclase. The chemical composition of rocks of this group is dominated by compounds of silicon dioxide (55-87%), iron oxides, aluminum oxides and elements of potassium, manganese, sodium, and magnesium;

- *up to* 29% of dispersed hematite-martite ore containing minerals of martite, hematite, quartz, carbonates (lime, chalk, marble), and aluminosilicates. The main chemical compounds of these rocks are iron trioxide (up to 84%), iron sulfide, silicon dioxide, calcium carbonate, calcium and sodium oxides, elements of potassium, sodium, aluminum, and iron;

- *up to* 24% of silicate-magnetite quartzites, granites, chlorite-biotite-quartz schists, quartz-biotite amphibolites, phyllites and talc containing minerals of quartz, hornblende, plagioclase, biotite, muscovite (potash mica), sericite (listwanite), graphite, chlorite (mica), albite (feldspar), amphiboles, ferruginous carbonate, and garnet (orthosilicate). These rocks contain chemical compounds of silicon dioxide, calcium silicate hydrate and calcium carbonate, magnesium and iron, iron and aluminum trioxide, as well as elements of aluminum, calcium, titanium, fluorine, magnesium, carbon, nickel, rubidium, lead, lithium, iron, beryllium, tungsten, manganese, vanadium, niobium and zirconium;

- 10% chlorite, sericite-chlorite, graphite-sericite, graphite-biotite and paint-chlorite schists containing minerals of quartz, biotite, chlorite, sericite, hornblende, graphite, and goethite.

The chemical components of these rocks are chemical compounds: silicon dioxide, calcium oxide, iron trioxide, nitric oxide and elements: magnesium, iron, aluminum, chromium, nickel, carbon, phosphorus, sulfur, molybdenum, chromium, iron, fluorine, silver, and zinc.

The waste rock mass of shallow and deep horizons is represented almost equally by lump fraction with a diameter of 10-100 mm (79-80%). The fraction up to 3 mm for rocks from shallow horizons is up to 6-11%, and for rocks from deep horizons is 2-2,5%.

These data show that chemical composition of the waste rocks from any mine horizons differs little and is characterized by the presence of significant amount of silica (silicon dioxide), soluble iron, metal oxides, microelements, and a low content of sodium salts. The reaction of aqueous extract of the waste rocks is close to neutral. The rocks have medium to high exchange capacity, contain elements of potassium and sulfur available for plants, but practically do not have nitrogen, phosphorus and humus.

Due to this, the waste rocks can generally be considered a conditionally suitable substrate for plant growth.

At the same time, it was found that the waste rocks from deep horizons contain significantly less weathering products, are characterized by the absence of clay shales and other rocks of eolian and deluvial deposits of the Quaternary period, and have a significantly lower percentage of fine fraction, which clearly worsens the agrotechnical qualities of the substrate of dumps of the empty rocks from sinking shaft deep horizons for plant settlement and growth, for example, during the "self-organized vegetation".

This is also evidenced by field observations of modern mine dumps, the surface of which is much more slowly settled by both ruderal plants and higher-order cenomorph plants: petrophytes and stepants.

Thus, in order to successfully carry out artificial planting of plants, or to stimulate the processes of "self-organized vegetation" of surface of dumps (including slopes) of the waste rocks of modern deep mines during their biological reclamation, it is necessary to increase the application of mineral fertilizers (nitrogen and phosphorus - up to 600 kg, and potassium - up to 100 kg per 1 ha of surface of dump), as well as to take measures to apply (for example, hydro method) at least 2,0 t/ha of the fine fraction of humus (sediment of sewage treatment plants, peat or other bioactive substances) to the surface of dumps.

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NATURAL AND ANTHROPOGENIC THREATS OF SEA COASTS

The task of technical protection of sea coasts is to restore the good condition of the coastal zone. The following methods are used for technical protection of the shore and its stabilization: artificial shore power supply, anti-storm embankments, bands, spurs, shore breakwaters, underwater thresholds. The most important sources of threats to marine nature include: fisheries (negative impact on species and the bottom of sea basins), shipping (noise, pollution, possible collisions, introduction of alien species), tourism and recreation (especially mass recreation), eutrophication of waters, exploration and oil and gas extraction, aggregate extraction, installation and operation of wind farms and other types of infrastructure, military operations, coastal urbanization. The threat is the erosion of sea shores, which is manifested in the disappearance of beaches and the occurrence of landslides on the slopes of coastal dunes and cliffs. The progressive erosion of the shores is a serious breach of the safety of the local inhabitants. There is a risk of flooding in coastal areas with repercussions for nautical and coastal tourism [1].

Ecological disasters may be a consequence of the processes taking place at the interface between the sea and the land, as well as the too close urbanized hinterland. Strong storms and flood waters destroy nearby buildings, sewage systems, septic tanks, household sewage treatment plants and gas stations, rainwater drainage systems, legal and illegal landfills, manure tanks, cemeteries, transmission pipelines, and warehouses of hazardous substances, and cause leaching of pollutants from half. This in turn causes bulky waste, hazardous chemicals and pathogenic organisms to enter soil, waters and marine sediments.

Waste is a deadly trap for fauna (bottles, bags, strings), it is confused with food (bottle caps and corks). Bulky waste is a long-term ecological contamination of the marine environment [2,3].

In the coastal zone of the Baltic Sea, a potential threat is the presence of plants with an increased risk of chemical contamination (petrochemicals, nitrogen plants, combined heat and power plants).

The ammunition and chemicals from World War II pose a great danger. Officially, there are six sites of deliberate sinking of weapons, and unofficially, there are even 60 such sites in the Baltic Sea. 70 years have passed since the end of the war, so progressive corrosion can unseal flooded containers and activate dangerous substances.

Such a case was reported in 2011 near the Słowiński National Park, where the sea washed up a corrosive substance [4]. As stated, it was a material with a high content of white phosphorus, or napalm.

All direct influences in the form of natural factors, and indirect ones, as a result of man-made work, translate into a specific state of the shore and the state of the marine environment.

Lack of activities related to the maintenance of the coast at the appropriate level of resistance to sea force will modify the space of the marine environment and the risk of pollution.

All hydrotechnical structures counteract the symptoms of damage on the shore and often have a negative impact on the neighboring sections of the shore. Preventing negative effects requires knowledge of the boundary phenomena occurring in the building's surroundings.

The implementation of projects will affect the maintenance of the environmentally valuable environment of the coastal zone, as well as the economic existence of the local community. Securing the seaside hotel and leisure infrastructure will contribute to increasing the tourist attractiveness of seaside communes.

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OVERVIEW OF THE LATEST TECHNOLOGIES IN THE REMOTE CONTROL OF ENERGY NETWORKS AT THE ENTERPRISE

Private Limited Liability Company "PivnGZK" is the largest mining enterprise in Europe with a completed cycle of blast furnace raw material preparation - iron ore concentrate, billets. It has a large power system that includes 96 substations, 5 of them have 150/35/6 kV voltage, 30 of them have 35/6 kV voltage, all others have 6/0,4 kV voltage for the needs of the enterprise. Most of the aircraft are controlled remotely only by input cells and CMV, an outdated system that has been in operation since 1961. For example, substation No. 22 with 35/6/0/4 kV voltage supplies quarry lines, technical water shop, administrative buildings and other objects. The remote control of the power system is not fully able to perform all the necessary switching. Presently, the development of technologies for remote control of electrical networks at the enterprise necessitates the updating of equipment, using the latest information technologies that will enable to manage operations, data and information through the use of computers and software that reduce the degree of human participation in the process, or completely exclude it. The main goal of automation of electrical networks is to increase the quality, speed of work, excludes the human factor during the execution of the pro-

cess. Collection and processing of data on energy consumption and distribution of electrical energy, automation of processes allows to increase productivity, reduce process execution time by 30-40%, increase accuracy and stability of performed operations. Today, automation is widely used in all branches of production, including the energy sector.

Many of the latest programs have been developed for remote control of energy systems at the enterprise, but they are all based on Smart Grid and ASDUE programs.

Smart Grid - "Smart" networks. Modern technologies for control and monitoring of electrical systems, which allows efficient, reliable consumption and transmission of electrical energy. One of the important characteristics of the program is "self-healing", which includes automatic diagnosing and elimination of the accident, which reduces the level of cascading outages and quick restoration of energy supply to disabled areas. Solving these tasks consists in using a hierarchical decision-making structure.

The Smart Grid concept includes:

- power electronics (FACTS/HVDC), it is easier integrated into computer networks.
- energy management systems (EMS);
- automation and protection of "intelligent" (digital) substations;
- integrated substation condition monitoring (ISCM)
- communication solutions;
- distribution network management system (DMS);
- automation and protection of network distribution ISSN 1813-5420 (Print).
- distributed energy resources (DER);
- decentralized energy management system (DEMS);
- intelligent Smart metre sensors and counters;
- wide integration of RES in networks and energy systems;

The current level of development of power electronics makes it possible to provide Smart Grid with the possibility of using power active filters and active rectifiers and, based on them, reactive and instantaneous active power compensators; widespread use of energy-intensive energy storage devices to compensate for instantaneous active power pulsations in power supply conversion systems with dynamic loads.

ASDUE - Automated system of dispatching control of power supply of substations. It is intended for automatic control and management of the plant's power supply systems in real time.

To ensure state control of parametres and equipment of the power supply system, remote control of power switches, security alarms, video monitoring, electricity accounting, as well as reducing the level of electricity losses, reducing the level of emergency and increasing reliability.

ASDUE provides a dispatcher with reliable and comprehensive information for interaction with the technological process and ensuring the operability of software and technical means.

The general software platform based on the technology is MicroSCADA.

MicroSCADA is automation of distribution substations of all voltage classes, the electrical part of stations and the creation of dispatching systems for managing distribution networks of various levels that enables complete functioning of the system and communication between data arrays. It consists of:

- application software;
- special software ABB; Siemens; Phoenix Contact; Schneider Electric;
- systems and software tools that expand the capabilities of the system;
- system software uses an operating system based on licensed Microsoft Windows 10 [3].

Special software includes the "ENERGO CENTR" tool set, which provides the following options: making changes and registering them in a special log; copying to the archive and restoring the necessary information from the archive; testing the functioning of the software and technical support of the system; system protection using passwords, protection against third-party intervention, erasure or change of system data [3].

Software from the world's leading manufacturers are more common in Ukraine and are effectively used by Hitachi Energy companies, Eknis-engineering, which basic tasks are effective protection, automation, control and monitoring for all types of substations in order to ensure maximum safety, efficiency and reliability. The most famous projects of Hitachi Energy: Substation 330/150/35 kV "Aquilon", Kherson region, "Kovel" with 330 kV voltage, "Boryslav" with 220 kV voltage and others. Ecnis - engineering: "Priorska" PJSC "DTEK Kyiv Electric Networks" 110/10 kV, VP "Zaporizka NPP" SE NAEK Energoatom", PJSC "ArcelorMittal Kryvyi Rih" and others.

Each consumer decides for himself, which program to use. But in my opinion, they both deserve attention and are the most competitive at the time of rapid changes in the latest technologies.

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ENVIRONMENT AND RADIATION

In recent years, the study of some environmental issues revealed that natural substances may have the same and sometimes greater impact on the biosphere than anthropogenic substances, and they can not always be considered environmentally safe. For example, an analysis of the elemental composition of various clay mineral deposits in Azerbaijan revealed that, together with other inorganic elements, they contain a number of radioactive elements, such as 235U, 232Th and others. In this aspect, it was of scientific and practical interest to study the distribution of radioactive elements in them. Forms of chemical elements are rocks, minerals, magma, etc.

Radioactive substances constitute a special group of chemical elements, a strong biological effect of which is caused by their ionizing radiation.

Living organisms may tolerate the presence of certain amounts of the contaminants, i.e. a threshold level below which no morbid reactions are observed, however the increased level of radiation originating from radioactive substances, such as 235U, 232Th, 90Sr, 137Cs whose spontaneous transformation may produce *a* and *b* particles, neutrons, g-rays and cause severe impacts on humans causing genetic alterations. Statistically high concentrations of radioactive elements cause health effects depending on the amount of the substance and the duration of the exposure or exposure.

At short exposures, higher levels of contaminants are tolerable, i.e. thresholds may be higher for short exposures and lower for longer exposures.

The exceptions are bio-accumulative substances and radioactive substances that have a zero threshold level, which means that any, even the shortest, exposure to a living organism can cause harm.

Based on the above, it was of scientific and practical interest to study the degree of radiation activity of bentonite rocks sampled from various clay deposits in Azerbaijan. Activity of radionuclides in samples of bentonite rocks was determined by means of gamma-spectrometer (Canberra) with HPGe detector, activity of uranium isotopes was determined by α-spectrometer (Canberra) of "Alfa Analist" brand. It was noted that uranium is a part of numerous minerals and its mineralisation is partially related to clay and bituminous shale, bentonite conglomerates.

Bentonit clays belong to the category of natural minerals that have found wide application in various fields of engineering, industry and agriculture, in textile industry, when sanding cotton fabrics. In the paper industry - to regenerate paper in the process of cleaning it from printing ink, in the ceramic industry - as an additive to refractory clay to reduce the melting point, for the clarification of wine and fruit juices, etc.. It is also used in the cosmetics industry, medicines based on them contribute to pain relief and speedy healing of wounds, etc.

In this connection establishment of quantitative content of radioactive elements and their radiation activity is of great ecological importance.

Studying the activity of radionuclide Pb_{-210} Cs_{-137} Th_{-232} U_{-235} U_{-238} Ra_{-226} Ra_{-228} and K_{-40} in samples of different clay mines in Azerbaijan: Gizildare, Agdere, Khizi, Alibairamli, Dashsalahli and Absheron from 34,5-146 Bk/kg showed that they are in permitted norms according to ecological norms.

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BIOMONITORING AND BIOINDICATION IN AIR PURITY TESTING

Anthropopression forced many scientists to find methods that allow to study the state of the environment, methods that are minimally invasive, quick to carry out and giving reliable results. The concept of bioindication has gained importance in recent years, as the deepening ecological crisis has started to be noticed. The concept of bioindication is defined in various ways in science. "Bioindication is understood as the identification of ecological systems, determining their state or certain environmental variables on the basis of information contained in the biological components of these systems" [1]. Indi-

cator taxa are used to explain the effects of environmental changes such as habitat change, fragmentation and climate change on a spatial and temporal scale.

Other concepts are active and passive bioindication. Active bioindication uses bioindicators grown in a laboratory, which are then exposed in a standardized form in a given area for a specified period of time. After the exposure time, the induced reactions are recorded or the xenobiotics taken up by the body are analyzed. In contrast, passive monitoring examines the reactions of organisms that occur naturally in the ecosystem.

Organisms or their communities are classified according to their origin. In this case, the authors distinguish between active and passive bioindication, but it can also be used for biomonitoring [2]. Biomonitoring is a measure of the response of living organisms to changes in the environment.

Regular temporal and spatial observations of living organisms as bioindicators enable, on the basis of their quantitative and qualitative characteristics, to determine the state of the ecological system and the biotic and abiotic parameters of its components, including substances and anthropogenic interactions [3]. Passive monitoring is the observation of organisms living in the natural environment in the place where the research is carried out, while active biomonitoring is the observation of organisms introduced into the studied area.

Bioindication is used in ecotoxicology and is a way to identify toxicity. For this purpose, biotests are used to determine the effect of a given xenobiotic on living organisms. The concept of bioindication is used interchangeably with biomonitoring. Bioindicators are used in the process of bioindication, ie organisms that contain information about the quality of the environment [2]. An important feature of bioindicators is the measurable response to environmental changes.

With the help of the organism's reaction, the researcher identifies the type and scale of pollution and the scale of the surveyed area. The bioindicator can react to anthropogenic stress in various ways. Lichen is a very popular and well-known indicator of air pollution. Due to their structure, lichens have a great ability to absorb water from the air. They do not have any covering tissue, which means that the pollutants contained in the atmospheric water are completely absorbed by them. Their particular sensitivity to contamination with sulfur oxides is valuable in bioindication.

By using lichens as bioindicators of air pollution, lichen-indicative maps are created. They represent the air cleanliness zones. These maps can be found in numerous domestic and foreign publications, because these methods have over a hundred years of tradition [4]. On the lichen scale, zones with varying degrees of air pollution are distinguished, from three to ten.

Other indicators sensitive to air pollution are mosses. Their advantage is that they are easy to identify and can accumulate pollutants. They are used to determine environmental contamination with heavy metals and sulfur oxides. An example of the use of higher plants in bioindication is

warty birch (*Betula pendula*). In one study, its cortex was used to measure the concentration of heavy metals.

The bark of trees can be used as an accumulating bioindicator due to the presence throughout the life of the tree, it enables the accumulation of pollutants with its entire surface. Moreover, it is a tissue in which no metabolism or excretion of products takes place [5]. Scots pine (*Pinus sylvestris*) is also a bioindicator.

The study with the use of pine needles confirmed its usefulness for monitoring the profile of air pollution with organochlorine compounds [6]. Scots pine is also a species sensitive to fluoride contamination.

Other plant species sensitive to fluoride contamination are: barberry (*Berberis vulgaris*), St. John's wort (*Hypericum perforatum*), lily of the valley (*Maianthemum bifolium*), mountain pine (*Pinus mugo*), gladioli (*Gladiolus sp.*) [7].

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FABRICANT OF HIGHLY TRANSPARENT WOOD BIOCOMPOSITE FROM BALSA WOOD BY UV SUPPORTING

Introduction

Transparent wood is an extremely desirable building material because of its advantages in terms of high optical transmittance, good mechanical qualities, and effective thermal insulation. However, because thick or large-size transparent wood is practically unattainable, the current research is restricted to producing small-size samples in the lab. For practical purposes, a technology that can easily and

quickly make transparent wood of any dimension and thickness is required. High light transmittance is achieved by using transparent wood manufactured from wood fibers as a substrate because it allows the cell walls to adhere to the impregnated polymer more firmly. The transparent wood produced by this method, as compared to wood produced using previously described methods, not only has the same benefits but also has a better preparation efficiency and is appropriate for commercial production.

The current approach for preparation of transparent wood [1] is based on delignification of the substrate followed by the polymer infiltration with matching refractive index to the wood substrate. Since lignin is responsible for 80-95% of the light absorption in wood, delignification is essential in the studies that have been reported [2]. To eliminate colored substances, including lignin, wood can be treated for 1-2 days with a 5% aqueous solution of sodium hypochlorite. Although lignin only makes up about 30 weight percent of wood, it builds cross-links with other polysaccharides in wood to provide structural stability [3]. The removal of lignin will damage the structure of the wood, making it difficult and impossible to handle and fabricate large substrates. This limits the variety of wood species that can be used to prepare transparent wood.

Research Objects

The idea of producing transparent wood without delignification was examined in light of the above-mentioned barriers. Large transparent wood preparation with independence from the species of wood may be possible through lignin modification by eliminating just chromophoric groups. Since alkaline H_2O_2 treatment is known to reduce wood's light absorption and has a low delignificationn. While the majority of the lignin is retained, chromophore structures are either eliminated during the process. As a result, the wood structure's hierarchical structure is better protected. In this instance, the reagent H_2O_2 was utilized to keep the primary structural elements of the wood while only removing the chromophores.

In this method, balsa wood with the thickness of 1 mm was exposed to alkaline H_2O_2 treatment with UV supporting. The lignin treatment samples were impregnated with epoxy in vaccum. The time is applied for lignin treatment in the range of 1-5 hours. After 1 hour, the brightness of natural wood begin to brighter. However, further increase in the processing time of 5 hours did not increase the brightness beyond 80% (Fig. 1)

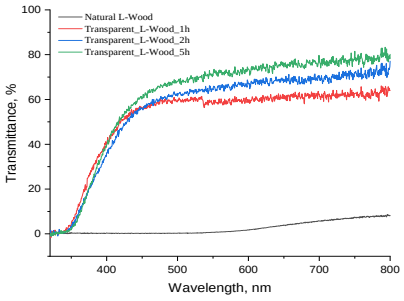

Fig. 1 The transmittance of natural and transparent woo

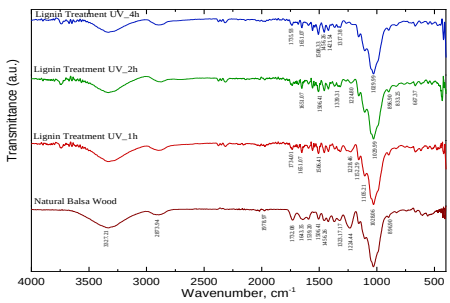

Fig. 2 The FTIR of natural balsa and modified wood

In addition, lignin is mostly maintained, which promotes the preservation of the wood structure. To confirm the presence of lignin in the wood template, FTIR was utilized. As can be seen in the Fig. 2, the aromatic skeleton vibration in lignin is thought to be responsible for the band at 1506,41 cm^{-1}, which is attributed to the aromatic compounds (phenolic hydroxyl group). Only chromophoric groups were impacted, and there was no change in intensity at 1506,41 cm^{-1}, showing that lignin was mostly maintained [4].

The SEM micrographs of the cell wall obtained before and after H_2O_2 treatment (Figure 3*a,b*) did not demonstrate any appreciable micro-scale damage, not even in the lamellae that is rich in lignin. Delamination of the cell wall occurred at the middle lamella to very limited extent. This supports the distribution of lignin being mostly maintained.

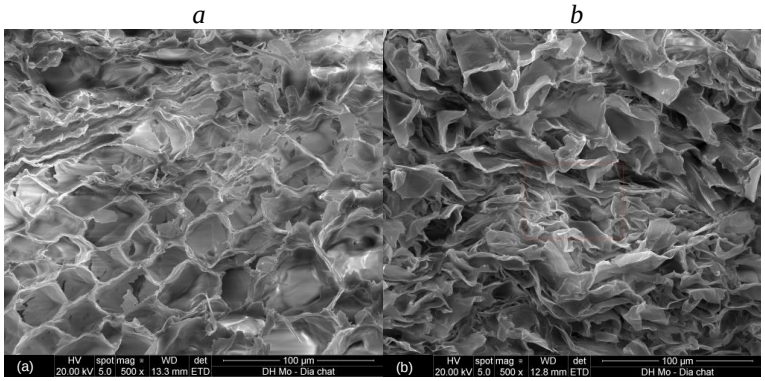

Fig. 3 The SEM of (*a*) natural balsa and (*b*) modified wood, after H_2O_2 treatment

Lignin is a polymer matrix bonding agent for cellulose microfibrils in the cell wall that, as is common knowledge, connects the nanofibrils and fiber together to give plants their great strength and stiffness. The mechanical strength of the wood template was decreased after delignification [4]. However, this is not a concern when using the lignin modification approach. The difference was barely noticeable for the low density balsa wood templates. Lignin modification effectively protects the wood's structural integrity. The sample's mechanical integrity was better preserved by the lignin modification technique.

Conclusions

In this study, lignin-retaining wood templates were used to create a novel kind of transparent wood samples with a high lignin content. Only a tiny fraction of chromophores were removed during an effective and eco-friendly process, which greatly improved the preparation of the wood template. For large transparent wood constructions made of different wood species, the retention of lignin results in much better mechanical characteristics than delignified samples. As a result, there is no glass-like shattering, which has significant implications for use in buildings. From a variety of wood species, transparent wood can be produced by simply eliminating the chromophoric lignin components.

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AN ANALYSIS OF THE IMPACT OF KRAKÓW-BALICE (POLAND) INTERNATIONAL AIRPORT ON ATMOSPHERIC AIR QUALITY

Airport pollutants are emitted by fuel combustion in aircraft engines and other diesel-powered motor vehicles. During the taxiing of aircrafts, particulate matter is emitted from the abrasion of the airport road and tires. Compared to road traffic exhaust emissions, aircraft pollutants are smaller. Total suspended particulates can be classified into: PM10 - the diameter no greater than 10 μm; PM2,5 - the diameter no greater than 10 μm; Ultrafine particles (UFPs) - far smaller than 2,5 μm. Fine and ultrafine particles are more dangerous than larger pollutants since they enter the bloodstream and cause many diseases [1,2,3].

Actions that could improve air quality include investments in zero-emission transport, both individual and public. Transport in the Sustainable Development Framework includes social, economic, and environmental aspects. The main environmental objective is related to reducing the impact of transport systems on the natural environment. The Electromobility Development Plan in Poland is being implemented as part of the National Research and Development Centre's initiative - Emission-free public transport. However, the objective is to strengthen the competitiveness of public transport against individual transport. Undoubtedly, air transport has the greatest impact on the environment, with ultrafine particles and also carbon dioxide emissions in the upper atmosphere. For long-distance fast travel, air transport has no alternative. It is worth mentioning that Airbus plans to introduce zero-emission hydrogen-based commercial aircraft by 2035 to achieve climate neutral targets. Until then, air transport will be a significant emitter of pollutants [4, 5].

The area of Kraków-Balice International Airport is about 400 ha. Emissions have an impact on Krakow and the surrounding area. The airport handles more than 300,000 passengers per month. It should be noted that, as part of the International Airport Investment Plan for 2020 to 2028, the airport is expanding to improve capacity so that the facility can handle up to 12 million passengers a year [6].

More than 50,000 people live within a 5 km radius of the airport. There are also forms of environmental protection near the sample site area. These include the Bielansko-Tyniecki Landscape Park, 2 km west of the airport, and the Tenczynski Landscape Park, 60 m from the airport border. Further examples of forms of environmental protection are three nature reserves: Mnikowska Valley, Skała Kmity, and Zimny Dół. The reserves are located at a distance of 2-6 km from the airport and play an essential role in protecting nature and animal life [6, 7].

Weather conditions have a significant impact on air quality. The Krakow-Balice Meteorological Station, located in the airport area, is responsible for regular measurements of weather conditions. The facility is located in a transitional climate zone with high weather variability. The average annual temperature is 8 °C, and the vegetation period can last 210 days. The average annual precipitation is 700 mm, with 175 precipitation days. On the other hand, the average annual relative humidity does not exceed 80%, and most days of the year are dominated by partial and total cloud cover. The South-West winds prevail at the airport site throughout the year with an average speed of 11,4 km/h. This wind flow means that the emitted pollutants are directed into Krakow. A monitoring station belonging to the Regional Inspectorate for Environmental Protection is located 2 km northeast of the airport. The station conducts continuous measurements of PM10 particulate matter [6].

Measurements were taken near the Kraków-Balice Airport (50°04'36,5"N 19°48'29,5"E), 500 m east of the runway. There are no obstacles on the side of the runway where the measurements were taken. The data collection procedure lasted from 17 March to May 8, 2022. The samples were collected between 12:00 and 15:00 each day. In addition, meteorological data, such as humidity, cloud cover, temperature, wind speed and direction, rainfall, and air pressure, were collected from the weather station, and using the Pearson linear correlation coefficient, correlations between weather parameters and the level of pollution were determined. The particle counter collected data in real time. The detection ranged from 0,1 $\mu g/m^3$ to 999 $\mu g/m^3$.

The highest particulate concentration was observed on March 26, 2021, in which PM 2,5 was 40 $\mu g/m^3$ and PM 10 was 55 $\mu g/m^3$. The lowest, was on May 3, 2021, with PM 2,5 concentrations of 5 $\mu g/m^3$, and PM 10 concentrations of 6 $\mu g/m^3$.

A strong negative correlation was calculated between wind speed and pollution (-0,64). As the speed of the wind increases, the amount of pollution decreases. A low positive correlation (0,31) was also found between air temperature and pollution.

In conclusion, particulate matter is particularly dangerous and causes many diseases that can lead to death. Research has confirmed that the Krakow-Balice airport contributes to the air pollution of the Kraków agglomeration.

Due to the west wind, the pollution is directed towards the centre of Krakow. Weather conditions affect air quality, especially wind speed. Unfortunately, only a few airports carry out this

type of measurement. These studies are necessary due to the impact of airports on residents who live nearby and forms of environmental protection.

Unfortunately, there are currently no green alternatives to long-distance transport. Very soon, aviation will be using clean energy sources.

Each of us has an invention, and many inventions have been inspired by a specific need. A particularly necessary model of limitations on the planet. It is important to take our actions part of the restoration of the environment. Nature and we ourselves will benefit from such a process because it is nature that makes the environment stable.

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PREVENTION OF ENVIRONMENTAL POLLUTION BY EVALUATING AND INCREASING THE DURABILITY OF CEMENT STONE IN THE WELL

Environmental protection and rational nature management in the oil and gas industry largely depends on the tightness of the well lining [1]. And the tightness of the well lining largely depends on the quality of casing cementing, and this is primarily due to changes over time in the quality of the cement stone [2].

Cement stone is an elastic-plastic material and its rheological properties depend on the duration of exposure to loads [3]. It has been experimentally established that the creep deformations of stones from the tested materials exceed the elastic deformation. Regardless of the tensile strength of the material and test conditions, the excess of total creep strains over elastic ones is 2,0-2,2 times [4]. In this regard, the practiced calculations associated with the cement ring, casing strings, based on the elastic state of the material, reflect the true stress pattern only for the initial moment of stress action. Because If the well support is designed for a long period of work, then, obviously, the above-

mentioned important creep property of stones from the materials used must be taken into account in the calculations [5].

In the model we have chosen for describing the creep process, the relationship between stress and strain explicitly depends on time. And although it is known that such an approach can only be suitable for approximate calculations, I calculated the duration of time during which this deformation is achieved, i.e. the probable service life of a stone from this plugging material in the well annular space is approximately determined, taking into account its rheological characteristics. The calculated service life of the stone corresponds to the most severe conditions of the stone. The samples were tested under the action of stresses (0,6-0,7) σ, where σ is the ultimate strength of the cement stone. Obviously, under the action of lower stresses, the service life of the stone will increase. Approximate calculations of these terms are consistent with previously conducted experimental data on determining the creep deformations of stone from various backfill materials. Thus, on the basis of experimental data and analytical studies, the following can be said.

For cementing wells, grouting materials suitable for the given geological and technical conditions should be used, giving preference to mixtures of grout cement with various fillers with high physical and mechanical characteristics. The main criterion when choosing these materials should be durability - the above service life of the well support stone.

When calculating the unloading coefficients of cement stone, one should use the minimum values of the elastic moduli of the material, calculated taking into account its creep deformations.

It is advisable to find ways to increase the strength and deformation characteristics of lightweight and weighted cements to increase the durability of the lining if they are used in well cementing. Due to the fact that, in terms of preference, lightweight cements produced are inferior to other grouting materials, it is of practical interest to develop lightweight grouting materials, the use of which will ensure the durability of the well lining.

When calculating casing strings that are lowered into rock intervals prone to deformation, it is advisable to use the refined values of the cement stone unloading coefficients.

It is recommended that the amount of unloading of cement stone from the applied backfill materials (before the development of new backfill compositions, the elasticity moduli of stones from which will be stable for a long time), be taken into account as an additional margin of safety for casing pipes used when fastening wells.

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RESULTS OF THE STUDY OF SUSPENSIONS WITH THE USE OF SODIUM GROUP MIXTURES IN THE TREATMENT OF COAL MINING WASTE

Burning waste heaps create a special danger of air pollution. According to Zborshchyk M.P., Leonov P.A., Surnachev B.A., the content of combustible substances in the form of coal, coal shale and pyrite in the waste heap reaches 40% [1]. These combustibles are able to oxidize under the influence of air at normal temperature with the formation of thermal concentrators of combustion [2]. Burning of the dump lasts for decades and a large number of various harmful substances and gases are released [3]. The results of studies have shown that on average, 150 tons of carbon dioxide, 10 tons of carbon, 1,5 tons of sulfur dioxide, 0,4 tons of hydrogen sulfide and 0,1 tons of nitrogen are released into the environment from one burning dump per month [4].

Spontaneous combustion of the waste mass of coal mine preparation wastes occurs under the condition of oxygen access inside the porous structure of the waste mass in the body of the waste heaps and the formation of thermal concentrator zones, which are formed as a result of chemical oxidation processes. Therefore, it is necessary to use suspensions-inhibitors for the treatment of waste mass. in the process of research, methods of processing the results of the experiment using student's t-test in the ms excel software environment were used [5,6].

For the study, samples of the waste mass of coal mining waste in the amount of 3 samples (samples of burnt rock of the waste mass) were selected, since they are the main largest fractional composition of waste heaps with the highest content of chemical oxide compounds that are of interest and provoke oxidation processes: silicon dioxide (SIO_2), aluminum oxide (AL_2O_3), iron oxide (FE_2O_3), calcium oxide (CAO), magnesium oxide (MGO) and potassium oxide (K_2O). also other elements of chemical compounds that are minor and contained in small amounts: titanium oxide (TiO_2), phosphorus oxide (P_2O_5), sodium oxide (NA_2O) and sulfur oxide (SO_3). The selected samples were treated with suspensions using sodium-based soda solutions additives: $NAHCO_3$, NA_2CO_3 and NAOH.

The procedure for conducting experimental studies was carried out once. the general parametric characteristics of the fractions of the samples of the dumped mass did not exceed 15-30 mm, the specific gravity of all samples did not exceed 3-14 g. the suspensions were prepared as follows: distilled water was poured into each of the three 100 ml beakers and 50 g were added. $NaHCO_3$, Na_2CO_3 та NaOH resulting in suspensions with a concentration of sodium agents of 50%. The samples of the dump mass were treated with a conventional spray gun (full-cone irrigation torch with

minimum and maximum irrigation angles of 150-125°, the theoretical irrigation width was 35 mm) at an irrigation distance of 10 cm with three types of sodium solutions: hydroxide, bicarbonate and sodium carbonate. the finished treated dump mass was kept indoors for 30 days at an average air temperature of 20-21 °C. For further processing of the results of the experiment, general methods of statistical analysis. Were used when checking the obtained data for homogeneity, the method of analysis using the parametric Student's t-criterion was chosen. This method of analysis allows to exclude from the sample questionable variants that may be erroneous and do not belong to the general population of data.

According to the results of the study, when using the threshold value of the criterion t_{gr}=2,14, we can see that the most statistically significant parameter according to the student's t-criterion in relation to the chemical element of silicon dioxide (SiO_2) is the treatment with a suspension of sodium hydroxide t=13,95 (3,95>2,14), that is, $t>t_{gr}$; the treatment of the waste mass using a suspension of sodium carbonate is statistically t=7,15 and is (7,15>2,14); treatment with a suspension of sodium hydroxide t=6,44 (6,44>2,14). All parameters are statistically significant, as evidenced by the use of these suspensions, the determination of the average deviation of the scattering coefficient by the distribution of the student's t-criterion for the treatment of sodium hydroxide of the dump mass is - σ_y=0,93; sodium carbonate - σ_y=2,65; sodium bicarbonate - σ_y=1,27.

The distribution of student's criteria based on proportional calculations for the effectiveness of processing the dump mass with suspensions based on sodium solutions was carried out. the greatest efficiency in interaction with pyrite Fe_2O_3 obtained by using a suspension based on sodium hydroxide - 76 %; the second place is the treatment with sodium carbonate suspension of the chemical element K_2O - 73 %; in third place is the treatment of the suspension with sodium hydroxide of the chemical element SiO_2 - 56 %. The diagram (Fig. 1) visually shows that the treatment of the suspension with sodium hydroxide has high performance in the interaction with all chemical elements of the dump mass.

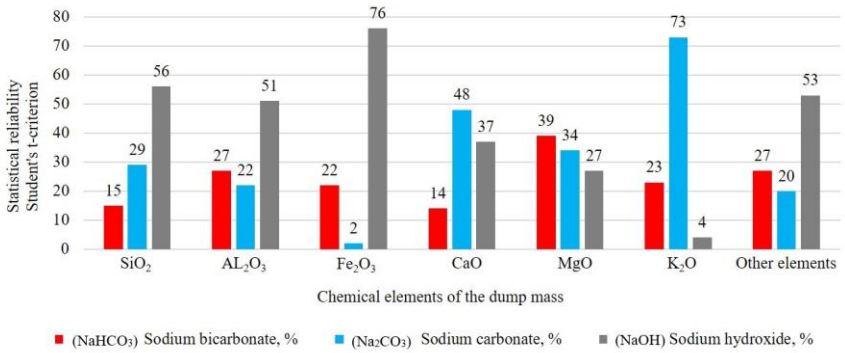

Fig. 1. Diagram of the results of treatment of the dump mass with hydroxide, bicarbonate and sodium carbonate

Conclusions

Analyzing the above parametric data by student's t-criterion, it can be concluded that there was a significant statistical significance in the treatment of sodium hydroxide of the dump mass. the

results obtained allow us to assert that the treatment with a suspension based on sodium hydroxide NaOH will have positive results in the elimination of oxidative processes in the waste mass with the participation of sulfur and pyrite, which are agents of spontaneous combustion of the waste mass.

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EFFICIENT URBAN WASTE MANAGEMENT IN JIU VALLEY, ROMANIA

Industrial society is harmful to natural systems and does not accept that there are limits to the ability of the planet to supply resources and to neutralize the harmful effects of man-made activities. A strong impact on natural resources has, first of all, population growth, which entails the need for economic growth based on technological progress in production processes, responsible for ensuring the need for consumer goods. There is a direct, proportional connection between the pace of economic growth and that of the volume of waste, which contributes to the sharpening of the conflict between the techno-sphere and the ecosphere. With the demographic explosion and the revolutions in agriculture and industry, waste has exceeded the capacity of the environment to absorb and neutralize it at a rate close to the rate at which it is generated. Population growth has led to an increase in the pace of expansion of habitable areas and has created the need to produce larger quantities to meet the needs of populations, so the amount of raw materials from the manufacturing process and after consumption has led to an increase in waste. Regarding waste, it is necessary to mention that it currently reproduces faster than humans. They have a much longer life and sometimes take hundreds or even thousands of years before they completely decompose as a form of reintegration into nature. At the scale of a nation, an economic agent or a simple citizen, no one can ignore the fact that, like landforms, mountains of waste grow a few meters each year, polluting water, air and soil

and significantly reducing resources in raw materials, representing a symbol of a society that wastes in an impermissible way the natural resources.

Environmental and health problems are also created by the non-collection or improper storage/management of urban waste, a situation encountered especially in developing countries, where the collection rate, between 30-50%, is very low.

The worst effects of poor management of this waste are air pollution and contamination of drinking water supplies, which leads to increased incidence of disease by pathogens. Some infectious diseases are directly related to the non-collection or improper storage of municipal waste of any kind. From this point of view, urban waste has experienced a continuous growth rate worldwide, both in global terms and in terms of population, reaching, in the highly industrialized states, an average annual level of 1t waste for every human being on the planet (3 kg / day / person).

The Jiu Valley is an intramountain depression located on the Jiu River. It is known for its natural riches, exploited by the Romanian state through coal mines. The surrounding mountains are in the Retezat-Godeanu group of the Southern Carpathians. The main cities in this area are Petroșani, Vulcan, Petrila, Aninoasa, Lupeni, Uricani. In popular speech, the notion of "Jiu Valley" refers to the Petroșani Depression in the south of Hunedoara County.

The Jiu Valley forms its own ethnographic area with many specific elements that distinguish it from the surrounding areas. The traditional occupations of the inhabitants - shepherding and mining - are specific to the Jiulu Valley, to which are added agriculture, forestry, peasant crafts.

The relief in the interior is represented by a plateau that maintains its barely undulating surface at an altitude of 800 m in which depressions of about 200÷300 m have appeared, forming narrow valleys (in Livezeni the riverbed is at 560 m). Only the western and eastern Jiu valleys are much wider and accompanied by well-formed trails. A characteristic of the relief is given by the combination of the smoothing of the terraces with the shapes of the relief carved in limestone.

Jiu Valley (Zone 4) covers 6 administrative-territorial units (3 municipalities: Vulcan, Lupeni, Petroșani; 3 cities: Aninoasa (along with the following villages belonging to Iscroni), Petrila, Uricani and 2 communes: Bănița, Baru), is located in south of Hunedoara county and has a total population of 111,033 inhabitants registered at the level of 2020, which represents approximately 29.45% of the total resident population of the county. Of the total population of the area, 95.35% (105,874 people) live in urban areas and 4,64% (5,159 people) in rural areas. At present, the waste is transported to the transfer station and the sorting station from Petroșani.

The quantities of waste sorted and recycled in the period 2017-2020 have a fluctuating evolution. Sorting yields are extremely low, ranging from 2,3% (in Brad sorting station) to 44% (in Petroșani sorting station), which is explained by the fact that both in Brad and in CMID Bârcea Mare, the sorting station mainly contains mixed waste, while the Petroșani sorting station only in-

cludes recyclable waste (with a fairly high degree of impurities). Most of the municipal waste ends up in landfills by 2016 in the Vulcan landfill, and from 2017 in the Bârcea Mare.

What we need now is systematic change. It is not effective enough to rely on fragmented taxpayer-funded recycling programs and voluntary corporate initiatives. The real, lasting changes that we need will not happen without government leadership. Individual actions matter, but the truth is that more federal, state, and local policies are essential if we are ever going to get out of this worsening recycling and waste crisis.

Here are some steps we could take to increase recycling:

- Reduce reliance on single-use plastics and, to be honest, single-use everything.
- Require at least a minimum amount of post-consumer recycled content in products and packaging.
- Adopt a proven policy solution - Extended Producer Responsibility (EPR) for Packaging.
- Adopt more beverage container deposit laws.

Following the studies and observations we can point out some important moments that we find in this paper: the problem of Waste Management in the Jiu Valley, the storage of large amounts of waste, the lack of a strategy for their efficient recovery and disposal.

Environmental and health problems are also created by non - collection or improper storage of urban waste, a situation especially encountered in developing countries, where the collection rate, between 30-50%, is low. The worst effects of mismanagement of this waste consist in air pollution and contamination of drinking water supplies, which leads to increased incidences of disease by pathogens. Some infectious diseases are directly related to the non-collection or inadequate storage of urban waste of any type.

Inadequate waste management contributes to climate change and air pollution and directly affects many ecosystems and species.

Landfills, considered to be the method of last resort in the waste hierarchy, release methane, a very potent greenhouse gas that is associated with climate change.

Methane is formed by microorganisms present in landfills due to biodegradable waste such as food, paper and waste from gardens. Depending on how they are built, landfills could also contaminate soil and water. After they are collected, the waste is transported and treated. As a result of the transport process, carbon dioxide - the most prevalent greenhouse gas - and air pollutants, including particulate matter, are released into the atmosphere. Some of the waste could be incinerated or recycled. Energy that comes from waste can be used for the production of heat or electricity, which could replace energy produced by using coal or other fuels.

The recovery of waste for energy production could thus help reduce greenhouse gas emissions. Recycling can contribute even more to lowering greenhouse gas and other emissions. When recy-

cled materials replace new materials, the need for extraction or production of new materials decreases.

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CREATION AND DESIGN OF DENITRIFICATION BIOFILTER "POINT OF USE"

Providing the population with high-quality drinking water is the "Sustainable Development Goal", declared in 2015 by the UN General Assembly. The most common groundwater pollutants, which are sometimes the only source of drinking water in some regions of the world, are nitrates (Abascal et al., 2022). The reason is due to the anthropogenic factor of disruption of the natural cycle of nitrogen in nature and the properties of nitrates, namely, their high solubility in water and poor fixation in the soil. The negative impact of nitrates on the human body, especially newborns, is described in the literature (Ward et al., 2018). Nitrates cause methemoglobinemia in infants. Nitrates affect the thyroid gland, exacerbate chronic diseases, and provoke the onset of oncological diseases in adults.

The removal of nitrates in centralized water treatment successfully achieves by using methods aimed at both their extraction from treated water (reverse osmosis, ion exchange, electrodialysis, etc.) and the conversion of nitrates into molecular nitrogen (biological denitrification, catalytic reduction). Providing safe and high-quality drinking water in places remote from water treatment plants and distribution networks is much more difficult. In Ukraine, only 30,1% of the rural population uses centralized water supply services (Yalovoj, 2021).

Decentralized post-treatment of water can be a solution to the problem. The most applicable methods are reverse osmosis, ion exchange and biological denitrification. The purchasing and sub-

sequent operation of devices based on the first two technologies are associated with high costs, making them inaccessible to users with a low-income level. The yield of purified water during reverse osmosis treatment is about 25%, the method is not applicable for the purification of waters with high salinity, and the resulting water is physiologically defective. An alternative could be biofiltration by "Point of entry" (POE) and "Point of use" (POU) devices for decentralized water purification from nitrates. Biofiltration, particularly biological denitrification, is in line with the modern trend of "green technologies". So the bacterial community "recycles" nitrates without waste generation with a 98-100% conversion rate.

The works (Roshanravan H. et al., 2021; Alyamani EJ et al., 2020; Lin Y-H et al., 2020) and others describe devices for water denitrification with mobile and immobile carriers of attached microflora. These devices operate both in continuous and intermittent modes. The performance of these devices and the quality of purified water depend on the following: the initial concentration of nitrates in the treated water; its flow rate; hydraulic retention time; quantity, type, and regularity of supply of external carbon sources to the biofilter; frequency and intensity of hydraulic flushing's.

The critical problem of decentralized biological treatment of nitrate-containing water with POE and POU devices operating in continuous flow mode is the complexity of controlling both process parameters and filter media clogging (Rocher V. et al., 2019).

This work aimed to improve the efficiency and sustainability of the biofilter operation by changing the following:

1. The overall biofilter design (geometry) and the trajectory of the pass of nitrate-contaminated water in its body. This provided the opportunity:

a - to increase the length of the biofiltration path and increase the deepness of the water treatment;

b - to realize additional opportunities for the "bacterial community" to remove heavy metal ions from the treated water and reduce its hardness;

c - to set the hydraulic retention time of the denitrified water in the biofilter within a wide range based on the desired quality of the resulting water (filtrate).

2. The design of the loading elements and the structure of the filter bed. The chips consisting of the filter bed must have *a* specific configuration and *a* highly developed surface. In the filter bed, the chips must form channels for water easy to pass along the biofiltration trajectory. Also, unhindered removal of gaseous products of microbial metabolism from the filter body should ensure. Together, this increases the resistance of the biofilter bed to biofouling.

3. Filtration mode changing from «continuous direct flow" to "piston". It prevents clogging of the biofilter layer and thereby increases the stability of the biofilter work, providing the consumer with the opportunity to receive the required amount of denitrified water in portions (in one gulp).

The developed biofilter has a U-shape with *a* vertical orientation of its conjunct elbows, with open upper ends, plugged bottoms, and *a* hydraulic jumper of *a* specific section in the bottom part.

This construction of biofilter allows set hydraulic retention of water time within a wide range. The design of the biofilter has been described in detail by (Gevod V. et al., 2020).

The time-dependent changes of nitrates concentration along the trajectory of biofiltration were studied under various operating modes of the biofilter.

Shown that the "bacterial community" demonstrates a high ability to adapt to "stressful situations" (cessation of the supply of the nutrient substrate). In that condition, bacteria continue to denitrify water due to consuming their own mucous secretions (EPS). The decreasing hardness of the treated water and its turbidity accompanying bio-filtration has been studied. The features of sulfate reduction processes linked with denitrification in the biofilter are also disclosed.

Sulfate reduction, controlled by dosing the substrate of bacterial nutrition into denitrified water, expands the biofilter's functionality. This device, in addition to de-nitrification, can provide water purification from impurities of heavy and polyvalent metals,

The right to clean and safe water is a fundamental human right. According to WHO experts, providing safe and high-quality drinking water in sufficient quantities is difficult for small-scale water supply systems. In this case, using individual water conditioning products, including filters for biological purification from nitrates, is optimal.

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LIQUID METAL MINERALIZATION OF METASOMAT ZONE IN ORES OF GNEISS-SCHIST COMPLEX OF KRYVYI RIH DIRECT

Metasomatic processes occur in a variety of ways within the boundaries of the Kryvyi Rih basin. They are connected with gipogenetic (aegirinezation, riebeckitezation, silification etc) and hypergenetic (getitization, martization, silification etc) processes [1,2,5].

Most actively epigenetic processes are failed in the North iron ore district of the Kryvyi Rih basin, where Gannivske and Pervomayske deposits are located. Majority of metasomatic bodies have lensoid forms. Thickness of these bodies reaches 1-70 meters, length is 2-3 kilometers [6]. The subducting channels of metasomatized solutions were faults, zones of mechanically weakened rocks, consistent with the occurrence of layers enclosing ferruginous quartzites. Rare metasomatic bodies are found cross course. They are characterized by much smaller sizes: thickness from 10-20 centimeters to 10-12 meters, length up to 100-150 meters. A peculiarity of crossbodies is the complex form of their contacts with interbeds ferruginous rocks and the complex internal structure of the contact zones, which is associated with the penetration of solutions along the subducting channel and in oblique directions - through the scaly of ferruginous quartzites.

The metasomatic changes of the gneiss-schist rocks of the Gannivske district of Kryvyi Rih basin was manifested in their silification, epidotization, carbonatization, and in the development of zones of alkaline metasomatosis [3,4]. Liquid metal mineralization is represented by zirconium, tantalum, niobium, beryllium, cesium, cadmium.

Zirconium mineralization is confined to the lower part of the gneiss-schist complex of the East-Hannivka strip and is associated with albitization zones. Albitization processes are manifested in schists, amphibolites, and aplitoid granites. Sometimes albitites are the end products of alkaline metasomatizm. Albitite bodies have a submeridional extension and coincide with the extension of rocks of the Kryvyi Rih series. They are spatially related to the exocontact of the sud-alkaline granites of the Dnipro-Tokiv complex and are possibly paragenetically related to these granites. Characteristic for subalkaline granites is their enrichment with an accessory group of minerals, where the largest amount belongs to zircon and apatite. The content of these minerals in the heavy fraction varies from 10 to 25%. In the albitization zones the zircon content reaches 60-65%. It turns out, the rocks contain a variety of zircon - malacon, in the form of dense inclusions. Under conditions of chemical weathering, malacon can form residual deposits of zirconium. Spectral analysis of zircon-bearing metasomtites showed zircon concentration from 2 to 500 g/t.

Tantalum-niobium mineralization within the Eastern Hannivska belt is noted in the development zones of the albitization process, which is widely manifested at the contact of the gneiss-schist complex with microcline granites. Albitized rocks were subjected to later pneumatolitho-hydrothermal processes, which are manifested by quartzization, tourmalinization, and sulfide min-

eralization. Microclinization, albitization, and seritization processes are widely manifested in granites. Albitized rocks and albitites of the Northern District of Kryvyi Rih district are enriched with yttrium earths, tantalum, and niobium, which are part of citrolite, zircon, malacon, xenotime, and apatite. The main minerals containing liquid earths are zircon and its variety malacon, secondary ones include apatite.

Analyzes of zircons from albitized granites of the Northern district show the presence in them of: Ta - 0,01%, Nb - 0,03%, La - 0,01%, Ge - 0,1%, Yb - 0,01%, Rb - 0,02%, Y - 0,01%, Th - 0,01%, Hf - 0,03-0,3%.

Albitized quartz-biotite schists are characterized by the following content of rare earth elements in zircons: La - 0,02%, Ge - 0,1%, Y - 0,002%, and in apatites - La - 0,01%, Ge - 0,1%, Yb - 0,1%. In albitized and silificatized migmatites, the presence of xenotime with a content of Yb more than 0,05%, Y more than 0,5%, Th more than 0,5% was established.

It turns out, neodymium was determined in the quality of 0.01% in the rutile monofraction from the same rocks, and a carbonate mineral with a lanthanum content of 0.01% was determined in metasandstones.

Concentration of rare-earth elements in apatite, epidote, garnet, and microcline is observed in pnematolitho-hydrothermally altered shales at the contact with granites of the Dnipro-Tokiv complex. Thus, epidote from quartzized migmatites contains: La - 0,03%, Ge - 0,1%, Y - 0,02%. Apatite from those migmatites contains La more than 0,05%, Ge less than 0,1%, Yb - 0,003%, Hf less than 0,01%, Th - 0,01%. Apatite from albitized and silificatized shales contain Th - 0,01%, La - 0,1%, Ge - 0,3%, Y - 0,1%, Hf - 0,01%, Vi - 0,1 %.

The given brief information about the concentration of rare-earth elements in the carrier minerals indicates that the younger microcline granites bear certain signs of their rare metal specialization. They are characterized by a much higher content of liquid earths. It is important to note that an increase in concentration is observed in the same rock-forming minerals of slates and paragneiss as microcline, hornblende, biotite, especially in the contact zone of granites, which is separated by quartz-microcline veins.

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APPLICATION OF GREEN METRICS FOR MEASURING ENVIRONMENTAL PERFORMANCE AND SUSTAINABILITY OF INDUSTRIAL PROCESSES

The existing methods for evaluating products and technologies in terms of environmental impact and sustainable development are numerous and evolving. The concepts, approaches and target components of industrial systems vary considerably. Consequently, the same process could be evaluated differently depending on the approach.

A **metric** is a system of measurement that includes:

- the item being measured (***what*** we measure),
- the method of measurement (***how*** we measure), and
- the aim of measurement (***why*** we measure or what we intend to evaluate) [1].

The choice of metrics depends on the purpose, field of study and available data. Obviously, the focus of such assessments is a key to the way data are collected and processed. The result obtained drives the decision making and implementation of the improvement measures.

Green metrics most commonly applied to give environmental and sustainability characteristics is built mostly on the chemical essence of the industrial processes, therefore it should be rather treated as the initial step of such assessments. This way the evaluation of environmental and sustainability performance for an industry should be process or technology specific and performed in a step-by-step manner, when each of the following steps cover next set of relevant parameters:

- *Level* 1 - compliance of a technology's parameters with regulations, in particular emission standards or wastewaters composition;
- *Level* 2 - inputs, outputs, and efficiency of a technological process during operation referred to volumes of production and wastes generation;
- *Level* 3 - potential impact of the technology and associated operation on human health and environment components.
- *Level* 4 - lifecycle effects of the technology, accounting impact at commodities acquisition, equipment manufacturing, operation, and disassembly stages;
- *Level* 5 - effects on the sustainability of an enterprise, local community or region and their perspectives on achieving SDGs.

Thus, the levels 1 and 2 practically deal with technical performance of the process or technology and are suitable for mass-based green chemical metrics application. The most representative parameters are the E-factor and PMI (Process Mass Intensity). However, being focused on mass and quantity, these parameters do not account the safety and environmental hazard of the substances involved [2]. Therefore E-factor and PMI

should be amended with toxicity and environmental hazard rating, when products and input materials toxicity class is input in the same equation as that used for PMI calculation.

Level 3 is a truly environmental overview of a process, which looks at its interactions with the environment. At this stage it is important to set clear border line between input and output parameters for the purpose of the efficient decision making, when seeking for efficient methods to improve environmental performance of the process or technology. Thus, the input metrics might include water use, land use or soil eroded, and energy consumed per unit of product and separately per unit of waste by types. The later one enables the assessment of the waste management environmental pressure from the earliest stages of a process. The output metrics relies on the emissions and discharges potential to cause environmental problems.

These include Global Warming, Ozone Depletion, Acidification, Ozone Creation and Eutrophication Potential. Since the exact degrading effect depends on the nature and properties of a substance, the lists of such parameters are amended on a constant bases and should be rechecked prior to assessment.

Level 4 is by essence coupled with life-cycle assessment (LCA). Besides its undoubted importance for both environmental and sustainability assessment, the most important drawback of LCA is need for a wide range of data, which are often hard to obtain.

Nevertheless, a list of key parameters should be developed and applied consistently through the whole LCA, not trying to cover all.

An interesting option is use of the energy transformity factor, which shows the input and flow of energy through the process, accounting all losses and transformations.

Sustainability parameters are among the hardest to measure when it comes to the industrial processes instead of communities and countries.

However, accounting the principles of sustainable development it is possible to recommend the application of sustainability index, which accounts the percentage of renewable resources involved into the process and localization of the sources for given resources.

Still, the sustainability metrics must account the social and economic dimensions, which could be measured through the costs of impacts mitigation, consumer prices and community related effects, in particular rental and property cost change as a result of the environment pollution and other effects of the technology at local level.

In any case, consistency and compatibility are the most important features of such assessment.

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SUSTAINABILITY OF NATURAL WATERS WITHIN THE AREA OF POTENTIAL IMPACT OF THE "KHOTYSLAVSKY" QUARRY

The Khotyslavsky quarry is located in an area with complex underground hydrodynamics and interdependence of underground, pressure, ground, and surface waters. It reveals aquifers of Quaternary and Upper Cretaceous sediments, which are the main sources of drinking and domestic water supply. Because of the geological structure of the territory and the absence of a continuous weakly permeable layer between the aquifers of the cover rocks and the fractured chalk zone, the aquifers form almost a single complex with active water exchange and high sensitivity to man-made disturbances in groundwater regimes and water supply.

Near the quarry, there is the Turske reservoir, a drainage system of the same name with an area of 10,000 hectares, as well as the boundaries of the Shatskyi National Nature Park, where there are more than 30 unique lakes of mostly karst origin. In 2021, the researchers of the Department of Ecology of Aquatic Ecosystems and Water Protection of the Institute of Water Problems and Land Reclamation of the NAAS continued to monitor the state of natural waters in the existing wells using the developed and improved system of integrated monitoring of the natural environment, as well as they carried out analysis, processing and scientific generalization of existing data on the quarry operation.

Based on the analysis of the results of monitoring observations on the state of the natural environment in the Volyn region in 2021, an assessment of the potential impact of the Khotyslavsky quarry on the water regime adjacent to the quarry territories, in particular, on the territory of the Shatsky Lake District, was carried out.

The analysis of climatic conditions showed that during the observation period (January-November) all months of 2021 were characterized by exceeding the precipitation norm and its total amount increased compared to 2020, namely: it was 730 mm in 2021 (by 43% more than the average multi-year norm) and in 2020 it was 715 mm (by 39% more than the average multi-year norm). During the observation period (1985-2021) according to the data from the Svityaz meteorological station, the highest average annual temperature was observed in 2019 - +10,4°C, when the shallowing of Svityaz Lake was recorded, in 2020 - +8,6°C, and 2021 - +9,3°C. In general, the climatic conditions of 2021 are characterized by lower average monthly air temperatures than in 2020.

Based on the results of hydrothermal coefficient calculations, it was specified that, in general, the entire observation period of 2021was excessively wet, and in the typical 2019 the predominance

of evaporation changed to the predominance of water inflow in 2021 that contributed to the replenishment of surface and underground waters of the studied territory. The analysis of observation data on hydrological, hydrogeological, and hydrochemical regimes of groundwater and pressure water within the network of existing wells showed that groundwater level fluctuations are synchronous and depend on climatic conditions.

It was found that the current amplitude of groundwater level fluctuations (2021) in the observation wells does not exceed a critical value. The amplitude of groundwater fluctuations is 0,12-0,6 m both in the areas adjacent to the quarry and in the territory of the Shatsky NNP. The amplitude of level fluctuations of the pressure aquifer is 0,12-0,7 m and is within the permissible parameters. Comparing the regimes of groundwater levels in the wells near Ratno town, where the level monitoring has been ongoing since 1954, a similar dependence of piezometric levels on meteorological conditions is observed. In the course of the research, there is a tendency of decreasing the surface water levels (fluctuations in the levels in the Svyate, Dovge, and Turske reservoirs, which are within the forecast funnel of depression), which may be related to the outflow from the Khotyslavsky quarry.

The hydrological situation in the territory of the Shatsky NNP is currently stable, in 2021 there were no significant and sharp drops in groundwater levels, although there is a trend towards a decrease in groundwater and pressure water levels in some wells, which does not exclude the effect of outflow from the quarry. It was specified that the groundwater levels in the Gutyanska, Zabolotivska, and Turska drainage systems did not exceed the background rates, and during the growing season an increase in groundwater levels was observed due to favorable climatic conditions.

As a result of hydrochemical observations, an increase in the content of nitrates in groundwater up to 3,03 mg/dm^3 was found, which is due to the domestic conditions of operation of the aquifer complex. Changing a water type from hydro carbonate-calcium to hydro carbonate-sulfate was recorded in the wells near Ratne town. In general, there is a deviation toward increasing mineralization, mainly due to hydrocarbons and nitrogen-containing compounds. In all lakes of the Shatsk group, hydrocarbons and calcium dominate in the chemical composition. The content of sulfate and chlorine ions in the water is insignificant. There are slight excesses of nitrite ions and chlorine in the water of Svityaz Lake, which is caused by the ingress of domestic sewage from populated areas.

As a result of reconnaissance surveys of the existing monitoring network and to prevent the threat of environmental deterioration, an improved scheme of monitoring observations in the zone of the potential impact of water outflow from the Khotyslavsky quarry was proposed.

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NEW ANTICORROSION MATERIALS BASED ON WASTES OF MINING ENTERPRISES OF KAZAKHSTAN

Annually about a trillion tons of minerals are extracted from the earth bowels, most of which are stored on the surface in the form of waste of various quality and structure, occupying large areas and having a negative impact on the environment. Consequently, the issue related to geo-ecological safety of mineral resources exploration and usage is gaining particular relevance.

Among the given wastes, the central place is occupied by refuse from mining enterprises by way of dumps of overburden and host rocks and enrichment tailings. Based on their chemical composition, most of these objects consist of silicate, alumino-silicate and carbonate minerals and can be used as raw materials for chemical enterprises.

The given work's purpose was to study chemical and phase composition of overburden rocks and waste from manganese ores enrichment at Zhayrem deposit as well as to examine the possibility regarding their use as a raw material source for obtaining the manganese-containing anticorrosive materials.

Earlier [1] we demonstrated that overburden rocks, created at preparing the Zhayrem deposit to extract the manganese ore, have a fairly high manganese content (14,6 wt.%) in the form of brownite $(Mn_2O_3)_3MnSiO_3$. The tailings of manganese ore enrichment are less rich and contain 2,4 wt.% brownite $(Mn_2O_3)_3MnSiO_3$. Enrichment tailings' main phase is calcite $CaCO_3$ (76,4 wt.%) and quartz (16,4 wt.%). Whereas overburden waste, in addition to calcite, contains kaolinite, hematite, barite, quartz, mica minerals [1]. Hence, for further research, enrichment tailings were selected as raw materials for obtaining the new anticorrosive materials, and in particular, phosphate corrosion inhibitors containing manganese.

Anticorrosive materials' synthesis was performed owing to the acid-thermal method using 85% phosphoric acid as an acid reagent. Charges, prepared by mixing the enrichment tailings with phosphoric acid at various ratios, were calcined at temperatures from 200° to 800°C.

It was shown that the maximum 92,4 rel.% water solubility has a product synthesized at 200°C. Molar ratio of components in the product (in terms of oxides) comprises CaO: MnO: P_2O_5 = 1,00:0,11:1,54. The product's molecular composition according to IR spectroscopy (IR "Nicolet 5700" Fourier spectrometer) and X-ray phase analysis (DRONE-3,0 diffractometer) is represented by calcium dihydric diphosphate with an admixture of calcium polyphosphate and manganese phosphate (III). The synthesis' temperature rise to 600°C reduces products' solubility by an order of magnitude. Accordingly, for further anticorrosive tests as metal corrosion inhibitors in aqueous environment, the product obtained at 200°C of composition CaO: MnO: P_2O_5 = 1,00:0,11:1,54 was selected.

The tests were spent due to the gravimetric method according to [SS 1050-98] standard procedure on St3 steel samples in the form of plates with 20×50×1 mm dimensions. Before testing, the samples' surface was sanded, washed with ethanol and the distilled [SS 9.502-82] water, and dried in a desiccator with

calcined calcium chloride to a constant mass with an error of no more than ± 0,1 mg. Aerated tap water was used as a corrosive medium. Sodium polyphosphate served as a comparison inhibitor. Concentration of the tested product, as well as sodium polyphosphate, in solutions was (in terms of P_2O_5) 1-100 mg P_2O_5/l. The researches were carried out under static conditions at room temperature.

It was assigned that the synthesized calcium-manganese phosphate product reduces the steel's corrosion rate in the entire studied concentration range. At the same time, when this product is added to water with 1 mg P_2O_5/l concentration, protective action degree comprises 16,8%, and corrosion inhibition coefficient is equal to 1,2. In sodium polyphosphate solution of the same concentration, protective action degree comprises 8,2% at corrosion inhibition coefficient of 1,09.

An increase in the given product's concentration by an order of magnitude (10 mg P_2O_5/l) provides the metal protection degree of 39,8% with 1,66 corrosion inhibition coefficient. Corrosion inhibition coefficient in sodium polyphosphate solution of the same concentration is equal to 1,1 with 8,8% protection degree.

Practically complete corrosion inhibition (99,9% protection degree) in the synthesized phosphate solution of CaO: MnO: P_2O_5=1,00:0,11:1,54 composition is observed at 50 mg P_2O_5/l concentration. Examining the sample surface after exposure in this solution owing to SEM HITACHI TM3030 scanning microscope with a built-in Bruker XFlash MIN SVE microanalysis system showed the formation on the steel of a protective film consisting of densely and uniformly packed crystal grains containing (at. %): 60,4 - O; 20,1 - Fe; 9,4 - P; 6.6 - C; 2,9 - Ca; 0,5 - Mn.

In the sodium polyphosphate solution at 50 mg P_2O_5/ l concentration, protection degree is only 38.9%, and corrosion inhibition coefficient is 1.63. In this case, on the steel's surface, there is a disorderly arrangement and accumulation of grains in vague fuzzy shape containing (at. %): 69.4 - O; 12,5 - Fe; 8,8 – P; 6,8 - C; 2,3 - Ca; 0,2 - Si.

Corrosion products formed on steel sample's surface in the water without inhibitors addition have (at. %): 48,4 - O; 45,5 - Fe; 5,6 - C; 0,2 - Si composition, and are represented by a chaotic accumulation of grains in various shapes and sizes.

Gravimetric tests' results are confirmed due to data of electrochemical studies conducted in the classical electrochemical three-electrode cell by removing the polarization curves using "Palmsens 4" potentiostat-galvanostat.

The tests were carried out in a potentiostat dynamic mode with 1 mV/s potential sweep rate.

It was found that at the concentration of synthesized calcium-manganese-containing phosphate product of 50 mg P_2O_5/l, the corrosion current density decreases by almost an order of magnitude compared with the current density for the sample in water without additives (0,514 μA/cm^2 and 5,083 μA/cm^2 respectively), and corrosion potential shifts in the positive direction from -0,545V up to -0,464V that confirms the creation of protective films on the steel surface.

Thereby, the conducted studies demonstrated the possibility of obtaining the new effective corrosion inhibitors based on waste of manganese ore enrichment at Zhayrem deposit for steel structures that contact with aquatic environment.

Manufacturing the similar materials will expand the range of anticorrosive products as well as minimize the amount of dump tailings of enrichment at mining enterprises.

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IMPACT OF ANTHROPOGENIC FACTORS ON WATER RESOURCES IN THE YELEK RIVER BASIN

Over the past two decades, there has been growing global concern about the state of the world's water resources due to increasing consumption and pollution. The growth of the world's population, the widespread development of irrigation and drainage, as well as the acceleration of industrialization have led to an increase in the use of more and more of the already limited fresh water resources. Massive and uncontrolled pollution of rivers and other water bodies in Central Asia and Kazakhstan continues. Attitude to water resources continues to be consumer-oriented, the rational use and protection of water have not become a matter of careful attention at all levels of the water management hierarchy [1].

There is no doubt that the main problem of mankind in the 21st century will be the problem of water resources. "Water is a matter of life and death", "A world of dwindling water reserves", "Water resources under stress", "Water of the whole world - is it enough?" - are the headlines of sections of World Meteorological Organization (WMO) documents in recent years. WMO has identified four levels of stress related to water scarcity. According to this gradation, the fourth, the highest level of stress includes territories where more than 40% of the available water reserves are used. Here, water is consumed with an intensity exceeding the natural replenishment (WMO 2018). In Kazakhstan, this gradation is exceeded in five of the eight water management basins (WMB).

The implementation of plans in modern conditions requires significant efforts. First of all, it is necessary to have a clear idea of water resources availability 85% of water resources consumed in

Kazakhstan are river flows. The total surface water resources formed in Kazakhstan and coming from the territories of neighboring countries are on average 122,0 km^3. Water resources formed within Kazakhstan amount to 58,0 km^3. The inflow from neighboring countries is estimated at 67,2 km^3: from China - about 26 km^3, Russia - 10,6 km^3, Uzbekistan - 26,5 km^3 and Kyrgyzstan - 4,1 km^3. As a result, if in the 1950s surface runoff resources of Kazakhstan's rivers were estimated at 150 km^3/year, in the 1970s-80s were at 115-125 km^3/year, then, as follows from the data above, they have further decreased.[4]

As of today, there are threats of changes in river flow in Kazakhstan, which will worsen in the near future and can be divided as follows:

1. Reduced inflow of transboundary rivers due to global and regional climate change;

2. Changes in the flow regime of transboundary rivers due to regulated inflow of water through transboundary rivers associated with the conditions of water use in the upper reaches;

3. Changes in the flow regime of rivers due to global and regional climate change;

4. Depletion of river flow resources. Agricultural demand for river water in Kazakhstan is satisfied by local and total runoff. The decrease in water resources occurs under the influence of anthropogenic and climatic factors [3].

The Yelek river, which is selected as the study area, is a large left tributary of the Ural river. The total length of the river is 623 km, the basin area is 41.3 thousand km^2. The Yelek river is a transboundary river. Water of the Yelek river is used for industrial and agricultural purposes. In the vicinity of the city of Aktobe on the bank of the Yelek river there are industrial enterprises such as "Akbulak" JSC, "Aktobe Chromium Compounds Plant" JSC, "Aktobe Thermal Power Plant" JSC, "Aktobe Ferroalloy Plant" JSC, as well as Aktobe, Shelek and Kargaly reservoirs. Due to the physical and geographical location of the Yelek river and its extreme continental climate, 90% of the flow is in the spring.

In this paper the range of 1940-2019 years was chosen as the calculation period for the considered Yelek river basin by using and analyzing multi-year data from hydrological gauging stations in the Yelek river basin at the Republican State Enterprise "Kazhydromet". Checking the series for homogeneity at a significance level of 5% by known methods in hydrology showed that the flow series is heterogeneous.

As a result of drawing the cumulative integral curve, the break-even point of disturbed flow series corresponded to 1974 [6]. In this regard, when assessing the flow of the Yelek river basin it is better to separate the natural period 1940-1974 and the disturbed period from 1975 to 2019. At the same time, the flow values for years 1940-2019 which were taken as the calculation period should not be neglected either. The construction of large reservoirs within the considered area since 1975 led to intensive changes in the river flow.

Therefore, taking into account the changes associated with anthropogenic impacts in this area, i.e., the useful volume of the constructed reservoirs, flow series in the disturbed period (1975-2019) was reduced to the conditionally natural period [2].

The result of the calculations shows that when disturbed period was compared to the natural period the value of flow decreased by 7,4%, the value of the change in the conditionally natural period was 4,2%. The decrease of flow values can be associated with the amount of water used to fill the reservoir, the costs of evaporation from the surface of the reservoir, as well as the costs of filtration into the soil layer.

In addition, the water used through the production facilities we indicated above can be added to the reduction in river flow. It is known that one of the most important and large consumers of water resources in the republic is industry. The Yelek river basin is not an exception. Its necessities are satisfied by the intake of fresh surface water [5].

Depending on the type of activity of the enterprise, the nature of the preferential use of water may be different.

The rate of water consumption is determined on the basis of calculations in relation to a specific production technology.

High volumes of water consumption and discharges into natural water bodies may characterize imperfect technological processes and water management schemes in production.

In some cases, the amount of water consumed depends on its quality.

An important reserve for saving water resources, especially in industry, is water recycling.

The following recommendations should be implemented for efficient use of water resources:

- reuse of wastewater at production facilitie;
- proper exploitation of water bodies;
- cleaning of river beds;
- application of sprinkler irrigation system.

Due to the large number of production facilities in the Yelek river basin, it is necessary to organize a system of cleaning and reuse of water used for production facilities and wastewater.

Efficient methods of wastewater treatment from production facilities should be used.

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USE OF RECYCLING MATERIALS FOR RADIATION PROTECTION CONCRETE

Environmental protection and rational use of natural resources is one of the most urgent problems of our time. Recently, the problem of lack of material and energy resources has been observed in Ukraine.

That requires the development of progressive low-energy technologies of the building materials and products production. The problem of complete processing enterprise waste is also ecologically important.

More than 160 million tons of metallurgical slags have been accumulated in Ukraine, 54,5% of their volume is placed in landfills. The output of blast furnace slag is the largest: it is 0,6-0,7 tons per 1 ton of cast iron. During the steel smelting process, the output of slag per 1 ton is much less:

- using the Marten method, 0,2-0,3 tons;
- using Bessemer's method and Tomas' method - 0,1-0,2 tons;
- at smelting steel in electric furnaces, 0,1-0,04 tons [1].

Less than half of the total amount of waste is recycled, while the rest is deposited in landfills, worsening the ecological conditions of industrialized regions. A large part of this waste is represented by finely dispersed components.

Pellet production technology makes it possible to obtain fractionated spherical material from finely dispersed materials containing iron. Until now, this technology is most often used in the production of iron ore pellets for ferrous metallurgy [2].

The metallized pellet consists of approximately 60-68% iron. The use of pellets obtained from finely dispersed waste (slurries and slags) will allow to expand the spectrum of construction materials and turn waste into resources. That is an actual task for the industrial regions of Ukraine [3].

Pellets are ore material that is obtained from dusty ore or from small concentrates in the form of spherical particles with a size of 0,3 to 3 cm (usually 1 to 1,5 cm).

The existing shredding technologies are represented by briquetting, coagulation (making pellets) and high-temperature processes (sintering or manufacturing pieces from fusion).

Briquetting has a number of advantages, including easy implementation and low energy costs. At the same time, briquetting technologies are sensitive to the properties of the raw material (granulometric composition, moisture, etc.) and the binders' properties.

The extrusion use eliminates these disadvantages and currently claims to be a large-scale replacement of existing coagulation processes. High-temperature processes require significant energy consumption (due to fuel or electricity) and their implementation is effective in the presence of fusion products as by-products of production (for example, liquid slags of blast furnaces) [2,4].

For coagulation, it is most rational to use the technology of obtaining non-firing pellets (material strengthened without the use of high-temperature firing) with the use of cement as a binder [2].

The choice of cement allows to exclude high-temperature firing, and the products' price increase due to heat treatment of granules, as well as because its use does not deteriorate the chemical composition of the fusion (it reduces the acidity module, but not significantly, unlike lime, for example).

It should also be noted that this technology will reduce the environment influence and ensure the reclamation of areas occupied by solid waste landfills.

Metallized pellets are a high-strength material that is not prone to destruction, so the aim of the research is to analyze the possibilities of using processed man-made waste in the form of pellets in the production of radiation protection concrete.

Concrete is the most widely used building material. Its strength is determined by coarse aggregates. Replacing part of the coarse aggregates with metallized pellets will provide the so-called "uniform heterogeneity" of the concrete mixture, which will significantly improve its properties, while the fine aggregate will ensure reliable contact between the particles of the large aggregate and the binder.

Barite, limonite, metal scrap are used as a coarse aggregate in extra heavy concrete, which is used for radiation protection.

The density of concrete with metal aggregate reaches 6000 kg/m^3.

During the research, 2 batches of concrete mixture were produced. M400 cement was used for their production and formwork is used for 4 cubes (10×10×10 cm).

The reserve ratio of the mixture was 20%, the crushed stone fraction was 20-40 mm. Pellets of Ferrexpo Poltava Mining processing plant were also used for the tests, their average diameter was 15 mm [5,6].

The composition of the concrete mixture:

- batch: cement - 1,4 kg; sand - 3,9 kg; crushed stone - 6,7 kg; water - 0,84 kg;
- batch of cement - 1,4 kg; sand - 3,9 kg; crushed stone - 4,5 kg; pellets - 2,2 kg; water - 0,84.

After reaching grade strength at the age of 28 days, 2 batches samples were tested for compression on a Tecnotest press. The results of compression tests for the first batch were 184,7 kg/cm^2, for the second - 251,2 kg/cm^2.

Conclusion

Research results show that replacing part of coarse aggregate with pellets increases the strength of hardened concrete by 36%. The rather high content of iron (approximately 60-68%) in pellets allows to consider the prospect of their use in radiation protection concretes.

Although the pellets are made from very small, almost dust-like particles, the finished product has good strength. The use of pellets obtained from waste (slurries and slags) will make it possible to expand the range of building materials, convert waste into resources, reduce the environment loading and ensure the reclamation of areas occupied by solid waste landfills. And that is precisely the problem of industrial regions.

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EFFECT OF OIL-CONTAMINATED SOIL TREATMENT WITH ORGANOMINERAL BIOFERTILIZER ON HUMUS CONTENT

Humus is the main parameter of soil fertility, an indicator of soil quality. The physical and physico-chemical properties of the soil, its water, air, thermal regimes, the regime of nitrogen nutrition, and the biological activity of the soil largely depend on its content.

An effective method of increasing the productivity of agriculture is the application of fertilizers [1]. This makes it possible to increase the genetic potential of plants and stabilize yields, increase their resistance to adverse environmental factors [2], and increase soil fertility [3]. In recent years, humic fertilizers have been widely used to improve the ecological state and fertility of the soil, saturating it with minerals, vitamins and amino acids and increasing the activity of soil microflora, stimulating plant growth due to better absorption of nutrients [2].

The aim of the work is to study the effect of oil-contaminated soil treatment with organomineral biofertilizer and activated aluminum alloy Rau-85 (AAA) on the humus content and plant germination. Oil-contaminated soil from the bottom of evaporation ponds in Atyrau were chosen as samples. Soil samples were treated with 0,5 wt.% solution of organomineral biofertilizer "Kazuglegumus" and 0,1 wt.%, 0,5 wt.% activated aluminum alloy Rau-85.

The humus content was determined by the gravimetric method in accordance with GOST 23740-2016 [4]. In oil-contaminated soil samples from the bottom of the evaporation pond, the humus content was 2,4%, which is low and corresponds to the podzolic soil type. The results of the study of the humus content before and after soil treatment are shown in Fig. 1.

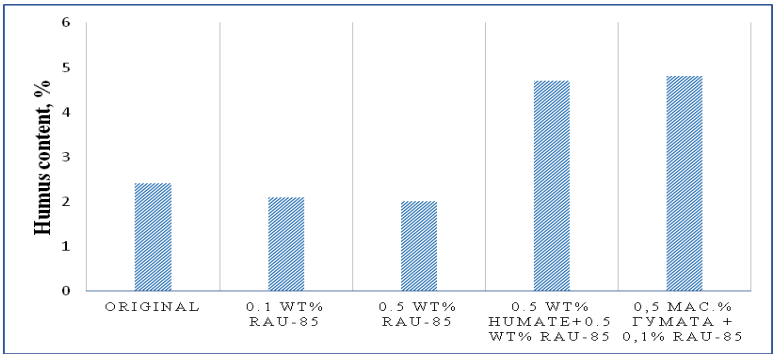

Fig. 1. Humus content in oil-contaminated soil before and after treatment

As can be seen from Fig. 1, the humus content slightly decreases when oil-contaminated soil is treated with AAA. However, after complex treatment with organomineral biofertilizer and AAA, the humus content in the soil increases by 2 times and amounts to 4,8% when the soil is treated with 0,5 wt.% solution of organomineral biofertilizer and 0,1 wt% Rau-85.

The increasing of the humus content improves agrochemical properties, improves soil fertility and crop quality. At the same time, with an increase in the humus content of the soil, not only the total nitrogen content increases in it, but also the biological activity. At the same time, microorganisms, like plants, need nitrogen. It can be assumed that microorganisms become competitors of plants in nitrogen nutrition. And if there is not enough nitrogen in the soil, then there is a decrease in yield [5].

The content of total nitrogen was determined in accordance with the international standard ISO 11261, the results of the dependence of the nitrogen content on the humus content in the studied soil are shown in Fig. 2.

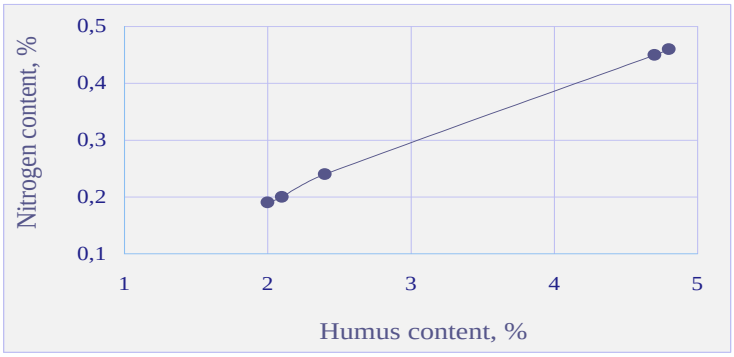

Fig. 2. Dependences of nitrogen content on humus content in oil-contaminated soil

The study of the efficiency of soil treatment for seed germination was carried out in greenhouse conditions according to the method called "Growth and development of plants on soil contaminated with oil" on herbaceous plants from the legume family - alfalfa, sweet clover, sainfoin. In the experiment, soil moisture (70-80%) and temperature conditions (24C-25°C) were maintained.

During the experiment, the best germination was observed on soil treated with 0,1 wt.% Rau-85 +0,5 wt.% solution of organomineral biofertilizer.

Seedlings of alfalfa appeared on the soil from the bottom of the evaporation pond on the 4th day from the moment of sowing the seeds, which is shown in Fig. 3.

Fig. 3. Germination of alfalfa on oil-contaminated soil before (*a*) and after treatment with 0.1 wt.% Rau-85 + 0.5 wt.% solution of organomineral biofertilizer (*b*)

In this way, studies show that the complex treatment of AAA and organomineral fertilizer of oil-contaminated soils not only has a positive effect on seed germination, but also significantly increases the humus content, which is the main indicator of soil quality.

Along with the increase in humus, the content of nitrogen also increased, which, in turn, is an essential element that has the greatest effect on the intensity of photosynthesis, the content of chlorophyll pigments, and the accumulation of organic matter.

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SYNTHESIS OF ZEOLITES AND ZEOLITE-LIKE MINERALS FROM GLASS OBTAINED BASED ON NATURAL VULCANIC TUFFS

High reactivity, homogeneity, the possibility of varying the chemical composition and introducing the desired component into the composition during glass formation make artificial glasses convenient and promising starting materials for the synthesis of zeolites and zeolite-like compounds. On the other hand, these glasses themselves can be obtained on the basis of local cheap natural aluminosilicates, such as volcanic tuffs, traces, clays, etc. Mordenite- and clinoptilolite-containing high-silicon rocks are preferred as raw materials for glass production. The foregoing determines the prospects for the synthesis of zeolite structures of great practical importance based on the above glasses [1-2].

We used clinoptilolite-containing tuffs of the Aydag deposit of the Republic of Azerbaijan as the starting material for glass production. Chemical silicate analysis of the initial tuffs and products of their transformation during glass melting was carried out on a multichannel X-ray spectrometer (manufactured in Germany).

According to the results of the analysis, the percentage oxide composition of clinoptilolite tuffs is: SiO2 – 66,14; Al2O3 – 14,25; Fe2O3 – 0,74; MgO – 0,08; CaO – 4,44; K2O – 1,10; Na2O – 0,44; H2O – 12,36

The charge for glass melting was prepared by adding 40-50% CaCO3 to clinoptilolite tuff. As you know, calcium oxide introduced into the composition of glass lowers its melting point and viscosity, improves a number of mechanical and chemical properties of glass.

Glass was boiled in corundum and platinum crucibles. The maximum cooking temperature was 1350ºC. According to the results of X-ray spectral analysis, the oxide composition of the resulting glass in percent is: SiO2 – 50,97; Al2O3 – 9,77; CaO – 32,03; Fe2O3 – 2,06; MgO – 1,23; Na2O – 2,03; K2O – 1,85

Experiments on hydrothermal crystallization of the obtained glasses were carried out in Mori-type steel autoclaves in the temperature range of 120-150ºC. The duration of the experiments was 5 days. The filling factor of the autoclaves in all experiments was kept equal to 0.6. The ratio of solid and liquid phases was 1/15. Given that the nature of the alkaline cation involved in the synthesis has a significant effect on the topology of the framework of the synthesized products, hydrothermal crystallization of glasses was carried out at various concentrations of alkaline solutions.: NaOH,

KOH, NaOH+KOH. The aluminosilicate-calcium components passing from the glass into the solution form a gel, from which, depending on the concentration of structure-forming agents, various zeolite and zeolite-like structures are formed. In a series of experiments on hydrothermal crystallization at low concentrations of the NaOH solvent, low-ordered phases are obtained, which could not be unambiguously identified. Beginning with 2n NaOH, as the solvent concentration increases, framework phases of analsim and carbonate-concrenite appear. Due to the low solubility of the calcium component of the glass in the NaOH medium, calcium atoms and CO3 anionic groups enter the zeolite voids of conkrenite. In experiments with the participation of KOH solvent, with an increase in the solubility of the calcium component of the glass, a phase is formed, which, according to the values of interplanar distances, corresponds to 11- A0 aluminum - substituted tobermorite. In the structure of tobermorite, octahedrons of calcium atoms form portlandite blocks, crosslinked on both sides by silicon–oxygen layers composed of wollastonite chains. The replacement of silicon atoms by aluminum takes place in the tetrahedra that bind the silicon-oxygen layers. Sodium and potassium atoms are introduced into the interlayer channels. Due to this structure, Al-tobermorites are used as absorbers of Cs and Rb nuclides during the disposal of radioactive waste. When glass is treated with a mixed 3N (NaOH + KOH) solution, kalsilite, tobermorite, and pectolite phases are formed. As the proportion of octahedral structural units of calcium increases, the octahedral walls of tobermorite disintegrate into columns. In the structure of pectolite, octahedrons of calcium atoms form columns on which silicon-oxygen wollastonite radicals adapt. The aluminum-silicon-oxygen tetrahedral units remaining in the solution around a large potassium atom form the zeolite framework of kalsilite.

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ECOLOGICAL ASSESSMENT OF GROUNDWATER AT THE AIRPORT ZONE

In complex natural, technogenic and anthropogenic conditions, when at the same time the quality of water directly in the underground part of the Hydrosphere or through other components of the

environment is affected by various factors of pollution, the assessment of the quality of underground water takes on a specific character. Carrying out constant monitoring of the state of the groundwater, comparing and assessing the compliance of pollutant concentrations with established standards makes it possible to assess the actual state of groundwater in the airport area and adjacent territories for the content of pollutants. The main sources of groundwater pollution as a result of the operation of aviation equipment are rainwater and meltwater, emergency discharges of petrochemicals, fuel and lubricant storage farms [1-2]. The purpose of the work: to carry out an ecological assessment of the quality of groundwater at the area of the International Airport Kyiv (Zhulyany) according to the main hydro-ecological indicators. The water quality of five drinking wells at different distances from the runway of the Kyiv airport zone was analyzed.

Since there is no single indicator that would describe the entire complex of water characteristics, water quality assessment is carried out on the basis of a system of indicators. Since the studied groundwaters are located within the city limits, they belong to water bodies for economic, drinking and cultural and domestic purposes, and therefore the results of the experiments were compared with the drinking water quality standards. The assessment of the quality of groundwater due to its specific location in the environment should have a deeper and meaningful essence, therefore, in addition to hydrochemical analysis of the main indicators, the study of selected water samples was supplemented with a series of additional control methods: microbiological, biotesting methods, and genotoxicity analysis. The results show that the pH value in all the tested samples does not exceed the permissible limits. According to the current standard, the hardness of drinking water should be within 1,5-7 mg-eq/l. Although Ca and Mg salts are not harmful to the body, their presence in water in large quantities is undesirable, because the water becomes unsuitable for drinking needs and industrial water consumption. On the other hand, the toxic effect of many heavy metal salts is reduced in hard water. This phenomenon is explained by the fact that highly mineralized waters, which contain calcium, magnesium, potassium, sodium, barium salts, reduce the solubility of toxic substances, forming insoluble sediments with them, and their toxicity is reduced tenfold. The degree of hardness of ground water exceeds drinking water quality standards by 6,7-3,8 times. Thus, the water sampled at a distance of 20 m from the runway can be characterized as water of medium hardness (4-8 mg-eq/l), that is, satisfactory for drinking and poor for household use. Water sampled at a distance of 250 m is very hard (10,5-14,4 mg-eq/l), but acceptable for drinking purposes. The water sampled at a distance of 500 m, 1000 m and 1500 m is hard (8-10,5 mg-eq/l), satisfactory for drinking and poor for household use. For drinking, the use of relatively hard water is allowed, since the presence of Ca and Mg salts is harmless to health and does not impair the taste of water. The use of hard water for economic purposes will cause a number of inconveniences. It is advisable to use water from a well located at a distance of 250 m for economic and drinking purposes in agreement

with the sanitary supervision authorities (hardness higher than 10 mg-eq/l). According to the oxidizability indicators, the water of all the selected samples cannot be considered suitable for drinking, because the oxidizability indicator exceeds the MPC, which is established for groundwater, by 3,7-6,8 times.Increased oxidizability may indicate the presence of organic substances, some humic substances, sulfides, nitrites, ferrous iron in the tested water and requires the use of appropriate protective measures when using it. According to the MPC for drinking water, the content of N/NH4 in water is not regulated, N/NO_3 (according to the nitrogen index) is not higher than 9,2 mg/l, and N/NO_2 should not be present. As a result of the analysis of the obtained results, we can draw the following conclusions about the ecological state of the airport groundwater. An excess of ammonium and nitrite nitrogen content was found in all investigated water samples. An increase in the concentration of ammonium nitrogen in water can be an indicator of the deteriorating condition of a water body.

The presence of N/NH_4 indicates water pollution by sewage and fecal effluents. Nitrites are an intermediate link in the chain of bacterial processes of ammonium oxidation to nitrates. A high content of nitrites indicates an increase in the processes of decomposition of organic substances under conditions of slower oxidation of NO_2 to NO_3. This indicates pollution of the water environment. Elevated concentrations of both nitrogen compounds may indicate the presence of a permanent source of pollution. Any elevated nitrate content is observed in the tested water. That is, the nitrification process of ammonium ions under the action of nitrifying bacteria does not occur in the studied water.

drinking water is hard - it is satisfactorily drinkable, it is contaminated with ammonium nitrogen and nitrites in all wells. According to the oxidizability index, it is determined as unfit for consumption.

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THE USE OF JUTE FABRICS AS FIBROUS REINFORCEMENT FOR THE MANUFACTURE OF COMPOSITE MATERIALS

Jute fabrics are widely used around the world to make storage bags for various types of goods. Due to constant use, the jute bag loses its strength and thus reduces its ability to store products, in which case it is considered waste and is usually disposed of as waste or incinerated. The possibility

of using jute fabric even in the event of waste can be a suitable environmental solution. One of these methods is to use this jute fabric in a limited proportion, as reinforcement in a suitable polymer matrix which can be strong and rigid enough to compete with products made of wood and other materials. In this work, Jute fabrics are used as fibrous reinforcement for the manufacture of composite materials (PP/Jute). To determine the best rate of fibers to use for optimal performance, biocomposites with different mass fractions are detailed (30, 40, 45, 50, 60 and 70%). According to ASTM D638-03, the static test results show that the material Bio-Com 40% performed well compared to the others ones. The maximum stress value of Bio-Com 40% was σ=39,07 MPa with an Young's modulus of E=4,60±0,16 GPa.

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ANALYSIS OF THE EFFICIENCY OF POLLUTED INDUSTRIAL WATERS DISPOSAL SYSTEM OPERATING IN KRIVBAS

As of 2021, the iron ore mines of Kryvyi Rih annually pump up to 22 million m^3 of underground mine water and 18-20 million m^3 of open-pit water saturated with pollutants from the earth crust interior. The chemical composition of underground mine and open-pit waters is described as chloride-sulfate-magnesium-sodium one, and the degree of mineralization depends on the combination of natural factors and the depth of mining operations. For open-pits, the level of mineralization of drainage water ranges from 2 to 18 g/dm^3, and for underground mines it varies from moderately mineralized (3-10 g/dm^3 at "Pershotravneva", "Saksagan" Mines) to highly mineralized (11-40 g/dm^3 at "Ternivska", "Frunze", "Drenazhna" Mines) and very highly mineralized (41-109 g/dm^3 at "Kozatska", "Yuvileyna", "Kryvorizka", "Colliery group PJSC "ArselorMittal - Kryvyi Rih" (CG "AMKR") Mines [1]. The ions of chlorine, sulfur compounds, calcium, magnesium, sodium, potassium, and iron predominate in the composition of underground mine and open-pit waters. For example, the water pumped from CG "AMKR" Mine contains suspended matter exceeding the norm by 5 times, dry residue by 19 times, chemical oxygen consumption by 280 times, chloride content by 30 times, sulfide by 2 times, and iron by 4 times. The main sources of inflows in udergound mines and open-pits are considered to be from: underground water - up to 17% of the total volume with a mineralization of 40-145 g/dm^3; technological water supply - up to 21% with a mineralization of 1-2 g /dm^3; tailings infiltration - up

to 32% with mineralization up to 21 g/dm^3; other sources (infiltration of urban and industrial buildings, rivers and precipitation - up to 30% with mineralization of 2-5 g/dm^3 [2].

The volumes of drainage from underground mine and open-pit waters vary from 20 to 1000 m^3 per hour, depending on the location of mining operations. Increased water inflows are observed at the Mines "Kozatska", CG "AMKR", "Drenazhna", as well as in the open-pits of the Northern Mining and Processing Plant (PivnGOK), the Southern and Inguletskyi GOKs.

During the entire period of industrial development of Kryvbas, a depression pit of more than 80 km long and 6-7 km wide with an average depth of up to 600 m has been formed in the zone of influence of its man-made geosystem, within the pit hydrogeofiltration system the volume of conditionally drained rocks reaches 190 km^3. In geospatial terms, the depression pit covers zones of active, slowed down, and difficult water exchange, which leads to significant variations in the mineralization of underground mine and open-pit waters and complicates the conditions for their accumulation, handling, and drainage [3]. According to approximate estimates, the total need for drainage in Kryvbas is 36-40 million m^3/year, while for many decades the total removal of a mixture of all salts with surface and underground runoff outside Kryvbas makes up 0,036t/sec, or 1,1 million tons/year.

According to the currently existing technology, the mineralized water of the southern group of mines is fed partially into the reversible cycles of the GOKs by four pumping stations, and the rest is pumped in transit through the Dzerzhinsk slurry storage into a mine water gathering pond with a capacity of 12,2 million m^3, created in 1972 in the Svystunov gully in the south of Kryvyi Rih. In this reservoir, mine water is naturally cleaned of suspended particles and then, according to special regulations, in the off-season (November - March) it is discharged without any chemical treatment into the Inhulets River, which is the main drain of Kryvbas (up to 12 million m^3/year). Today, four groups of enterprises operate according to the mine water utilization system described above, the share of which is determined by the volume of water pumped into the storage pond. PJSC "Kryvbaszalizrudkom"'s ("Pokrovska", "Kryvorizka" Mines) share makes up 45,0%; the one of PJSC "Central GOK" ("Hihant" Mine) is 25,2%; CG "AMKR"'s share is 24,7%; the PJSC "Evraz Sukha Balka" ("Frunze" Mine)'s one makes up 5,1%.

Thus, the mine water pumped into Inhulets remains chemically highly mineralized, has a predominantly chloride-sodium composition, an alkaline reaction (pH 8,4-8,7) and high hardness (64-80 mg-eq/dm^3). Chloride content reaches 17650-19000 mg/dm^3, sodium one makes up 10240 mg/dm^3). The mineralization of the water mixture from all suppliers is from 34,8 to 38 g/dm^3.

According to the current regulation, the discharge of underground mine and open-pit waters into Inhulets is followed by washing the river bed with fresh water from the Karachuny Reservoir with simultaneous feeding of the latter with Dnipro water through the Dnipro-Kryvyi Rih Canal. At the same time, from 43 to 51 million m^3 of fresh water is supplied annually from the Karachuny Reservoir to dilute the discharges. It is obvious that according to the described mine water disposal technology, the volume of emissions of harmful substances into the environment does not decrease, the polluting components eventually accumulate in the coastal silt along the entire riverbed, causing

significant damage to the ichthyofauna. The external consequences of the contamination of the Inhulets River with mineralized mine water are evident both in the area of the Svystunov gully itself, and in the water area of the downstream of this river, where Inhulets water is widely used for irrigation by farmers in the Dnipropetrovsk, Mykolaiv and Kherson regions.

Highly mineralized water from underground mines and open-pits has caused and continues to cause significant hydrogeological disturbances for the entire hydrosystem of the Kryvyi Rih region. Thus, for example, the infiltration of water from the gathering pond in the Svystunov gully leads to groundwater pollution within a radius of up to 5-6 km from its location and exits through unauthorized watercourses along the left bank of the Inhulets River at a distance of up to 7-8 km.

Chlorides, sodium, calcium salts, magnesium, bromine and cadmium are the main pollutants in this case. Getting into the underground horizons, the brines of the Svystunov gully intensively lead to geological disturbances associated with the formation of cavernes in the radius of several kilometers from the area of their location, and also contribute to soil salinization on the adjacent agricultural lands.

Drainage water from open-pits and tailings storage facilities, the mineralization of which can reach 11-18 g/dm^3, represents another significant source of harmful influence on the hydrological situation in Kryvbas.

According to the existing practice, water from the open-pits is pumped into the tailings storage facilities of the respective GOK and further is partially used in the system of circulating water supply of technological processes, and the rest of it accumulates in the sediment tanks of the tailings reservoirs.

Taking into account the geography of the location of the tailings storage facilities and the imperfection of their hydrogeofiltration protection, the infiltrates of the pits within the entire city create a colossal unauthorized pollution of both underground waters and open bodies waters, including the Saksahan and Inhulets Rivers, and outside the city limits the Shyroka, Kamianka, Bazavliuk Rivers, the waters of which eventually fall into the Dnipro River, which is the source of drinking water for the entire south of Ukraine.

Implementing methods of integrated management of the process of surplus mine waters removal by economic and ecological measures can be one of the options for optimizing the existing system of polluted industrial waters disposal.

For this purpose, it is necessary to adopt the method of objective determination of mining enterprises share participation not only on the basis of the economic criterion (by the volume of discharged water), but also taking into account the ecological criterion, such as mineralization indicator of these waters at the stage of accumulation of highly mineralized mine waters in the Svistunov gully.

This approach will stimulate mining enterprises to take measures to gradually reduce not only the volume of discharge of return water excesses into the Inhulets River, but also to reduce the mineralization of pumped water.

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DETERMINING THE LEVEL OF SOIL DEGRADATION ASSOCIATED TO THE COKE CHEMICAL PLANT AND FURNACES WITHIN THE FORMER HUNEDOARA STEEL WORKS

The analyzed site is located in the south-western area of the former Hunedoara steel platform, information from multiple sources was used to document the existing situation of the site. Several types of information and historical data were collected and processed to investigate and monitor the quality of existing environmental factors, in order to develop a conceptual model of the site. Based on the analysis and interpretation of the information collected in the documentation stage (inventory of potential sources of pollution that existed/operated in the past on the site, analysis of the level of pollutants in soil, surface water and groundwater, geological, geotechnical and hydrogeological studies) was elaborated the conceptual model specific to the investigation of contaminated sites under lithological, hydrogeological and contamination aspects.

In order to develop the conceptual model of the potentially contaminated site, relevant information was aggregated for the footprint of the site and the areas in its vicinity, collected in the period 2006-2021. From the studies and investigations carried out previously on the site, all the relevant information was selected during the documentation period for the characterization of the site, the determination of the geological, geotechnical, hydrogeological characteristics and concentrations of heavy metal ions, petroleum products, soil gas content, etc.

To increase the knowledge of the site, in addition to the existing data and information, based on historical maps, the activities carried out on the site until the beginning of the 2000s were inventoried, 10 locations were selected and soil samples were taken from depths of 30 and 50 cm to be analyzed to determine the concentrations of heavy metal ions and hydrocarbons in the oil.

The main source of contamination on the site is heavy metals. In the soil and underground water in the analyzed locations, other contaminants were also identified in significant concentrations (naphthalene, benzene) in locations located 200 m north of the analyzed area. Two heavily contaminated areas were identified:

- the northern part of the site - the former coke chemical plant;
- the former water treatment plant for phenols.

In these areas, the values recorded for most pollutants exceed the intervention limit established by national legislation. In the rest of the industrial area, pollution is mainly generated by heavy metal ions. Due to the clay layer that seals the aquifer, the groundwater in the analyzed area is not significantly contaminated, the areas where additional contamination was identified are to the north and northwest of the studied site, and the direction of groundwater flow, as illustrated in the figure below it is from the western area of the former industrial platform to the northeast.

In October 2011, a campaign of taking cores from trees took place. The purpose of the tree coring was to demonstrate whether the method can serve as a tool to assess BTEX components, heavy metals and PAHs. Most of the samples were taken from the western parts of the former steel platform in the vicinity of the analyzed site approximately 100-150 m NW from the northern limit of the area analyzed in the present study, on the former location of the chemical plant characterized as a high risk area. In one or more cores taken from the trees, benzene, toluene, ethylbenzene, xylene and naphthalene were detected in different concentrations.

The areas most exposed to pollution and which were contaminated by pollutants with high toxic potential, constituting areas with a high risk of soil and groundwater pollution, are the following (in descending order of contamination intensity):

✓ ***Area of the Coke Chemical Plant***

- the substances that polluted the soil were those from the range: suspended and sedimentable powders, CO, SOx, NOx, H_2S, VOC, BTX, phenols, ammonia, cyanides, benzene, oily substances, naphthalene, tar, heavy metals and fuels;

- the substances that polluted the underground and surface waters were: phenols, cyanides, hydrogen sulphide, ammonium, sulphides, benzene, tars, oils, fuel oil, organic substances, chlorides and suspensions.

✓ ***Furnaces 1 and Furnaces 2 section area***

- the substances that polluted the soil were those from the range: dust from emissions from furnace purging or accidental releases, suspended and sedimentable powders (iron, magnesium, silicon and non-ferrous metal oxides with high toxic potential, agglomerated dust, limestone, coke, flue gases, etc.;

- the substances that polluted the underground and surface waters were: heavy metals, oils, diesel and suspensions.

Regarding the pollution with heavy metals, sulfates, cyanides and petroleum hydrocarbons, the interpretation of the chemical analyzes was carried out taking into account the normal values, the alert thresholds and the intervention thresholds, for the concentrations of polluting agents in soils, resulting the following conclusions:

Copper - is within the limits of the alert threshold for less sensitive uses - 250 mg/kg dry matter, for most of the analyzed soils, the determined values being between 51-125 mg/kg dry matter, which indicates insignificant or reduced pollution this element.

Lead - is within the limits of the alert threshold for less sensitive uses - 250 mg/kg dry substance, for the furnace area and in the scrubber area at depths between 80 and 120 cm. The soils in the area of the coke chemical plant are within the limits of the intervention threshold for less sensi-

tive uses - 1000 mg/kg dry matter, having determined values between 281485 mg/kg dry matter, which indicates significant lead pollution.

Zinc - falls within the alert threshold limit for less sensitive uses - 700 mg/kg dry substance, the contents being between 141-281 mg/kg dry substance, causing a reduced or even insignificant pollution of the soil with this element.

Nickel - falls within the alert threshold limit for less sensitive uses - 200 mg/kg dry substance, the determined values being between 28-182 mg/kg dry substance, which indicates insignificant nickel pollution.

Manganese - in the area of the coke-chemical plant, in the area of the scrubbers at a depth of 80-10 cm, the soil falls within the alert threshold limit for less sensitive uses - 2000 mg/kg dry substance, the determined value being 1646 mg/kg dry substance.

Chromium - falls within the alert threshold limit for less sensitive uses - 300 mg/kg dry substance, the maximum value being 128 mg/Kg dry substance in the plant area at depths of 30-50 cm.

Iron - it is within the alert threshold limit for less sensitive uses - 50000 mg/kg dry substance, for the soils in the area of the scrubbers and the Furnaces area, but in the area of the coking plant (coking battery no. 4) and the area of the furnaces I, iron falls above the limit of the intervention threshold for less sensitive uses - 100,000 mg/kg dry substance, having concentration values between 63,417-10,137 mg/kg dry substance, which indicates significant iron pollution, especially in the areas of iron ore of Furnaces sections.

Phenols - in the area of the scrubbers they fall within the alert threshold limit for less sensitive uses - 10 mg/kg dry substance, with values ranging up to 1,94 mg/kg dry substance, which determines a reduced pollution with phenols.

PAH (polycyclic aromatic hydrocarbons) - for all analyzed soils, it is within the alert threshold limit for less sensitive uses - 25 mg/kg dry substance, with values up to 11,0 mg/kg dry substance, indicating low pollution.

The residence time of metals in soil can be of the order of thousands of years, so new technological approaches are needed to remove excess toxic metals from the environment. A variety of different metals can be taken up by natural hyperaccumulators. The most readily bioavailable metals are Cd, Ni, Zn, As, Se and Cu. Phytoremediation of heavy metals in soils uses plant species that are capable of absorption and accumulation of contaminants in plant tissues, not only in the roots, but especially in the aerial part or in the shoots. For example, Thlaspi caerulescens was identified as a hyperaccumulator for Zn and Cu. Several species, such as the plants Erica andevalensis and Erica australis, grow naturally in heavily contaminated sites and are suitable for phytostabilization of polluted sites in abandoned mining areas. About 45 plant families are known to hyperaccumulate toxic heavy metals. Of the 45 families, Scrophulariaceae, Lamiaceae, Fabaceae, Asteraceae, Euphorbiaceae and Brassicaceae are frequently used for phy-

toremediation. Plants that are effective in accumulating larger amounts of heavy metals include Alyssum bertolonii and Thlaspi caerulescens. Increased concentrations of heavy metals such as Zn, Ni and Cd are best accumulated by Thlaspi caerulescens. This plant has the potential to accumulate 0,3-1020 mg kg-1 of Cd and 500-52 000 mg kg-1 of Zn.

Conclusions

The soil in the area of the coke oven and furnaces in Hunedoara is contaminated with various chemical substances, but the most dangerous pollutants identified are heavy metals. Heavy metals are stable and persistent soil contaminants that cannot be easily degraded or destroyed. Therefore, they tend to accumulate in soils and sediments. Polluted lands constitute a risk factor for human, animal and plant health and present higher than normal concentrations of some chemical compounds/elements. These high contents of contaminated soils originate from the industrial activities carried out over the years in these areas.

Phytoremediation is currently proposed as a soil decontamination solution. For phytoextraction to be a viable solution, plants must have the ability to absorb specific ions and accumulate them at high concentrations without suffering harmful effects from their toxicity.

Furthermore, since the objective of phytoextraction is to remove a contaminant from the environment, hyperaccumulators must be harvested and disposed of properly.

Different methods are available for this purpose: incineration, direct disposal, ashing and liquid extraction. Several analyzes have demonstrated that the cost of metal phyto-extraction is only a fraction of that associated with conventional engineering technologies.

Furthermore, because it remediates the soil in situ, phytoremediation avoids dramatic landscape disturbance and conserves the ecosystem.

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Section "Mining and processing of useful minerals"

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ANALYSIS OF EXCAVATOR AND LUMP METHODS OF PEAT EXTRACTION

The peat industry is a branch of the fuel industry the enterprises of which develop peat deposits, extract and process peat. Peat is developed in an open way, because all peat deposits are located on the earth's surface [1].

Currently, peat is extracted in two ways: milling and lumping.

According to the first of these methods, peat is extracted by cutting out the thin upper layer of the deposit, so this method is also called layer-surface or milling [2]. The milling method is a method that includes several stages. First, the upper layer is milled, then the processed layer is moved, the dried raw material is rolled, the raw material is removed and delivered to the stacks [3].

Then the rollers are stacked and peat insulation is carried out. During the season, depending on the weather, you can conduct up to 50 such cycles. Milled peat is a dried crumb [3] that has different shapes. The size of peat can be from 5 to 60 mm. It includes special plant fibers. With the help of which it maintains light water balance. It also contains many trace elements and nutrients.

According to the second method, peat can be mined by the excavator method, when bucket devices are used and the peat deposit is produced to the full maximum possible depth, as well as by the method of slot milling to a depth of 0,4-0,8 m.

The lump or excavator method is a method of quarrying peat with the help of an excavator that penetrates the entire depth of the deposit. With the excavator method, peat fuel is obtained in the form of large pieces weighing 500-1000 grams. Usually, this method can be used to extract peat with a decomposition rate of up to 15 and an ash content of up to 23. Production of lump peat is similar to milling technology, but less dependent on seasonality. The technological cycle of lump peat production is quite long, and it includes several stages: first, the excavation of the mineral, then its primary processing in the quarry and transportation. After that, the peat is laid out for drying near the quarries, also for drying with overturning, and if necessary, drying figures are laid out.

After the peat dries well, it must be collected. In order for this method to be implemented, special excavator machines are used - excavators, barnoelevatormachines, peat excavators with accumulators, diesel excavators.

The lump peat extraction process includes operations for excavation, processing and shaping of peat, lining and drying of lumps, collecting and stacking finished products. During the drying process, the pieces are stirred and rolled.

When moving, pieces of peat detach from the underlying surface of the peat deposit and turn over, which contributes to the equalization of moisture in different places of the volume and shortens the drying time.

Currently, there are two methods of extracting lump peat: excavation and milling-forming [4].

With the excavator method (Fig. 1), the peat extracted from the deposit by the bucket frame of the excavator enters the dispersing device, where it is processed and, with the help of an auger, enters the hopper-accumulator.

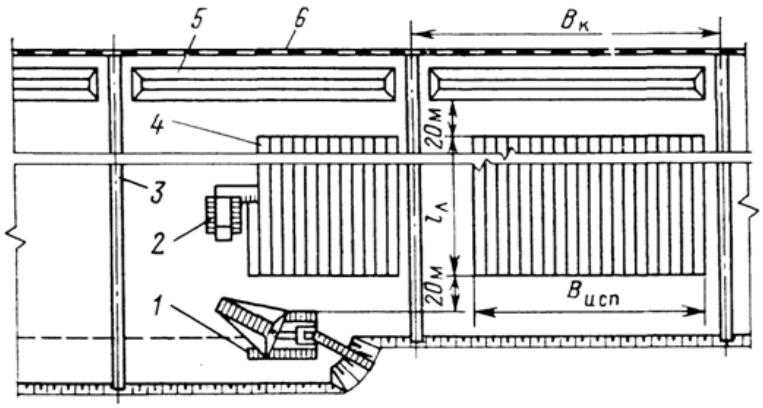

Fig. 1. Scheme of the technological site for the extraction of lump peat by the excavator method: *1* - excavator; *2* - forming machine; *3* - map channel; *4* - lined peat strips; *5* - stack; *6* - railway

From the hopper, it is transferred to a forming machine that forms pieces and lays them out on the drying fields.

The lining direction is perpendicular to the axis of the quarry. During the drying process, lined peat is turned over and, if necessary, rolled, when using universal drying machines. Peat is collected by hopper harvesting machines.

The same operations are performed when extracting lump peat by the milling method. However, the number of machines in the technological cycle is less.

Milling and forming machines excavate peat with the help of cutters (Fig. 2), compact it and line the pieces in the same areas where the excavation was carried out, as shown in Fig. 3.

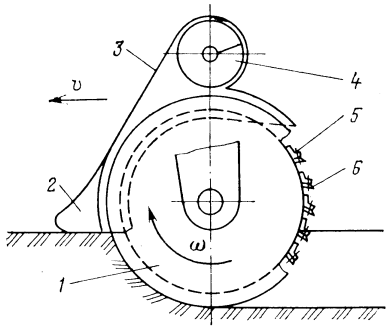

Fig. 2. Scheme of a disk cutter: *1* - disc; *2* - baffle plate; *3* - protective cover; *4* - screw; *5* - knife holders; *6* - knives

Fig. 3. Extraction of lump peat by the milling method

After several hours of drying in the sun, the formed peat almost does not absorb moisture.

Sufficiently well-dried lump peat is collected in rolls, where it continues to be dried. Then, the dumped peat is collected and transported for stacking.

The further development of peat production can be carried out not only by improving the means of mechanization and automation of production, but also by improving technologies, better organization of the technological process and the operation of machines.

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METHOD OF EVALUATING AMBER VALUE

Amber is a fossilized fossil resin in the form of colorless, yellow-white, yellow, brown-yellow, light and yellow-brown, transparent, translucent and opaque stone. The change in the degree of transparency of the stone by section was investigated.

Transparent amber is concentrated in its middle. Amber deposits are found along the shores of the Baltic Sea in Poland, Germany, the Baltic states, Denmark, and Sweden [1,2]. In geological terms, Baltic succinite is the most widespread [3].

A gem with the same composition was also found on the territory of Ukraine (near Kyiv, Kharkiv, in Volyn) in the Rivne region (Sarnensky and Varasky districts) [1].

Research on the detection of the presence of amber was carried out in amber-bearing deposits of the Rivne-Volyn region (Ukraine). Amber, which has been explored by geologists, occurs in sandy or sandy-clay soils.

The depth of occurrence is small - from 1 m to 10-15 m. The age of the sediments, determined by spore-pollen analysis, is defined as early and middle Oligocene-late Oligocene.

Using the method of infrared spectroscopy, the presence of structural elements was determined. Thus, during the study of amber from the Klesiv deposit (Ukraine), aliphatic saturated and unsaturated ethers were found.

Depending on the deposit and age, amber has different absorption spectra. In some samples etheric functions predominate, in others - acidic functions.

The value of amber depends on the uniqueness of the amber samples and is established collegially by experts.

To determine the value, a method has been developed that includes the classification of pieces of amber by shape (form *A,B,C,D*), size (from 1 to 5) and color (from 1 to 4).

Form *A* - the form of the sample is close to isometric, the surface is smooth, without bumps and depressions.

The ratio of the smallest to the largest indicators of linear dimensions is no more than 0,75.

Form *B* - the form of the sample is close to isometric, the surface is even with existing depressions or bumps (the depth of which is no more than 3 mm).

The ratio of the smallest to the largest indicators of linear dimensions is no more than 0,5.

Form *C* - the shape of the sample is not isometric, there is a complex surface with depressions up to 5 mm. The ratio of the smallest to the largest indicators of linear dimensions is no more than 0,15.

Form *D* - the form of the sample is very non-isometric, complex, whimsical, twisted, lamellar, the surface is cracked with deep depressions, hills and even holes. The ratio of the smallest to the largest indicators of linear dimensions is no more than 0,15.

Size 1 - these are unique samples: more than 100 mm in the largest linear dimension.

Size 2 - large samples: more than 50 mm in the largest linear dimension.

Size 3 - medium samples: greater than 25 mm in greatest linear dimension.

Size 4 - small samples: more than 10 mm in greatest linear dimension.

Size 5 - small samples: less than 10 mm in greatest linear dimension.

Color 1 is a rare color. Transparent red, greenish-lemon, blue-greenish-yellow, translucent greenish-lemon, white with a greenish and blue tint.

All colors are pure without visual defects.

Color 2 - traditionally dyed. Brownish, golden yellow, yellow without inclusions and defects.

Color 3 - traditional brown-yellow, yellow with a grayish tint with a small number of microscopic inclusions unevenly colored.

Color 4 - contaminated transparent, translucent and opaque gray-brown, the frequency is corrupted.

According to research data, it has been established that amber of form *A*, size 1 and color 1 is most valued, and amber of form *C* or *D*, size 5 and color 1-4 is the least valued.

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DEPENDANCE OF MINING DRIVE POSITIONING IN SUBLEVEL OPEN STOPING ON MINE DEPTH, OREBODY DIP AND RECOVERY AT MUFULIRA MINE, ZAMBIA

Introduction

Mufulira mine consists of three superimposed ore bodies namely *A*, *B* and *C* with a plunge of 40° to 55° degrees from east to west. The mine uses a variant of sublevel open stopping known as MCR (Mechanised Continuous Retreat) which utilises gravity assist for ore flow in the stope. The effective angle of draw lies between 45° and 55° degrees. However, when the ore body dips below this angle, some ore fails to flow into the stope for mucking because the angle of repose of the broken ore is more than the inclination of the footwall contact and is less than the effective angle of draw. Therefore, the ore that fails to report into the stope remains on the footwall thereby reducing its recovery. Additionally, even when the ore body dipping is within the angle of draw, some of the ore still fails to flow due to the position of the mining drives. Hence, correct positioning of the mining drive is key in reducing ore losses and improvement in ore recovery.

Aim. The aim of this study is to determine the optimum position of the mining drive in sublevel open stoping in relation to varying dips, mine depth and stress redistribution.

Methodology. Methods involved establishment and analysis of stress redistribution around the mining drives in the process of mining the stopes using PHASE2 and examine 2D softwares fol-

lowed by simulation of probable positions of the mining drives at different ore body dip angles using AUTOCAD and SURPAC software. An orebody dip angle of 43° was used as a worst-case scenario for simulation. The different options of arrangements of the mining drive was also analysed based on its geotechnical stability and stope recovery during ore extraction.

Results. The Induced stresses around the mining drives at Mufulira mine have led to spalling, rock bursts and general instability of excavations.

The Mufulira mine ore-bodies are more competent than their footwall formations and the footwall contact is the plane of weakness. The majority of the maximum principle compressive stresses are inclined at 45° perpendiculars to the dip of the orebody. The maximum principal stress (σ_1) recorded around the mining drive was 46 MPa.

Conclusion. Three options for positioning of the mining drive were considered and simulated based on stability and stope recovery. The best option chosen was one in which the mining drive was positioned 30% in the footwall quartzites and 70% in the ore body.

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CREATING OF MODELS FOR THE FORMATION AND DEVELOPMENT OF THE STRESS-STRAIN STATE ANOMALIES IN THE MASS USING THE LATEST TECHNOLOGIES FOR MAINTAINING EXTRACTION WORKINGS UNDER CONDITIONS OF HIGH ADVANCE VELOCITY OF STOPE FACES

At present, the successful development of the coal industry within the framework of the technical and technological policy is possible only if mining operations are concentrated and underground mining is intensified based on the effective use of modern equipment and technologies. And

in this regard, special attention is paid to studying the stress-strain state (SSS) of the mass and fastening elements under conditions of high advance velocity of stope faces.

For many years, the patterns of changes in the state of the coal-bearing mass have been studied as the stope face approaches and retreats. The formation of anomalous state zones around stope workings and the extraction drifts associated with them has been proven: zone of frontal bearing pressure ahead of the face; lateral bearing pressure zone that occurs in the side of the extraction drifts from the side of virgin mass; destressing zone behind the stope face. The specified zones depend on the mining-geological parameters of mining, as indicated by numerous studies in various periods of the coal-mining industry development both in Ukraine and in other countries [1-3]. The authors performed a detailed analysis of existing analytical studies and experimental measurements [4-6] of the rock pressure manifestation parameters. The significance of the influence of technological parameters for the coal seam mining on the formation of SSS anomalies in a coal-bearing mass has been proven. For the studied three SSS anomalies, a set of parameters is substantiated that completely characterize the studied object. Two technological parameters have been distinguished that, on the one hand, influence the formation and development of SSS anomalies, and, on the other hand, are associated with the intensification of mining the coal seams. This is the average daily velocity V_d of the stope face advance and duration t of its stoppage.

The most expedient three-stage structure of research implementation is substantiated. Within the framework of this structure, mine instrumental observations and multivariate computational experiments are combined and complement each other by a connecting element - the mechanism of the coal-bearing mass displacement in terms of the impact of the selected technological parameters for conducting stope operations. At the same time, the composition and properties of the Western Donbass coal-bearing stratum have been generalized with a division into two main structures.

When substantiating the methodology for conducting a complex of computational experiments, three groups of factors have been distinguished that affect the reliability of the SSS calculation process while minimizing computer equipment failures. The necessity of introducing a number of idealizations and simplifications into geomechanical models has been proven, which minimally affect the adequacy and accuracy of the SSS calculation final results, but at the same time significantly save computing resources and sharply increase the reliability of the calculations.

A new methodological approach has been developed in the technology for conducting computational experiments, which ensures the continuity of research in the separation and sequential solution of two groups of problems on a common macromodel and subordinate models with a more detailed reflection of real conditions. Such a two-stage research structure makes it possible to more adequately and reliably determine two groups of patterns of the influence of technological parameters on the rock pressure anomaly indicators, as well as on the stress-strain state of fastening and

security elements in the latest schemes for resource-saving maintenance of extraction workings in the conditions of highly-stressed longwall faces.

A fundamentally new methodological approach is proposed for taking into account the time technological parameters (V_d and t) through their connection with the mechanical characteristics of the rocks in the coal-bearing stratum. A calculation algorithm has been developed taking into account creep deformations. In addition, a methodology for calculating the deformation characteristics of lithotypes is given, taking into account the influence of the average daily advance velocity V_d of the stope face and the duration t of its setting.

The principles of coordination of the macromodel and subordinate models are substantiated in terms of the most reliable consideration of the influence of rock pressure anomaly parameters on the SSS of modern fastening and security structures of extraction workings intended for reuse. An algorithm for implementing coordinate actions has been developed, based on five provisions implemented in the process of successive approximations of the SSS of subordinate models to the SSS of the macromodel until the required accuracy is achieved.

A three-stage algorithm for analyzing and presenting the results of multivariate computational experiments is substantiated. A complex of graphical and empirical dependences provides a comprehensive assessment of the rock pressure anomaly parameters, the emerging stress on the maintenance facilities of mine workings and their SSS during the operation of highly-stressed longwall faces.

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INFLUENCE OF INITIAL ROCK PERMEABILITY ON THE FORMATION OF A POLYMER-REINFORCED ZONE WHEN USING INJECTION ROCK BOLTS

Injection rock bolts are applied to consolidate and harden disturbed unstable rocks while driving mine workings [1]. An injection rock bolt is a metal pipe used for injection fortifying polymer

solution into the fractured rock mass under high pressure. The reagent mixture is polymerized with 1,5-3,5 times increase in volume. The foamed composition fills even the small fractures in the rocks. When the foamed polymer hardens, the metal pipe is used as additional reinforcement, and a consolidated gas- and water-proof zone is formed around the rock bolt.

When developing a mine working support pattern with injection rock bolts, one should know how close is interaction between the hardened zones and whether they form an integrated mechanical structure being an integral arch capable to protect the mine working against failure, gas emission and water inflows [2-4]. If the consolidated zones do not interconnect then breakdown of the arch and roof failure are possible.

Thus, the purpose of this research is to study changes in shape and size of polymer-hardened area depending on the initial permeability of host rock.

A numerical model of the coupled processes of rock deformation and liquid polymer filtration was developed to study geomechanical and filtration parameters in the mine working roof with injection rock bolts [5].

The problem is solved in elastoplastic formulation. Mathematical description of rock transition into the disturbed state involves Mohr-Coulomb failure criterion [6]. It is widely thought that when a mine working is driving, a field of technological permeability $k_{tech,}$ depending upon stress tensor values is imposed on the initial permeability field k_0: $k=k_0+k_{tech}$.

The solution involves a finite element method. Each time iteration takes into consideration the stress field influence on the filtration area shaping; influence of changes in pressure of the polymeric composition on the stress state of the rock; and changes in physicomechanical as well as filtration characteristics of the rock during the polymer solidification [5].

This model takes into account that a metal pipe begins to work as a reinforcing support element only after the polymer solidification.

Paper describes simulation of rock reinforcement during injection and solidification of the polymer. Parameter $Q^*=(\sigma_1-\sigma_3)/\gamma H$ characterizing a degree of variety of the stress field components is applied to evaluate the stress state.

Consider a rectangular cross-section mine working with 5,2 m width and 3,0 m height being driven through the soft rocks (elasticity modulus is $E=10^4$ MPa; and compressive resistance is $\sigma_c=28$ MPa).

Number of rock bolts is $N_a=3$; distance between them is $l_a=2,0$ m; delivery pressure is 6 MPa. The computations have helped obtain distributions of values of geomechanical and filtration parameters, Fig. 1 and 2.

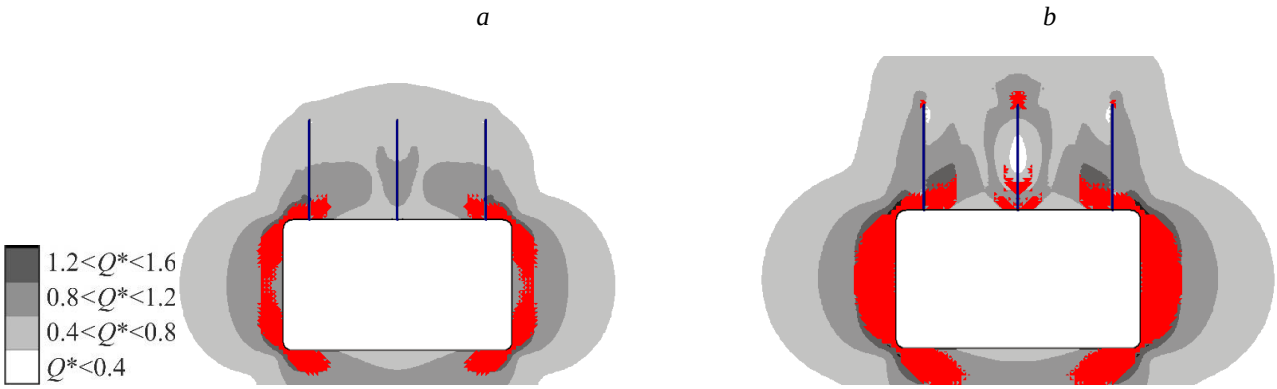

Fig. 1. Distribution of Q^* parameter values and nonelastic deformation area (red color): *a* - start of injection; *b* -after injection and hardening of the polymer

The areas of high component variety and nonelastic deformations extend in the course of time (Fig. 1*a*). Roof rock permeability *k* is very high (Fig. 2*a*).

After injection and hardening processes is over, the area of the reinforced rock around rock bolts expands; diameter of a zone where $0{,}4<Q^*<0{,}8$ is 1,7 m (Fig. 1*b*).

The area of uniform compression $Q^*<0{,}4$ arises around the central rock bolts. Since the moment, each rock bolt is surrounded with a zone of completely impermeable rocks with more than 0,6 m diameter shown clearly in Fig. 2*b*.

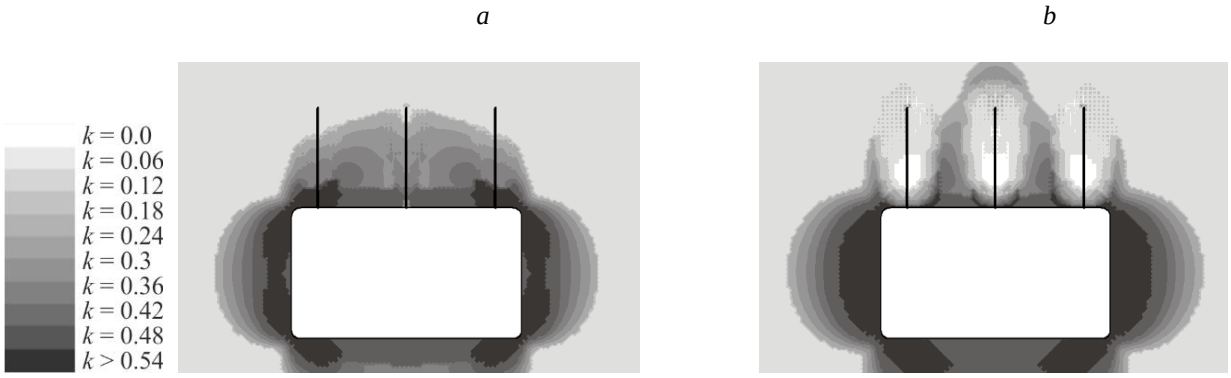

Fig. 2. Distribution of the permeability coefficients while installing injection rock bolts: *a* - start of injection; *b* -after injection and hardening of the polymer

The areas of high component variety and nonelastic deformations extend in the course of time (Fig. 1*a*). Roof rock permeability *k* is very high (Fig. 2*a*). After injection and hardening processes is over, the area of the reinforced rock around rock bolts expands; diameter of a zone where $0{,}4<Q^*<0{,}8$ is 1,7 m (Fig. 1*b*). The area of uniform compression $Q^*<0{,}4$ arises around the central rock bolts. Since the moment, each rock bolt is surrounded with a zone of completely impermeable rocks with more than 0,6 m diameter shown clearly in Fig. 2*b*. However, highly permeable rocks occur between the impermeable areas. Three monolith polymer-reinforced rock-bolt supports are not linked; they are separated by zones of the fissured disturbed rocks.

Fig. 3 demonstrates the areas where fractured rock in the mine working roof are consolidated with the polymer for different values of initial permeability of host rocks. In the context of two first

cases (Figs. 3*a*-*b*), the polymer-consolidated areas around the rock bolts are independent. In terms of low initial permeability values (Fig. 3*a*), the upper share of rock-bolt supports is not shaped completely. If k_0>0,1 mD then the initial permeability starts influencing the consolidated area diameter. If k_0=0,4 mD they contact (Fig. 3*c*).

Generally, quite typical increase in the dimensions of the hardening zone is observed along the increase in the initial rock permeability.

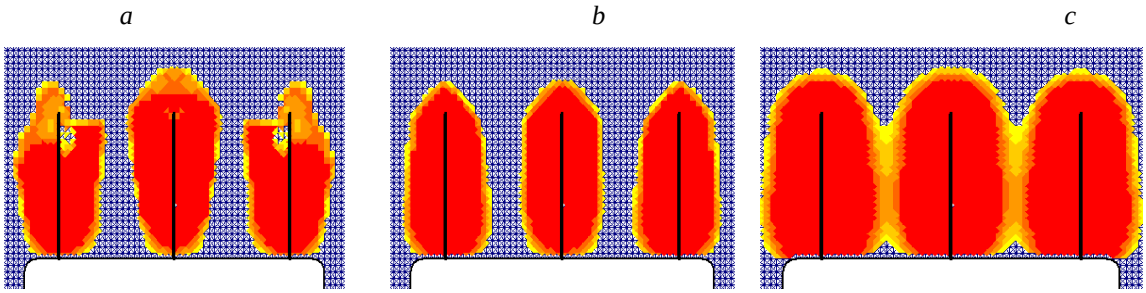

Fig. 3. Changes in the shape of the consolidated area depending upon the values of initial permeability k_0: *a* - k_0 = 0,001 mD; *b* - k_0 = 0,1 mD; *c* - k_0 = 0,4 mD

Fig. 4 represents dependence of changes in the reinforced area upon the value of initial permeability of enclosing rocks for the mentioned conditions of the mine working driving.

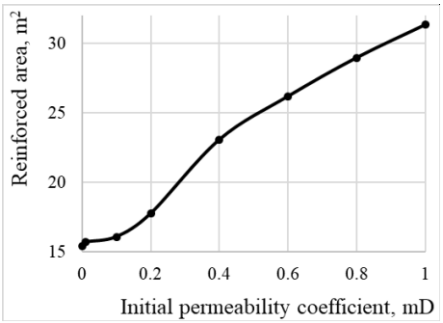

Fig. 4. Dependence of changes in the reinforced area upon the value of initial permeability of the host rock

Conclusions

Development of schemes for the mine working support and computation of the polymer-consolidated area around the injection rock bolt should take into consideration the initial permeability of the host rock.

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PROPOSING TECHNICAL AND TECHNOLOGICAL SOLUTIONS WHEN EXPLOITING COAL SEAMS UNDER COMPLICATED CONDITIONS AT MONG DUONG COAL MINE, VIETNAM

When exploiting the coal seams under complex conditions may lead to unsafety risks due to the influence of displacement zones. The research and selection of unreasonable mining solutions will lead to potential unsafety risks during the mining process, affecting the production plan of the whole mine. In this study, the author propose technical and technological solutions to ensure safety and avoid potential risks that may occur when exploiting the coal seams under complicated conditions, namely coal seams located under open pit mines that have finished exploitation and under works that need to be protected on the surface of Mong Duong coal mine. Through the assessment and analysis of coal seams under complex conditions, combining methods of comparison and calculation, and synthesizing data collected at the mine, the author has selected technical and technological solutions reasonable. As a result, a reasonable mining solution was selected for the longwall in Seam L7 at East Side. The research results of the article can serve as a basis for Mong Duong Coal Mine to apply in actual production in order to proactively prevent possible incidents and at the same time maintain normal operation in the mine, ensuring efficiency in mining and ensuring safety when mining coal seams under complicated conditions. The results of this study can also be applied to other coal mines with similar conditions.

Mong Duong Coal Mine is one of the underground mines in Quang Ninh coalfield, Vietnam. To prepare for mining to -400 level, Mong Duong Coal Mine has dug underground tunnels from -97.5 to -250 level and from -250 to -400 level (station area, tunnel area) [1]. During the mining process, the Mong Duong Coal Mine has deployed and applied many types of mining technologies to suit the actual conditions of the mine [2]. Currently, Mong Duong Coal Mine is also exploiting coal seams located in difficult and complicated conditions. Specifically, the coal seams located under the open pit area have ended exploitation and the coal seams are under the works to be protected. These are areas with the risk of affecting and unsafe for the longwall as well as the works on the surface of the mine.

Exploiting the longwall will cause displacement and deformation area in the surrounding rock mass, and they can affect the ground, adversely affecting surface construction works [3-5]. Calculating displacement and deformation is an extremely important problem in underground mining. This is also an important problem to study mining solutions for coal seams in the above complicated conditions.

There have been many studies on the exploitation of coal seams in complex geological conditions. Studies [6-8] have mentioned digging the tunnels, calculating the pressure exerted on the support in complex geological conditions. Studies [9-11] have calculated the displacement and deformation of rock mass

when exploiting the longwall, etc. In the Mong Duong area, there have also been studies [12-14] through displacement monitoring, field survey to determine the safe distance when exploiting the seams in complex geological conditions.

Thus, it can be seen that the above studies refer to the characteristics and causes of incidents, as well as technical solutions in specific conditions for the longwall. In this study, the author analyzes the causes of problems when exploiting the complex seams, on that basis will propose technical and technological solutions to exploit those coal seams to ensure safety, avoiding potential risks. The research results of the article are also useful documents for Mong Duong Coal Mine to apply, proactively choose solutions to exploit coal seams in complex conditions to bring the best efficiency.

* Proposing technical solutions and mining technology for seams in complex conditions

+ Technical solutions

For the seams located under the open pit area

Before proceeding to exploit the seam under the open pit area, it is necessary to prepare all the steps to ensure safety during the mining process, a number of technical solutions can be applied as follows:

1. Selection and supervision of open pit filling techniques

Some mines in Quang Ninh often fill open pits at the end of mining to restore the surrounding environment. The selection of waste material and backfilling technique should be ensured that the material (waste rock) is compacted. This is very important to limit and avoid water from places that can flow into the open pit, especially in the rainy season.

2. Monitoring and calculating the amount of water in the open pit

3. Arrangement of hydrogeological monitoring station system

In order to arrange a hydrogeological monitoring station system, it is necessary to drill holes from the surface to the bottom of the open pit. Then install equipment into those boreholes to monitor groundwater in the open pit. This is a method of monitoring and calculating, assessing the amount of water in the open pit accurately and effectively. However, the arrangement of this monitoring system is also difficult for the mines due to many different reasons. Currently, this method is being implemented at Ha Lam Coal Mine, in the coming time, it will continue to be applied at Duong Huy Coal Mine.

4. Build a suitable drainage pump system

The mine drainage pumping system needs to be designed and invested effectively. The water pumping system for the mine must be arranged not only outside the site but also in the mine. The water pumping system must be able to meet even in the rainy season.

For seams located under works that need to be protected on the ground

Trước khi tiến hành khai thác vỉa than nằm dưới các công trình cần bảo vệ, cần phải thực hiện tốt giải pháp kỹ thuật sau đây:

Before proceeding to exploit coal seams located under works to be protected, the following technical solutions should be well implemented:

1. Arrangement and installation of surface movement monitoring station

Installing a surface movement monitoring station is the basis for assessing the impact of mining on the surface works. Before exploiting, it is necessary to arrange monitoring stations at suitable locations and record data to monitor the level of movement. Monitoring during mining and after the end of mining. It is necessary to calculate the monitoring time, this is done until the rock mass in the mining area has stabilized (the end of the subsidence process).

2. Evaluation and reinforcement of surface works

The assessment and reinforcement of the surface work before exploitation is also one of the technical solutions to ensure the safety of that works. The right reinforcement solution will save and minimize the impact from the mining process.

+ Technology solutions

1. Calculate the allowable safe distance

The calculation and prediction of the safe distance is the main problem and also the basis for evaluating and selecting mining solutions for coal seams under complex conditions. Currently, there are many methods to calculate the safe distance, one of the methods used is the numerical simulation model method. The numerical modeling method can also calculate and predict the level of subsidence caused by the impact of mining.

2. Selecting suitable mining technology

The selection of mining technology and parameters of the longwall is also one of the solutions to the problem of exploiting the coal seams under complex geological conditions. The selection of reasonable parameters for the longwall corresponding to specific conditions will ensure the safety of the surface works that need to be protected.

*** Conclusions**

Exploiting coal seams in complicated conditions always has potential risks of unsafety. In this study, the author mentioned two complex seam conditions, including the coal seam located under the open pit area that has ended mining and the coal seam located under the works that need to be protected on the ground. The article analyzed the characteristics and causes of incidents affected by the mining process. On that basis, the article also proposes a number of technical and technological solutions when exploiting the coal seams in complex conditions, thereby minimizing the impact on the open pit mining, as well as works on the ground, and at the same time ensure safety during exploitation.

The research results of the article have been applied to the conditions of the longwall in Seam L7 at East Side at Mong Duong Coal Mine. This is also the basis for Mong Duong Coal Mine to determine the movement and deformation of rock mass when exploiting the longwall in Seam L7. Thereby assessing the stability of the G9 surface works, and at the same time proactively select the technical and technological solutions to ensure the stability of the G9 surface works during the exploitation of this longwall.

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ELIMINATING PARAMETER UNCERTAINTY BY FUZZY LOGIC METHODS FOR RISK MANAGEMENT IN A MINING SYSTEM

In order to prevent emergency situations in mine roadways, it is necessary to maintain them in an equilibrium state [1,2]. At the same time, there are many problems in mines for solving of which it is enough to slightly change the uncontrolled input data (for example, the uncontrolled physical and mechanical properties of rocks during flooding) in order to move from an exactly solvable problem to an indefinite one or to obtain a certain degree of uncertainty. This fully applies to solving the problems of increasing stability and safety of mine roadways, for which absolutely accurate data exist only in analytical calculations.

To maintain the equilibrium state of the mining technical system "support-rock massif", the deviation of the system parameters from the equilibrium point and the rate of this deviation change are controlled. Based on these data, personnel warning signals are generated, a recommendation is given for the use of a number of technical and technological measures in the production process that contribute to the return of this indicator to its original range. When assessing the mine roadway state, this signal is

one of the criteria for monitoring labor safety. It can also be used as an addition to the control signals generated by classical control systems [3]. This is necessary to prevent gas-dynamic phenomena, sudden drift of the roadway roof and floor and other dangerous manifestations of rock pressure.

The assessment of probable scenarios for changing stability of a complex mining system is carried out by analytical methods with using geomechanical *models* and methods for assessing scenarios of development of situations. To apply the model using fuzzy logic methods for assessing the risks of loss of the geotechnical system stability, the forecasted basic and integral informative parameters were determined. The parameters were calculated by the methods of mathematical modeling of the rock stress-strain state [4]. This made it possible to correctly identify the input dominant characteristics for fuzzy logic model and assess scenarios for the future behavior of the controlled object.

General scheme of the stability control model for the "support-rock massif" geotechnical system with using fuzzy logic methods is shown in fig. 1.

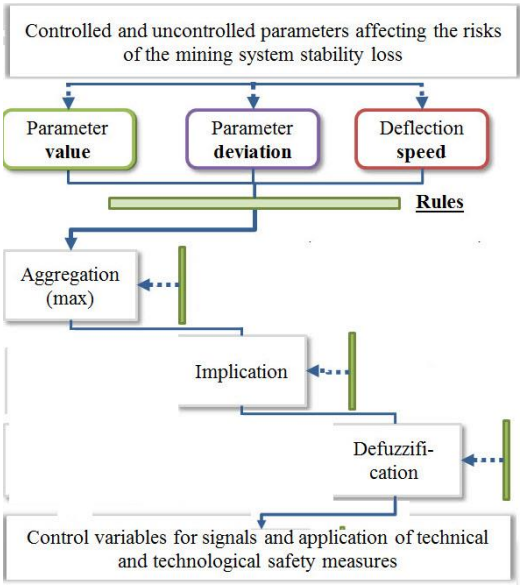

Fig. 1. Risk management model scheme with using fuzzy logic methods

When implementing the model in real time, three stages of data processing are performed: translation of accurate input signals into logical-linguistic variables (fuzzification); the conclusion that experts form in the process of interpreting the received messages (inference); transformation of a fuzzy set into a clear number for use in digital systems (defuzzification).

At the stage of inference, expert knowledge, initially qualitatively stated in the form of expert rules with a table of possible risks of the roadway stability loss, is converted into the control law implemented by software and hardware if the system is configured to generate and transmit signals of potential danger.

Further, guidelines are initialized, which regulate the activation of danger signals at production sites and the implementation of technical measures, which, as a result, ensures the restoration of the system's operability (for example, an order to carry out auxiliary measures to protect the roadway in zones of geological disturbances).

In the process of fuzzification, the value of all membership functions is determined for the current values of the deviation arguments and the derivative deviation.

The integral value of all membership functions for one input variable, regardless of the current value of the argument, is equal to 1, which is one of the advantages and, in this case, determines the use of triangular activation functions.

The calculation of the parameters of the stages of inference (sections, combinations, aggregations and implications of fuzzy sets) is performed according to known relations.

The implementation of fuzzy inference is based on fuzzy rules that make it possible to represent the control process through sentences like "If - condition, then - action".

A condition is understood as a sample sentence for making searches in the knowledge base, and an action is the actions performed upon successful search.

A distinctive feature of the model is the ability to select rules from a set of possible rules depending on the established criteria.

The advantage is that the control surface is static, unchanged for given data processing algorithms and expert rules, and, therefore, can be specified in tabular form.

This facilitates the technical implementation of the control system, where the rules are recorded in the permanent memory of the digital system.

After expert knowledge is set forth qualitatively in the form of expert rules, the control law is implemented by software and hardware.

Thus, information hardware technologies are improved and algorithms for digital conversion of automated system signals from the time domain to the frequency domain are proposed, which provide an increase in reliability and a reduction in the size of transmitted geotechnical information.

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A NEW TECHNOLOGY FOR EXTRACTING ORE UNDER A PROTECTIVE SLAB

Rational use of subsoil in the development of deposits, complete and high-quality extraction of mineral reserves largely determine the effective operation of mining enterprises.

The use of high-performance mechanical equipment that intensify the production and transportation of ore in underground mining only partially resolves the issue of reducing losses and dilution, since the use of powerful technical means is limited by the parameters of mine workings.

Thus, the need for seeking new technological solutions to reduce ore loss and dilution in underground mining comes into the foreground.

Ukrainian and foreign scientists have and continue to address reducing loss and dilution of minerals by applying new technological improvements to existing development systems.

Most of the iron ore deposits in the Kryvyi Rih iron ore basin are of weak and medium hardness. This predetermines their development by systems with caving of ore and host rocks. Considering the physical properties of the broken ore and the processes in ore released from the blocks, dilution occurs long before the broken ore is completely excavated. The dilution process can be suspended a little by observing the planogram for extracting ore from the outlet workings. However, this does not completely solve the problem.

The main dilution occurs along the upper contact of the collapsed ore - rock. Therefore, scientists are considering the possibility of reducing the direct contact of broken ore and collapsed overburden waste rocks.

In [1-3], it is proposed to mine a layer of minerals and then lay a slab (made of wood, metal mesh, concrete) on the soil of the layer; under its protection the underlying mineral is to be mined out.

In [4-6], the separation along the perimeter of the collapsed rock and ore can be achieved by using a "floating" ceiling or a flexible slab. In this case, the block is to be processed in two stages. At the first stage, a protective slab is formed as a "floating" ceiling or a flexible metal ceiling made of strip iron. At the second stage, all cutting workings and cleaning operations are carried out. These options for development systems can significantly reduce losses and dilution of collapsed ore, however, the cost of mining minerals increases significantly. In addition, a large amount of ore remains in the ridges between the outlets at the bottom of the block. Thus, it is necessary to find the best

option to reduce material and labour costs for loading and supplying workings, to reduce the loss and dilution of minerals when extracting ores of weak and medium hardness.

The technology [7] provides for the preparation of horizontal and rising loading and supplying workings in the block and forms a "floating" ceiling in the ore or rock mass. When forming a "floating" ceiling, loading and supplying workings pass in it. In the lower part of the ceiling under each working, longitudinal niches are formed between which longitudinal pillars with inclined side walls are formed, forming them at an angle of internal friction of the collapsed mineral. Ore is excavated under a uniformly descending "floating" ceiling. At the same time, the overlying waste rocks ensure the constant lowering of this ceiling.

After the ore is extracted in the block, an ore "floating" ceiling is mined using an ore end outlet.

Laboratory studies of ore release technology under the "floating" ceiling with loading and supplying workings located in it confirmed a significant reduction in loss and dilution rates and the need for further research into the parameters and functions of the "floating" ceiling.

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EFFICIENCY OF FUZZY CONTROL IN RESOURCE-SAVING ELECTROMECHANICAL SYSTEMS WITH ELASTIC CONNECTIONS IN MINING ENTERPRISES IN UKRAINE

Improved technical characteristics and found solutions to technological problems in the areas of power electronics, digital control systems and advances in the theory of automated electric drives make it possible to widely use in industrial production resource and energy-saving frequency-controlled transistor electric drives with asynchronous motors with a squirrel-cage rotor instead of thyristor DC drives [1].

The increased tendency to oscillatory processes of transient AC drives in systems with elastic transmissions adversely affects the electromagnetic compatibility of power supply and electromechanical systems. Elastic vibrations in the transmission of the actuator lead not only to active power fluctuations, but also to the circulation of additional reactive power in the power supply system [2].

The replacement of a thyristor DC drive in the drilling rig rotation mechanism with a transistorized AC drive with pulse-width modulation of an autonomous voltage inverter during the modernization process worsened the energy characteristics of the entire electromechanical system, since in the latter case, due to an increase in the bandwidth of the electric drive control loops, additional current and voltage harmonics are generated [3,4].

The relevance of the topic is determined by the significant influence of electromechanical processes on the energy processes occurring in the power supply system, especially when its power is limited at the mining enterprises of Ukraine. When the drive system is connected to the power supply system, the electric motor makes the inertial mechanical transmission move with the help of elastic links that oscillate, and the inertial vibration power is directly converted into reactive power of the power supply system, which, firstly, worsens its parameters, and secondly, elastic vibrations are accompanied by heat losses of reactive (inertial) power due to its circulation in the power supply system.

Elastic vibrations in a mechanical system are converted into electrical reactive power. The frequency of mechanical oscillations generates the corresponding harmonics of the full power in the network with a frequency that is not a multiple of the main frequency of the power supply network, the so-called interharmonics. These factors lead to additional thermal electrical losses, which adversely affects the electromagnetic compatibility of power supply and drive systems. In accordance with the principle of conservation of energy, it is shown in [5] that inertial, deformation and dissipative powers are analogues of inductive, capacitive and active electrical powers, respectively.

The research methodology is based on the law of conservation of energy, when the flow of electromagnetic energy is supplied by the power supply system, converted by the electric drive system into a controlled flow of mechanical energy. Mechanical and electrical energy flows are mutually balanced and flow into one another, and inertial, deformation and dissipative powers are analogues of inductive, capacitive and active electrical powers, respectively.

The task is to analyze the elastic properties of a mechanical transmission, quantitatively describe these properties, establish the patterns of their appearance and develop appropriate control actions that lead to the suppression of elastic vibrations, which directly leads not only to a decrease in the instantaneous values of interharmonics in consumed power, but also to reducing the values of additional thermal electrical losses, which also leads to an improvement in the electromagnetic compatibility of power supply and drive systems.

The purpose of the study is to find patterns in which interharmonics are eliminated in the consumed power of the power supply network by suppressing elastic oscillations in the electric drive system with elastic links in the transmission, that is, in determining drive system control algorithms that improve the electromagnetic compatibility of power supply systems with electromechanical ones.

The study was carried out on the basis of the compatibility of the resource-saving electric drive of the drilling rig and the power supply system.

When modernizing the rotator drive of the drilling rig, a thyristor DC drive with a DC motor was replaced with an AC transistor drive with an asynchronous squirrel-cage motor. The drive is connected to the power supply system by a long cable line with a limited allowable transmit power. This technical solution led to the appearance of additional consumed power interharmonics in the power supply system, which worsened the electromagnetic compatibility of the systems. [6].

To determine the degree of influence of the elastic properties of the drilling string, its frequency response was found.

During the operation of the drill string, longitudinal, transverse and torsional vibrations occur in it [8,9]. Transverse and longitudinal vibrations do not directly affect the dynamics of the drive system.

Elastic torsional vibrations of the shaft in the AC drive directly affect the functioning of the power supply system, which degrades the energy efficiency of the electromechanical installation.

Comparison of the transmission frequency characteristics of the drilling rig rotator drive with the frequency characteristics of the transistor drive revealed additional dynamic links in the control loops, which are determined by the elastic properties of the transmission and are not taken into account in the general industrial drive [7].

The natural elastic vibrations of the drilling string fall into the passband of the active compound current circuit and the motor shaft speed, which lead to the appearance of weakly damped oscillations of the current and speed of both the engine and the string itself and load the power supply system with additional interharmonics.

The frequencies of mechanical elastic oscillations generate the corresponding harmonics of the consumed power in the network with a frequency that is not a multiple of the main frequency of the power supply network, the so-called interharmonics.

These factors lead to additional thermal electrical losses, which adversely affects the electromagnetic compatibility of power supply and drive systems.

The quantitative and qualitative influence on the value of the generated interharmonics is directly due to the elastic properties of the drilling string, which leads to the appearance in the control object of the current loop of an uncompensated dynamic link with four zeros and poles in the transfer function, and in the speed loop - with two zeros and poles.

Moreover, the coefficients of the polynomials of the additional transfer functions depend on the mass of the stave, which changes in accordance with the number of attached rods, which leads to the movement of zeros and poles of the transfer functions on the complex plane.

Compensation of the dynamic properties of an additional dynamic link to the dynamics of the current loop in the field of classical controllers leads to the need to use an additional controller with adaptive tuning and the need to determine derivatives up to the second order, which, in the presence of noise in the control signals, will adversely affect the loop control process.

An effective solution to the problem of compatibility of a resource-saving transistor AC drive with a power supply line is the introduction of a fuzzy proportional-differential controller from mismatches at the inputs of proportional-integral speed and current controllers to the controller output, which allows you to maintain the advantages of control systems with active serial correction and effectively suppress interharmonics in the system power supply, improve the energy efficiency of the entire electromechanical complex.

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PLANNING OF MEASURES TO REDUCE ACCIDENTS IN THE UNDERGROUND DEVELOPMENT OF IRON ORE DEPOSITS IN KRYVBAS

The analysis of the state of accidents at the enterprises of the mining industry of Ukraine, and in particular, of the Kryvyi Rih iron ore basin, showed that there are several main reasons for the increase in accidents during underground mining.

One of them is a violation of the technology when fastening and re-fastening mining workings. This is especially important when placing these workings in the zone of influence of mining operations. This is also caused by neglecting the influence of the physical and mechanical properties of the host mining rocks in which these workings are located.

The level of injuries from falling pieces of mining rocks is about 30% of the total injuries in underground works. In addition to violations of fastening technologies, the main place of injury is the impact zone.

Problems in this area arise due to the implementation of insufficiently perfect passports for drilling and blasting, in which the roof of the workings is severely disturbed, and tightening parameters, which often do not ensure the regulated lag of the fastener from the chuckhole. Also due to the use of imperfect and inefficient tools for frilling the rock, untimely and poor-quality frilling of the part of the excavation, lack of protective (precautionary) fastening in the area near the excavation.

A number of measures are proposed to reduce injuries from falling pieces of ore, in particular:

- place the mouths of the contouring upper holes at a distance of 0,5-0,7 m from the edge of the fastening when drilling with manual perforators, i.e. contour the workings with inclined holes so that they cross the design contour of the workings at the end of the hole;

- when drilling workings with a cross-sectional area of more than 12 m^2, use drilling carriages;

- in cracked, unstable ores, use hinged fasteners that move, and in ores of medium strength, with a regulated fastening lag of less than 3 m, use pulls of differentiated length;

- projects of cutting and cleaning works must provide that those parts of the roof or sides of the workings, which are temporarily not supported by fasteners, are minimal in size and remain without fasteners for a minimum period of time.

Another cause of injuries is due to a technological problem, such as uneven crushing of the ore massif, which during the release of ore causes the formation of hanging pieces of ore in the output workings, during the elimination of which miners may be injured.

The solution to this problem can be to change the parameters of the workings in the bottom of the block, in particular, to increase the diameter of the outlet funnels, but this, in turn, reduces the stability of the bottom of the block.

The use of vibratory mechanisms during workings can increase the intensity of ore production and reduce the number of suspended pieces of rock, however, the presence of workers at the workplaces of vibratory installations in the area of influence of the ore mass flow is an additional source of injury to working personnel.

In order to prevent injuries from falling pieces during the release and delivery of ore, it is necessary to:

- carry out reflection of the ore massif in heterogeneous environments, which ensures its good crushing, and leads to a reduction of ore suspensions;

- use the optimal cross-sectional areas of the bottom workings and the optimal distances between them, selected from the condition of touching the ellipsoids, as they ensure the stability of the workings, the minimum number of ore suspensions and safer conditions for their elimination;

- use effective types of fastening of the connection of workings and delivery products, which ensure their stability;

- to increase the stability of hozorts, use an aimless scheme of cutting blocks;

- when delivering ore by self-propelled equipment, use a two-sided end discharge with a slope height of ore in the workings of no more than 2,5 m;

- in the case of scraper delivery, in order to reduce the number of ore suspensions and make their elimination safer, it is advisable to abandon funnels, replacing them with funnels with a bell up to 1,5 m high and up to 3 m in diameter.

The implementation of these and other measures will reduce the level of injuries during underground mining of iron ore raw materials in Kryvbas.

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APPLICATION OF SATELLITE 3D GRADE CONTROL SYSTEM FOR MAINTANANCE OF MINE HAUL ROADS

Purpose. Mining haul road conditions has a significant impact on efficiency of mining transportation processes. Haul road grade and rolling resistance are one of the main indicators effecting fuel consumption of mining haul trucks and has direct effect on carbon emission level from mining operation.

Heady motor graders are widely used in mine haul road construction and maintenance. Luck of experienced operators for machines for mining operations are well know problem. Thus, purpose of the work is to increase quality and efficiency of motor grader operation by integrating modern satellite technology for grade control and optimal haul road design by modern software solution.

Methodology. This article contains the original results of experimental application of automatic 3D grade control system based on satellite technology for motor graders installed on Caterpillar 16M in conditions of Bogatyr coal mine in Republic of Kazakhstan. Haul road section was designed by modern road modeling software.

Finding. The result shows the effectiveness of satellite 3D technology for mining haul road construction and maintenance. Automatic grade control significantly reduces workload to motor grader operator and increase productivity and accuracy of road maintenance process.

Originality. The first time the satellite 3D technology was used in mining haul road maintenance of heavy motor grader. Road design was done by modern software usually used for highway design.

Practical value. Growing mining industry worldwide must focus on efficiency of its processes in order to meet requirements to reduce carbon emissions and be competitive on the market. This study proves that use of modern digital satellite technologies can help to improve mining haul road conditions that will contribute to significant decrease in transportation costs in mining operations.

Keywords: mine haul roads, motor grader operation, mining dump truck, satellite 3D technology, automatic machine control, rolling resistance, mine haul road grade.

Introduction. Proper layout and geometry are essential for effective way of transportation of mining material. Mining haul roads should be able to support heavy truck loads, should have environmentally friendly riding surface and an appropriate level of maintenance to counteract wear and tear [1]. Modern mining industry is moving toward automatic machine control, autonomous driving, autonomous trucks can significantly improve safety, productivity, and lower cost per ton moved through safe and efficient driving. There are many constraints to be considered to design feasible trajectory for mining trucks due to the rough terrain in open-pit mines [2]. Modern software solutions created by Trimble Business Center can help to design accurate 3D models of roads. It helps to make optimal decisions, decrease costly mistakes, and increase efficiency on the job site. One of the main benefits are reduction of drive time and safety. Technology includes data management between Trimble site positioning system and Trimble machine control technology [3]. Research on a trajectory following algorithm for pure pursuit method to control an autonomous grader are going on [4].

Site study methodology. Study held in Bogatyr coal mine on 6 July 2022. Digital 3D road project was created by Trimble business center software. Trimble machine control equipment was installed to Caterpillar 16M motor grader. System automatically controls height and angle of motor grader blade as per 3D project. Trimble automatic machine control system continuously analyses data from GNSS receivers, calculates deviations from target positions and reposition blade position. Positioning set includes GPS base station and GPS rover, Fig. 1. Keep the optimal grade and rolling resistance is primary target for many mining operations. Payload and Road condition are the main factors effecting to fuel consumption of mining haul trucks [5].

Fig. 1. Machine grade control equipment installed on Caterpillar 16M on Bogatyr coal mine

Results. Study showed significant grading accuracy 2-3 centimeters in compare with manual grading on 5-10 centimeters. Productivity of motor grader increased due to 50-60% less passes was required. Onboard vital information management system (VIMS) of Caterpillar 785C mining haul truck showed road quality index improvement from 8 to 5 which is on acceptable level to efficiently operate 140 tones payload truck. Fig. 2 shows VIMS recoding, where we can observe reductions of diagonal (RACK) and side (PITCH, BIAS) strains before and after automatic machine control application.

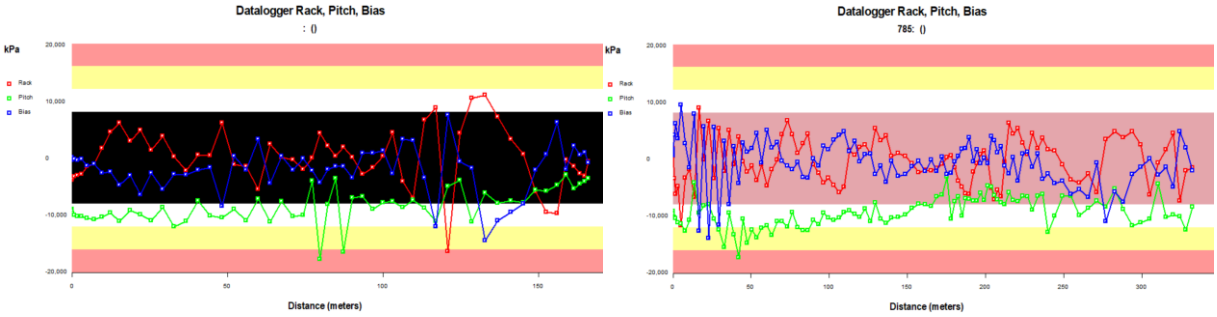

Fig. 2. CAT 785C truck VIMS recording a-before and b-after automatic machine control application on section of the haul road: *a* – before; *b* - after

Conclusion

Automatic machine control and autonomous drive technologies are strategically important direction for mining companies. Application of modern haul road design software and machine control technologies significantly increase efficiency motor grader operations on mining sites.

Study on Bogatyr mine site showed 200-300% grading accuracy which will affect positive to rolling resistance parameters and therefore fuel consumption and carbon emission.

More accurate grading also affects positively to production of haul truck's fleet and repair and operation costs.

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ESTABLISHMENT OF FACTORS OF INFLUENCE ON THE STRENGTH OF ROCK MOUNT

The rocks that make up the rocky massif are characterized primarily by strength. However, due to the presence of various violations of the array of rocks, its overall strength is usually less than the individual components of this array (pieces or structural block) [1]. Natural and laboratory tests are used to determine the strength properties of rocks. In field tests, the strength of the rock is established directly from the rock mass. This method is the most accurate and reliable for obtaining the physical and mechanical properties of the breed, but is characterized by high complexity due to the use of large equipment and test duration.

Laboratory research methods are less expensive, more convenient, affordable and relatively reliable. However, when the studied rock mountain massif consists of separate structural blocks, the reliability of laboratory methods is significantly reduced due to the manifestation of the large-scale effect and disregard for the impact of the structural structure of the massif [2]. Therefore, to adjust the mechanical properties of rocks, certain coefficients are used, which take into account the decrease in the strength of inhomogeneous fractured rock mass.

To obtain the actual strength of the rock mass through the strength of rocks in the sample, for use in further calculations, enter the coefficient of structural weakening of the massif K_s [3], which is characterized by the ratio of the strength of rocks σ_m of the array for uniaxial compression to the strength of rocks in the sample σ_{zp}.

According to the normative and reference literature, the coefficient of structural weakening of the massif K_s is recommended to be determined according to the data of the quantitative analysis of the disturbance of the rock massif by natural cracks. It is necessary to take into account engineering and geological studies to determine the average distance between the weakening surfaces of rocks, i.e. the distances between cracks.

However to determine the numerical value of the coefficient of structural weakening of K_s only on the basis of cracks in the rock mass is insufficient. According to numerous scientific studies, the difference in rock strength in the sample and the ancestral massif is determined not only by the coefficient or fracture of the massif, but also by other natural and technological factors.

Let's analyze the main factors influencing the strength of the rock fracture. As noted earlier, one of the determining factors is the influence of the relative fracture intensity, which is characterized

by the ratio of the size of the mountain mass to be deformed to the average size of the individual structural block of which this massif consists.

Next in importance to the impact on the strength of the massif is the factor of diversity of rocks, which consists of the rock massif [4].

In a rock massif there are almost always separate structural blocks of increased or decreased strength compared to the average strength of the massif. They significantly affect the strength characteristics of the array in its individual sections.

Scientists also note that the strength of the rock mass is influenced by the shape of the structural blocks, namely the angles of slope of the blocks [5]. Depending on the value of the slope angle of the structural blocks and the direction of the possible action of the load on the mountains, its strength can vary significantly. In fact, the angles of slope of the structural blocks are set by the direction of propagation of the main systems of natural cracks.

The strength of the rock mass, in addition, may depend on the ratio of the linear dimensions of the structural blocks [6]. Thus, at the ratio $b/a<1$ (where a is the horizontal size of the structural block, b is the vertical size of the block relative to the stratification of rocks) there is a slight strengthening of the rock compared to the massif, which adheres to the block size ratio $b/a=1$.

At $b/a>1$, on the contrary, there is a decrease in the strength of the rock compared to the massif, which has a ratio of $b/a=1$ under all other conditions being equal.

The average size of individual structural blocks is determined in kind in the bare areas of rocks, usually on the ledges or sides of quarries. According to the researchers, at $H/b>10$-15 (where H is the total height of the massif), the non-isometric factor can be ignored, because it then has almost no effect on the overall strength of the rocky massif.

One of the factors that can affect the overall strength of a structurally inhomogeneous rock mass is the presence in the array of oblique cracks, which intersect the main systems of natural cracks at an angle of 40-45° and divide the structural unit of a certain strength into at least two parts [7]. In this case, the strength of the rock decreases depending on the number of such cracks and the direction of their propagation.

Scientists also note that the strength of the massif is influenced by the relative position, relative to each other, of individual structural blocks in adjacent layers of the mountain massif. However, if there are more than three systems of cracks in the array, this factor can be ignored.

In addition, the strength of the rock mass is significantly affected by the initial direction of the main stress under external load. This factor takes into account the change in the shear resistance of the array on the slope of the board or ledge.

In [8] it was noted that the influence of the degree and quality of filling natural cracks with natural materials on the strength of the mountain mass should also be taken into account, as its characteristics can be decisive in determining the coefficients of structural weakening.

In [9, 10] the analysis of methods for determining the coefficient of structural weakening of the rock mass is given, which shows that the above factors influencing the strength of rock inhomogeneous rock mass are partially taken into account when determining the coefficient of structural weakening.

Almost all formulas for determining K_s are based on the fracture modulus of the rock mass and only a few take into account the angle of incidence of natural cracks, the minimum size of the structural block in the rock massif and rock diversity. Comprehensive consideration of all the above factors influencing the strength of the mountain massif has not been identified. This can be explained by the complexity and diversity of these factors.

Thus, despite the knowledge of most of the factors that affect the strength of the mountain range, to establish their actual role and numerical value is quite difficult.

Therefore, the question of determining the real value of the coefficient of structural weakening of the array remains relevant and requires further study.

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THE PROBLEMS OFTEN HAPPENING AT THE FULLY MECHANIZED LONGWALL IN QUANG NINH PROVINCE AND METHODS OF SURMOUNTING

After analyzing current state and exploitation process of some of the fully mechanized longwall in Quang Ninh province, as well as analyzing the geological conditions, the paper has synthesized and analyzed some of the problems often happening at the fully mechanized longwall. At the same

time, mention the shortcomings of existing fully mechanized longwalls are applying at some mines in the Quang Ninh. As a result, the paper proposes appropriate for technical and technological solutions to surmount the problems often happen at the fully mechanized longwall. These technical and technological solutions after application in practice has achieved good results. They are effective in the problems surmounting with specific geological conditions. The faces can be exploited safety, from there, to formulate important technical and technological methods to surmount the problems at the fully mechanized longwall in Quang Ninh province.

Currently, there are many fully mechanized mining longwalls being exploited in a number of coal mines in Quang Ninh coalfield [1]. During the exploitation process, the initial assessment shows that these longwalls have brought remarkable results. However, these longwalls also often have problems due to many different reasons, when an incident occurs in the longwall, it will interrupt the production cycle of the longwall, reduce labor productivity and reduce efficiency, as well as the safety problem in the longwall oven is threatened [2-5]. In order to continuously operate the fully mechanized mining longwall and bring efficiency in the use and operation of synchronous equipment, problems need to be handled quickly and promptly.

In the fully mechanized mining longwall, due to the operation of many machinery and equipment, in addition to the changing and complicated geological conditions of the longwall, so incidents may occur. Among the incidents at this longwall, the most common incidents are such as: the phenomenon of face spall and roof falling; the phenomenon of subsidence of support and the phenomenon of the shearer plugged into the floor [6-8]. Before proposing solutions to handle the problem, it is necessary to clearly analyze the cause, on that basis, select the right and timely solution to ensure the safety of the longwall. Through analyzing the characteristics of the mechanized longwalls being exploited in some underground mines in Quang Ninh, the article also analyzes the causes of the incidents in each longwall, thereby synthesizing some effective solution that is being used to handle this problem. Through testing for a number of malfunctioning longwalls, each solution is effective, contributing to improving safety and efficiency when exploiting the fully mechanized longwall [9].

*** Incidents in the fully mechanized mining longwall in Quang Ninh coalfield**

+ The phenomenon of face spall and roof falling in the longwall [9].

This is the most common problem in the fully mechanized longwall today. The face spall is the phenomenon of coal being separated from the original coal seam and overflowing into the space of the longwall, which affects the activities in the longwall. When exploiting coal seams with soft, loose, high pressure and unreasonable mining techniques, the phenomenon of face spall will occur more frequently and continuously. When the phenomenon of face spall occurs, the roof loses its support, if it is soft rock, it will tend to fall into the space of the longwall, which can cause impacts

and incidents, this is called the phenomenon of the roof falling of the longwall during the mining process. This phenomenon occurs in a large space, leading to the hollow roof of the longwall, which affects the quality of the support, the shield may be tilted, even the shield will fall and become unsafe for longwall. In the longwall, the process of face spall may occur first, the next by the phenomenon of roof falling. When the longwall operates stably, the phenomenon of face spall and roof falling occurs in turn according to the process of the movement in the direction of the longwall.

+ The phenomenon of subsidence of support in the longwall

The incident occurred because the floor is soft rock, the support has a large load and is under great pressure. At that time, the support was subsided to the floor, it difficult to move the support to the new web, sometimes it can't be done because the support is too deep. This incident occurred at the longwall in coal Seam 7 at Ha Lam Coal Mine, Khe Cham III Coal Mine and Duong Huy Coal Mine.

+ The phenomenon of the shearer plugged into the floor

This incident occurred because the geological conditions of the longwall were too complicated, during the cutting process, there was a fault in the longwall, causing the coal seam to change in lying position, and the control of the shearer was incorrect. This phenomenon occurs at the longwall Nga Hai Coal Mine, Quang Hanh Coal Company.

*** Solutions to prevent face spall and roof falling in the fully mechanized mining longwall in Quang Ninh coalfield**

+ To prevent face spall and roof falling

Using chemicals to reinforce the longwall face [9].

The solution of using chemicals to reinforce the longwall face is one of the most technically effective solutions. In some countries such as China, Poland, Australia, this solution is widely and popularly used to solve the problem of face spall and roof falling, this solution is not only used to handle face spall and roof falling in the longwall, but also used to handle the problem of the roof falling when digging the roadway in the soft coal seam and rock. The essence of the solution is to force-pump chemicals directly into the longwall face through drilled holes, from which chemicals pass through the cracks in the coal mass and bond into a solid block. At the mechanized longwall in the coal area of Quang Ninh, Vietnam, in order to handle the roof and coal with face spall and roof falling, drill rows of holes with a diameter of 42 mm in the section of the longwall need to be reinforced, each hole is drilled from 2.5 m deep, the distance of the holes drilled in the slope direction is 3 m, then the chemical mixture is force-pumped through the drilled holes into the cracks for reinforcement. After each force-pump chemical, the longwall face will be stable for about 5 web cuts, equivalent to 3.15 m (the depth of one web cut at the fully mechanized longwall is 0.63 m). Currently, the chemicals used to reinforce longwall face have many different types and their prices are

also different. The mechanized longwall in Quang Ninh coalfield often uses Chinese chemical DMT-601A/B or some longwalls use Polish chemicals to reinforce.

Using the method of pumping water into the coal seam

One of the effective solutions to handle the phenomenon of face spall is to force-pump water through the drilled holes into the coal mass in the longwall, this is a very effective solution in terms of economy, however, in locations where the phenomenon of the face spall and roof falling are heavy and strong, this solution cannot be handled. The essence of this method is to drill holes (short, medium and long) into the coal seam and use those holes to force-pump water into the coal seam to increase the humidity of the coal until it reaches the limit request. The scientific basis of this method is that when the humidity of coal increases to a certain extent within the limit of unsaturation, it will change the physical and mechanical properties of the coal such as the adhesion force between coal particles increasing, the plasticity of the coal increases, the brittleness of coal decreases, so when forcepump water into the coal seam, it will be effective for maintaining the monolithic nature of coal. Currently, the longwall in Seam 14-5 of Khe Cham III coal mine and the longwall in Seam 7, Seam 11 of Ha Lam are using this solution. The evaluation shows that, if the phenomenon of face spall in the longwalls does not occur too much, this solution is relatively effective.

Conclusions

Analysis of the causes and rules of the phenomenon of face spall when mining at soft coal seams shows that, this phenomenon is mainly due to the effect of self-weight and mine pressure on the coal mass in front of the longwall face, causing the form of cut break and the form of tensile break. Therefore, the study of minimizing the influence of mine pressure or changing the mechanical properties of the coal mass in front of the longwall face are the two main research to reduce the incident of face spall and roof falling. The force-pump of water, the force-pump of reinforcing chemicals into the coal seam are two of the effective solutions to prevent face spall because water and reinforcing chemicals can increase the cohesion and reduce the brittleness of the coal mass, so it improves the stability of the coal seam. The above solutions are applied to the actual fully mechanized longwalls in Quang Ninh, Vietnam. Applicable results have also affirmed that force-pump of water and the forcepump of chemical solutions reinforced on coal seams meet the requirements of the ability to prevent face spall and roof falling. In addition, the application of these solutions also contributes to improving mining output and labor productivity and improving working conditions in the longwall. In exploitation, the problem of increasing the linkage of coal mass is mainly done by force-pump chemical methods and recently the force-pump water method. In these methods, the method of force-pump water into coal seams to increase the coal's association although effective is not high with force-pump chemical, but it has many advantages such as simple construction work, can be used available equipment and supplies of mine for implementation, low cost, can contribute

to improving working environmental conditions. For longwalls with mirror surroundings, rendering large, frequent, frequent occurrence, solutions of the force-pump water into coal seams is not effective, the method of the force-pump of chemical must be applied in order to ensure safety for longwall, although the cost of this method is relatively high for the conditions of underground mines in Vietnam today. Combined solutions such as increasing the speed of moving the shear, the longwalls are supported promptly, force-pump water and force-pump chemical reinforcing into coal seams are also applied in mechanized longwall to increase the effect of preventing the phenomenon of face spall and roof falling.

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ANALYSIS OF TECHNOLOGICAL PARAMETERS OF HYDROMECHANICAL AMBER MINING

Today, amber mining requires the latest technologies and the improvement of technical and technological means to intensify the production process, which achieves higher productivity and efficiency, as well as reducing the negative environmental impact on the environment. The most rational is the implementation of a hydromechanical method of amber extraction, which does not require expensive geological exploration and reclamation works. It is characterized by minimal capital and operational costs and has the prospect of improvement by controlling the speed of amber floating from sand deposits by changing the airflow and the frequency of oscillation of the working body. When applying the hydromechanical method, there is an effect of mechanical vibrations of the working body and saturation of the sand massif with water and air.

The movement of particles of loose material in the field of action of forces similar to those acting during hydromechanical mining was considered by a number of Ukrainian and foreign scientists when solving the problems of movement, mixing, segregation and separation, as well as during the intensification of chemical and thermal processes [1-4].

The movement of amber in a sand massif is characterized by movement with resistance of the dry friction type. The movement of a particle placed in a medium that carries out horizontal translational oscillations with frequency f and radius of the trajectory r and offers a resistance to the particle similar to dry friction. The relevant task was considered by V.V. Hortynskyi, G.E. Ptushkina and I.I. Blekhman [1]. Let's consider the main results of their solution from the point of view of hydromechanical extraction of amber. A system of differential equations of motion of the particle relative to the medium was considered to determine the speed of amber floating. This made it possible to propose the following dependence for determining the speed of amber floating

$$v = \frac{a^2}{\sqrt{\left(\frac{F}{gm}\right)^2 - a^2}} \frac{a}{k_m}, \quad \alpha = \begin{cases} Af, & A^2 f < kg \\ \dfrac{kg}{f} & A^2 f > kg \end{cases}, \quad a = p\text{-}1, \quad \rho = \frac{\rho_c}{\rho_s}, \tag{1}$$

where v - the speed of amber particle floating, m/s; m - weight of a particle of amber, kg; a - the Archimedean parameter for a particle of amber; g - acceleration of free fall m/s^2; k_m - attached mass coefficient; f - frequency of oscillations of the working body, Hz; F - the resistance of the sand layer to the relative movement of the amber particle [1]; ρ_s - amber particle density, kg/m^3; ρ_c - density of water-sand medium, kg/m^3; A - amplitude of oscillations of the working body, m; k - coefficient of friction.

The formula was obtained for the case of the floating of a particle of lower density in a layer of particles of a heavier material when the working body oscillates in the plane of the containing medium. In this case, we assume that in addition to the forces of inertia, Archimedes and gravity, only the forces of resistance to relative motion act on the particle, and the trajectory of the particle's movement is a spiral.

Taking into account the size and nature of the force affecting the particle, and the fact that it characterizes the interaction between the amber particle and the particles of the soil skeleton, the following option is proposed for determining the magnitude of this force

$$\frac{F}{gm} = \phi\left(1 + a\right), \tag{2}$$

where ϕ - the coefficient of resistance of the sand medium to the movement of the amber particle.

To determine the value of the coefficient ϕ, we will use the results of experimental studies on the floating of amber particles in laboratory and field conditions.

It follows from the above that the force that prevents amber from floating in a fluid medium under the influence of vibration and air supply depends on the properties of the medium and the

parameters of the hydromechanical effect. The obtained expression for determining this force allows efficient extraction of amber, with the least expenditure of resources and energy open-pit.

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FORECASTING OF THE ROCK MASSIF DANGEROUS STATE BASED ON THE CONTROL OF RADON DECAY PRODUCTS

Content of methane gas and radon aerosols in mine roadways is determined primarily by geomechanical processes in the rock mass, since its stress-strain state affects the permeability of rocks and filtration of gases from their sources to the exposed surfaces [4]. Volumetric activity of radon and concentration of radioactive aerosols in the mine roadways are uneven. Therefore, monitoring of variations concentrations of methane and radon decay products in space and time at the constancy of natural sources of their supply makes it possible to track changes in geomechanical and gasdynamic processes occurred in the rock massif along the whole length of the mine roadways. The conditions for filtration of methane gas and radioactive radon aerosols through the rock cracks, as well as changes in their physical parameters in the atmosphere of mine roadways, can be indicators of sudden rock falls, outbursts and gas pollution.

Radon produces α-emitters, which are solid substances in the form of unstable isotopes of polonium, lead and bismuth and the most promising informative parameters for operational control in mine roadways. On the basis of a complex of experimental studies carried out in the mine roadways of the m_3 coal seam [1,2], we established a number of physical features of emission of radon decay products together with methane gas into the atmosphere of mine roadways, as well as a relationship between the emission and formation of cracks and dynamic manifestations of rock pressure.

The forecast of gas-dynamic manifestations of rock pressure and reduction of risk of the mine roadway destruction is based on stable relationships between the stress-strain state of rocks and the filtration of methane gas and radon decay products into mine roadways. The task to control parameters of the rock massif stress-strain state is settled by measuring and estimating intensity of deviations from the average value of the gas methane concentration and the normalized equivalent equilibrium volumetric activity of radon decay products in the gas-air environment of the preparatory roadway.

The technology of forecasting danger destruction of a mine roadway due to a sudden gas-dynamic phenomenon is as follows:

- concentrations of methane and radon DDP are measured in the nearest zone of possible gas-dynamic manifestation of rock pressure (closer to the face) and in the farthest zone relatively to the point of possible gas-dynamic manifestation (at the beginning of the mine roadway, fig. 1).

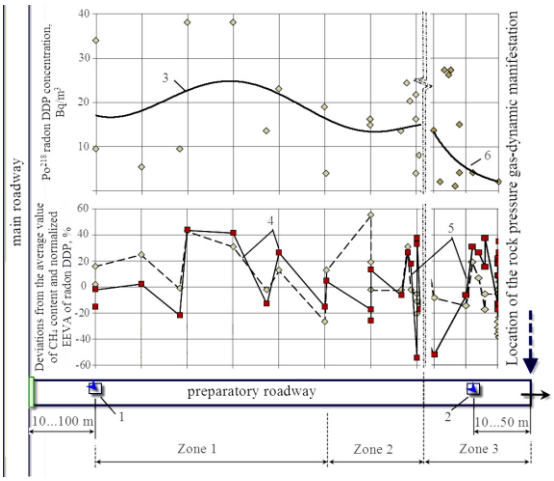

Fig. 1. An example of forecasting a rock massif dangerous state based on radiometric monitoring of indicators of radon decay products: 1,2 - radiometric sensors in the farthest and closest zones, respectively; 3 - average values of DPP of radon Po^{218} ; 4 - interrelated changes of normalized EEVA of radon DDP and methane gas (zone 1); 5 - antiphased and abrupt changes of the normalized EEVA of radon DDP and methane gas (zones 2 and 3) before the gas dynamic manifestation; 6 - decrease in the concentration of DDP of radon Po^{218} before the gas dynamic manifestation:

– deviations from the average value of methane gas (CH_4) content

– deviations from the average value of normalized EEVA of radon DDP

Radiometer RGA-09MSh or a similar device is used for measuring radon equivalent equilibrium volumetric activity;

- at the control points, concentration of methane is assessed simultaneously with radon. According to the ratio of the amount of methane gas to the volume of air, deviations from the average value of the methane content and the normalized values of the EEVA of radon DDP are corrected;

- a marked decrease in the concentration of radon DDP will be observed near the working area, where conditions with a potentially dangerous state of the rock massif can be formed. This process is typical for distances up to 100 m from epicenter of the upcoming gas-dynamic manifestation of rock pressure. The Po^{218} radionuclides are the radon decay products the most sensitive to changes of stress-strain state in the mine roadway contour zone. This is due to the effect of permeability reduce of the zone closest to the contour of the roadway, when pressure on the rock massif increases sharply briefly reducing the release of inert gas before a sudden outburst of rocks;

- further, dynamics of changes of methane gas content, normalized EEVA of radon DDPs and their deviations from the average value along the length of the mine roadway are analyzed. Dynamics of indicators changing differs depending on the stress-strain state of the rock massif. Areas in the working areas

where indicators changing is synchronous (zones 1 and 4, fig. 1), and where - antiphased (zones 2 and 3, fig. 1) are identified;

- then, the farthest zone of the mine roadway at distances of 300-3000 m from the possible potentially dangerous zone of the rock massif, where the change in the concentration of radon DDP is significantly different, is analyzed. In this zone, it is not a decrease that precedes, but a sharp increase (by 8-10 times) in the concentration of radon DDP in the mine roadway. The gas-dynamic manifestation of rock pressure will most likely occur after passing the maximum radon concentration.

According to the diagrams (fig. 1), comparison of methane emission and the normalized EEVA of the radon DDP indicates the following:

- synchronous changes in the intensities of gas emission indicate safe changes in the stress-strain state of the rock massif;

- abrupt, antiphased or chaotically abrupt changes in gas emissions indicate a potential danger associated with dynamic manifestations of rock pressure;

- decrease of concentration of radon Po^{218} DDP below 5% indicates the readiness of the rock mass for dynamic manifestations of rock pressure (closure of cracks in areas of high rock pressure before a sudden outburst of rocks and gas).

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ON THE QUESTION OF THE ENERGY SECURITY STRATEGY AND THE ROLE OF COAL IN IT

For more than 100 years, the standard of living in Western countries has been growing rapidly, especially after the Second World War. Modern comfort is connected to a large extent with the wide use of electric energy and the development of energy technology. Several generations can no longer imagine their existence without the usual things powered by energy networks. Lighting, transport, communication, water supply, Internet, air conditioners, heating, etc. - everything needs electricity.

Unfortunately, renewable sources of electricity generation cannot yet fully meet the growing demand for it. Modern technological solutions for the use of alternative sources, although rapidly developing, still cannot exist separately from energy networks formed by traditional (non-renewable) sources of electricity. Moreover, the popularity in the mass media of the ideas of abandoning the production of electricity using fossil raw materials in favor of alternative sources greatly harms the development of coal, nuclear and similar energy technologies, which interferes with the efficient functioning of energy systems as a whole and endangers the energy security of developed countries.

Now, in connection with the war unleashed by the Russian Federation in Ukraine, the energy sector has become the object of foreign political pressure. Dependence on the import of energy sources endangers the energy security and standard of living of a number of European countries, which affects their internal and external policies. It is obvious that power system components may become targets of terrorist attacks in the future.

In this regard, diversification of the sources of obtaining electrical energy is necessary. Ukraine is a vivid example of an efficient energy system. Despite a number of shortcomings [1], during active hostilities under conditions of occupation of part of the territory and constant targeted shelling of power system facilities, Ukrainian electricity was exported to European countries until the massive missile strike on October 10, not to mention providing its citizens with electricity and quick liquidation of the consequences of terrorist attacks.

More than half of the capacity of the Ukrainian energy system is accounted for by nuclear power plants: Zaporizhzhya NPP, South Ukrainian NPP, Rivne NPP and Khmelnytsky NPP. In second place in terms of the amount of electricity generated are thermal power plants that use mainly coal. The least amount of electricity is produced at power plants with renewable sources. These are traditional for Ukraine hydroelectric power plants and newly built wind and solar power plants located in the south of Ukraine.

Of all the above, nuclear power plants are the most effective. However, in many parts of Europe, civil nuclear energy is either prohibited by law or its capacity is significantly reduced. The decisive reason for this is the threat of nuclear radioactive contamination. Thermal power plants are less powerful than nuclear ones, but their large number makes it possible to rapidly reconfigure power systems when one plant fails. They can use coal, liquid fuel and natural gas. Liquid fuel and natural gas produce less harmful emissions than coal. However, their delivery is carried out by pipes of high throughput, which may be the objects of terrorist attacks in the future.

In this regard, the relevance of the use of coal-fired power plants is still there, although it is decreasing. The world's explored coal reserves will last for several generations. Coal deposits are widespread in many countries [2]. In addition, coal can be converted into both liquid fuel and gas

[3]. It is also possible to improve its energy characteristics [4]. Coal ash can become a source of obtaining strategically important substances, for example, aluminum [5]. In boilers, together with coal, organic waste or biofuel can be combusted in a certain proportion [6, 7]. The air-pulverized coal mixture can be used in metallurgy [8].

Unlike gas-fired power plants, for coal-fired power plants it is not necessary to build additional gas storage facilities and pipes for delivery – coal most of the time lies underground and in warehouses, and its delivery is ensured by rail transport.

Thus, it is clear from the experience of the functioning of the energy system of Ukraine that the relevance of coal-fired power generation is still quite high, in particular as a strategic reserve for maintaining the main power generation capacity in emergency situations. Further development of coal-fired power generation should be aimed at reducing damage to the environment, in particular, reducing emissions of toxic gases and carbon dioxide, increasing the efficiency of power plants, comprehensive use of coal raw materials and its mineral part.

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THE DEPENDENCE OF THE CONCLUSION OF MINERAL BODIES ON THE TECHNOLOGY OF UNDERGROUND STONE EXTRACTION

One of the gold-multimetallic deposits of Armenia is characterized by the average stability of ore and enclosing rocks, the tendency of ore durability, the steep angles of decline of mineral bodies, the extremely uneven distribution of mineralization, favorable hydrogeological conditions, the small capacities of mineral bodies or their separate parts (from thin to medium capacity) and with indistinct contacts of the ore with the enclosing rocks.

In the latter case, in order to determine the capacity of industrial importance of the mineral body, it is necessary to determine the borderline content of conventional gold in the edge sample (group of samples) $-\alpha_d^{Au}$.

The following technically applicable technologies of underground ore extraction are distinguished in the geological and technical conditions of the deposit under consideration [1]:

- the processing system of ore with sub-floor removal and subsequent dry bulk filling of the mining area,

- the processing system with horizontal layers and filling with a solidifying filler.

The natural density of conventional gold border content in the case of using the i-th processing system (α_d^{Au}, g/t) is determined by the following formula

$$\alpha_d^{Au} = D_{di}^{Au} / \left(P_C^{Au} \varepsilon^{Au}\right)$$

where *D* is the monetary output of the conditional marginal gold exchange expressed in incremental costs, in the case of the i-th processing system, $ US/t, P_C^{Au}: the price of 1 g of gold in the concentrate, P_C^{Au}=55 USD/g, ε^{Au}: the recovery of gold concentrate, ε^{Au}=0,75, part of the unit.

In the case of the i-th processing system, the monetary contribution of the conditional gold marginal product determined by incremental cost, is the result of 1 *t* of the mining stone. The total cost of mining and renovation and the passive part of the basic funds, the technical allocations. The difference between capital and preparatory cutting drilling costs [2].

According to technical and economic calculations, it was decided that:

In case of application of the 1st processing system: P_{C1}^{Au}=37,07 USD/t,

- In case of application of the 2nd processing system: P_{C2}^{Au} = 47,29 USD/t.

Placing the numerical values of the specified quantities in the aforementioned formula, we will obtain:

- in case of applying the 1st processing system: α_{d1}^{Au}=37,07/(55×0.75)=0,90 g/t,

- in case of appliying the 2nd processing system: α_{d2}^{Au}=47.29/(55×0,75)=1,15 g/t.

The Figure below shows the demarcation diagram of a certain interval according to capacity in the direction of the spread of the mineral body of the mine on the presented sampling plan.

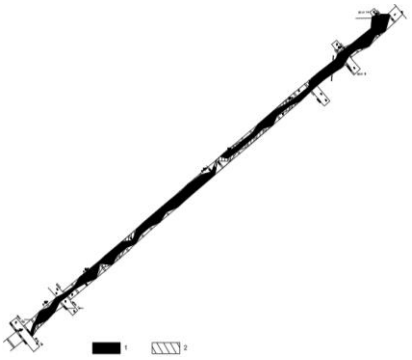

Fig. 1. Ore body interval delineation diagram: *1* - conventional gold content ≥1,2 g/t; *2* -conventional gold content ≥0,9 g/t

As a result of the calculation, it was determined that:

- in case of applying the 1st processing system, when the conventional gold boundary content is 0,9 g/t, the area of the mineral body interval is equal to 184 m^2 with an average conventional gold content of 11,7 g/t,

- In case of applying of the 2nd processing system, when the border content of conventional gold is 1,2 g/t, the area of the interval of the mineral body is equal to 160,6 m^2 with an average content of conventional gold of 13,1 g/t.

Summarizing the above statement, it can be concluded that, unlike the expensive ore mining technology (the 2nd processing system), the cheap ore mining technology (the 1st processing system) provides relatively large reserves of ore in the subsoil with a low content of the useful component. Therefore, there is a problem of choosing the best - the optimal among the compared technologies of underground extraction of ore from the subsoil, which is a matter of separate discussion.

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A PROMISING METHOD FOR INCREASING THE STABILITY OF HANGING WALL ROCKS DURING UNDERGROUND MINING OF HIGH-GRADE IRON ORES

Today, about 15 million tons of raw iron ore is mined by underground method at 9 mines, 8 of which are located in the Kryvyi Rih Iron Ore Basin, and 1 mine is in the Belozerskyi iron ore region [1-3]. Sufficiently high-quality iron ores with an iron content of 59-67% are mined by the underground method. The most powerful, modern and efficient enterprise is PJSC Zaporizhzhia Iron Ore Plant, which develops high-grade iron ores of the Bilozerskyi field with an iron content of 60-67% using highly efficient environmental technology with uncemented rockfilling [4,5]. The share of the plant in the underground mining of Ukraine is 25-30%. Mining companies are constantly concerned about maintaining the mined ore quality, since the market prices for iron ore are set depending on the content of iron in it. Moreover, successful export requires maintaining quality characteristics in order to remain competitive. A significant decline in the quality of ores may lead to the need to introduce a cycle of their beneficiation, which will significantly affect the cost of mining in the future [6,7].

When mining ore reserves in the depth range of 640-940 m, a significant problem arises at the enterprise in the stability of the hanging wall rocks, as a result of which, during the mining of the stope chambers that are in contact with the hanging wall rocks, there are cases of rock caving into their mined-out space [8,9]. This leads to the following negative phenomena: a decrease in the iron content in the mined ore and a decrease in its quality; increase in the volume of cavities in the stope

chamber to be filled with a backfill mixture and, as a consequence, attracting additional costs; threats to the safety of workers, which is associated with the proximity of cavings to the hanging wall drifts, along which people, equipment and materials move. Therefore, a very relevant scientific and technical task for the conditions of the enterprise is the development of effective technical measures to strengthen and, accordingly, increase the stability of the hanging wall rocks, in contact with which iron ore is mined by primary stopes.

As a promising direction for increasing the stability of the hanging wall rocks, their fastening with rope bolts is studied. Fastening of rocks with rope bolts for the conditions of Ukrainian iron ore mines is a new direction that has not yet been thoroughly studied. The authors have previously studied the effectiveness of fastening rocks with rope bolts. To achieve the objectives set, an integrated approach is used, including the analysis of mining documentation based on geological data and rockfalls, as well as a numerical modeling in the Solid Works software.

It has been determined that the main reason for the decline in the quality of iron ore mined from the primary stopes in the conditions of the field is the low stability of the host rocks, which leads to their caving and entry into the stope chambers, as well as their mixing with broken ore.

A methodology has been developed for determining instability zones in the hanging wall rock mass, which contains and is performed in 2 stages: an algorithm for analytical studies on the variability of the field geological structure along the strike of ore deposit; an algorithm for analytical studies on instability zones in the hanging wall rocks and their relationship with the geological structure.

Tendencies of changes in the intensity of hanging wall rockfall formations, depending on the morphological composition of rocks, their strength, incidence angle and horizontal thickness of the ore deposit, have been revealed. The instability zone length along the strike of the ore deposit reaches 600 m. Further, numerical modeling is performed specifically for the stope chambers in the instability zone of the hanging wall rocks.

A computer model has been developed and substantiated for calculating the stress state of the geomechanical system around the stope chamber in contact with the hanging wall rocks, fastened with rope bolts. The stope chamber is modeled, which is in contact with unstable rocks of the hanging wall in the 740-840, 840-940, and 940-1040 m levels, both with and without fastening with rope bolts. It is preliminarily determined that the rock instability zone is located in the rocks of the first sublevel. For example, for the stope chamber of the 740-840 m level, this is a depth range of 740-775 m. When modeling, it is assumed that the hanging wall rocks are fastened from the side of the drift on the 740 m horizon in the direction of the stope chamber with the following parameters: the quantity of rope bolts is 5; drilling angle between the rope bolts is 9 degrees; the length of the rope bolts is 17 m; the first ropebolt incidence angle to the horizontal is 50 degrees.

It has been determined that with rope bolt fastening, tensile stresses in the hanging wall rocks are significantly reduced (by 50-60%), compared to the absence of rope bolting, and change according to the 2nd order polynomial dependences in the direction from the contour deep into the mass. The formation of rockfalls into the mined-out space of the stope chamber is practically unpredictable and is within the design level. Only in the 940-m level, insignificant rockfalls deep into the mass by 3-5 m are possible.

The analysis of the preliminary numerical modeling has confirmed the effectiveness of fastening the unstable hanging wall rocks with rope bolts. Further research should be aimed at substantiating specific technological parameters by numerical modeling in a three-dimensional formulation of the problem (rock mass per a width of the stope chamber): the quantity of rope bolts in a row, the angle of setting the rope bolts, the step of setting the rope bolts in the hanging wall drift per a width of the stope chamber.

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NATURAL OILS AS LUBRICANT ADDITIVES FOR TREATMENT OF DRILLING MUD AND TECHNOLOGICAL FLUIDS

In recent years, besides to traditional lubricant additives for drilling mud and process fluids, lubricant additives based on environmentally friendly products of natural and animal origin, as well as by-products of oil production, which are based on carboxylic acids, have become widespread.

Oil, from the point of chemistry view, is a complex of esters chemical mixture of fatty acids and triatomic alcohol glycerol and various non-fatty substances: phosphatides, vitamins, waxes, enzymes, protein substances, essential oils, dyes, etc. The basis of oils are fatty acids and glycerin (97-98%), all other substances are included in their composition in small quantities. The properties of oils depend on their fatty acid composition. The most common are liquid oils containing about 80-90% unsaturated acids. Animal fats are chemically similar to oils, but their content of unsaturated acids is much lower, so they are characterized by a relatively high melting point [1].

Research has established sufficiently high tribological properties of natural oils due to the fast interaction with metals, high lubricating capacity, corrosion protection, neutral relation to seals. The main disadvantages of oils include intensive thickening when the temperature drops 15 °C below minus (full crystallization at 280 °C minus), relatively fast aging during operation, as well as the tendency to hydrolysis under the influence of water. To combat the mentioned shortcomings, the tasks of creating additives with appropriate properties are being formed [2].

Nowadays, during the lubricating additives testing, specialists take into account the shear coefficient of the filter cake thickness. This is a value that characterizes the strength of the cake thickness filter and is determined by the ratio of the force required for the tangential displacement of the ring load along the cake thickness to its weight and the coefficient of friction of the filter cake thickness. It is a value that indirectly characterizes the lubricating properties of the drilling mud [3].

The coefficient of friction is the main criterion for evaluating the lubricating properties of additives, the decrease of which characterizes their effectiveness. In addition to the value of the coefficient of friction, the value of filtration of the solution, pH and rheological properties were also taken into account. The density and conditional viscosity of the solution did not change significantly.

Testing was carried out on the KTK-2 device and using the OFI Testing Equipment (OFITE) limit pressure and lubricity tester in accordance with the API standard. The latter, in accordance with the American Petroleum Institute standard, measures the coefficient of friction when the prism is pressed against the ring with a load of 1,03 MPa (150 pound /inch^2) and a shaft rotation frequency of 60 min^{-1}. The lubricating properties of castor, hemp, rapeseed, soybean, mustard, sunflower and corn oils were studied. Separately, each type of oil in concentrations of 0,5%, 1% and 3% was added to samples of fresh, mineralized and salt-saturated solutions. The purpose of the work was to determine the prospects of using vegetable oil as a lubricating additive on the basis of laboratory studies.

The results showed that even minor additions (as little as 0,5%) of some oils to the specified solution samples significantly improve the lubricating properties of the solution and the coefficient of the cake thickness friction (CFC). At the same time, the main parameters of the solution do not deteriorate. In some cases, the addition of oil to the solution contributed to the improvement of the

lubricating properties and the coefficient of the cake thickness friction (CFC), but worsened the main parameters of the solution, primarily filtration or fluid loss and rheology.

According to the test results, the lubricating properties of the solution samples and the coefficient of the cake thickness friction are significantly improved: when adding 1% of rapeseed oil to the mineralized and salt-saturated solutions and 3% to the fresh solution; when adding 0,5% of corn oil to fresh and salt-saturated solutions and 3% to mineralized solutions; when adding 0,5% of sunflower oil to the mineralized solution and 1% to the fresh solution; when adding 3% castor oil to the fresh solution and 1% to the mineralized solution; when adding 0,5% soybean oil to mineralized and salt-saturated solutions and 1% to fresh; when adding 0,5% hemp oil to mineralized and saline solutions.

Analyzing the tests results, it was established that, in terms of technological efficiency and price policy, the most acceptable for our conditions are the lubricating additives of sunflower and rapeseed oils. Thus, the addition of 1% rapeseed oil to all types of solutions significantly improves the lubricating properties, which decreases from 0.063 to 0.054, and the coefficient of friction of the cake thickness decreases from 0,20 to 0,13, the filtration of the solution decreases from 11 to 7 cm^3 in 30 min, in conditional viscosity decreases from 27 to 24 s. With the addition of 3% rapeseed oil, satisfactory test results were obtained only for the fresh solution.

The lubricating properties decrease from 0,067 to 0,061, the coefficient of friction of the cake thickness decreases from 0,11 to 0,09, the filtration of the solution does not change, and the conditional viscosity increases slightly.

Additions of 0,5% sunflower oil improve lubricating properties, which decrease from 0,065 to 0.042, and the coefficient of friction of the cake thickness decreases from 0,23 to 0,19, solution filtration decreases from 19 to 15 cm^3 in 30 min, conditional viscosity decreases from 20 up to 19 s for mineralized solution.

Additions of 1% sunflower oil improve lubricating properties, which decreases from 0,036 to 0,033, the coefficient of friction of the cake thickness decreases from 0,08 to 0,07, and filtration and conditional viscosity are unchanged for the fresh solution.

Given that sunflower oil additives showed satisfactory test results only for fresh and mineralized solutions, rapeseed oil was chosen for further research. During the processing of drilling mud, depending on their composition and initial characteristics, the concentration of the additive can be optimal from 1% to 3%.

Further research is aimed at determining the optimal concentration of reagents - defoamers and surface-active substances (PAR), which will be included in the composition of the lubricating additive. After analyzing the main types of these reagents, they selected the PAR-1 reagent and the «PENTOSIL plus» defoamer reagent.

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RESEARCH OF PROCESSES OF BROWN COAL PROCESSING TO INCREASE ITS QUALITY CHARACTERISTICS

Introduction

Lignite, being a solid fuel of a lower rank (degree of coalification), is significantly different in its characteristics from hard coal groups that are widely used in the energy sector of the country. High levels of humidity, release of volatile substances, sulfur content and often ash content prevent the inclusion of lignite in the energy balance of Ukraine. The development of an ecological and energy-efficient technology for the processing of lignite (drying and removal of mineral substances, reduction of sulfur content) with simultaneous coalification allows it to find wide application, potentially reducing the country's dependence on hydrocarbon imports [1].

Scientific novelty of this technology is a combination of thermovacuum drying processes [2], heat treatment [3] using special separation methods [4], which made it possible to develop technological regulations for the enrichment of lignite to obtain fuel with increased quality characteristics. At the same time, in the course of the work, the thermodynamic and kinetic parameters of the thermodestructive effect on the coal substance were determined, in which the maximum preservation of hydrogen and carbon in the coal is observed with the minimum possible loss of them with gaseous and liquid products. The operating parameters of the separation are defined under the condition of minimal losses of carbonaceous matter with an inorganic part with its maximum transition to coal concentrate. The developed lignite processing process is energy-saving with minimal impact on the environment [5].

The main essence of technology consists in carrying out complex studies of intensification of heat exchange processes in energy-saving thermovacuum heat technological installations and with the help of special methods of enrichment in separators with different distribution characteristics;

determination of the scheme and parameters of industrial ecologically clean and energy-saving technology for obtaining high-quality fuel from lignite; conducting a comprehensive study of solid fuel processing processes with the aim of improving the quality characteristics of lignite.

Composite technologies. Lignite processing technology includes the following processes: coal preparation (preparation of raw coal and carbonaceous clay; drying of coal mass; conditioning of coal mass); heat treatment of coal mass and conditioning; magnetic and electrostatic separation; chunking of concentrate (finished products). Each technological process is provided with appropriate hardware design, technological transport, steam, water and electricity supply systems, systems for ensuring safe process management, control and automation devices, environmental protection equipment [6].

The sequence of lignite processing. The first stage was the preparation of lignite, that is, its crushing and thermovacuum drying. The process of crushing ordinary lignite during the operation of two-roll and hammer crushers was used to obtain the necessary fractional composition of it.

Since the grinding of coal occurs unevenly, then therefore, this stage of preparation was carried out in a closed cycle in the bolt-conveyor for the purpose of classification and screening of the necessary fraction. Unconditional granules, the size of which exceeds the required values, are returned to the cycle.

The next stage of coal preparation for further processing was its drying, i.e. extraction of ballast in the form of moisture, for which a thermal vacuum drying unit was used.

The drying of lignite and carbonaceous clay in an experimental and industrial sample of a thermovacuum dryer showed maximum moisture extraction with acceptable energy consumption indicators. At a temperature of the heating element of 250 °C and a drying time of 15 s, the heating temperature of lignite did not exceed 76 °C [7].

Heat treatment of dry high-ash lignite made it possible to significantly improve the consumption indicators of the organic part of the fuel while simultaneously increasing the share of the inorganic part.

The high content of the mineral part in heat-treated coal requires its further processing on separators.

Cascade separation thermally treated lignite on electric and magnetic separators allowed to obtain a concentrate with ash contentfrom 17,72 to 22,8%, yield of volatiles ≤ 35%, higher heat of combustion from 7256,1 to 7523,6 kcal/kg.

Conclusions

1. Data from experimental studies made it possible to develop optimal technological processes for obtaining high-quality fuel from lignite, taking into account its physico-chemical and structural composition, to reduce energy costs per unit of obtained products, to speed up the technological process, to develop energy-saving, highly efficient technology.

2. On the basis of the conducted studies, comparative indicators of the initial raw materials (ordinary lignite and carbonaceous clay) were obtained; mixtures of dry lignite and dry carbonaceous clay; indicators of the quality of carbonaceous matter after heat treatment and enrichment. At the same time, the following qualitative characteristics of the solid fuel were established: the ash content of the mixture at the working state of the fuel (Ar) after heat treatment was 50,2%, and after separation (concentrate) it was at least 17,72%; lower calorific value (Qrt), correspondingly increased from 3316,1 to 5817,7 kcal/kg in the dry state. The yield of volatile substances decreased from 62% to 45%.

3. Potentially, with the simultaneous operation of the most powerful lignite mining enterprises, Ukraine can annually extract at least 15 million tons of brown coal, and, taking into account carbonaceous clays, much more than 20 million tons/year. In the calculation per ton of conventional fuel, the production may amount to more than 4,7 million tons of reference fuel, which will allow to reduce the projected deficit in the gas group of coal. The obtained and systematized parameters of processing and enrichment of lignite can be the basis for the manufacture of an industrial technological line taking into account thermovacuum installations for further implementation at industrial enterprises of Ukraine.

4. The proposed technology makes it possible to optimize energy costs per unit of coal production and obtain solid fuel in the form of standard solid fuel briquettes. Heat treatment of lignite helps to reduce the content of oxygen and hydrogen, and therefore the release of volatiles to the level of coal gas group. The inclusion of accompanying minerals (for example, carbonaceous clays) in the production of lignite made it possible to reduce the overburden coefficient, and therefore the cost of the mined mass. The inclusion of carbonaceous clays in the total gross production can further expand the resource base of Dniprobas by 1,5 billion tons, and the Novo-Dmytrivske deposit - about 600 million tons.

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DEVELOPMENT OF AN INNOVATIVE COMBINED WELL REGENERATION METHOD FOR UNDERGROUND BOREHOLE LEACHING OF URANIUM

Kazatomprom has the status of the national operator of the Republic of Kazakhstan for the export and import of uranium and its compounds, nuclear fuel for nuclear power plants, special equipment and technologies. This status grants the company certain privileges, including obtaining subsoil use rights through ЬIdirect negotiations with the Government of the Republic of Kazakhstan, and, accordingly, priority access to high-quality natural uranium deposits in the Republic of Kazakhstan suitable for production by underground borehole leaching (UBL). The method of uranium extraction by underground well leaching (UBL) was first used in the 1960s and accounted for 50% of world uranium production in 2017.

The UBL method, in comparison with traditional methods, provides a lower cost of extraction, has less negative impact on the environment and provides high performance in the field of production safety and labor protection. Kazatomprom's experience in the extraction of uranium by the UBL method and the introduction of technical innovations allowed the company to achieve commercial production at mines using the UBL method within 18 months after the start of construction. While in global practice, the average launch period of a uranium mine by the UBL method is about 3 years. All uranium mining processes are automated and constantly monitored by the company, technical equipment at Kazatomprom mines fully complies with international safety and environmental standards, such as OHSAS 18001 and ISO 14001.

The current uranium production at the UBL is made up of the amount of uranium extracted from each pumping well and is determined by multiplying the uranium content in productive solutions by the productivity (flow rate) of pumping wells. Since the injection of leaching solutions and pumping of productive solutions is carried out while maintaining the balance of the volumes of pumped - pumped solutions, the production is directly affected by the intake of injection wells and the debit of pumping wells. In this regard, the efficiency of UBL directly depends on maintaining the productivity of technological wells at the optimal or achieved level during their development.

To solve the problems of increasing decrease in the productivity of wells during the extraction of uranium by the method of underground borehole leaching, repair and restoration works (repair and restoration work) are used to remove colmatation in the filter and in the filter zone of wells.

During the operation of geotechnological wells, their specific flow rate decreases as a result of mechanical, biological and chemical colmatage processes. The efficiency of metal extraction by underground leaching through a system of technological wells significantly depends on the stability of the wells. In case of violation of the specified operating modes of wells, the parameters of the kinetics of metal extraction from the subsurface are violated, the efficiency of the mining complex

is reduced. One of the characteristic reasons for the violation of the operating mode of wells are chemical colmatations of ore-bearing rocks, near-filter zones and well filters. The analysis shows that chemical colmatage is caused by a change in the hydrodynamic situation in the formation during the operation of the well and is considered an inevitable process. The intensity of the chemical colmatation process depends on the chemical and mineral composition of the ore-containing rocks, on the type and concentration of the working reagent used for metal leaching. Chemical colmatation occurs as a result of the deposition of solid phases formed during the dissolution of minerals of ore-bearing rocks.

In most cases, sediments, colmatating filters and near-filter zones of wells are multicomponent and can simultaneously contain iron, manganese salts and their hydroxides, calcium and magnesium carbonates, silicic acid and sulfides, as well as sand and clay. They are deposited on the surface of filters and in the pores of adjacent aquifers under the influence of gravity or adsorbed under the action of surface tension forces. After the time has elapsed, the sediments are dehydrated and compacted. The deposits have a loose-porous and conglomerate structure and at various stages of formation are characterized by different strength and activity to react. The formation of insoluble sediments is associated with the processes of chemical and mechanical cementation of aquifers adjacent to the filter or gravel sprinkling with chemical deposits.

The main methods for restoring or increasing the permeability of the rocks of the bottomhole zone during repair and restoration work (repair and restoration work) are physical, chemical and combined methods.

When choosing the repair and restoration work technology, one should proceed from the possibility of decolmatization of filters and near-filter areas of wells, take into account hydrogeological conditions, drilling technology, well design, filter and other characteristic factors of the field.

In this regard, there is a need to develop and implement three operational methods in one unit in the uranium production, namely in the repair and restoration work division.

This method has received a new name: Combined mobile unit well cleaner (the unit is a combined mobile installation well cleaner) for chemical treatment and flushing with process water with pneumatic pulse compressed air supply (hydraulic shock) directly to the filter part of technological wells.

The development of an innovative method of well regeneration will increase the coefficients of uranium extraction in difficult mining and geological conditions by restoring the permeability of the encrusted ores, taking into account geological features based on the widespread introduction of innovative approaches to carrying out repair and restoration work and increasing the filtration parameters of the reservoir. Improvement of the combined method of reservoir permeability restoration and effective removal of physical and chemical colmatation products from the pre-filter zone of the

formation includes metered supply of chemical reagent solutions, flushing with a pneumatic pulse directly into the filter part of technological wells.

The implementation of this project will solve the following problems:

- ✓ filtration characteristics of hard-permeable rocks of deep occurrence;
- ✓ filtration of the formation with high reservoir pressure;
- ✓ increasing the inter-repair cycle of technological wells;
- ✓ reduce the specific norms of material costs;
- ✓ the efficiency of using the integrated method will make it possible to reduce the time for carrying out repair and restoration work of wells;
- ✓ *f* development of new geological deposits.

The development and implementation of the combined mobile well cleaner Unit (the unit is a combined mobile installation well cleaner) is characterized by high throughput, will allow safe pumping, preparation and supply of various types of solutions of decolmatants reagents and flushing with process water with pneumatic pulse compressed air supply directly into the filter zone of the technological well.

Also included in the package of the unit is a compressor for pumping with compressed air of installed cylinders.

The exclusion, as part of this installation, of open tanks for reagents and crushing solutions under pressure of the leaching reagent, opens up the possibility of a significant increase in the safety and environmental friendliness of work.

The mobility of the unit for the preparation and supply of solutions of decolmatants reagents and flushing with a pneumatic pulse will increase the number of repair and restoration work of wells per day, ensure the versatility of its application at various technological wells and increase the efficiency of the repair and restoration work method.

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INFLUENCE OF EXTERNAL PRESSURE ON ROCK DESTRUCTION

In recent years, various research organizations have carried out a large amount of research in the field of rock mechanics in relation to the conditions of drilling deep wells. Experience shows that if, when assembling sets of rock cutting tools, it is necessary to consider the physical, mechanical and deformation properties of rocks in passable intervals, considering the impact of drilling mud on the bottom of the well, the indicators of bit mining increase by 20-25% both in terms of penetration and mechanical speed of drilling.

The foregoing indicates the need for comprehensive studies covering a wide range of issues related to the study of the patterns of bottomhole processes in the drilling of deep wells, aimed at the effective destruction of rocks at the bottomhole.

Under laboratory conditions, the energy required to destroy the rock remains relatively constant and equal to the uniaxial compressive strength of the rock. In the field, however, there is an efficiency factor. Drilling analysis shows that 30-40% of the energy is efficient and 70-60% is inefficient. The main reasons for the loss of efficiency are drilling vibrations (longitudinal, torsional, bending) and lithology, as well as the design of the bottom of the drill string (BHA), well geometry, well trajectory, friction coefficient, etc.

In turn, the efficiency of destruction of rocks at the bottom of the well is a function of many variables and depends on natural, technological and technical factors. In this regard, the problem of rock drillability in relation to the conditions of drilling deep wells has not yet been finally resolved.

In the process of drilling wells, as in any other technological process, a certain amount of energy is expended on the destruction of a unit volume of rock. In turn, the energy spent on destruction is determined not by any one mechanical characteristic, but by the whole set of physical and mechanical properties of rocks.

In this case, the specific volumetric work of destruction will be the most objective indicator for the classification of rocks by drillability. In this case, it should be taken into account that the mechanical characteristics of rocks, which determine the total work of destruction, must be obtained under conditions that take into account the influence of rock and hydrostatic pressures.

To date, a clear relationship has been established between the physical and mechanical characteristics of rocks and drillability categories, which makes it possible to choose a rock cutting tool and drilling regime parameters for specific geological sections.

With an increase in the depth of the rocks, their resistance to destruction increases. With an increase in the depth of the well, the energy costs for destruction increase sharply, i.e., the drillability of rocks is deteriorating. An analysis of the influence of the depth of occurrence of rocks on the

energy intensity of their destruction showed that the higher the hydrostatic pressure on the bottom of the well, the faster the energy intensity of rock destruction increases with depth.

1*a* 1*b*

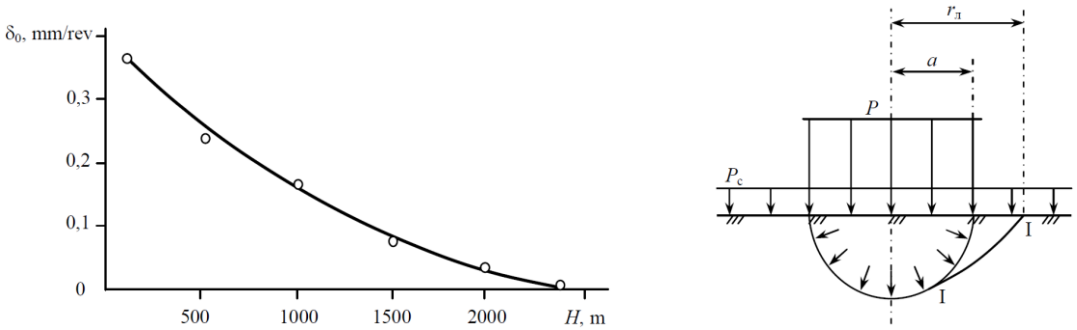

Fig. 1*a*. Dependence of the bit depth per revolution on the depth of the well; 1*b* - Scheme to the mechanism of the influence of pressure in the well on the destruction of rocks

The influence of the depth of rocks on the intensity of their destruction can be judged from the results of field observations (Fig. 1*a*). Fig. 1*a* shows that as the depth of the well increases, the drillability of rocks sharply decreases.

The study of the mechanical properties of the rocks being drilled showed that the change in their hardness and plasticity with depth is small and cannot cause such a significant decrease in the drillability of the rocks.

The increase in hydrostatic pressure due to an increase in the depth of occurrence is about 1,0 kPa for every 1000 m. With a hardness of the rocks under consideration of about 25 kPa, this value can cause a multiple change in the drillability of the rocks.

An analysis of literary sources [1-3] and a generalization of field studies made it possible to establish that pressure in the well has a decisive influence on reducing drillability.

Considering the data and analysis of the materials given in [2-3], the effect of pressure on the drillability of rocks can be explained by considering the patterns of indenter indentation into the rock (Fig. 1*b*). Under the action of pressure on the indenter, a fracture core is formed in the rock, which creates pressure on the environment.

The pressure component directed upward to the separation of the rock surrounding the indenter is about 4-7% of the pressure on the indenter.

When a crack is formed (I-I in Fig. 1*b*), a cavity is formed in the dense rock, the pressure in which is equal to zero.

The opening of the crack is prevented by the pressure P_c, which creates an opposing load on the detached part of the rock. Then

$$P_p = \pi P_c (r^2 - a^2).$$

It follows from the expression that the greater the pressure in the well, the greater its influence on the final stage of rock destruction when the indenter is pressed in.

The specific work of destruction, or the breaking stress of rocks, is a physical quantity and, according to the decision of the strength group of the International Bureau of Rock Mechanics, when determining the loading rate, it should be in the range from $(5\text{-}10)\cdot\theta$, where θ is a structural coefficient taking into account the plasticity of rocks.

Thus, with an increase in the rate of deformation, the resistance to destruction of the rock increases.

With an increase in porosity or fracturing, the effect of velocity on the magnitude of the failure stress decreases.

Thus, it can be concluded that the efficiency of destruction of rocks at the bottom of a drilling well is significantly affected by pressure, the value of which depends on the physical and mechanical properties of rocks, the density of the drilling fluid, its viscosity, and hydrodynamic parameters.

Therefore, when designing the technical and technological parameters of rock destruction during drilling, it is necessary to consider the nature of the technical and technological interactions of the rock cutting tool with the rock, but also the hydrodynamic parameters of the drilling fluid flow.

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STUDY OF HARDENING OF CHARGES DURING EXPLOSIVE OPERATIONS IN UNDERGROUND MINING WORKS

The degree of crushing of rocks by explosion determines the total amount of dust that is generated. It, in turn, other things being equal, depends on the power, density, and size of the explosive charge.

It is known that at least 2-3% of coal production turns into dust. Dust is carried by the ventilation jet over considerable distances [1].

According to the studies, there are approximately 95% of dust particles smaller than 2 microns, 5% - 2-4 microns, and a small amount - more than 5 microns in the lungs with anthracosis and silicosis. The amount of dust entering the atmosphere and consisting of particles with a diameter of fewer than 10 microns per 1 m^3 of blasted mining mass is 80-500 g. The pathogenic effect of coal mine dust is determined mainly by its mass, structural composition, and dispersion [2].

Improvement of the sanitary and hygienic working conditions of the working personnel is achieved in practice by the use of developed new rational technological parameters of tunneling of mine workings aimed at chemical binding and deposition of fine dust, reducing the content of toxic explosion products in the ventilation stream.

The purpose of the developed method is to increase the effectiveness of dust control, deposition, and binding of finely dispersed dust, which consists mainly of silica-rich (silicon dioxide - SiO_2) products of the destruction of rocks, formed in the face during the explosive method of mining workings [3].

A traditional way of reducing dust formation during preparatory works in coal mines is the use of such structures of blast charges, which allow increasing the time of the explosive impact on the massif that is being destroyed.

According to the results of experimental studies, a technology for the production of a hardening mixture was developed, in which dolomite dust with a fraction of 0,2 mm and a moisture content of 13-15% is used as a binding component that fills the space between the particles of the sand-clay mixture. An aqueous solution of lignosulfonates makes it possible to form a stable mixture of high density, plasticity, and mobility during its transportation, and aluminum-potassium alums – high strength during its hardening. Therefore, as a result of mixing the above components with their optimal ratio, a composition with stable deformation and physical and mechanical characteristics is formed in the mixture. Since in the given task it was necessary to create punches that can expand during hardening, lignosulfonates (salts of lignosulfonate acids), which are quite cheap and are waste products of the sulfite method of obtaining cellulose, were tested for these purposes.

Based on the results of the research, a rational ratio of the components included in the hardening mixture containing sand-clay mixture, dolomite dust, lignosulfonates, aluminum potash alum, and water was obtained in the following ratio: sand-clay mixture - 50-45%; dolomite dust fraction d = 0.2 mm with a moisture content of 13-15% - 17-20%; lignosulfonates - 12-15%; aluminum potassium alum (Ka $(SO_4)_2$ 10 H_2O) - 6-3% and water - 18-20% [4].

The use of the developed charge composition with the specified characteristics ensures the redistribution of the explosive energy throughout the charge column and the reduction of the specific

impulse in the near zone of the explosion. It is in this zone that the rock is intensively crushed with the formation of a large amount of finely dispersed dust that enters the mine atmosphere.

In order to check the effectiveness of the developed method of reducing the output of fine dust, comparative tests were conducted in mining operations at the Pokrovska mine of JSC Coal Company "Krasnoarmiiska-Zakhidna Mine № 1".

Mining operations carried out on sandstones with the use of drilling and blasting were selected for the research.

Before carrying out blasting in the production, the actual aerodynamic parameters were determined: the speed of movement of the ventilation jet at the exit from the pipeline and the consumption at a distance of 100 m from the face.

In order to verify the effectiveness of the developed method of reducing the concentration of fine dust in the mine atmosphere during the destruction of rocks by the energy of the explosion by reducing the strength of the environment at the "BP-rock" contact, as well as the developed composition of the stuffing, which expands, experimental explosions were conducted.

To determine the change in dust concentration along the length of the mine, air velocity and dust concentration were measured at 10 points every 25 m of the mine.

It was found that the dust concentration in the experiment using the developed composition of the stuffing, which expands, decreased by an average of 6 times in comparison with the use of the traditional composition of the stuffing.

The reduction of dust concentration occurs due to the use of explosive charges with a charge of the developed composition during detonation.

Thus, the performed comparative experimental studies show that when using a rammer that expands in the holes during drilling and blasting, the dispersed composition of the dust changes significantly, i.e., dustiness is reduced on average by up to six times due to the reduction of the amount of fine fraction to 10 microns.

Conclusions

1. The composition of the mixture for filling hole charges, which expands during hardening, has been developed. The main component of the mixture is a sand-clay mixture with the addition of binding additives: aluminum potassium alums and lignosulfonates, dolomite dust – waste from the woodworking and mining industries. A methodology for determining optimal compositions, properties of the hardening mixture, and technology for its preparation has been developed.

2. It was experimentally established that the ram with a hardening mixture used in the detonation of explosive charges increases the time it stays in the hole compared to other designs of charges, creating a reliable closure of the detonation products. At the same time, the degree of use of ex-

plosion energy for the destruction of the rock mass, the uniformity of its crushing, and the amount of fine dust emitted into the mining atmosphere are reduced by an average of six times.

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DATA OF COMPUTER ESTIMATION OF THE VOLUME OF WORN-OUT GRINDING BODIES IN DIFFERENT-SIZED OPTIMAL BALL LOADING

Nowadays mining and processing of minerals is closely connected with their enrichment. Iron ores are nowadays mostly enriched, which requires ore dressing associated with high energy and material costs. Particularly costly are the processes of grinding minerals in ball mills, especially in the first stages of ore processing, where the full volume of the initial crushed ore is processed. In recent years, it has been established that grinding ore with balls of four, five initial sizes is much more effective compared with single-sized grinding bodies. However, this new approach of ore grinding requires the creation of different-sized optimal ball mill loading and its maintenance during operation. Therefore, these studies are carried out within the framework of the theme "Optimization of ball mills productivity by ore and finished product at minimum energy and material costs" (0115U003942), which is part of the plan of scientific subjects of the Central Ukrainian National Technical University. In view of the above, the topic of this publication is relevant.

The task of grinding ore with such a ball loading consists of two parts - creation of different-sized optimal ball loading and its maintenance during operation, taking into account the wear of grinding bodies. These tasks are rather complicated.

And the most difficult is the task of estimating the volume of worn balls in different-sized optimal ball loading and determining the initial data for this.

Among the input data to estimate the volume of worn-out balls of different-sized optimal loading are a priori known parameters of the process of grinding of a particular ore in a particular ball mill - it is the specific consumption of balls per 1 kW·h of ore grinding $\Delta q_к$, coefficient k_f, evaluat-

ing the share of worn-out lining compared to ball wear, and coefficient $k_{f.k}$, evaluating the volume of balls to be created and loaded into the mill to replace the worn lining - it is less than the volume of the worn lining, and the energy parameter A of grinding a particular raw material. These data are known from the experience of grinding ore at the concentration plant and are constants for a given technological variety of ore or mixture of ores and a particular type of ball mill.

Another group of data is the parameters of different-sized optimal ball loading. It is possible to find them for the specific technological variety of ore and ball mill.

For example, for ball mill МШЦ 4,5×6,0, the variegated optimum ball load of four ball sizes accommodates 32% of bodies with diameter of 90 mm, 27% - 75 mm, 23% - 65 mm and 18% - 50 mm.

Then the parameters of different-sized optimum ball loading can be designated: D_{90}, k_{90}; D_{75}, k_{75}; D_{65}, k_{65}; D_{50}, k_{50}.

They will be constants in this different-sized optimum ball loading. The masses of balls of a particular material produced by a particular technology will also be constant, for example m_{90}=2,9758 kg, m_{75}=1,7221 kg, m_{65}=1,1210 kg, m_{50}=0,5102 kg.

A separate group of data are parameters which are necessary to assess in the process of grinding the ore - the weighted average size D_{CZ} of pieces of ore fed into a ball mill, the weighted average size of a solid in the discharge of ball mill d_{CZ}, the estimated volume of processed ore Q_Z, ton approximately for one hour of operation and output for the same time of scrap ΔG_C from the ball mill.

In the current control systems, only the power used by the mill motor to grind the ore is monitored and used to feed single-sized balls into the process unit.

The effect of such control is low due to uncontrolled power losses, which generate a measurement error of 10-25% and, accordingly, inaccurate dispensing of only one-size balls. The given parameters D_{CZ}, d_{CZ}, Q_Z evaluated in the process of ore grinding allow to determine with high accuracy the amount of energy E spent on grinding Q_Z tons of ore analytically [1].

The weighted average particle size of the crushed material D_{CZ} can be determined by the proportionality factor k'_P, ore density δ_T, distance L between the support rollers of the conveyor scales, acceleration of the Earth's gravity g, which are constants, and measured ore load $F(t)$ on the conveyor belt and cross-sectional area of the ore flow $S_P(t)$ [2]. The unit load of ore on the conveyor belt is measured with high accuracy by conveyor scales, the relative error does not exceed ±1,0%. Practically at the same level it is possible to provide a relative error of measurement and the area of the cross-sectional section of the ore flow [3].

The weighted average coarseness of the solid in the discharge of the ball mill can be measured accurately enough by the device described in [4], which provides a relative error not higher than

±1,74%. The set amount of processed ore is measured by conveyor scales, where the relative error does not exceed ±1,0%.

With such results of measurement of the listed technological parameters it is possible to estimate rather precisely useful energy spent for grinding of the set amount of ore Q_Z, and further to find quantity of balls of various sizes 50 mm, 65 mm, 75 mm and 90 mm which should be added in a ball mill for compensation of the worn-out metal at grinding of raw materials in volume Q_Z according to the developed mathematical models of processes and algorithm.

Thus, the specified initial data allow us, in accordance with the proposed mathematical models of the process and algorithm, to determine quite accurately the composition of different-sized balls, which after loading into the mill compensate for the worn grinding bodies.

Thus, there is a stabilization of different-sized optimal ball loading during operation of the process unit and, as a consequence, a significant reduction of overuse of balls and liners during ore grinding in the first stages of ore dressing at concentrators.

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RESULTS OF SIMULATION MODELING OF THE INFLUENCE OF TECHNOLOGICAL PARAMETERS ON THE OUTBURST HAZARD OF COAL SEAMS

The process of developing mineral deposits implies a number of requirements for engineering, technological and organizational support. However, the development of coal deposits of minerals by the underground method is complicated by unfavorable mining and geological conditions, high risks of sudden outbursts of coal, gas and coal dust. The paper [1] describes the mechanism of the sudden emission of coal gas and dust. According to this mechanism, a sudden outburst occurs in the event of an avalanche-like excess of the tensile strength of the rocks of the rock mass as a result of the loss of stability

of the marginal part of the mineral reservoir, or any block of rocks that are under support or cantilever pressure, which leads to its brittle fracture [2]. Today, there are a number of theories of the occurrence of a sudden outburst: energy, power, different approaches to solving problems, but there is no clear understanding of the physical essence - the only thing that all researchers have agreed on is the development of technological solutions to prevent sudden outbursts of coal and gas [3, 4].

The purpose of the work is to develop and verify a new approach to substantiate optimal technological schemes for the development of coal seams. In accordance with the goal, the conditions can be formed as follows: there is a coal seam or a group of coal seams that are dangerous due to sudden outbursts of coal or gas, at the same time they are not protected by satellite seams. It is necessary to create or substantiate such a reservoir development scheme so that the probability of a sudden rush in a breakage face is minimal or equal to 0.

In the mathematical formulation, this problem will have the following formulation. There is an ordered graph of the qualitative characteristics of the technological system and ways of actively influencing the rock mass, for which the permissible paths from the minorant to the majorant are determined [5]. To move from a general problem statement to an applied one, it is necessary to formalize it. That is, as a result of the solution, a technology for the development of coal seams prone to emissions by a mechanized method can be proposed. Here are the parameters that can be controlled x_1 – type of mining machine, x_2 – technological scheme, x_3 – method of degassing the rock mass.

The general algorithm for substantiating technological schemes for mining outburst-hazardous coal seams based on simulation modeling provides for the following sequence of actions: setting the initial parameters of a rock mass and dividing them into discrete values; for possible routes of the graph of technological solutions, the mathematical expectation and dispersion are determined; the probability of sudden outbursts of coal and gas for the studied parameters is determined; on the basis of the calculated probability, dependences of the occurrence of a coal or gas outburst are obtained in accordance with the values of the parameters (face length, the speed of movement of the breakage face, etc.); on the basis of the data obtained, the optimal technological schemes for mining outburst-hazardous coal seams are substantiated; based on the application of the application package, mechanization means are selected.

The State Enterprise "Coal Company" "Krasnolymans′ka" is considered as the object of study. The mine is deep, dangerous due to sudden outbursts of coal and gas, dangerous due to the explosiveness of coal dust. The task was to substantiate the optimal technological solutions, as well as the choice of mechanization means.

At the first stage, simulation modeling of the occurrence of the probability of sudden outbursts of coal and gas was carried out for various parameters. The parameters of the rock mass were set and it was found that the control parameters are: the web width, the speed of movement of the

breakage face, the face length, the depth of development. For these parameters, optimal values were justified in terms of minimizing the likelihood of a sudden outburst of coal and gas. It was found that the rational web width of a face machine is 0,63 m, and it was also found that the probability of a sudden release increases with increasing web width. The speed of movement of the breakage face line should be less than 3 m/day, because with an increase in the speed of movement of the breakage face line, the probability of a blowout increases. In the case of slow movement of the breakage face line, the zone of maximum support pressure goes "into the depth" of the breakage face, which leads to a decrease in contact stresses that affect the likelihood of a sudden blowout. It was also found that the most optimal is the face machine method of extracting minerals. The length of the breakage face should be more than 250 m, because with an increase in the length of the stope, the probability of a release decreases. In addition, it was found that with an increase in the depth of development, the likelihood of a sudden outburst of coal and gas increases.

After that, for the conditions of the mine "Krasnolymans′ka" it was necessary to choose the means of mechanization of the breakage face, which provides for the rationale for the structure of the technological chain "powered support - face machine - face conveyor". To select the equipment, the "Program for selecting the optimal complete sets of breakage face equipment", developed by the co-author of this work, was used.

It should be noted that, depending on theworking width, various configurations of breakage face equipment can be offered. We preliminarily chose the MDM mining system, because it has the highest performance indicators for the given parameter values: seam thickness, length of the breakage face. The specified complex includes DM powered support, and can also be equipped with different types of face machine and face conveyor.

The main requirements include: availability of the proposed equipment at the enterprise; availability of a repair fund of mining equipment and experience in its operation; low instantaneous ash content of coal; availability of serial production; screw type of the executive body; interaction with the face conveyor.

It is convenient to search for the optimal configuration based on a comparison of configurations. That is, it is necessary to determine the value of the optimization parameter for each configuration, and then present the alternatives in the form of a network model [6].

Using optimization algorithms on networks and graphs [7], one can find the shortest route corresponding to the optimal solution [8].

On the basis of the analysis, for the specified technological schemes, the following equipment of the mining system "powered support MDM - face machine UKD400 - flight conveyer SP326" was chosen. The specified technological chain meets all the requirements, and is also the most optimal in terms of the

unit cost of production, in addition, it can be used with a production breakage face length of more than 300 m, which significantly minimizes the likelihood of a sudden outburst of coal and gas.

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MAIN CAUSE OF DYNAMIC PHENOMENA IN COAL MINES

The authors [1] analyzed hypotheses and theories aimed at revealing the nature of the mechanism of manifestation of gas-dynamic phenomena (GDP) in coal mines and came to the conclusion that “in general, the creation of a theory explaining the nature and mechanism, both in general and of individual types of GDP, cannot be considered complete, and research in this direction must be continued. We will present our point of view on the nature and mechanism of the GDP, in contrast to the well-known hypotheses and theories.

It is clear that GDP occurs when the potential energy of rock pressure is converted into kinetic energy. This is possible when the coal seam loses its bearing capacity, i.e. strength. After all, it has long been known [2-5] that the strength of coal increases with the removal of gas from it. The authors indicate that as a result of underworking or overworking, the strength coefficient of coal samples increases by 1,2 times [2]. V.I. Nikolin [5] writes that from the experience of developing highly gas-bearing seams, it is known that in a gassed working, the bottom-hole zone of a coal seam is destroyed by a jackhammer, etc. much easier than in the same working with normal ventilation. In the literature, a mathematical description of the phenomenon of a decrease in the strength of coal during its gas saturation could not be found. Let's try to fill this gap. To do this, it is necessary to

develop a method for calculating the bearing capacity of the bottomhole zone of gas-bearing coal seams, taking into account the internal pressure of the gas.

The bearing capacity of a part of the formation is determined by the formula

$$p = \sigma_{y_\xi}\left(1+0{,}5 f_c \left(l - x_\xi\right)/h\right), \quad (1)$$

where σ_{y_ξ} - vertical normal stress at crack tip; f_c - coefficient of contact friction between the formation and side rocks; l – distance from the bottomhole to the considered point; x_ξ - crack tip abscissa; h - formation thickness.

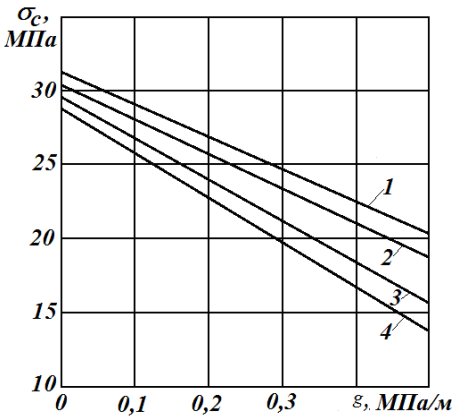
As can be seen, it is necessary to know the value of the vertical normal stress at the tip of a bottom-hole crack in a gas-bearing formation. The book [7] provides a method for determining vertical and horizontal normal stresses at the crack tip. Now the formulas of the book should take into account the pressure of the gas σ_g. We accept the condition that the gas pressure σ_g along the bottom of the formation plane changes according to a linear law and is expressed by the formula

$$\sigma_g = g \cdot l, \quad (3)$$

where g - the gradient of the increase in gas pressure deep into the array per unit distance from the free surface, from the working bottom; After solving the equations of the book [7] for a crack, taking into account the gas pressure, a method was developed for calculating the bearing capacity - the ultimate strength of the bottomhole zone of a gas-bearing coal seam.

Based on the method, dependences of changes in the ultimate strength of the bottomhole formation zone with coal shear resistance k_n=1,5 MPa, internal friction angle ρ=45° и f_c=0 and a length equal to the thickness of the seams were established (Fig. 1).

As can be seen, the internal gas pressure sharply reduces the bearing capacity of the bottomhole zone of gas-bearing coal seams. Thus, at a gas pressure gradient g=0,3 MPa/m, the strength of the bottomhole zone decreases by 20%. g=0,3 MPa/m - by 30%. In the future, based on the foregoing, it is planned to describe the mechanism of coal explosion with a sudden release of its gas.



Formation thickness: *1* - 1,35 m; *2* - 1,5 m; *3* - 1,8 m; *4* - 2,0 m

Fig. 1. Dependences of the ultimate strength of the bottomhole zone of gas-bearing coal seams on the gas pressure gradient

Let us now compare the theoretical conclusions with experimental observations. An analysis of the development of gas-bearing seams gives an unambiguous answer to the question of the influence of the magnitude of gas pressure on the outburst hazard of coal seams. It has been established that the outburst hazard of coal seams of various deposits increases with increasing gas pressure. At one time [3-5], work was carried out to determine the “critical” gas pressure, above which the formation becomes dangerous due to sudden outbursts. The critical pressure in the

reservoir turned out to be 1,0-1,5 MPa.

Consequently, the gas pressure is the "starter" of the transfer of the limiting stress state into an outburst hazardous one, which leads to the emergence of the process of converting the potential energy of rock pressure into kinetic energy in the form of gas-dynamic phenomena in mines.

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ADJUSTMENT OF MINING TECHNOLOGIES IN QUARRIES LOCATED IN CITIES

One of the main problematic features of the Kryvyi Rih iron ore basin is the location of part of the iron ore quarries within the city, among its densely populated areas. Under these conditions, these territories not only suffer from seismic manifestations of technological mass explosions, but also from atmospheric pollution with mineral ore dust, which is unacceptably intense in the area of the studied quarries.

The only real way to solve this problem is to find an effective, simple and inexpensive technology to combat dust generation from mining operations through the introduction of available chemicals and modern mining equipment available in quarries and progressive technologies for their application. Therefore, the purpose of the presented studies is to determine the main factors of dust formation in such problem areas and their susceptibility to the action of various reagents in order to substantiate appropriate options for technological solutions to reduce atmospheric pollution to an environmentally acceptable level using the example of one of the quarries of PJSC ArcelorMittal Kryvyi Rih. The task of the foregoing is to determine effective dust-suppressing agents for the indicated conditions and to substantiate the appropriate options for their use.

The results of the study are presented on the example of dedusting surfaces of the composition of oxidized quartzites (Avtootval № 4) and reducing dust formation during blasting of rocks in the conditions of a quarry of the Mining Department of the Mining Department of PJSC ArcelorMittal

Kryvyi Rih for the ideas of using the modified by the authors to reduce dust formation from the surfaces of transport routes and bulk quarry objects bischofite - a solution based on magnesium chloride due to its binding properties, as well as a new reagent DUSTRON™ EX17 in mass explosions.

As for the study of the effectiveness of the use of the DUSTRON™ EX17 reagent solution in the formation of internal and external hydraulic plugging of wells during mass explosions, it was initially carried out according to the approved methodology by representatives of CE "SCIENCE" Academy of mining sciences of Ukraine on September 28, 2021 on the territory of the Yuzhny complex of JSC «Interexplosionprom» and successfully tested during a mass explosion at quarry № 3 of PJSC ArcelorMittal Kryvyi Rih on September 30, 2021 at block № 76, horizon -135 m.

For dust suppression of the composition of oxidized quartzite on the surface of the road, a solution of crystalline bischofite was used, the solution of which was applied to the surface by spraying with a watering installation according to the developed test program:

1. The horizontal section of the composition of oxidized quartzites was divided into two grounds: №1 - experimental, where dust separation was recorded during the movement of a BelAZ dump truck with a carrying capacity of 40 tons, and № 2 - where no vehicles were moving.

2. As a reagent for dust suppression, a solution based on bischofite according to TU 25 22529511-003:97 was used, but modified according to the author's recipe.

3. The experiments were carried out on August 31, 2021, September 9, 2021, September 14, 2021, and September 17, 2021. When performing dusty measurements, the parameters of the state of atmospheric air were also controlled.

4. Ground № 1 was irrigated with a watering machine with a bischofite solution once on August 31, 2021. In the following days, dust concentrations were measured at this ground after watering with a bischofite solution after a 10-fold passage of the indicated BelAZ, and at ground № 2 - control measurements without traffic.

5. To reduce dust formation during blasting of rocks in a quarry, ArcelorMittal Kryvyi Rih, PJSC tested a new reagent DUSTRON™ EX17 during the formation of internal and external hydraulic filling of explosive wells.

The results of experimental measurements showed the following.

08/31/2021. The concentration of dust in the atmospheric air was: at both ground of the dump Avtootval № 4, layer +180 m before irrigation with bischofite without traffic - 1,87 mg/m^3; at ground № 1 for irrigation while driving a dump truck - 5,75 mg/m^3; on the irrigated plot - 0,66 mg/m^3.

09/09/2021 Dust concentration in the atmospheric air at ground № 2 - 0,11 mg/m^3; at ground № 1 without traffic - 0.16 mg / m^3, with the movement of a dump truck - 0,54 mg / m^3.

09/14/2021 Dust concentration in the atmospheric air at ground № 2 - 0,17 mg/m^3; at ground № 1 without traffic - 0,17 mg/m^3, with the movement of a dump truck - 2,98 mg / m^3.

09/17/2021 Dust concentration at ground № 1 without traffic - 0,51 mg/m^3, after the passage of a dump truck - 1,53 mg/m^3; at ground № 2 without traffic - 0,41 mg/m^3.

On September 9-14, 2021, a significant change in wind speed and direction was observed, as well as precipitation.

Calculations of dust emissions after the explosion on 09/16/2021 at a level of -60 m of block № 72 using internal and external hydraulic ramming using DUSTRON™ EX17 in the conditions of a quarry of the Mining Department of PJSC ArcelorMittal Kryvyi Rih showed the following.

With an air flow rate of 4,2 l/min, an average dust concentration of 921,13 mg/m^3, a specific explosive substance (ES) consumption of 0,90 kg/m^3, a total mass of ES of 27926 kg, a dust and gas cloud with a volume of 1809453 m^3 was formed after the explosion; whereupon the specific dust separation was 0,0537 kg/m^3 of rocks and 0,0597 kg/kg of ES.

Conclusions

1. Taking into account the fact that during the movement of transport the protective film formed as a result of the action of bischofite is destroyed, with the loss of its binding properties and the formation of dust, the use of this solution in areas with the movement of technological dump trucks is not advisable.

2. According to the results of dust concentration studies at non-operated ground No. 2, changes in dust concentration from August 31, 2021 to September 17, 2021 amounted to 1,87-0,41 mg/m^3, respectively, that is, a decrease in dust concentration by 4 times is observed. At the same time, on September 9, 2021 and September 14, 2021, a decrease in concentration was observed compared to the first day of testing from 17 to 11 times (0,11-0,17 mg/m^3).

3. The efficiency of using the reagent "DUSTRON™ EX17" in comparison with the use of technical quality water for dust suppression was 9,4%.

Recommendations. Based on the results of pilot tests, it is recommended:

1. Use a solution of bischofite to fix surfaces that are not used as transport.

2. Irrigation of dusty surfaces should be carried out during periods of dry, warm weather in the absence of precipitation.

3. During the explosion of rock masses, taking into account the peculiarities of the quarry of PJSC ArcelorMittal Kryvyi Rih, as well as the fact that the location of the object is located in the city and requires extremely effective dust suppression, the authors propose to apply methods of explosive destruction of rocks with a symmetrical action of groups of charges, the adaptation of which is most consistent with the considered conditions and requires minimal experience in combination with the new technology of rock destruction developed by CE "SCIENCE" of the Academy of Min-

ing Sciences of Ukraine, the effectiveness of which was reliably proven in 2021 during pilot tests to determine the effectiveness of reducing dust emissions using the surfactant solution "DUSTRON ™ EX17" at the quarry of PJSC AMKR during blasting.

Drilling and blasting technology is being implemented taking into account the recommendations through the use of borehole charges with internal and external hydraulic blasting in polyethylene sleeves using a solution of DUSTRON TM EX 17, the ES charge is initiated using intermediate detonators and a non-electric initiation system of the Prima-Era type.

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ABOUT SOME RESULTS OF LABORATORY RESEARCHES WHICH SHOW INFLUENCE OF AN ORE DRAWING ON ROCK PRESSURE SIZE IN THE BOTTOM OF BLOCKS

The model of release of the brought down ore from final apertures near which strain gauges for definition of value of loading on each strain gauge settled down is presented.

The model is presented executed to scale M 1:100 with a forward glass wall.

The distance between final apertures - 5 m, diameter of final apertures - 2 m. As a loose material is used martite ore from granules by metric structure +1÷-5 mm.

Height of the brought down layer in the panel - 40 m. Depending on a location of strain gauges on the panel bottom accordingly change values of loading at an ore drawing.

From received a drawing it is visible considerable non-uniformity in pressure distribution. The profile maximum is dislodged to a lying side and corresponds to pressure of a column of broken-down rocks.

Pressure of broken-down rocks upon the block bottom at mining of thick steeply dipping deposits of the big prodeleting depends not only on depth of the mining operations, determining the elevation a column of broken-down rocks over the bottom, but also from the horizontal sizes of the block, from intensity of an ore drawing and sequence of operations in a mine field, defining the sizes and a location of the areas which are simultaneously being at a stage release.

Accepting certain parities between these parameters it is possible to regulate size of pressure of broken-down rocks, over a wide range keeping it at level considerably smaller weight of all columns of broken-down rocks.

The analysis of results of laboratory researches allows drawing following basic conclusions:

1. In the separate block located the long side an across the strike of a deposit, the size and character of distribution of pressure of broken-down rocks on the bottom basically depends on the sizes of the block along the strike.

With increase in the size of the block along the strike increases not only absolute size of pressure, but also non-uniformity of its distribution. Thus the pressure maximum in the block located in a massif is mainly dated for points of a lying side, and in the block located between broken-down rocks - in the center.

2. Along with the horizontal sizes of the block considerable influence on size and character of distribution of pressure caused in the weight of broken-down rocks, renders intensity and an order of an ore drawing from the block. The increase in intensity of an ore drawing promotes pressure decrease on the bottom. Experiences, however, show that depending on width of the block and a massif condition on boundaries of the block release influence is shown variously. Thus the release order has extremely important role. At non-uniform release by the most widespread in practice, instead of a decrease increase of pressure upon those sites of the bottom in which limits an ore drawing rather is observed is less intensive.

In connection with non-uniform distribution of reserves of the brought down ore over ore chutes for preservation of horizontal contact between ore and leaning barren rocks more intensive release is made usually from ore chutes at a lying side.

Thereof along with sharp pressure decrease in this part of the bottom pressure increase in the center of the block and at a trailing side is observed.

It occurs, because at an ort to the scheme of preparation of the bottom of inset horizon the storage drift usually settles down in soils of a lying side, therefore release occurs basically from first and second pair of final cone raises. From here more often, the air roadway where the ore drawing occurs not intensively (the big length of scraping) from the cone raises located around air roadway fails, and pressure upon bottom developments in this area first of all therefore increases.

The release role is especially great in the event that as vertical boundaries of the block broken-down rocks serve.

At a non-uniform and not intensive ore drawing from the block adjoining from two sides with broken-down rocks, pressure is considerable above, than in the block being in a massif, even in the event that from the block in a massif the ore drawing is not made.

By experiences it is established, that after an ore drawing from an aperture 100-120 м^3 on distance of 8-10 m from its axis pressure increases by 15-20%, and on distance of 12-16 m - on 30-40% from initial.

On more remote sites pressure increase gradually fades. Such laws of distribution of pressure are characteristic at release from one aperture.

At an in regular intervals-consecutive mode of an ore drawing from the brought down panels and blocks these laws continuously repeat in process of inclusion in operation of other apertures.

Pressure change (a decrease or increase) occurs in steps in the expiration of ore from a final aperture, and its size changes from a minimum to a maximum in any point of the panel (block).

The size of the minimum pressure does not depend on a location of an aperture within the panel (block) and (its) its sizes, and is defined only by quantity of the released ore [1-3].

At release from an aperture of ore of 20-30 sm^3 the size of the minimum pressure is in limits 35-40 g/sm^2. The further ore drawing causes rock pressure slight increase in connection with increase in height of an ellipse of loosening.

The size of the maximum pressure depends on the sizes of the panel (block), intensity and an ore drawing order.

The increase in length of the panel (block) an across the strike at invariable to width along the strike, intensity and an ore drawing order leads to growth of size of the maximum pressure upon the bottom of the panel (block). In panels in the size 24×60 sm is pressure was on 25-27% more than in panels in the size 24×30 see especially sharply the size of the maximum pressure upon the panel bottom increases at increase in width of the panel along the strike.

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SIMULATION OF THE SYSTEM OF AUTOMATIC CONTROL OF THE PROCESS OF WELL HYDRAULIC PRODUCTION

The most promising alternative way of developing mineral deposits of low and medium strength are geotechnological methods, among which one of the main ones is the method of well hydraulic extraction [1-3].

Peculiarities of well hydrotechnology of mineral extraction, as well as its energy and resource intensity, require the use of modern automation systems to optimize technical and economic indicators. At the same time, the complexity and conditions of the technological process of underground hydraulic washing create problems of operational control of technological parameters [4-6].

The processes of hydraulic destruction of the massif during the development of deposits have already been investigated under various conditions and methods of influence, and the dominant parameters affecting the technology of hydrodynamic erosion have been identified. The dependences of erosion performance and flow transport capacity on these parameters were also established [7].

The researched hydromonitor flushing control system involves the selection of controlled parameters and control influences, establishment of structural relationships between input and output parameters, development of the structure of the automation system, and selection of equipment. The controlling influences during hydromonitor washing are selected water pressure and flow rate, the speed of the jet movement along the wall of the hole, and the angle of rotation of the hydromonitor. The feeding of sections of the telescopic hydromonitor into the hole is also taken into account.

It is proposed to control the process of hydromonitor erosion based on the control of the distance between the hydromonitor nozzle and the wall of the hole and the rate of rock erosion. Monitoring the change in dimensions of the extraction chamber also provides information on the performance of the washing process.

The algorithm of the system is based on the calculation of the washing speed and its adjustment by changing the water pressure in the hydromonitor based on the signal from the sensor of the distance of the hydromonitor head to the hole, which is sent to the controller, which, depending on the change in distance over time, issues a control signal according to the established regulation law to the regulating electric drives for control by the process of erosion. When the maximum permissible distance between the wall of the hole and the nozzle of the hydromonitor is reached, a signal is generated to advance the next section of the telescopic hydromonitor, the use of which makes it possible to adjust the dimensions of the washing chamber with minimal energy costs. When the distance from the nozzle of the hydromonitor to the wall of the hole increases, the linear velocity of the jet along the wall of the hole will increase, so the angular speed of rotation of the hydromonitor decreases proportionally. A frequency-regulated electric drive is used to maintain a constant linear speed of the stream along the wall of the hole, which rotates the hydromonitor around the axis. After the completion of erosion at a certain depth, a signal is generated about the need to change the position of the technological equipment for borehole hydraulic production in height.

When studying complex control systems, such as the control system for hydromonitoring washout during borehole hydraulic production, their simulation is carried out at the design stage.

The developed simulation model of the control object provides blocks of approximation of the function of two variables for automatic calculation of transfer coefficients and time constant. Arrays of experimental data generated for specific deposits and minerals are entered into the blocks, on the basis of which linear or cubic splines are interpolated and extrapolated.

The hydromonitor flushing control system model developed and researched in the Simulink software application of the MatLab package made it possible to correctly build the process control logic, select the necessary control laws, and determine the optimal settings of the automatic regulators. The result of the simulation of the automatic control system is the dynamic characteristics in transient modes and the switching diagrams of the system states. The results of the simulation of the hydromonitor flushing control system made it possible to optimize the transient characteristics of the flushing range and speed, the rotation speed of the hydromonitor, and to improve the process of switching the technological modes of operation of the equipment.

The implementation of this system in practice will ensure high technical and economic indicators of the hydromonitoring erosion process and is the basis for building flexible management systems that will allow them to be used for the extraction of various minerals.

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DESIGNING FILTERS FOR WATER WELLS

Construction of the water production wells is accompanied by a series of rather problematic factors; among them, special attention should be paid to the fact that it is necessary to reduce the

prime cost of mining as well as prevent environmental contamination and disturbance of the aquifer structures [1]. Minimization of the operation costs related to the water preparation for its supply into the network (in our case - elimination of the reservoir rock fragments and other foreign admixtures from the fluid) can be considered as the reserve for reduction of the extraction prime cost. It is possible to prevent carrying out of solid phase from the productive seam while its operation by equipping a receiving part of a hydrogeological well by the filters of different types. The requirements for the latter include ensuring the reliable operation of a water supply well with the designed well rate within a certain time period. Hydraulic characteristics creating the water flow conditions in the bottomhole zone are the determining factor of the filter operability [2].

Thus, we can state the following. A filter for a water supply well should have maximum capacity with minimum hydraulic losses; long service life; and sufficient mechanical and chemical resistance. Moreover, it should be simple for manufacturing and have low prime cost.

Almost all known assemblies of the currently applied filters are characterized by technological complexity of manufacturing; need for costly and deficit materials for the components; considerable complexity in production and interaction of its separate units; availability of filtering screens that increase the total hydraulic resistance of a filter; great imperfection of a technological compliance of the operation with a water receiver in the form of a centrifugal pump; no possibility for operative maintenance and effective use, e.g. in oil wells, that narrows significantly the range of potential filter application.

There is the following task for improving a basic filter design: to get such a filter arrangement where there is fundamentally different version of filtering tubes with the substantiated selection of the parameters of flowing siphon-type equipment and a scheme of their uniting into a single interacting hydraulic mechanism; development of a hydraulic circle with low resistance values; and considerable increase in the filtration surface.

Altogether that provides substantial increase in filter permeability for the well fluids; great reduction (up to impossibility) of the chance that mechanical admixtures in the form of sand will enter the well; complete elimination of electrocorrosion for the mentioned filter type; possibility of quick filter maintenance or its replacement at the well bottomhole.

All the mentioned things help widen the application range of the improved filters in wells with different fluid types, increase mineral extraction rate, prolong the filter service life at the bottomhole, and reduce the operating period of a filter at the bottomhole along with the great reduction of the production well servicing.

The specified problem can be solved by the fact that for a filter that includes cylindrical frame (plugged in the lower part) with a filtering component fixed stiffly on it, its filtering component is made in the form of cambered siphon-type tubes.

The tubes are fixed in the frame in the separate continuous rows at similar distances from each other, their siphon parts are filled with gravel material; and the internal and external ends of each tube are wedge-shaped towards the flow direction in it. In addition, each tube is installed so that its internal end will be higher than the position mark of the external one.

Besides, the lower part of the filter frame is equipped with the reverse valve (fig. 1) [3].

Fig. 1. Bottomhole screen

The proposed filter design operates as follows: a filter, which upper part is equipped with a clamping nut with T-shape slots, is descended directly into a well on a drillstring that contacts the clamping nut with the help of a traveller ring with L-shaped arms that is placed on the lower drillstring part. The clamping nut with T-shape slots is connected to the external surface of a filter adapter on the right thread. Within the productive seam interval, the filter is descended with constant hydraulic washing-out through the reverse valve of a plug-settler and if an adapter is put on the end hooks located on the lower shoe of the production string. Rightward rotation of the drillstring and, consequently, the clamping nut is used to unfasten an elastic seal ring resting on a stopper; that is accompanied by covering a gap between the external surface of the filter frame with the adapter and internal surface of the production string. During a slow leftward rotation of the drillstring, the L-shaped arms of the traveller ring are being released from the T-shaped slots of the clamping nut with further drillstring ascending from a well. Filtering tubes remains to be the only channel of connection of the production string with the productive seam.

Owing to pressure difference between the external and internal part of the productive string, changing shape and position of a circulation circuit and internal part of the production string and active filtration of the formation fluid, the latter starts its directed motion through the filtering tubes. Due to complex spatial shape of each filtering tube, difference in the position level of their input and output ends, and formation (owing to specific profiling of the filtering tube ends) of certain mode of fluid flowing, the obtained velocity head is being constantly lost and balanced, by the gravitation force of a filtering surface in the form of a gravel material layer.

Finally, that favours clear gravitation separation of the formation fluid and foreign mechanical admixtures, e.g. sand particles, and excludes entering of foreign components into the internal filter part and the production string.

The necessary effective condition of the specified filter operation is the connection of its design parameters with the circuit-circulation characteristics of the captured horizons, i.e. material and granulometric composition of the rocks of a productive seam-reservoir. It is also required to select a ratio of piezometric positions of the ends of filtering tubes in the form of V-shaped cuttings as the

geometric angular characteristics of the arrangement of their ends as well as consider the flowing size of a siphon part of the filtering tube and granulometric, quantitative, and material composition of the sand-control gravel filling.

The reverse valve function is to allow direct hydraulic washing-in of the filter into the productive seam that is possible by pumping necessary amount of pressing fluid through the plug-settler and further complete insulation of the internal part of the filter to prevent uncontrolled entering of the formation fluid.

As a result of implementation of the developed filter design, the technical and economic indices are expected to grow; in this context, it will be possible to widen both technological and hydrogeological range of the sand filter use.

Therefore, the proposed design belongs to mining technology, i.e. to oil industry and water economy. To be more specific, it belongs to filtering equipment of drilling wells. It can be applied in the equipment of hydrogeological, productive hydrocarbon and geotechnological wells of wide diameter and depth ranges in the rock-reservoirs of sand type.

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MODERN METHODS OF OBTAINING GEODATA FOR SURVEYING OF MINING ENTERPRISES

The variety of measurements and obtaining geodata opens up a wide range of new opportunities, but also daily puts the professional world in front of new challenges. In this regard, in practice, surveyors use more and more alternative measurement and shooting systems. Surveying has always been an important part of the process of extracting minerals.

The preparation and maintenance of a series of mining maps is the most important part of the surveyor's tasks. The supervision of its conduct in mining is the responsibility of the controlling body. Measurement results must be documented so that they can be reconstructed, and the correctness of the results and graphic images based on them must be guaranteed minimum distances to other zones.

Regular measurement of raw material volumes, preservation of ledge angles and working marks is the main requirement for performing these tasks. That is, to a large extent, the activity is associated with the use of modern measuring and geodetic technologies, which have always made surveying a strong driver of technology in related and specialized industries.

Today, tools and systems still mostly adhere to the same functional principles, and the basic skills and abilities required to perform measurements are not so specific.

The RTK (*Real Time Kinematic*) GNSS (Global Navigation Satellite System) systems play an important role and are undoubtedly among the most important for classical high-altitude filming methods, as well as for determining the number and additional filming in open mining operations.

With the help of GNSS signals, it is possible to determine the position of the receiver on the Earth's surface with decimeter accuracy. However, due to distortion without the use of special equipment, the real positioning accuracy is usually measured in meters or tens of meters (depending on latitude, number of visible satellites and other conditions). Distortion can be significantly reduced with the help of additional ground infrastructure – differential correction systems.

To obtain corrections, phase measurements of the carrier GNSS signals are used simultaneously on two GNSS receivers. The coordinates of one of the receivers (basic, fixed) must be accurately determined (for example, it can be installed at the point of the state geodetic network); it transmits through a communication channel (radiomodem, gsm modem, Internet and others.) a set of data, called amendments.

The corrections received by the station and the satellite signal are processed by the software in accordance with software algorithms and accumulated statistics of satellite ephemerides. After that, the second receiver (movable, "rover") from the base station is transmitted a differential correction-clarifying the satellite signal.

Due to the development *of unmanned technologies*, in recent years drones have become a common tool for shooting and cartography. When mapping with drones, the photogrammetry method is used to create accurate real 3D models from 2D images. Photogrammetric methods combine and process several aerial photographs with geographical reference, allow you to create three-dimensional point clouds, raster digital elevation models and orthophotomaps.

Perhaps the main advantage of photogrammetric mapping from drones is time saving. Geodetic work, which usually takes weeks, with the help of drones is carried out in a matter of days. Thus, the use of drones can reduce costs for many projects. But despite all the advantages of photogrammetry from drones, shooting is a job that requires the maximum degree of accuracy. And the stated accuracy of drones usually did not correspond to their theoretical potential.

Tacheometric survey consists in simultaneously determining the planned and high-altitude position of points on the ground, that is, in calculating their coordinates: direction, distance and excess.

According to the survey, topographic maps and terrain plans with horizontal terrain images are compiled on a large scale (1:5000 1:500). Tacheometric survey is used in geological exploration, construction and operation of mining enterprises, roads, pipelines, industrial structures.

The use of laser scanning in the extraction of minerals in an open way allows you to quickly determine the volume of moved rock, calculate deviations from the design values, take into account volumes and plan costs.

If you scan an object before and after the explosion (or before the start of rock extraction and after the end), then the three-dimensional surfaces (TIN) obtained from the point clouds will accurately show the results of the rock movement.

The accuracy of measuring the coordinates of points is quite sufficient to create plans of a scale of 1:500 and larger, even at the maximum distance of objects from the scanner, the accuracy of determining the coordinates remains no worse than 3 cm. It is laser scanning for the mining industry that allows you to create copies of the desired high-precision object by translating geometric shapes into mathematical models.

Scanning an object before an explosion and scanning an object after an explosion allows you to get a lot of useful information, therefore it is a very valuable function. Scanning for the mining industry eliminates repeated studies and reduces the budget for work several times.

The methods described above have the specifics of use, the main goals and the area of application. That is why each method has its drawbacks that overlap with another method. In the article, they go in order of decreasing the area of application and conditionally increasing the accuracy of obtaining models after processing.

Of course, the current specialist uses several at once, which simplifies and improves the accuracy of the results obtained. Currently, digital technologies and automation are developing, which greatly simplifies processing and obtaining the desired result.

And even if there are more and more changes and simplifications of surveying work, it may seem that the role of the surveyor is no longer needed in modern mining, it is just the opposite.

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ANALYSIS OF THE FEATURES OF 3D-PRINTING TECHNOLOGY FOR ITS USE IN THE CREATION OF NEW TYPES OF FASTENING OF MINING WORKINGS

Every state strives to maintain economic and, in particular, energy security. Ukraine is among the many indicators of national economic security [1], and an important place is given to the degree

of providing the country with basic natural resources and, in particular, energy carriers. From the point of view of Ukraine's energy security, coal is a fairly reliable fuel [2].

The problem of supporting underground mine workings with new types of fasteners is becoming more and more important for the mining industry of Ukraine for the main reasons: first, the steady tendency to complicate mining and geological development conditions; secondly, constantly growing material and labor costs for fastening products; thirdly, the need to strengthen the requirements for the safe conduct of underground works [3].

The process of increasing the reliability of fastening preparatory products becomes more complicated with an increase in the depth of their implementation, as well as the search for rational technological parameters.

The need to create new means of fastening mining workings with a significant increase in the stability of parameters [4], as well as operating characteristics, is objectively dictated by high requirements for fastening and the severity of mining and geological conditions.

A new solution for fastening mining workings is the development and printing of fasteners on a 3D-printer. But it is impossible to print fasteners from metal, because steel materials do not meet the requirements of 3D-printers. The best solution to this problem is to print the fasteners for composite materials, namely carbon fiber-reinforced plastic.

The first attempts to use 3D-printers to print models have been known since the end of the 20th century. But it was in the last decade that 3D-printing technologies became widespread [5].

Thus, the study [6] analyzed the current state of light industry and the prospects for its development using the latest technologies. Areas of application of 3D-printing technology in various branches of industry are considered and characteristic areas of its application in light industry are given, in particular during the manufacture of clothes, shoes and parts in industrial engineering.

In construction, the method of creating houses using 3D-printers is widespread, and leading scientists from the University of Southern California have created a 3D-printing system for working with large objects [7]. The system works on the principle of a construction crane, which builds walls from layers of concrete. Such a 3D-printer can build a two-story house in just 20 hours. The workers will only have to install windows and doors and finish the interior of the room.

3D-printing technologies were officially used in medicine back in 1999, when employees of the American Institute of Regenerative Medicine implanted an organ made with the use of computer tomography and a 3D-printer into a person. Currently, 3D-printing in medicine [8] is quite widely used due to the variety of directions and possibilities. Among them are the following: creation of implants, printing of bones, modeling of internal human organs, creation of medical tools for doctors.

3D-printing technologies have also found their application in bridge construction. Bridges printed on 3D-printers are now actively used in the Netherlands, China and the USA.

In mechanical engineering, 3D-printing creates conditions that allow solving various tasks efficiently, quickly and qualitatively. These tasks include: development of prototypes and production of new components and assemblies (concept models, test samples), creation of more modern systems and their elements, as well as production and repair of old parts. In practice, 3D equipment has shown its effectiveness and the ability to produce higher-quality and less expensive products [9].

In the energy industry, 3D-printing technology has made quite a breakthrough. American scientists created and printed a prototype of the core of a nuclear reactor [10]. It is also worth noting that 3D -printing is also actively used in renewable energy, and that solar panels made on a 3D-printer are 20% more efficient than standard ones. New materials and technologies further increase the efficiency of devices.

Based on the above, an alternative option for solving the current problem of fixing the produced space and increasing the stability of mining products in coal mines is to change the material from metal to composite and print the fasteners on a special 3D-printer. The authors have developed fasteners models [11] that can be printed on a 3D-printer for further mining experiments.

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ENERGY-SAVING COMPUTER-INTEGRATED DRILLING TECHNOLOGY

Drilling a rock mass is an extremely energy-intensive process. It is therefore very important to optimise it in order to minimise energy costs. The solution to this problem depends on the availability of information about the characteristics of the rock to be drilled and the condition of the drilling

tool. This information makes it possible to formulate a drilling regime that is optimal in terms of energy input per drilled meter of rock.

One possible way to assess the physical-mechanical characteristics of a rock is to analyse the noise generated during the drilling process. This approach allows identification of the specific acoustic signature of each type of rock drilled, or at least class of rock. During rotary drilling, the sources of noise are the rig mechanisms and the drill's contact with the rock. A number of studies have shown that the frequency range carrying the acoustic signature of the rock during drilling is in the range of 5-8 kHz [1].

Drilling rocks generates strong vibrations in the drilling rig, which can cause reduced rates of penetration (ROP) and premature failure of the equipment. The only way to limit vibration during the drilling process is to change the ROP or weight-on-bit (WOB). These changes often result in reduced drilling efficiency. At the same time, the vibrations that occur during the drilling process carry information about the condition of the drilling tool. A roller cone bit is a kind of mechanism that converts the rotation of the drill string into longitudinal, torsional and, under certain conditions, transverse vibrations during contact with the bottom hole [2].

In [3], a method for direct quantification of various forms of vibration with parameters that can be easily transferred to the surface is justified. The system uses four accelerometers and a magnetometer installed on the drillstring. Using different combinations of accelerometer output signals it is possible to differentiate between swirling, intermittent sliding, bit bounce and lateral vibrations.

The main objective of power-consuming drilling process control is formulated as follows: by indirect process data (electromechanical drive motor characteristics, characteristic parameters of acoustic noises and mechanical vibrations of the rig) to restore both general picture of interaction process with definition of current values of functional characteristics and regime parameters of rig's work and values of strength and physical-mechanical parameters of rock mass and its structure. Realisation of the listed tasks provides the decision of tasks of informativeness and optimum control of the process in real time.

The modeling task was to estimate the power inputs per drilled meter of rock by predicting the rate of penetration of the borehole based on measurements of parameters that indirectly characterize this process. Identification of obtained dependencies at the stage of experimental studies was carried out using MATLAB software. Adjustment of the Sugeno fuzzy model was carried out using ANFIS (Adaptive Network based Fuzzy Inference System) technology by an iterative procedure of finding the parameters of the identity functions that minimise the discrepancy between the actual and desired behaviours of the model. The fuzzy model is optimized on a training sample of 105 numerical input-output arrays. The root-mean-square identification error of this model on a control sample of 25 points is 0,92.

Obtained results show that the proposed approach is promising for solving the problem of increasing energy efficiency of the drilling process.

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MINERALOGICAL ANALYSIS OF IRON ORE DEPOSITS BY ACOUSTIC LOGGING OF DRILLING WELLS

Borehole logging is based on the measurement of some quantities depending on one or a combination of physical properties of rocks with the help of geophysical sensors.

Logging is carried out by electrical, magnetic, nuclear, thermal, acoustic and other methods. Signals from the sensors are transmitted to the surface and recorded by ground equipment in analog or digital form.

Acoustic (ultrasonic) logging is based on the study of propagation parameters (velocity, attenuation, etc.) of elastic waves in the rock mass. In rocks, the propagation velocities of elastic waves vary in a wide range and depend on physical properties, mineral composition, structure, texture, condition and other internal and external factors.

The propagation velocity of longitudinal elastic waves in rocks varies in the range of 1500-7000 m/s, transverse waves - 800-5000 m/s. The ratio of propagation velocities of longitudinal and transverse elastic waves in igneous and metamorphic rocks is usually 1,7-1,9.

he damping of elastic vibrations in the rock massif in which they propagate depends on their frequency. In a wide frequency range - from 1 Hz to 10 MHz, the attenuation coefficient in different rocks varies from $1 \cdot 10^{-8}$ to $2 \cdot 10^{2}$ m^{-1} [1,2].

These parameters of ultrasonic wave propagation characterize the physical properties of rocks, but they are not enough to identify at least the main mineralogical and technological varieties of iron-bearing ores of a particular deposit.

The variety of sizes and shapes of inclusions of iron-bearing minerals in ore allows us to conclude that it is advisable to use these features for their identification by acoustic logging methods.

The computer-integrated technology of geological and mineralogical analysis of rocks based on the fuzzy classification of parameters of ultrasonic waves propagating in the studied medium has been developed.

During the propagation of ultrasonic waves in the rock, they are absorbed and scattered by ore inclusions: separate (individuals) and aggregates.

The parameters of these processes are characterized by their effective cross-sections of attenuation σ_p, absorption σ_c and scattering σ_s.

Under the effective cross-sectional attenuation *p* is meant the cross-sectional area perpendicular to the direction of incidence of the ultrasonic wave, for which the incoming energy is equal to the sum of the energies absorbed and dissipated by ore formations.

Reflection and scattering of elastic vibrations on structural inhomogeneities in the rock massif and their superposition lead to variations in the frequency of the resulting elastic vibrations.

The magnitude of these variations is determined by the ratio of the wavelength of the generated elastic vibrations, the size and structure of the distribution of mineral inclusions in the rock. With a change in the frequency of ultrasonic vibrations filling the probing pulse, the conditions of their propagation in the measurement area change.

This, in turn, leads to changes in the average value and dispersion of the intensity of the received signal. The ultrasonic wave is distorted due to the nonlinearity of the medium and, consequently, higher harmonics are generated. Thus, the received signal consists not only of a fundamental frequency wave, but also of a second or higher harmonic wave.

To evaluate the nonlinearity of the ultrasound propagation process, the attenuation coefficient of the ultrasound at the fundamental frequency and the first harmonic, as well as the ratio of these parameters, is determined.

In accordance with the above, as an information base for the identification of mineralogical varieties of iron ore, we used: the results of measuring the velocity and attenuation of longitudinal and transverse ultrasonic waves of the corresponding frequency, the characteristic parameter S_1, which is determined by the dispersion and average values of the intensity of the received ultrasonic signal, and the characteristic parameter S_2, which characterizes the nonlinearity of the propagation process.

The iterative method of fuzzy identification of mineral-technological varieties of iron ore, based on the clustering of the results of ultrasonic measurements in the vector space of features, was used.

This allowed, by minimizing the sum of the weighted distances between the analyzed and exemplary values of the results of ultrasonic measurements with a confidence probability of 0,93, to recognize the seven main technological types of ores of the exploited deposit.

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EQUIPMENT COMPLEXES AND TECHNOLOGICAL SCHEMES FOR EXCAVATING FLUVIOGLACIAL DEPOSITS IN QUARRIES

The number of quarries that develop fluvioglacial deposits in Ukraine is about 20 % of the total number of quarries for the extraction of non-metallic building materials [1]. As a rule, gravel-sand mass is used for the production of sand, stone and rubble. However, in some cases, fluvioglacial deposits are classified as overburden rocks, because they block access to the development of the main rock fossil. In this case, the traditional technologies of removing the overburden layer of waste rocks used in the development of rock minerals are usually inefficient and even impossible [2].

Scientists note [3] that the technology of development of fluvioglacial deposits depends primarily on the content of gravel-boulder material, which can be distributed both throughout the capacity and area, and accumulate locally. Therefore, at the stage of exploration it is necessary to study in detail the composition and structure of the thickness of the covering gravel-sand rocks.

In most cases, quarry excavators such as "mechanical shovel", hydraulic excavators and draglines are used to remove fluvioglacial deposits [1, 3]. Rotary and multi-bucket excavators, loaders, bulldozers, wheel scrapers, rope scrapers, tower excavators can also be used [4,5]. If the field is flooded, the so-called hydromechanization equipment is used [1].

On the basis of the selected extraction and loading equipment technological complexes of the equipment for the development of fluvioglacial deposits are formed, the main task of which is the achievement of the maximum productivity of each unit of the equipment at the minimum expenses.

If the deposit of fluvioglacial sediments is not flooded, the technological scheme of development with excavator excavation and loading into vehicles is recommended [6,7]. The main advantages of this scheme are convenient separation of boulders from the main rock mass, selective extraction of sand, clay, and gravel. With small volumes of fluvioglacial deposits, limited space for mining and (or) lack of appropriate equipment for extraction of compacted boulder-gravel mass, this technological scheme is difficult to implement, and in some cases even impossible.

If the deposit is partially flooded, it is recommended to use draglines, which remove and stack the rock sand-gravel mass in a pile for drying to natural humidity [3]. In rock deposits covered with overburden from fluvioglacial deposits, dragline can be used only in the presence of large areas and volumes of overburden, insignificant content of boulders and gravels, and only at the stage of opening the deposit, i.e. when the mining front is not limited to mining ledges.

Rope scrapers and tower excavators are used in the development of dry and flooded fluvioglacial deposits of large area [3,4]. In this case, the capacity of the rope scraper bucket is 4 m^3 and more, and the distance between the towers - up to 200 m and more. The main disadvantages of this design are the need to leave the pillar at the junction with the main support (with losses can reach 20 %) and a sharp decrease in equipment productivity with increasing scrapping distance and content of gravel-boulder material.

Scraper technological complexes can be effectively used as the main equipment in the development of sand and gravel deposits in the absence of boulders [5]. The appropriate average transport distance is not more than 600 m with a scraper bucket capacity of 6-10 m^3. Possible schemes are characterized by the location of the rock dump relative to the contour of the quarry.

When using bulldozers for the development of sand and gravel rocks, it is recommended to remove with fan, parallel longitudinal or transverse, diagonal or combined approaches [5]. The most rational distances for transporting rock mass are 70-120 m. Bulldozer development of rocks is expedient if it is carried out at the opening capacity $H_p \leq 3$-4 m and moving it at a distance of L≤100-150 m in external dumps.

The use of combined scraper-bulldozer complexes is also possible for the development of sand-gravel mass at the overburden during the development of construction rock deposits [5]. Scrapers can remove the rock by transverse steps or frontal pits. Bulldozers perform dump formation.

Bulldozer-excavator complexes are effective in extracting rocks if the width of the mining front is up to 40-60 m and the opening capacity is up to 4-6 m. Extraction and movement of rock mass is carried out by bulldozers, and loading of rock mass into vehicles is carried out by excavators.

To develop a layer of gravel-sand mass with a thickness of 6-10 m and in the presence of boulders, it is advisable to use bulldozer-excavator-car or bulldozer-loader-car complexes [8]. When using bulldozers and excavators (or loaders) the gravel-sand mass is moved by bulldozer to the stack, from which the excavator (loader) loads it into dump trucks.

The scheme is also quite effective, when the rock mass is dumped by bulldozer on the lower ledges and there the excavator is loaded into vehicles (Fig. 1) [4,9]. At the same time high productivity of the excavator is reached and width of working platforms decreases.

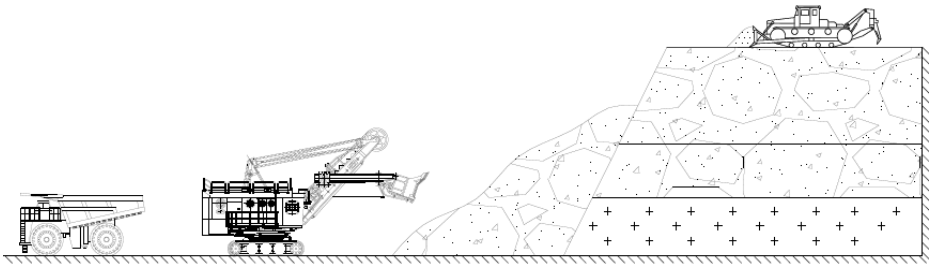

Fig. 1. Bulldozer-excavator technological complex

Floating dredgers can be used only in the development of naturally or artificially flooded sand and gravel deposits [3]. Despite the low cost of extracting sand and gravel by floating dredgers and low production costs, their use in existing quarries of rocks is impractical, as such technology is not suitable for excavation in these development conditions. It is necessary to organize a complex organization of works on flooding of areas of sand and gravel mass and prevention of water leaks from artificial reservoirs.

A result of the analysis of technological complexes of equipment that can be used to remove fluvioglacial deposits in quarries revealed the main advantages and disadvantages of each of these complexes. The factors under which a certain technological scheme of development will be effec-

tive for specific working conditions are indicated. It is proved that the efficiency of each technological scheme of development of fluvioglacial deposits on the overburden ledges of quarries is determined by mining-geological, hydrogeological and technological conditions of development, area and volume of mining, the availability of mining equipment and working area parameters.

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STUDY OF THE JOINT INFLUENCE OF STATIC AND DYNAMIC LOADS ON THE CHARACTER OF DESTRUCTION OF A SOLID ENVIRONMENT EXPLOSION ENERGY

Currently, the extraction, processing and use of uranium raw materials is given a significant share in the energy security of the EU countries, the USA, Japan and Ukraine. In terms of total uranium reserves, Ukraine is among the top ten countries in the world. Only explored reserves are able to provide for more than 100 years the need of Ukrainian nuclear power plants in natural uranium. The uranium reserves of the Kirovograd and Nikolaevskoy regions, explored and approved by the State Reserves Committee, are equivalent in their energy potential to the Donetsk basin.

With a relatively low content of uranium in ores, the deposits of Ukraine are distinguished by a number of advantages that determine the competitiveness of the produced uranium concentrate [1], namely:

- large size of uranium deposits, allowing the use of high-performance mining systems;

- carrying out mine workings without fastening and creating large-size treatment blocks due to the high strength of ores and host rocks;

- ensuring a normal radiation situation at workplaces without the use of special methods, limited only by sufficient ventilation, due to the low content of uranium in ores;

- the monomineral nature of ores makes it possible to simplify the processing of ore and the production of high-quality uranium concentrate;

- the deposits are located on a well-developed territory, with a developed network of transport routes.

Despite the creation of new destruction technologies based on non-traditional approaches (thermal destruction, impact of high-energy particle streams, etc.), the explosion remains an effective method with the widespread use of resource-saving and environmentally safe methods of mining mass preparation in mines. They are based on an in-depth study of the features of the destruction mechanism of polymineral media in relation to gas-dynamic phenomena during an explosion.

One of the ways to improve explosive technology is to take into account the geomechanical characteristics of the massif, in particular the stress-strain state, the physical and mechanical properties of rocks, the fragility of rocks, which depends on the structure, mineralogical composition and orientation of minerals (crystals in the rock), etc. from the size and shape of the destructive bodies, the type of loads and the rate of deformation of the rocks in the massif [2-3].

The study of the influence of the previous load of the solid medium on the nature of its further dynamic destruction is becoming more and more relevant in mining in connection with the transition of cleaning operations to depths in many deposits, where it is no longer possible to ignore the initial stressed state of the rock mass [3].

The reduction in the level of cleaning works has a particularly negative effect on the conditions of development of iron ore and uranium deposits of Ukraine, where chamber systems of development are used with the preparation of blocks by subsurface mining and trenching with their alternate excavation and filling of the produced space with a hardening layer. At the same time, more than a quarter of the labor and material costs are accounted for by operations related to the explosive removal of ore [4-5].

One of the promising ways to overcome the existing situation is that when developing new technical solutions and their further development in the process of mining ore deposits, it is taking into account the main laws of the destruction of a pre-stressed solid medium. In this regard, the fact that in the conditions of comprehensive compression of the rock volume, the increase in stress values worsens the quality of the destruction of the massif, and at a certain level of fissuring of the rock massif after the explosion, is of great importance. The presence of tensile stresses in a solid environment, on the contrary, improves the degree of destruction of rocks, which leads to a lower consumption of explosives. Thus, for the development of effective methods of chipping and further extraction of ore deposits at great depths, the study of the influence of the own stress field of the massif in the ore block around the mining chamber in order to determine the maximum possible zones of action of tensile stresses that affect the destruction of a steep ore deposit is of great importance, represents a personal interest.

Tasks, methodology and presentation of the results research. To study the joint influence of static and dynamic loads on the nature of model destruction, a methodology has been developed that

consists in the use of well-known methods of modeling the stress-strained state (SSS) of the array and the polarization-optical method of stress research. The essence of which is to use 30 mm or 40 mm thick organic glass for research. Models with a length of 180 mm and a width of 150 mm were made from samples of sheet organic glass. To simulate a massif of rocks with an extraction chamber with an extended collapse vault, a cavity in the form of a parallelogram with a side of 40 mm and 80 mm was formed inside the model at an angle of inclination of 75° to the horizontal plane. Models were loaded on a hydraulic press PSU-125. The dynamic loading of the models was carried out by a charge of high-explosive substance weighing 80 mg, formed in different contact zones in the model of a mountain massif with an extraction chamber.

According to the developed research methodology, several series of experiments were conducted:

- study of the formation of a static stress field around the mining chamber with a continuous collapse vault;

- detonation of an explosive charge in the central part of the mining chamber with a long vault of collapse, in the zone of increased stresses with loaded and unloaded models;

- detonation of the explosive charge at the contour zone of the extraction chamber of the loaded and unloaded model;

- detonation of the explosive charge in the hanging sides of the extraction chamber with loaded and unloaded models.

In the process of experimental research, the prepared model with a chamber and a cavity for the charge of an explosive substance in its vertical position was placed in a specially made device between the pressure plates of the press and loaded with a fixed duration of the model being in a loaded state for a certain time. The results of the formation of stress fields under different loading conditions of the model were recorded with a digital video camera OLIMPUS.

The obtained research results will be taken into account in the development and substantiation of the rational parameters of drilling and blasting, the location of wells and their drilling conditions in the block, which will allow to increase the efficiency of the work of well charges for the removal of the ore deposit, reduce the specific consumption of explosive materials (EM), desalting minerals and thereby improve the performance of loading and transport vehicles.

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INVESTIGATION OF THE INFLUENCE OF CONTACT BOUNDARY OF DIFFERENT ROCKS IN THE MASSIF ON THE RESULTS OF THE EXPLOSION

Rock massifs in most cases have a complex structure, which is characterized by fracturing and the presence of rocks of different strengths on the same structural unit. Often the properties of rocks, which are in contact with each other, significantly differ from each other. Scientific extensive studies have proven that the presence of contact boundaries in the rock massifs has a negative impact on the quality of the mining mass which is prepared for extraction by means of mass explosion, especially in the near-contact zones.

Despite the high number of scientific researches on the problems of explosive destruction of structured rock massifs, the scientists have not fully solved the problems of the quality of their crushing. This can be explained by the fact that the mechanics of rock crushing in the contact zones of rocks of different strengths and peculiarities of mining and geological and technological conditions in which the crushing is carried out [1] are not studied in detail. As stated in scientific papers [2-4] the peculiarity of the explosion in structured and multi-strength and fractured massifs is that the energy of the voltage wave, which occurs at the moment of undermining the charge and passes along the rock massif, is reduced as a result of dispersion in the contact places of the rocks of different strengths and surfaces of natural or artificial cracks. In addition, the pressure of the explosion gases when penetrating existing natural cracks also reduces significantly. This leads to a shortening of the duration of their effect on the rock mass and, as a consequence, the quality of demolition of rocks is deteriorated. The presence of cracks and contact points in the rock massifs substantially reduces the impact of the explosion on the rocks.

Given the above, the study of the effect of near-contact zones of rocks of different strengths in the structured rock massifs on the result of their explosive crushing is relevant.

It is not uncommon in large quarries to see drilling operations carried out on an industrial block with rocks of different strengths [5, 6]. In this case borehole charges of explosive materials (EM) in the near-contact zones, on the different sides of the division boundary, have different conditions for the destruction of the rocks. Scientific studies show that if the first borehole charge destroys one rock, the second charge located beyond the contact boundary destroys another rock and the blast wave of the first charge reaches the contact line with the first one, the values of its maximum voltages will change. They will increase or decrease depending on the conditions of contact boundary-crossing. At the same time, the values of maximum voltages of the second charge of EM will re-

main unchanged until the contact with the blast wave of the first charge. According to the obtained data [7], as a result of two charges of EM discharged on both sides of the contact, the reduction of the maximum voltages can range from 3 to 27 % depending on the properties of the rocks located in the near-contact zone and the type and conditions of blowing of the explosive materials.

Studied the zones of destruction on the surface of the rock massif of different strengths of magnetite quartzite and quartz-biotite schist. The calculations have been carried out for the conditions of the explosion of borehole charges of an Anemix explosive material 70 with radius r_3=0,1 m and a length of 15 m. The distance between borehole charges of EM is 6,0 m. The position of the contact boundary in the rock massif varied from1,0 to 5,0 m (10-50) *r*, where *r*=0,1 m is the charge radius) from the first charge.

Defined, that quartz magnetite the zones of destruction are always smaller than the zones of destruction in quartz-biotite shale, regardless of the location of the contact boundary. It should be also noted about formation between the main crushing zones, and additional zones of destruction, which arose as a result of the interaction of blast waves of voltages of two charges located nearby.

Calculations were made to determine the volume of crushing (Fig. 1). They showed that, when the contact boundary is placed at 10 and 20 *r* distances from the first charge, the destruction of the massif of different strengths is greater, than the volume of destruction of the homogeneous massif from magnetite quartz (*V*=1496 m^3) which is 1610 and 1558 m^3 accordingly [7]. Obviously, this can be explained by the increased energy of the explosion from the second charge of EM, which was plac.

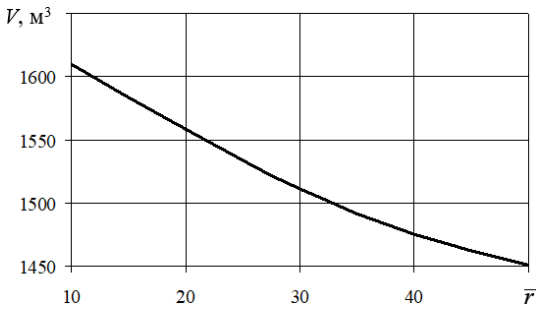

Fig. 1. The value of the volume of destruction of a difference in strength rock mass by explosion depends on the location of the contact boundary of the rock massifs

If the contact boundary is placed in the middle between borehole charges of EM, i.e. at the distance of 30 *r* (3,0 m) from the first charge, the volume of the destruction zone is 1511,1 m^3. At contact boundary distances of 40 and 50 *r*, the volume of destruction is 1475,3 m^3 and 1450,8 m^3.

To reduce the negative impact of the contact zone of different rocks, it was suggested to carry out the charges detonation of EM in such an order that their contact area was placed perpendicular to the reflection direction of the mining mass [8]. In this case, the distance between borehole charges in the contact zone should be determined for rocks of greater strength. If it is not possible to direct the reflection direction of the rocks perpendicular to the boundary of their contact, it is recommended to form a place of mutual interaction of the voltages of the blast waves of each of the charges placed nearby on the interval of the subduction of the rocks.

Therefore, the results of the research showed that the presence in the rock mass of the contact boundary of rocks of different strengths between the charges of explosive materials reduces the total volume of destruction by 9,7-12,3 % as compared to the destruction of the massif created by one type of rock.

To reduce the negative impact of the interval of the subduction of different rocks, it is proposed to carry out the detonation of charges of EM in such an order that their contact area was placed between the charges of different detonation groups, and the reflection direction of the mining mass was perpendicular to the contact area of rocks of different strengths. If such location of charges is not possible, the place of interaction of the voltages of the blast waves of each of the charges placed nearby should be formed on the contact boundary of the rocks.

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RESOURCE PROVISION OF UKRAINE WITH CRITICAL RAW MATERIALS IN THE FIELD OF ELECTRIC VEHICLES PRODUCTION

The development of alternative energy sources and compact, powerful electric motors, as well as the constantly growing request for electric vehicles, has led to a significant increase in the demand for the extraction of minerals that are necessary for the production of electric vehicles. Among the most essential minerals needed to produce electric vehicles are: lithium, nickel, cobalt, graphite, steel, aluminium, copper, manganese, cadmium, titanium and others. In this article, we will focus on 4 minerals which, according to the Atlas of Investment Opportunities of the Ukraine State Geology Service, are classified as critical raw minerals [1].

Among the general list of components for the production of electric vehicles in Ukraine, critical minerals include: lithium, nickel, cobalt and graphite. Other components are currently available and

are not considered as critical for the development of the Ukrainian economy. However, the list of these components may be revised in the future in accordance with new challenges of economic development.

After analyzing the data about the global production volume of electric vehicles and motor vehicles in the period from 2010 to 2021, it can be seen a gradual decrease in the production of motor vehicles over the past 5 years by 24% and a significant increase in the production of electric vehicles over the same period by 400% [2].

Nowadays, lithium is the most important and crucial of these four critical elements in the world, as it is an irreplaceable component for the production of modern electric vehicle batteries. An analysis of the processes of manufacturing hybrids and electric vehicles shows that a standard hybrid requires up to 12 kg of lithium, while Tesla electric vehicles require 22 to 50 kg of this raw material. Determining the exact amount of lithium in Ukraine is currently limited, as this information is classified by the Security Service of Ukraine.

Cobalt is the second most important component in the electric vehicle production. Notably, this mineral is very scarce in the world, and its reserves may be depleted in the coming decades. About 8 kg of cobalt is used in the electric vehicle battery production on average. Generally, cobalt production is dependent on the copper and nickel market, as it is developed as an associated raw material of these deposits in 98% of cases.

The next critical mineral is graphite. Ukraine ranks 8th in the world in graphite production with an annual extraction rate of 20 thousand tons [3]. Ukraine has significant graphite deposits related to the Ukrainian shield with the concentration of valuable components ranging from 2,5 to 20%. Graphite has the greatest resource potential of Ukraine's critical minerals in supplying the world market.

Although nickel is an integral part of the electric vehicle production, this mineral is scarce on our planet and hardly ever found in its pure form. Over the past 11 years, nickel production has increased 1,8 times from 1500 to 2750 thousand tons. The low concentration of nickel in ore in Ukrainian deposits leads to unprofitable production. However, if the projecting of these deposits takes into account the profit from associated copper production, the investment attractiveness of the development of nickel deposits in Ukraine will increase.

In the article "Resource provision of Ukraine with critical raw materials in the context of global trends in the development of the electric vehicle industry" [4], the estimated data on the resource supply of Ukraine with critical raw materials for the electric vehicle batteries production are presented. According to the known volumes of consumption of critical mineral raw materials for the production of one electric vehicle with average parameters, the potential role of Ukrainian resources in the development of the global electric vehicle industry is determined.

The greatest resource potential in supplying the world market is graphite, the reserves of which can produce more than 80 million electric cars. Nickel and lithium reserves also allow to produce about 20 million cars. At the same time, the explored cobalt deposits are extremely limited and the resource potential of Ukraine can provide raw materials for the production of only 0,5 million electric vehicles.

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STUDYING OF THE MANIFESTATION LATERAL PRESSURE ON A THREE-DIMENSIONAL MODEL STAND IN THE CONSTRUCTION OF A DUMP IN GORGE

The developed three-dimensional model stand of a multi-tiered dump allows to solve a volumetric problem by the method of physically modeling and, depending on the slope angles of the side surfaces of the ravine, to reveal the regularities of stress changes in the central axial plane of the dump. At the present stage of the development of upland quarries, the formation of multi-tiered dumps of overburden rock mass in difficult conditions of mountainous terrain and limited land resources, remains a problematic task. The analysis of the research has shown that the design of multi-tiered dumps in gorges and the issues determining the distribution of stresses in the dump body, depending on the formed slopes of the dihedral angle value of the gorge side faces, have not been properly considered. The fact is that the process of the connection stress forces are transmitted to the central axial plane of the dump body from the gorge side with the gorge surface angle inclination. These lateral stresses play a positive role during the formation of the overburden dump in the acceleration of the process of consolidation of the rock mass in the clamped environment and have an inclination angle in the direction of the shear forces acting in the dump. The decreased shear forces in the dump will lead to an increase in its stability, and in this regard, give an opportunity to determinate the rational volumes of overburden placed in it, and also define the main parameters of a multi-tiered dump. It should be noted that using graphical and analytical methods for identifying and objectively assessing the nature of the occurrence and distribution of stress forces in the dump constructed in the gorge are significant difficulties. In this work an attempt is made to reveal and

record the stress forces in the body of a multi-tiered overburden dump formed in a gorge using the physical modeling methods. The analysis of the research has shown that, at present, several issues related to the substantiation of the main parameters of multi-tiered dumps constructed in difficult relief conditions are insufficiently substantiated. In the current "Methodological Guidelines ...", the recommended methods for calculating the parameters of multi-tiered dumps constructed in canyons are the same as for dumps located on flat areas or in the inclined foundation [1]. In well-known studies, it is shown that the nature of distribution of forces in the dump constructed in the gorge differs from the analogous indicator formed on flat or slightly sloping dumps. It is also known that the dump mass of overburdened rocks in gorges is in a “squeezed environment” where a significant role is assigned to the influence on the dumping rocks mass of the dihedral angle formed by the side planes of the gorge [2]. In this case, when justifying and calculating the stability coefficient of a multi-tiered dump in the gorge, in addition to determining the holding and shear forces acting in the dump body, it is also necessary to take the reactions of the forces transmitted by the side faces of the central axial plane in the dump into account.

In this article, the nature of distribution of forces in the overburden dump in the gorge identified and determined. The structure of the physical three-dimensional rotary model stand method (the patent of Republic of Armenia for invention № 3350A, 2019) was developed and used [3].

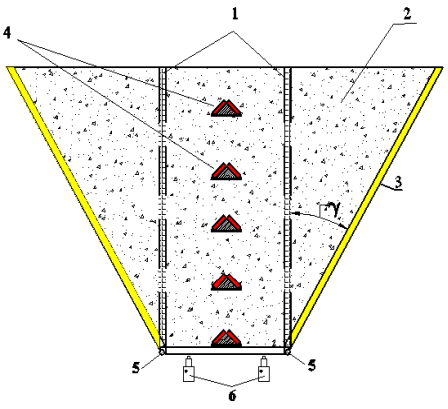

Fig. 1. Installation of stress sensors in the central vertical plane of an equivalent material in the model stand: *1* - model stand frame; *2* - equivalent material; *3* - sidewalls; *4* - sensors; *5* - horizontal hinges for attaching the side faces to the base of the model; *6* - jacks

It is known from the technical literature that the modeling of the geotechnical structure from equivalent materials is performed on flat benches in two ways: on rotating and stationary stands [4]. However, in these dump of a physical modeling stand structure, due to the neutralization of the effect of lateral forces in them, it is impossible to reveal the stress forces transmitted to the mass of dump rocks from the side surfaces of the gorge [5]. The developed three-dimensional physical modeling stand, in comparison with the above-mentioned ones, has side faces, connected to the base frame with hinges and with the possibility of tilting in the direction of the base. The installed stress sensors are located in the central axial plane in the mass of the equivalent material. The side walls (edges) are connected to the base of the stand body with horizontal hinges, double stress sensors are placed in an equivalent material over the entire height of the central axial plane. In this case, the angle formed between the paired sensors is twice the angle of the internal friction formed between the central vertical plane of the model and the equivalent material. On the developed model stand, it is possible to register the regularities of changes in

stresses in an equivalent material transmitted to the axial plane of the model of a multi-tiered dump from the side faces of the gorge [6]. Two, independent of each other side faces rotating around the longitudinal axis of the model stand can change from a vertical to a horizontal position.

The developed three-dimensional model stand has the ability to change its own position in the vertical plane using a hydraulic jack. Based on the Culon theory, the direction of the full equivalent of pressure is determined by the angle of deviation from the vertical, perpendicular to the sidewall of the retaining wall, which is taken to be equal to the angle of the soil with the vertical axis of the model plane [7]. In accordance with this theory, the determination of the resultant pressure is a priority, especially when choosing a sensor installation scheme for recording the stresses transmitted from the side planes of the developed model stand to the central vertical (axial) plane of the multi-tiered dump model.

The study of the lateral impact on the central part of the model, in cases of developing the model with the simultaneous opening of two edges, shows that the nature of the stress distribution, due to the weight of the equivalent material, basically remains unchanged, as in the development of a model with one movable edge.

The experiments have shown that with a uniform change in the angles of inclination of the two side faces of the stand, the pressure on the registering dynamometers increases almost twice in comparison with the previous experiments performed with one fixed and one movable facet of the model. Here, a further increase in stresses on the central section of the model mixture occurs, which leads to an intensive change in some of the physico-mechanical characteristics of the equivalent material.

Volumetric physical modeling of a multi-tiered dump makes it possible to determine the rational volumes of overburden and thereby solve an ecologically important problem - the formation of a multi-tiered dump in the gorge, with the justification of its stability.

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PLASMABREAKINGOFMAGNETITEQUARTITES

Carrying out workings at the Krivbass mines is carried out in difficult mining and geological conditions on hard-to-drill, highly abrasive rocks of medium and high hardnessTherefore, the problem of intensifying workings on hard rocks for Krivbass is relevant.

In IGTM NAS of Ukraine, studies have long been conducted on the destruction of ferruginous quartzites by thermal method with chemical burners. The first works on the thermal destruction of quartzites were carried out at the quarries of YuGOK and InGOK [1]. Specialists of the NIGRI Institutein work [2] found that the method of combined drilling of wells turned out to be effective in the development of hard ores.

Today, a promising way to destroy hard rocks is the plasma method.New principles of thermal breaking of rocks are laid down in electric arc plasma torches..This is a new and promising direction in solving the problem of mining and processing of minerals.. The efficiency of plasma destruction is determined by the modes of rock heating. Therefore, the development of methods and means of heating in the creation of rock-cutting organs of mining machines is the main task.

For many years, robots were carried out at the mines Gvardeiskaya, Ordzhonikidze, Lenina, Pervomaiskaya.Experimental work was carried out to create chamber cavities and expand wells in magnetite quartzites.

The employees of the plasma laboratory V. Lebedev, V. Osenniy and B. Alymov developed a small-sized experimental plasma installation (SEPI). Industrial tests of the installation were carried out in the conditions of the Gvardeiskaya mine in the block of magnetite quartzites of ore body №3. The process of chamber formation and expansion of wells took place in fan holes from 0 to 90°. Based on the results of industrial tests of the SEPI installation and the method of plasma chamber formation and expansion of wells, the institute and the design bureau completed the working documentation of experimental samples of the installations UPRS, UPRS-1, UPRS-V. The UPRS and UPRS-1 were made by the experimental production IGTM. The UPRS-V installation was made by the experimental production of the NIGRI Institute. These installations have been tested in the rocks of the Ordzhonikidze mine.

Studies were carried out on the destruction products of magnetite quartzites in monitoring the development of chamber cavities [3].

The method of destruction of ferruginous quartzites when exposed to high-temperature plasma flows was studied under an EPYTIP microscope [4]. For this, polished sections were used. The planes of the thin sections were strictly oriented perpendicular to the direction of the plasma action

front. Thus, it was possible not only to observe changes in the structure and composition of ferruginous quartzites, but also to monitor the development of the chamber cavity by 2- 12 mm.

It was found that in the samples, changes in the rocks are recorded from the side that faces the front of the plasma impact. The nature of the change depends on the intensity of plasma exposure. Changes in the rocks during the development of the chamber are considered on the example of a series of husks with a size of -12 + 10 mm and -10 + 7 mm.

Petrographic studies have shown that the direction and nature of changes in ferruginous quartzites occurs under conditions of increasing thermal effects. Under the influence of high temperature, the rock softened somewhat, glass formation occurred less frequently due to the fusible silicates.

Samples of magnetite quartzites after plasma chamber formation were taken at intervals of 10 minutes in monitoring the development of the chamber cavity for 50 minutes. The products of thermal chamber formation were collected in 5 containers and dried. Sieving was carried out through a column of sieves on a vibration stand. The slice particles were subjected to granulometric and morphometric analysis. The study of the characteristics of single pieces of ferruginous quartzites was carried out according to the method of L.I. Baron.

Were selected from the fraction-10 + 7mm of the same size 100 slices in 5 cycles. These slices were ground in a mortar into powder and studied by thermogravimetry and X-ray methods using «Derivatograph» (firm MOM, Hungary) and «Dron-3m» instruments.

Petrographic studies, X-ray diffraction and thermogravimetric analysis, together with physical and chemical studies of parent rocks and breaking products, made it possible to develop a cyclic plasma torch.

As a result of industrial and laboratory studies of the method of plasma breaking of hard ores, it was established:

- the energy of breaking of the crystal lattice of ferruginous quartzites changes in monitoring the development of the chamber cavity;

- the effect of the explosion is enhanced by the larger size of the breaking cavity than the explosive charge;

- the energy of breaking of hard ores depends on the metasomatism of rocks.

The conducted researches and experiments allowed:

- change the modes of the plasma torch to intensify the process of chamber formation;

- change the parameters of the charging chamber cavities for various designs of charges, which allows breaking the ore body with less energy.

The following prospects for the breaking of hard rocks are possible. First, the production of plasma torches on steam. Secondly, the production of industrial plasma installations for breaking

hard ores into a chamber. Thirdly, the production of industrial plasma installations for sinking horizontal and vertical mine workings.

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RESULTS OF MICROSCOPIC STUDIES OF SANDSTONES CLOSED POROSITY

The study of carboniferous sandstones of the Donets Basin at the micro level made it possible to establish that the main volume of closed micropores is located in clastic quartz grains. Closed micropores are gas, less often gas-liquid inclusions. The composition of the gas inclusions are methane, carbon dioxide and nitrogen. By origin, gas inclusions in the quartz grains of the Donets Basin sandstones are primary and secondary. The primary inclusions probably formed in the mother rocks. They are well identified by optical research. Their peculiarity is that they are mainly two-phase and their size is 1,5-2 times larger than the size of the secondary inclusions. The average size of the primary inclusions is 3-4 μm. Compared to the secondary inclusions in the quartz grains of the Donets Basin sandstones, they are less common. Secondary inclusions are represented by two types - inclusions of Bohm strips and of "spongy" structure. Boehm strips are microstructural deformations that are decorated with gas inclusions. They are formed when numerous microcracks begin to appear in the quartz, the most fragile sandstone mineral, under the influence of the pressure of rock mass. Microcracks are a favorable environment for fluid migration.

After the healing of the microcracks by the secondary quartz, separate inclusions are formed, which preferably have a clear isometric shape. Inclusions of the "spongy" structure are formed by the "reaction" of the inclusions of the Bohm strips to increase the pressure of the rock massif. In other words, the formation of a "spongy" structure is the next step in transforming the inclusions of the Bohm strips. As the pressure of the rock mass increases, the inclusion of "seek" to energy equilibrium, resulting in their grinding to smaller sizes [1].

The practical interest of studying closed porosity is that gas inclusions in the clastic grains of the Donets Basin sandstones are considered as an additional factor of influence on gas-dynamic phenomena in coal mines. According to scientists, who studied fluid inclusions in minerals of different genesis, one of the causes of gas-dynamic phenomena in rock massifs is the natural decrepitation of gas inclusions in thousands of tons of rock [2]. This is due to the high fluid pressure in the inclusions and the additional pressure of the rock massif. The presence of fluid inclusions in minerals of different rocks with an increase in temperature and pressure leads to the appearance of internal stress in the mineral, which provokes natural decrepitation. It is decrepitation of fluid inclusions that can act as an additional energy source for rock emissions. In addition, gas in closed pores weakens the strength of sandstone cement and, together with free gas in open pores and cracks, leads to the destruction, grinding and removal of rocks during rock outburst.

Another interest of work is that the absolute porosity, which is determined after the crushing of the rock sample to the size of the rock-forming grains, is essentially not absolute, since a significant amount of micropores remains in the clastic grains. Studies have shown that the size of the sandstone sample particles after the determination of the absolute porosity index is significantly higher than the size of inclusions found in the grain fragments. That is, to reveal the entire volume of pores, the rock needs to be crushed to particles of micron size or to determine the volume of closed pores in rock grains according to the proposed method [3].

To study closed grain porosity, transmission and scanning electron microscopy methods and the optical microscopy method were used. A comparative analysis of different methods made it possible to determine that the most informative and economical method for studying closed grain porosity is the optical microscopy method, with transmitted light and a magnification of 1200 times using an imersion liquid. As preparations, thin sections of carbon sandstones of Donets Basin were used.

Sandstone thin sections, used in the study, were made from samples selected in five geological areas of the Donets Basin - Pavlogradsko-Petropavlovskiy, Krasnoarmeyskiy, Donetsko-Makiivskiy, Almazno-Mariivskiy and Dovzhano-Rovenetskiy. These areas contain coal of different grades and differ in tectonic dislocation.

Thanks to this, it was possible to establish the size of micropores, their number, shape, volume, regularities of changes depending on the degree of transformation of rocks under conditions of catagenesis. Inclusions and micro-deformations in optical examination were taken into account in quartz grains with their size not less than 0,05 mm, which corresponds to the minimum grain size of the sand fraction.

Using the optical studies the ontogenesis of the grain closed porosity of the Donets Basin sandstones have established.

The ontogenesis consists in the formation of fluid inclusions at the early stage of catagenesis, development at the middle stage of catagenesis, when a large number of individual inclusions with clear forms are formed, and annihilation at the late stage of catagenesis, when inclusions begin to decrease to the smallest size.

As a result of the grinding of the inclusion, the gas seems to dissolve in the mineral and forms pores in thousands and hundreds of microns, after which it diffuses into the zones of lowest pressure.

The volume of grain closed porosity in the quartz grains of the Donets Basin sandstones is on average 1,5-2 times higher than the indicators of cement closed porosity (volume of isolated pores in the cementing substance of the rock). If the closed porosity index, calculated on the difference between total and open porosity, for sandstones of Donets Basin is on average 1-2%, given the grain closed porosity, it can reach 4% and more.

The obtained results are important in the study of the porosity of rocks. It is known that porosity is one of the indicators that are taken into account when predicting gas-dynamic phenomena and determination the reservoir properties of rocks.

It is important to consider the volume of closed pores contained in the clastic grains of the rocks in the form of gas inclusions. This will allow us to get more accurate data.

Also, grain closed porosity indices must be taken into account when predicting thermal and gas-dynamic phenomena in coal mines, since significant volumes and pressures of fluid inclusions, in conjunction with the additional pressure of the rock mass, may cause the additional impulse of these phenomena.

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EFFICIENCY OF CONTROLLING FACTORS FOR REGULATING THE OPERATION MODES OF THE GAS TRANSPORTATION SYSTEM UNDER-LOAD CONDITIONS

The operation modes of gas transportation systems (GTS) are usually controlled by management decisions made at compressor stations. Such adjustment methods should include turning off or re-starting the compressor station (CS) as a whole, turning off or re-starting a separate gas pumping

unit (GPA), changing the technological scheme of their joint operation, adjusting the speed of the HPA rotors rotation, bypassing gas from the output line to the input line. However, different regulation methods have different technological efficiency and environmental justification. Thus, the method of the CS regulating the operating modes by bypassing from a technological point of view is highly efficient, but economically not justified, as it leads to excess energy loss on compression. Therefore, there should be a comprehensive approach to the selection of methods regulation of the GTS operation mode.

It should be noted that a number of studies by V. Grudz [1, 2] were devoted to the development of regulation methods and determination of their effectiveness M. Zhidkova [3] and others.

In these works, well-known methods of regulating the operation modes of the GTS are described in detail, their numerical characteristics, methods of calculating process parameters and their changes during the transient process are given.

However, the authors neglected the principles and methods of minimizing the time of non-stationary transient processes, which in general will allow more complete and timely provision of gas to consumers, while reducing pumping costs.

The control is selected in accordance with the given optimality criterion. When stabilizing the mode of gas transportation systems, the minimum root mean square deviation from the optimal mode is taken as a criterion.

Management of the operation modes of the gas transport system can be carried out at the expense of the control influences adopted on the CS. GPA can be considered as controlling factors.

A change in the mode leads to a change in the technological scheme of turning on the HPA and a change in the operation parameters of a single unit, which is carried out by adjusting the speed of rotation of its rotor. Therefore, the general control scheme can be conditionally divided into discrete and continuous.

Management of CS modes is carried out in accordance with the control laws, which determine the degree of control factors influence on the system response.

Perturbations and counterperturbations are superimposed on the control laws. A disturbance is considered to be the reaction of an arbitrary parameter of the system's operation (for example, a jump-like change in the gas temperature at the entrance to the HPA), which leads to the creation of a reaction to a given influence. Counter disturbances arise as a result of the system's reaction to the controlling influence.

The management law together with goal determines the management strategy. The control strategy must be permissible, i.e. its implementation must not lead the system to an impermissible mode of operation. On the other hand, the implementation of this strategy should provide a certain benefit in the operation of the system. Among all strategies, at a certain stage there is one that can bring the most profit. Such

a strategy is called optimal. For example, with uneven gas consumption, one should be guided by the strategy of stepwise adjustment of the CS operating modes, which will lead to fuel gas savings.

Technological control objects, which include such elements of the GTS as CS, linear section (LD) and the main gas pipeline (MG) as a whole, are described by functional, algebraic, differential or integral equations with respect to coordinates, which characterize the state of the objects. Identification in the general case consists in determining their structure and parameters based on observational data.

For objects with a complex structure, which include the elements of the HTS, the output response and the input signal are random variables. This is explained by the influence of a large number of random uncontrolled factors, such as the unevenness of gas consumption and gas supply to the system, fluctuations in the ambient temperature, changes in the gas composition, the trend in the characteristics of HPA, etc. Therefore, it is customary to solve the problem of identification of such objects in a statistical formulation, taking into account that the modeled object is stochastic.

For stationary objects, the application of one or another identification algorithm allows for a finite number of steps to determine the parameters of the model with a given accuracy. If the object is non-stationary, then its parameters change over time, and their estimates must be continuously refined. In the opposite case, after a certain period of time, which depends on the degree of non-stationary of the process, the model will cease to adequately describe the functioning of the object, it will be impossible to predict its behavior and control the object. Models refined in the process of object functioning are called adaptive models [5]. Their application is fundamentally necessary for the control of non-stationary technological processes.

Modeling of non-stationary HTS objects should be carried out with the help of an adaptive system with an identifier, which implements the principle of dual control, that is, it allows specifying the parameters of the technological object and controlling its operation at the same time.

The method of an adaptive system with an identifier involves two stages of identification: strategic or identification in a broad sense and operational or identification in a narrow sense [2, 5]. Strategic identification includes the selection of information variables of the process, assessment of the type and tightness of the connection between input and output, selection of the type of model and verification of adequacy to the real process. Strategic identification is carried out outside the contours. The inclusion of a strategic identifier in an adaptive system with an identifier is connected with the need to periodically recalculate certain characteristics of the model in connection with the change of the object. Operational identification is related to the current estimation of model parameters. Here, the input information is the model, which is produced in the strategic identifier, and the control data indicate the results of measurements of the entrance and exit of the object. Operational information is contoured, it is implemented in real time of the process on the basis of recurrent relations - adaptation algorithms, the main requirements of which are simplicity and a minimum of operations for any level of model complexity.

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THE ESTIMATION OF THE STRESS STATE OF THE OPEN-PIT ROCK MASS IN MOUNTANIOUS-LOADING CONDITIONS WITH 3D PHYSICAL MODELING

Abstract

A 3D physical modeling stand has been developed to estimate the redistributed stress field and pattern consistency of the stresses in the exposed open-pit wall on the mountain terrain due to natural unexposed slope of the mountain above the crest of the wall in loading conditions. In such a geotechnical analysis, the modeling stand can also be used to determine the rational parameters of the multistage waste rock dumps or stockpile structures constructed on shallow terrain, as well as in hard topographical conditions, based on the assessments of the redistributed stress field due to each depositing layers.

The above-mentioned 3D physical modeling stand to define the stresses in natural-mountain-loaded open-pit wall have been certified as a patent by RA Intellectual Property Agency of №13 Y.

Keywords: natural mountain slope, open-pit wall in loading conditions, 3D physical modeling stand, multistage waste rock dump and stockpile, mobile and immobile prisms.

Evaluating the stability of open pit slopes in difficult terrains remains a critical issue in the design of rock slopes.

When designing rock slopes, it is essential to choose an appropriate method of stability analysis, depending on a correct estimation of the rock mass strength and a proper understanding of the failure mechanism behavior of the slope under consideration, especially under conditions of loading induced by low confinement stress. The rock mass undergoes various geological processes, such as tectonic movements, weathering, seismic impacts, etc. As a result of these processes, a 3D equilibrium geostress state is formed in the rock massif [1].

Any excavation process violates the previous equilibrium stress state and leads to the development of an unloading geomechanical environment near the excavation boundary. In other words, after the removal of the rock support, a low confinement condition will develop in the rock massif, and the 3D stress state will practically turn into a 2D stress state in which the confining stress has a lower value near the excavation boundary. In this redistributed stress field, the low confining stress, acting normally or tangentially to the exposed mining slope, has a major impact on the in-situ strength of the rock mass [2,3].

In high stress and weak rock conditions, it is necessary to take into account the maximum component of the redistributed stress field due to unexposed mountainous slope above the crest of the open-pit wall. It is well known that weak rocks are considered to have very small resistance to tension and to shear [4,5], therefore it is essential to estimate the maximum component of the redistributed stress field due to natural mountainous above the crest of the exposed mining slope:

As we know there are lots of factors are affecting on the open-pit slope and hence on the shear strength of the rock mass.

However, today, in many slope stability analyses, geotechnic engineers do not always consider the impact of the redistributed stress field on the slope stability. In mountainous terrain, it is essential to pay attention to the impact of the redistributed stress field due to natural, unexposed mountainous above the crest of the open-pit wall during stability analyses.

There have been world-wide observations in geotechnical engineering domain to take into account the redistributed stress field into the open-pit rock mass due to the external loading conditions. It is well-known various methods to observe mechanical processes in geomechanical environments based on the in-situ observations, theoretical methods and physical modeling as well as.

It is necessary to point out that one has estimated the redistributed stress field due to external loads by 3D numerical modeling [6], one has assessed the stress field based on analytic concepts by considering the external loads as a additional weight in the active driving prism [7]. On the other hand, there has been proposed lots of physical modeling stands to observe various mechanical processes in the rock mass [8,9], however, by using these type of stands to estimate the redistributed stress field due to natural mountainous rock mass in loading conditions, it is not possible. The analyses of the technical and engineering proposals has shown that it is not possible to consider and estimate the redistributed stress field due to unexposed mountainous rock mass above the crest of the open-pit wall in this loading conditions which is considered to be a main limitation of the available physical modeling stands.

When you have correct observations of the estimation of the redistributed stress field in this loading conditions by 3D physical modeling, the estimation of the maximum components of the stress field is considered to be essential and important engineering task.

A 3D physical modeling stand has been developed to estimate the redistributed stress field and pattern consistency of the stresses in the exposed open-pit wall on the mountain terrain due to natural unexposed slope of the mountain above the crest of the wall in loading conditions. In such a geotechnical analysis, the modeling stand can also be used to determine the rational parameters of the multistage waste rock dumps or stockpile structures constructed on shallow terrain, as well as in hard topographical conditions, based on the assessments of the redistributed stress field due to each depositing layers.

The above-mentioned 3D physical modeling stand to define the stresses in natural-mountain-loaded open-pit wall have been certified as a patent by RA Intellectual Property Agency of *N* 713 Y. By using the above-mentioned certified physical modeling stand, we can observe the external loads due to natural, unexposed mountainous rock mass above the crest of the wall in different geometric configurations and then to estimate the maximum components of the redistributed stress field. This estimation allows us to raise the credibility of the pattern consistency of the stresses in the open-pit rock mass by applying in slope stability analytical methods as a additional stresses with depth.

In 3D physical modeling, it has been kept all necessary criterions for laboratory-based physical modeling type of observations, and the mechanical and physical properties of the equivalent material has been determined in laboratory conditions due to the modern, very sensitive to small strains, direct and triaxial equipment and in-situ CPT geotechnical investigations as well [11,12].

It is suggested that by using the above mentioned 3D physical modeling stand, we will raise the correctness of the pattern consistency of the redistributed stress field due to mountainous-induced loading conditions, will estimate the maximum component of the stress field with depth which will be applied directly in proposed mathematical analysis calculation method and to consider the potential impact of the natural mountainous rock mass on the open-pit wall stability.

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ABOUT PRESSURE CONTROL QUESTIONS AT AN ORE DRAWING

In mining by the important process of underground mining operations there is an ore drawing on which qualitative and quantitative results of extraction of ore depend.

Therefore, improvement of parametres at an ore drawing, is an actual scientific and technical question.

Pressure at an ore drawing from the brought down blocks located on depth of some hundreds of meters and more, considering from a surface, establishes the specific problems before analysis of dynamics of this process.

At an ore drawing from the brought down blocks under leaning soils in the conditions of the raised rock pressure the expiration of a loose material from a vertical cylindrical vessel (release from bunkers) proceeds much more difficult, than. In the latter case problems of dynamics of release are reduced to definition of pressure of a stream of a loose material at its movement on the bottom and walls of a continuous part.

A pressure source here is the stream of a moving loose material. In the conditions of underground ore mines constructive elements of the block and the brought down ore even before its release are under the static pressure which size in tens, time exceeds the pressure rendered by streams of brought down ore at its movement to final apertures.

Release of the brought down ore from the block or the panel causes redistribution of this pressure and can be in communication by this important action for a decrease of its size in a zone of coal-face works.

The main constructive element of caving systems subject to pressure, the bottom of the block and its wall in a zone of abutment vertical pressure is.

Horizontal pressure under influence, the so-called broken expansion, caused by formation of a crest and of interest at the expiration of loose bodies from silage towers, at release of the brought down ore recedes on a background.

First, because calculation of walls of the block on durability is not necessary, and, secondly, because its size is insignificant in comparison with a vertical abutment pressure.

As an ore drawing conduct, as a rule, from a series of final apertures of the block with formation of the general zone of breakage within all fulfilled area, sealing of ore under the influence of horizontal expansion at release from any aperture remains at inclusion in operation of the next apertures adjoining to it.

Besides this phenomenon has no serious value for practice as lateral dilution at an ore drawing from the apertures adjoining on a goaf, is observed always in spite of the fact that sealing of dead rocks under the influence of horizontal tensions should take place.

It is all it is necessary to consider if to let out ore from one final aperture in delivery developments. But the situation can change, if release to make zones.

Therefore in this case horizontal expansion will influence sealing of barren rocks and a decrease of lateral dilution that it will be possible to establish in the long term in laboratory conditions.

It is accepted to understand set of such practical actions for artificial regulation of size of character of increase and distribution of pressure to associates as pressure control under level roads which allow to provide stability of soils in one developments and on the contrary, uniform development of their caving in others.

At an underground extraction of ore deposits this complex of actions consists in a choice of the rational sizes for the given concrete conditions and forms of developments, pillars and application of certain sequence of conducting coal-face works within the block and all deposit [1-3].

Transition of mining separate, located in a massif, blocks to wide application of systems of a floor caving, thus mass application of system has faced the whole complex of the phenomena which had no place at an extraction of the isolated blocks.

The strengthened display of pressure concerns their number in slusher level developments, their complete destruction on the considerable areas, and on occasion - destruction of an ore in place of the bottom and developments in it before the termination of a block undercutting.

So, mining of new effective and harmless mining methods is a correct solution at an ore drawing.

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TO DETERMINE STABILITY OF THE ROAD TRAIN WITH O1-CATEGORY TRAILER

Small and medium business development in Ukraine has led to an increase in demand for trailers used in a coupling with light vehicles. This is, first of all, the O1- and O2-categories trailers. Accordingly, the O1-category trailer is, so-called, "light" trailer. In addition, O2-category trailers can be used with M1 vehicles, which are often called "heavy". For these trailers, which are operated, as a rule, by private entrepreneurs and amateurs, very important are parameters concerning loading on a tractor and trailer, in particular cargo location in a trailer. The trailer must be loaded evenly over the floor area of the trailer or van and unit loads shall be located and fixed above the axle or paired axles. The centre of mass arrangement above the trailer axle ensures a normal load on the hitch ball [1].

Load displacement and, respectively, the trailer centre of mass in running order forward of the trailer wheels axle causes an increase in the load on the vehicle traction coupling device. This leads to more than just pinning the vehicle rear part to the road, moving back the vehicle center of mass and lifting its front. This mass distribution impairs the front wheels road adhesion and car becomes less controlled. In addition, due to loosening of the road adhesion, during braking on the front wheels do not generate sufficient braking force, particularly required when the trailer is in motion.

Loading of the trailer causing its centre of mass to be reversed behind the trailer wheels axles, is also unacceptable. If the load on the hitch ball is low, the trailer will swing vertically. Its vibrations will lift the vehicle rear part, making rear wheels less tractable, which can lead to skid on slippery or wet roads and during turns.

It is clear that improving the efficiency of road trains by increasing speed shall not be detrimental to traffic safety [2]. Study of the road trains stability with O1-category trailers is an urgent task.

When studying road trains stability is generally considered the plane-parallel motion of it links. It is believed that the normal reaction of the supporting surface to the wheels on the starboard and port sides are the same. Under this condition the motion stability is considered for plane road train model. However, if the trailer centre of mass is high, it is possible to significantly change support-

ing surface reaction on it wheels. Therefore, it is necessary to consider the road train motion in both horizontal and longitudinal vertical and transverse planes.

In controlled road train theory and modeling are rather justified assumptions [3], that the road train is moving on level horizontal surface; the unsprung mass is considered not to be heeling; control influence on the motion parameters of the road train is carried out via steered wheels of traction vehicle. Consequently, steering changes are not taken into account; gaps of the hitch-mechanism are not taken into account; the longitudinal speed of the road train is constant; the distance between the road train links does not change due to the small folding angles. Road train components are totally rigid bodies: the load on the road train is located so that the traction vehicle centre of mass, trailer and also its hitch-mechanism are located in the vertical symmetry plane of the link; main trajectory is the trajectory of the towing vehicle centre of mass.

Basic kinematic and dynamic properties of the road train with trailer, as a single mechanical system of bodies, depend on the physical phenomena that arise during movement of all its elements and their interactions with each other. In turn, these phenomena are determined by the geometry and structure of the road train.

Paper [4] presents constructing method of the vehicle mathematical model in a transverse plane. This methodology can also be used to construct such model of road train with O1-category trailer. We take that the road train is moving on a horizontal surface with constant speed, no vertical motion and rotation of the vehicle and trailer body around its transverse axis (galloping). That is, for each link of road train there are three degrees of freedom, in particular lateral motion along the transverse axis, rotating motion around the vertical axis (yawing) and rotating motion around the longitudinal axis (roll).

The analysis of cumbersome road train static stability conditions showed that aerodynamic drag forces do not affect the critical velocity (aerodynamic drag coefficient and therefore aerodynamic drag force is not included in the expression for critical velocity), and values of motion resistance coefficients on the road train first, second and third axles have almost no effect on critical velocity value. To this end, integrate the system of equations, which describes the plane-parallel movement and road train links movement in vertical plane by roll angles, was performed separately using Maple software.

The results of the calculation show that highest roll and axle load, angular yaw velocity, lateral velocity and lateral acceleration of road train links are inherent to the vehicle, which is a limiting factor when performing different manoeuvres.

Road train links sustainability during the «shuffle» manoeuvre indicates the attenuation of road train links angular velocity and yaw velocity oscillations.

The motion stability can be better measured by the magnitude of lateral accelerations, operating at the centre of mass of its individual links.

Motion stability may be considered satisfactory if transverse accelerations at the centre of link masses do not exceed 0,45 g. The road train in question corresponds to this condition.

It was found that vehicle body roll has a significant impact on road train motion stability when performing different manoeuvres. For example, vehicle body lateral acceleration amplification factor when body roll is taken into account and “steering wheel jerk” manoeuvre performing, increases by 19,92% in comparison with its absence and this should be taken into account when selecting a towing vehicle, in particular the chassis and suspension.

Analysis the spatial stability model in general requires further study, for example, it is possible flater loss of stability, that will occur before divergent stability. The complexity of the analysis will be related to the definition of necessary suspension and tyres characteristics, centrifugal moments of inertia affecting both the vehicle and trailer.

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CALCULATION OF PARAMETERS AND MODERNIZATION OF THE SCREW CLASSIFIER SCREWS

Screw classifiers 2KSP-12×84 (Fig. 1) are widely used in construction, mining, processing and other industries [1-3]. They are used for deslamation, fractionation and dehydration of ore and non-ore granular materials.

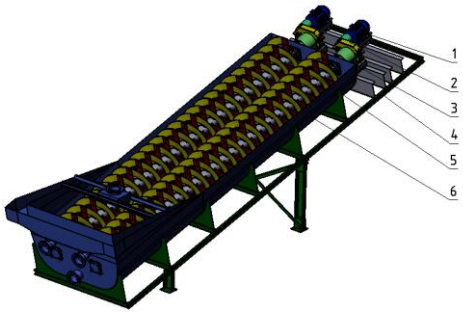

Fig. 1. Screw classifiers 2KSP-12×84: *1* - motor; *2* - gearbox; *3* - clutch; *4* - support frame рама; *5* - screw; *6* - trough

With minor improvements, it is advisable to use such machines in the production of construction materials (gravel, sand, limestone, crushed stone, etc.), glass, molding and other non-metallic materials if they are slightly contaminated with dusty impurities. In such processes, a screw classifier with a submerged screw is designed to wash granular material from dusty impurities and dehydrate it, therefore the lower part of the screw is completely immersed in the slurry [4-7].

The classification process implemented in such devices is based on the difference in hydraulic coarseness, i.e. the speed of fall of particles of granular material of different sizes and densities in a liquid horizontal flow. The input slurry, which includes raw sand, enters the classifier through the inlet pipe . To intensify the classification process and the possibility of adjusting its parameters, water is supplied to the trough through a nozzle located in the lower part of the trough [8-10]. Under the action of gravitational forces and horizontal flow, the granular material is separated into two products. Small classes sediment in the composition of the sludge to the overflow thresholds located along the perimeter of the trough, and then through the drain pipes, the flow is directed to the sludge clarifiers, decanters, etc. The sand sediments to the bottom of the trough and is continuously transported to the unloading hole using screw.

Screw classifier 2KSP-12×84 has two screws, which are fixed in the trough, and in the lower part are immersed in the slurry. Screws are mirrored and rotate in opposite directions. Thanks to this rotation, the commercial sands move evenly along the trough to the unloading window, which is located in its upper part. During such transportation, the deposited material is dehydrated and becomes suitable for further transportation. However, constant friction of screw blades against sand particles leads to their abrasive wear. Rubber or polyurethane pads are usually used to protect metal surfaces. Screw classifiers are massive and metal-intensive machines. Therefore, in order to reduce the cost, if possible, it is advisable to reduce the metal content of the structure. For this purpose, calculations of the cross-sectional area of the sand flow moving along the trough should be performed (Fig. 2).

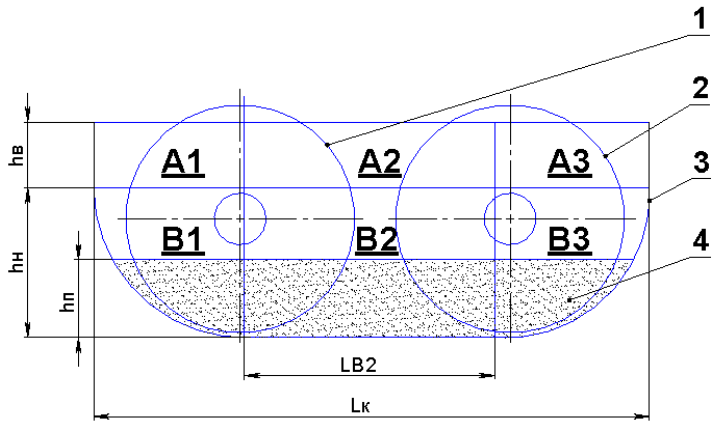

Fig. 2. Schematic representation of the trough camera of the screw classifier:
1 - left screw; *2* - right screw; *3* - trough; *4* - sand

Based on the calculated height of the sand layer, which was 188 mm, the screw design was modernized. The basic and modernized design of the screw is shown in Fig. 3.

a *b*

Fig. 3. Screw classifiers screw: *a* - basic; *b* - modernized

In the new design, the height of the screw blade is 190 mm. The blades are protected from abrasive wear by a layer of polyurethane. Thus, due to the modernization, the metal capacity of the screw was reduced while simultaneously increasing its resource. Modernization also makes it possible to simplify the production and maintenance of the screw. According to the new design, the screw spiral is divided into separate sections, in order to simplify their replacement.

Conclusion

According to the results of the calculation of the screw classifier trough design parameters and the parameters of the sand flow moving by the bottom, the classifier screw design was changed. The new design of the screw consists of separate sections with the calculated height of the blades protected by a layer of polyurethane. A reduction in the metal capacity of the screw was achieved while simultaneously increasing its resource, the process of replacing individual screw sections was simplified.

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REVIEW ON THE DESIGN OF NON-CONTACT ULTRASONIC TRANSDUCERS USED FOR CONTROL OF MATERIALS

Established methods for non-destructive ultrasonic testing of materials include the use of ultrasound transducers. The function of these transducers is to produce directly or indirectly piezoelectric effect to generate and detect ultrasonic signals. The best known is the immersion control technique, when the piece is completely immersed in a water bath. But there are some cases when the piece cannot be immersed in the bath due to its large dimensions such as airplane wing, wind turbine blade, airplane fuselage. Also, the tested specimen can be damaged by direct contact with the ultrasonic transducer, for example electrical scheme, porous materials, sandwich composite materials.

However, in the last ten years in the research laboratories and specialized institutions of the world, the emphasis was placed on non-contact ultrasonic control of materials, that is, through an air gap. Unfortunately, the transmission of ultrasound between the transducer and the tested piece through an air gap is insufficient due to the large acoustic impedance mismatch between air and the ultrasound source and air/solid materials [1]. This means that the ultrasound waves is almost entirely reflected at the interfaces between the transducers and tested part. Many methods have been investigated to overcome the acoustic impedance mismatches. Among the most popular achievements, it is worth mentioning the non-contact electrostatic transducers [2,3,4]. These transducers have a wide frequency bandwidth for investigating a large range of materials by different types of waves, [5,6,7,8]. In 1997, Hayward and Farlow [9] designed non-contact piezo-ceramic transducers with 1 till 3 matching layers using a composite design. Transducers of this type have a narrow bandwidth so that the response pulse has a long-time duration. Also, in [10] is specificated that the use of multiple matching layers is intended to increase bandwidth frequencies. Later, were proposed ultrasound transducers with more active layers necessary for frequency bandwidth expansion and simultaneous two-mode excitation (for therapy and imaging), [11,12]. The mismatch between the acoustic impedances of air and piezoelectric ceramics is very large which causes the low sensitivity and narrow bandwidth. The approximation of the impedance values between air and piezo ceramics ensures increased sensitivity and broadening bandwidth, therefore the use of matching layers is a good option in non-contact ultrasound defectoscopy. The main problem in the design and manufacture of non-contact ultrasound transducers consist to choose matching layers with very low acoustic impedances (0,01-0,1 MRayl) and with very low

attenuation coefficient (<500 Np/m), [13]. A category of this type of material would be ferroelectrics which are dielectric materials with permanent electrical polarization and good piezoelectric properties, with mechanical flexibility and low acoustic impedance (<0,1 MRayl) [14-15]. This type of transducers is new generation and have the following disadvantage: high design and manufacturing cost, use in metrological environments (constant air temperature and humidity, the presence of impurities in the air cause wrong interpretations signals and frequent failure of transducers).

Non-contact industrial ultrasonic defectoscopy need transducers with low design-production costs, possible to use them in the production sections of construction industries. Such transducers usually have an active element and a passive matching layer (or layers).

Finally, it may be concluded that during the design of non-contact transducers, the following factors must be considered:

a - large mismatch between the acoustic impedances of air and solids,

b - the enormous difference between the propagation speeds of ultrasound in air and solids;

c - high attenuation of ultrasound in air;

d - high frequencies ensure a high spatial resolution but an increased attenuation.

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SUBSTANTIATION OF EDDY CURRENT SEPARATION PARAMETERS FOR CAR RECYCLING TECHNOLOGY

Today, the number of cars that are already out of service and subject to disposal is about 170 thousand per year. Given the rate of aging of the modern fleet, the number of cars that may be decommissioned in 10 years may double. In addition, the share of electric vehicles has begun to grow rapidly, and in such conditions it will be necessary to use modern high-performance shredder technologies for car recycling.

Decommissioned cars are resources of secondary raw materials. They include 67-72,2% of steel and cast iron, 8-12% of plastics, 6,2-8% of non-ferrous metals and other materials.

After the separation of a mixture of non-ferrous metals and alloys by eddy current (electrodynamic) separation in the shredder technology of car recycling, these metals must be separated by type by eddy current, heavy media or x-ray separation after additional grinding in a shredder. T should be done for the possibility of their further use.

The main purpose of the work is to substantiate the possibility of selective separation of copper, aluminium and plastic particles after fine grinding with a size of 5-10 mm to obtain marketable products with a purity of more than 95%.

In the process of eddy current separation (Fig.1) the following forces act on the product particle: gravity F_m, electrodynamic force Fe_∂ and centrifugal force F_b.

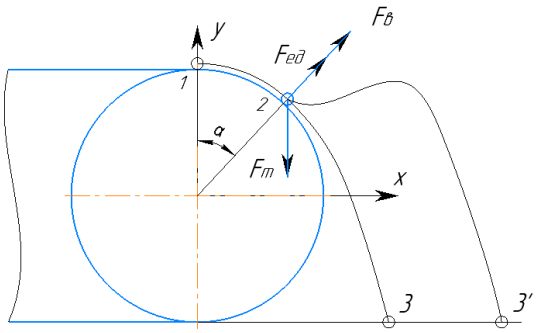

Fig. 1. Scheme of forces action in the process of eddy current separation

The electrodynamic force acts only on electrically conductive particles and rejects them from the main product flow. The process itself can be divided into two stages: the movement of the particle on the drum until the moment of separation (section 1-2); the movement of the particle after separation from the drum (section 2-3).

The electrodynamic force acting on the particle is determined by the known formula, H

$$F_{e\partial} = mB^2 v_m \left(\frac{l}{s}\right)^2 \left(\frac{\sigma}{\rho}\right)^2, \qquad (1)$$

where m is the mass of the particle, kg; B is the magnetic induction, T; V_m is the velocity of the running magnetic field, m/s; l is the length of the particle, m; s is the spacing of the magnetic poles, m; σ is the electrical conductivity of the particle material, S/m, ρ is the density of the particle, kg/m^3.

The angle of separation is determined by projecting the electrodynamic and centrifugal forces on the y axis by the formula

$$\alpha = \arccos\frac{F_{\text{в}} + F_{e\partial}}{F_m}, \tag{2}$$

If the particle is non-conductive, the electrodynamic force equals zero.

After separation, the electrically conductive particle is subject to gravity and electrodynamic force. Only gravity acts on a non-conductive particle.

In general, the equations of motion of a particle have the form

$$\ddot{x} = \frac{F_{e\partial}\sin\alpha}{m}, \quad \ddot{y} = \frac{F_{e\partial}\cos\alpha - F_m}{m}, \tag{3}$$

Initial conditions for solving equations (3).

Coordinates of the center of mass of the particle at the point of separation 2: $x0=x(t0)$, $y0=y(t0)$. Initial velocity at the moment of separation (at point 2): $v_{x0}=-\omega(R+d/2)\cos\alpha$, $v_{y0}=-\omega(R+d/2)\sin\alpha$.

The value of the electrodynamic force depends on the ratio of conductivity to the density of electrically conductive particles, which is much higher in aluminium than in copper and brass, so there is a theoretical possibility of separating these particles by type by eddy current separation.

The modelling of the process was performed by solving the system of equations (3) by the numerical method of Euler. The value of the acting electrodynamic force on the drum surface for aluminium particles was 5g, for copper particles - 1,8g. The size of a characteristic particle was assumed to be 7,5 mm.

The results of the simulation of eddy current separation in which the movements of aluminium, copper and plastics particles were studied at the rotational speeds of the eddy current separator drum 60, 50 and 40 rpm and the rotational speed of the magnetic rotor 3000 rpm are shown in Fig. 2.

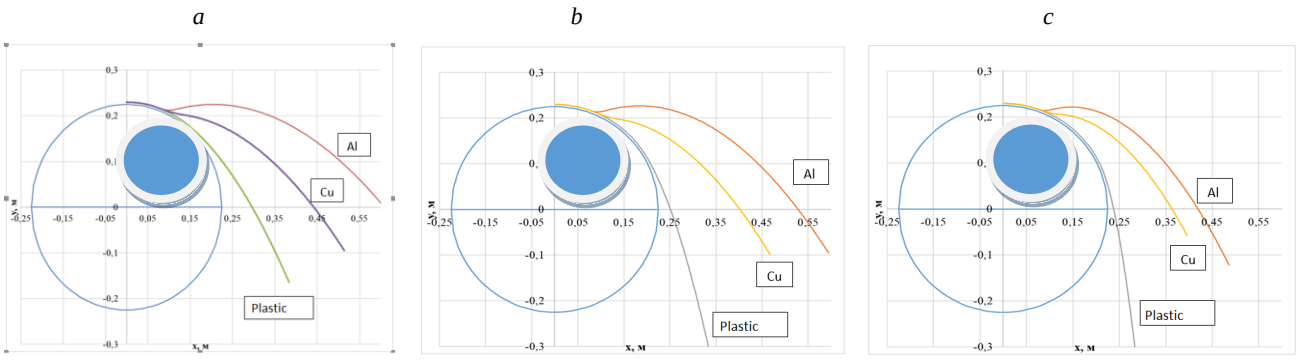

Fig. 2. Results of modelling the movement of Al, Cu and plastic particles on the eddy current separator, rpm: *a* - at a drum rotation speed of 60; *b* - at a drum rotation speed of 50; *c* - at a drum rotation speed of 40

The best separation of products can be achieved at a rotational speed of the eddy current separator drum of 60 rpm. With increasing speed, particles break away from the drum at point 1 (Fig. 1), not reaching the zone of electrodynamic forces.

Experimental studies were carried out on the eddy current separator of SMF "Prodecologia".

For the research, a model sample was used, which included particles of car elements made of aluminum (63,8%), copper (8,3%) and bronze (27,9%) of 5-10 mm size class. The results obtained are given in Table 1.

Table 1

Results of eddy current separation of a mixture of non-ferrous metals and their alloys on an eddy current separator

Product name	Mass yield, %	Aluminium content, %	Copper content, %	Bronze content, %
Source product	100,0	63,8	8,3	27,9
Conductive product	52,1	96,3	3,7	0
Non-conductive product	47,9	28,4	13,4	58,2

Thus, on the basis of experimental studies it was found that from the scrap of automotive parts made of aluminium, bronze and copper it is possible to isolate an aluminium product with a purity of 96,3%, which is suitable for further recycling.

The rest of the product can be further purified by other methods, in particular x-ray separation, which is a more expensive method.

The use of eddy current separation before x-ray separation will reduce the productivity of the latter, which will increase the economic efficiency of non-ferrous metal sorting technology.

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STUDY OF STRESS-STRAIN STATE OF MINE WINDER SPLIT DRUMS OF HOISTING MACHINES WITH INCREASED ROPE CAPACITY

Due to the need to increase the lifting depth and the associated complication of the drum structure, the calculation of axial displacements of the brake discs for the possibility of using disc brakes requires the development of methods for calculating the hoisting machine drum in terms of axial

stiffness based on the analysis of the operation of individual nodes, as well as the creation of their simplified models and the calculation of the drum model displacements with the subsequent calculation of stresses in the initial nodes.

A distinctive peculiarity of the studied drums is that they consist of two jammed parts and one adjustable part. This drum has two shells, six frontals strengthened with gussets and ribs, six frames, two bearing ribs, two brake discs, a shaft with hubs and two spherical double-row roller bearings (Fig. 1). To develop a calculation method, the drum is presented as a structure consisting of ten nodes.

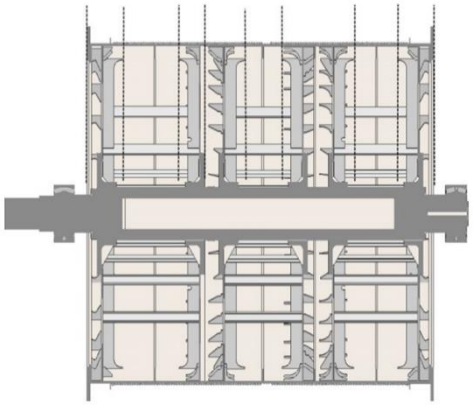

Fig. 1. Drum structure

In the studied drum structure, two spherical two-row bearings are used, which provide the possibility of shaft rotation in three directions and prevent its vertical displacement.

The essence of using the averaging method in structural mechanics can be briefly described by the following algorithm [1]:1. The initial structure is presented in the form of a set of nodes that allow a priori representation of their load and SSS 2. The averaging parameter is chosen, usually the thickness of the shell or frontal, etc. 3. Parametric models of each such node are constructed. 4. Typical calculation cases are selected for all nodes, for example for strengthened drums - this is an axially-symmetrical compression or bending of the drum as a beam. 5. The values of optimization parameters are determined for each node, at which the averaged node stiffness in the selected calculation case of loading coincides with the initial strengthened node stiffness. 6. For each calculation case of loading the strengthened structure, an assembly is performed from the corresponding averaged nodes. 7. The calculations are compared and the most dangerous one is chosen.

As boundary conditions, the loading of the drum by gravity, two tensile forces from the running off and running on ropes, as well as pressure from the wound rope, are studied.

Due to the small width of the gap between both parts of the drum (3 mm), the stiffness of the rope connecting these parts is neglected.

As a parametric model of the bearing, the SolidWorks Simulation “Bearing support” tool is used.

It is unacceptable to select the shell thickness as an averaging parameter, since it is impossible to take into account the influence of ribs on the particular node behavior by changing this parameter. Therefore, the shell thickness is chosen equal to the initial one, and the influence of strengthening elements is taken into account by changing the frontal sheet thickness.

As a result of the calculations, the axial displacements of the drum brake disc edges have been obtained:

- calculation case “shifting”: for the jammed part (Fig. 2*a*), the maximum positive value is 0,654 mm, the minimum negative value is 0,355 mm; for the adjustable part (Fig. 2*b*), the maximum positive value is 1,766 mm, the minimum negative value is 0,176 mm.

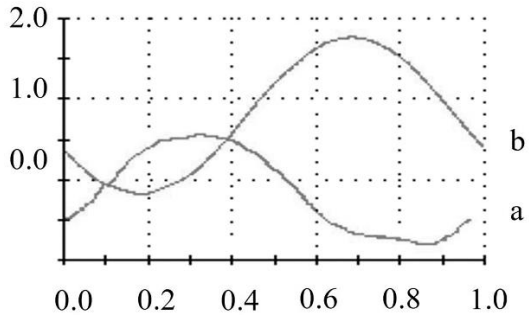

Fig. 2. Axial displacements of the drum brake disc edges in the computational case “shifting”: *a* - for the jammed part of the drum; *b* - for the adjustable part of the drum

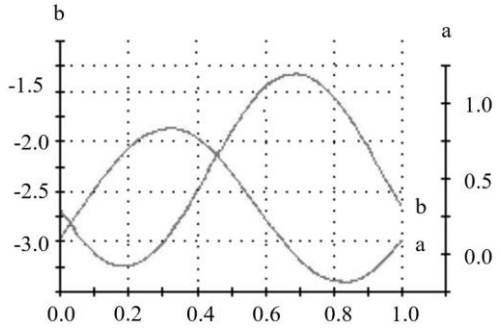

Fig. 3. Axial displacements of the drum brake disc edges in the computational case “pressure”: *a* - for the jammed part of the drum; *b* - for the adjustable part of the drum

- calculation case “pressure”: for the jammed part (Fig. 3*a*), the maximum positive value is 0,584 mm, the minimum negative value is 0,433 mm; for the adjustable part (Fig. 3*b*), the maximum negative value is 1,327 mm, the minimum negative value is 3,246 mm.

The maximum error for “shifting” case is 8,1 %, for “pressure” case it is 69 %.

Conclusions

In the averaging method, an important role is played by the choice of the so-called trial load, which is loaded on a separate element (node) of the structure with the selected fixing method. Thus, for the studied structures of drum nodes, two types of loading have been chosen: uniform external pressure and shifting during fixing the nodes along the border of their connection with the hub.

Then the frontal thickness is determined, which provides the appropriate stiffness in the first and second cases. It has been revealed that the error of the maximum axial displacements of the brake disc edges is 8,1 % in the first case, and 69 % in the second case, when assembling from the nodes with averaged frontals.

This indicates that, in fact, the nodes are exposed to a combined loading and, when using the first or second case separately, leads to an unacceptable error, which requires the development of other calculation methods.

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BURRS AS A PRODUCTION PROBLEM

The large range of machine parts produced today is due to the variety of their functional purpose in products of all industries. It is this circumstance that determines their significant difference in terms of constructive implementation. Parts often have a complex configuration of the external contour, most of them have low-tech elements (grooves and holes of small sizes, deep holes, blind holes with threads, etc.), a significant part of the product range consists of volumetric asymmetric parts. All these factors complicate the technological processes of their production.

According to the technical conditions, the following are not allowed on machine parts:

- cracks, delamination of metal, traces of corrosion, burrs;
- torn and sharp edges (dulling radius - no more than 0,3 mm or chamfer);
- potholes, chips, dents and lines that go beyond the parameters of surface roughness.

Most of the surfaces of machine parts have high accuracy requirements: external surfaces - 5,6 and 7 qualities, internal - 6,7 and 8 qualities. Metal and non-metal coatings are often used to protect parts from corrosion: zinc plating, cadmium plating, nickel plating, chrome plating, and others. The surfaces of some electrical contact parts of devices are covered with silver and gold.

It is worth noting that high-quality coating on the surface of machine parts can be ensured if there are no burrs and sharp edges on them.

As you know, the main method of shaping machine parts is cutting, which leads to the formation of various kinds of defects on the marginal edges of the surfaces of the parts, the most characteristic of which are burrs. Even when using modern metalworking machines and optimizing processing modes, this cannot be avoided.

Burrs on the surface of the part can cause a decrease in the accuracy of the part, complication of processing and assembly of machine products on automated lines.

Disadvantages can also include:

- the difficulty of controlling the dimensions of the part;
- a burr can be the primary cause of damage to the mating surfaces;
- deterioration of operational characteristics and aesthetic appearance of the product;
- burrs can cause injuries.

Thus, the negative role of burrs can be represented by the following aspects:

- functional (difficulty in assembling parts, their positioning, activation of corrosion processes, tendency to metal fatigue, deterioration of unit operation, etc.);

- economic (increasing costs for maintenance work, risk of injury, etc.);

- aesthetic (decrease in consumer value and appearance of products

As is knowna burr is a plastically deformed material formed on the edges of a part as a result of cutting or stamping (cutting or punching). Burr includes all metal that protrudes beyond the theoretical intersection of two mating surfaces adjacent to the burr. It can be a sharp, ragged, firmly or weakly fixed protrusion, sometimes - a bulge of material on the edge.

The formation of burrs occurs as a result of plastic deformation in front of the cutting zone, usually in two directions at the same time - in the direction of the main movement and in the direction of feed. The process of forming burrs is complex, therefore the type of burrs and their characteristics depend primarily on the type of processing and its parameters, the geometry of the tool, and the properties of the workpiece material. Thus, during milling, burrs are formed at the exit of the cutter from metal in the form of bent plates, and during drilling - at the exit of the drill in the form of a "crown" located along the edge of the holes. During turning, burrs are located on the edge of the part at the exit of the cutter or in the form of a saw-like comb with ragged edges. When processing parts from soft material, burrs are longer and thinner than when processing hard materials. But during stamping, burrs are located on the upper part of the tie in the form of a uniform torn ridge along the edge.

When removing burrs from the surfaces of workpieces or parts, a number of requirements must be taken into account:

- the burr must be removed completely and on all elements of the part;

- simultaneously with the removal of burrs, the sharp edges of the workpiece must be rounded - within the radius set by the technical requirements;

- the value of the surface roughness should not exceed the value established by the requirements;

- there should be no secondary defects: new burrs, clogging of grooves and holes, creasing and surface scratches.

Preservation of integrity and continuity of the surface of the part, removal of burrs and rounding of edges should be accompanied by the formation of a transitional element with a minimum radius between adjacent surfaces.

Taking into account the causes of the formation of burrs, the types and features of their removal, several stages of improving the quality of machine parts can be determined:

- at the stage of construction - careful processing of the construction of parts and assembly units of machine devices;

- during the preparation of production tools - the correct selection of the design of the cutting tool or dies;

- in the production process - optimal choice of mechanical processing technology;

- use of finishing and cleaning treatment (OZO).

Of the above-mentioned ways of improving the quality of machine parts, only the finishing and cleaning treatment is not related to the prevention of the appearance of burrs, but is used to eliminate those already obtained as a result of previous operations of the manufacturing process.

In connection with the constant growth of requirements for the accuracy of manufacturing machine parts, the labor intensity of workpiece control operations for the purpose of detecting burrs and operations for their removal is continuously increasing. Thus, an increasing number of metalworking enterprises are becoming interested in the development of deburring technology and the implementation of finishing and cleaning operations, which would ensure that the workpieces are brought to the required quality with minimal costs and high productivity.

Currently, domestic and international practice has developed a relatively large arsenal of burr removal methods using abrasive tools and media, flexible tools, a special blade tool, as well as methods of surface plastic deformation, ultrasonic treatment, chemical and electrochemical methods.

Each method is characterized by its rational areas of application, advantages and disadvantages. However, with all the variety of methods for removing burrs, preference is given to those methods that are based on the use of flexible processing media (volumetric processing). This is due to the fact that a flexible working environment (flexible tool) from the point of view of forming is the most acceptable, while a large number of cutting elements participate in the work at the same time, creating conditions for high productivity

Considering volumetric vibration processing as an effective method of solving this problem, which is characterized by versatility and productivity, it should be noted its limited practical application for finishing and cleaning processing of some types of parts. The main restraining factor is the lack of unity of approaches to the description of the shape of burrs and the mechanism of their removal when processed with granulated media; science-based methods of designing technological operations, ensuring a rational choice of the type and characteristics of processing media.

In our opinion, the promising direction of using vibration methods as volume finishing and cleaning treatment is the joint use of volume vibrations and centrifugal forces - with different combinations of them. To implement the proposed process, we created structural diagrams of vibro-centrifugal installations and conducted theoretical studies of the movement of the working environment under the combined action of vibration and centrifugal forces. The use of such equipment allows you to improve both the quality characteristics of complex surfaces of parts and the productivity of the technological process - mainly due to the minimization of manual labor.

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TEMPERATURE DEPENDENCE AND OPERATIONAL CORRECTION OF PARAMETERS FOR ASYNCHRONOUS MOTOR REPLACEMENT SCHEMES

Introduction

It is known that industrial and mining enterprises use various lifting means quite widely. Gantry cranes are among them, they perform the function of delivering goods to the main production site, ensuring the technological process and transporting people. The experience of operating such equipment in the conditions of the open platform of Dnipro subway revealed that a wide range of changes in temperature and humidity of the environment leads to significant changes in the parameters of the drive electric machine. The result is a decrease in the accuracy of the task of the lifting winch drive depending on the season, which accordingly complicates the safe operation of the gantry crane, especially when transporting people. Preliminary diagnostics established that the drive returns to normal operation when the parameters are redefined. At the same time, it was also found that a simplified approach to determining parameters automatically at each start of powerful motors takes about 4 minutes. Such a situation reduces the productivity of the mechanism significantly and entails the occurrence of inconvenience for the personnel who perform their duties on this equipment.

The purpose of the paper is to develop an original method of operational determination of the parameters of the asynchronous motor replacement scheme in order to ensure passport accuracy of the control system operation regardless of environmental conditions**.**

The main content of the work. Modern systems of automatic control of the coordinates of an alternating current electric drive are usually based on frequency converters that work according to the principles of scalar, vector or direct torque control. The approach to selecting the desired control law is dictated by the requirements defined by the mechanism. With any control law, the structure of the control system is built based on the input data of the electric motor replacement scheme.

During the operation of the specified type of equipment, it turned out that the parameters of the electric motor replacement scheme for the climatic conditions of central Ukraine cannot provide the characteristics declared by the manufacturer, when determined once. The reason for this is the significant influence of ambient temperature and humidity on the parameters of the substitution scheme. Accordingly, when the environmental conditions change, the preliminary adjustments of the control system for each season float. This is manifested in the deterioration of the accuracy of working out the movement task. The procedure for automatic determination of electric motor pa-

rameters is long, especially for fairly powerful equipment, which cannot be accepted to eliminate the problem of accuracy loss of the automatic control system.

The studied sources [1-2] demonstrate the reaction of the influence of temperature on the static and dynamic properties of an asynchronous drive controlled by frequency converters. According to their materials, it is claimed that for static characteristics, when the temperature decreases from +20 to -60°C, there is an increase in starting and critical torque. The explanation for this is a decrease in the active resistance of both the stator and rotor windings. As for dynamics, in this case, the speed of starting and braking of the electromechanical system increases. Unfortunately, for all the determined research results, the publication does not give recommendations for the rational use or neutralization of the effect of temperature on the asynchronous motor frequency converter system.

In our case, it is proposed to compensate the significant effect of temperature on the parameters of the substitution scheme by the operational correction of their quantitative values depending on the continuous measurement of the ambient temperature. The implementation of this involves conducting a cycle of experiments with the determination of parameters for the temperature range that occur within the territory of the location of the equipment. A trend line should be constructed according to the tabular functions and a polynomial with the maximum value of the coefficient of determination should be obtained. From the obtained equation, a regulator is developed for operational control of the parameters of the substitution scheme, the output of which should have a high-speed response under a constantly monitored environmental condition. The schematic implementation of autocorrection of parameters can be implemented both on an analogue and on a digital platform.

Thus, the proposed system of operational correction of the parameters of the asynchronous motor replacement scheme will allow:

- Avoid the situation of deterioration of the accuracy of working out the movement task regardless of the season;
- The presence of a speed regulator will ensure prompt and rapid adjustment of the control system of the asynchronous drive of the lifting winch;
- Implementation of the proposed system stabilizes the performance of the mechanism at the guaranteed level declared by the manufacturer;
- Schematic implementation of the control system for the correction of parameters of the substitution scheme can be implemented on any platform.

The scientific novelty of the paper consists in the development of an original method of operational correction of the parameters of the asynchronous motor replacement scheme, which will ensure guaranteed accuracy and speed of the task of moving the drive of the lifting winch of the gantry crane.

Conclusions

The proposed original method of operative correction of the parameters of the asynchronous drive replacement scheme will avoid the long procedure of determining the parameters and thus increase the productivity and safety of using the lifting device.

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UDC 621

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JUSTIFICATION OF THE DESIGN OF THE CONVEYOR ROLLER BEARING SEAL WITH THE INFLUENCE OF THE THERMAL FACTOR

The main trend of the modern development of belt conveyors in Ukraine and the world is a significant increase in their productivity, length and power. This is mainly achieved by increasing the speed of the conveyor belt, which is already more than n on some conveyors 5 m/s.

Thus, to ensure modern mine and quarry cargo flows, the domestic industry produces conveyors with a capacity of up to 5000-6000 m^3/h. Conveyor lines with a length of 3 km or more are operated at mining enterprises of Ukraine, and conveyor lines with a length of more than 100 km are known in world practice, with the length of one conveyor being 8-10 km [1-5].

Actuality of theme. The main consumable element in the depreciation of belt conveyors is the conveyor roller. Thus, the need for this element only for Ukraine at the beginning of our second decade amounted to an average of 3 million units.

To determine the values of the main parameters of conveyors in the mining industry, we will consider the main types of conveyors produced in the post-Soviet territory.

The main parameters of conveyors, which significantly affect the design and resource of the roller, include: weight capacity; the speed of the tape; width and type of tape; diameter, weight and length of rollers; working conditions.

A characteristic that particularly affects the work of both the conveyor as a whole and its individual components is the working conditions, which are determined by: climate; temperature conditions; working conditions depending on the nature of the installation; busyness; chunkiness of the transported material; humidity; dustiness.

The purpose of the work is to study the physical and mechanical processes that accompany the operational cycle of conveyor rollers with the establishment of the main factors that affect the resource and justification of the design of the seal to ensure the maximum period of operation and production costs.

Tasks of research:

- establishment of regularities of the main processes accompanying the operational cycle of the conveyor roller, thermal expansion and cooling of the roller space - "breathing", heating of the roller from atmospheric effects, friction of the roller on the conveyor belt and in the bearings;

- creation of a model of thermodynamic equilibrium of roller elements, which will combine the main processes accompanying the operational cycle;

- creation of uniform recommendations that will allow to ensure the maximum period of operation and production costs of conveyor rollers.

When establishing the regularities of the main processes that accompany the operational cycle of the conveyor roller, we will consider the main designs of the flagships of the domestic conveyor construction VP Transvugillia and NKCP Press (Fig. 1).

Let's consider the main sources of thermal energy radiation.

From the analysis of the design of elements that are sources of thermal influence, it is necessary to determine the following: bearing friction; friction of seals; friction of the roller tip on the tape.

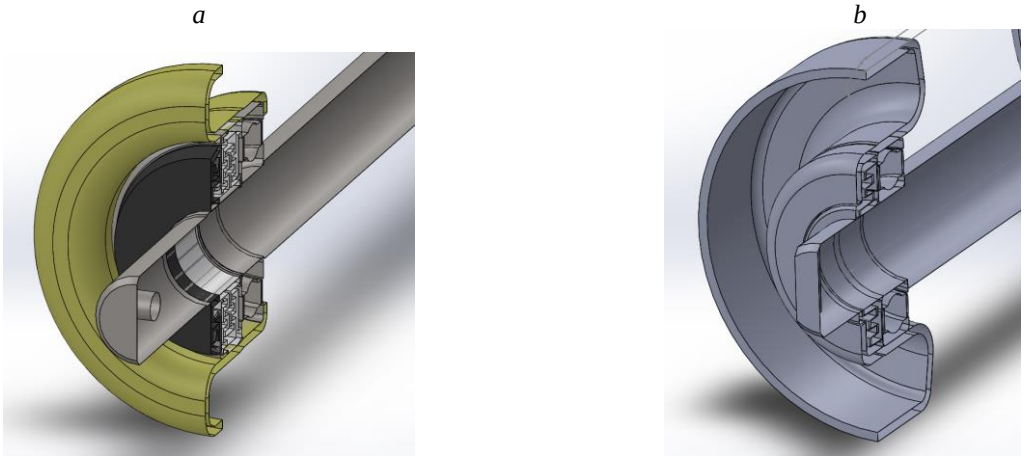

Fig. 1. Typical designs of conveyor roller bearing seals: *a* - open case; *b* - closed case

The results of theoretical studies of physical and mechanical processes that accompany the operational cycle of conveyor rollers, with the establishment of the main factors that affect the resource, made it possible to determine: regularities of the main processes accompanying the operational cycle of the conveyor roller, thermal expansion and cooling of the roller space - "breathing", heating of the roller from atmospheric effects, friction of the roller on the conveyor belt and in the bearings; a model of thermodynamic equilibrium of roller elements, which combines the main processes accompanying the operational cycle; the only recommendations that will allow to ensure the maximum period of operation and production costs of conveyor rollers.

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SUBSTANTIATION OF THE DESIGN AND FIELD STUDIES OF THE ROLLER SHREDDER OF PLANT RESIDUES

Modern technologies for growing agricultural crops provide for the maximum use of plant residues of the predecessor crop and siderates. In both cases, it is necessary to grind the green mass located on the surface of the plantation. At this stage, the ribbed and plate roller-shredder is the most effective means for performing this operation. On the market of agricultural machines, each manufacturing company offers units of its own design. These machines are, as a rule, narrowly oriented and cannot be used in conditions different from those declared by the manufacturer. The roller-shredder in its modern form is a relatively new machine, but it quickly proved its effectiveness and became widespread. According to its purpose, the machine grinds plant residues, plows and mixes them with the soil, and thus forms a layer of mulch. In general, the machine is in demand and eliminating a number of design problems is an urgent task.

By reviewing literary sources, we have outlined a number of studies in which the parameters of shredder rollers are substantiated from the point of view of the quality of the technological process [1,2]. In these works, the rational values of the diameter of the drum, the number and width of the knives are substantiated through analytical and experimental studies.

Structurally, all types of machines are united by a single design solution: a drum in bearing supports with radial cutting plates-knives fixed around the perimeter. Depending on the diameter of the drum, the rollers are divided into those that work according to the agro-background of rough-stemmed crops of various grasses.

The peculiarity of the interaction of this design with the processed environment is that the knives perform vertical cutting. The peculiarity of the interaction of this design with the processed environment is that the knives perform vertical cutting.

That is, they grind plant remains and loosen the surface layer of the soil, but do not perform mixing. At the same time, in order to form a layer of mulch, it is necessary that part of

This problem is successfully solved in garden plots with the help of an ordinary garden shovel. Having analyzed the technological process, which is performed with the help of a shovel, we proposed to install part of the knives at an angle of 75 degrees to the axis of rotation of the roller and shift their fastening from the radial knife by the amount of eccentricity *a*.

The angle of entry ensures undercutting, and the eccentricity of the rotation of the layer. But this design does not ensure the cutting of plant remains, because the cutting becomes unsupported. Therefore, both variants of knives are installed on the drum in the ratio of 12 radial + 4 cutting ones (Fig. 1).

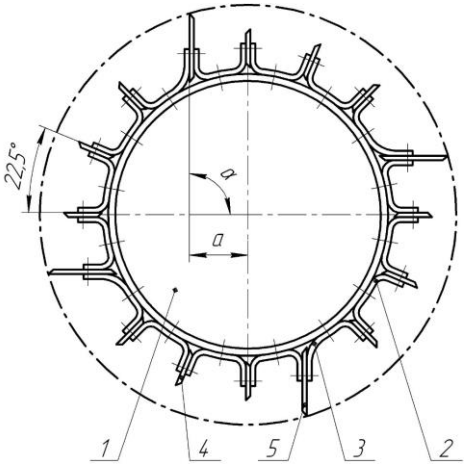

Fig. 1. Structural scheme of the rink: *1* - ube; *2* - radial knife support; *3* - ndercutting knife support; *4* - radial knife; *5* - undercutting knife

The project was based on a constructive solution [1]. As such, which has found a material embodiment in a real machine, which simplifies the further course of experimental research.

We made a prototype and conducted preliminary experimental studies, but due to the lack of generally accepted criteria for evaluating the quality indicators of the formation of the mulch layer, it is not possible to objectively compare it with known models of machines.

Purely visually, the machine qualitatively performs the technological process.

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SELECTING AND JUSTIFYING TEMPORARY SUPPORT PARAMETERS OF A ROCK-TUNNELING MACHINE

Mining and geological conditions as well as the type of propping preliminary or permanent development of underground structures stipulate the cost of support varying from 30 to 45% of the total cost of the works, and the time spent on propping reaches up to 20-25% of the time to complete a tunnelling cycle. These workings are fixed with wooden, arched steel, anchor and prefabricated reinforced concrete props or monolithic concrete.

The process of erecting roadway support especially single-piece propping made from wooden or reinforced concrete props and arched metal, is still difficult to mechanize.

To a greater extent, the process of rockbolting from reinforced concrete or metal tubing and from monolithic concrete should be mechanized as well.

However, insufficient interconnection of other processes with such mechanisms as tunneling machines, drilling rigs, load-carrying vehicles used for development as well as other means of transportation makes it difficult to mechanize the process of erecting temporary sectional support. In addition, the variety of cross-sections of mining workings and constantly changing mining pressure aggravate the process of installing a small number of props having standard size and unified form.

These circumstances also complicate the task to mechanize support erection process.

In general, stulled propping device is a hydraulic manipulator with a hydraulic cylinder and an overlap (stop). The number of devices being installed according to different schemes on the basic or subsequent machine can vary.

The overlap interacts with the roof and (or) a side wall of the working. The design solutions of the devices may be different due to operating conditions.

Based on the predicted data of the stress state of a lying ahead rock mass, local propping of the working area is stipulated at a distance up to one meter deep into the rock.

Geometric parameters of permanent or preliminary mining workings as well as mining and geological conditions of their development can be taken as input data to calculate loads. The overlap is required to follow the mine working shape and be adjusted to an uneven roof surface. The existing overlap structures are metal-intensive and heavyweight.

Therefore, it is necessary to provide overlapping being capable to withstand rock weight taking into consideration acceptable stress values to occur in that overlap.

The optimal design of the sections of stull-timbered overlaps of a selected type tunneling machine stipulated by minimum mass criteria with the specified structure strength and rigidity is a sectional overlap with the following parameters: R - upper radius; R – lower radius; B - overlap thickness; k - the number of reinforcement ribs.

The development of mining engineering is provided by continuous improvement of machines and mechanisms and results in reducing a manual labor proportion, upgrading the quality of extracted coal as well as increasing productivity performance.

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RESULTS OF THE EXPERIMENTS ON HARD ROCKS CRUSHING BY THE WAVE PROFILED ROLLS

Processing of mining rock mass usually involves several stages of crushing. Fine crushing is considered the most important stage, because the control of granulometric composition of obtained products is carried out exactly at this stage.

The shape of pieces, namely, the content of flaky pieces is controlled just at the last stage, in the case of crushed stone production for construction purposes.

Flaky pieces include those, in which the largest size in three dimensions (length) exceeds the smallest size (thickness) by at least three times. According to the standard [1], crushing products are divided into classes by the content of flaky pieces:

- I - rounded form, no more than 10% of flaky pieces;
- II - cuboid, from 10 to 15%;
- III - improved, from 15 to 25%;
- IV - normal, from 25 to 35%.

Materials containing more than 35% flaky pieces are considered non-compliant.

In the case of the production of particularly critical building structures operating under conditions of high dynamic loads, it is recommended to use only crushed products that have a rounded or cube-shaped pieces. This makes it possible to save binders, to provide a more dense packing of frame particles in concrete products made from crushed stone, and, in general, to reach higher load-bearing capacity and consumer properties of products.

Roll crushers with smooth rolls belong to one of the equipment types for production of crushed stone from hard rocks, the use of which, however, is limited by restrictions:

- according to the strength of the material supplied for crushing, with a compressive strength of not more than 150 MPa, which is also caused by the need to reduce the deflection of rolls in the middle of the working part, where there is no bearing support;
- by the size of the initial pieces, which should be no more than 5% of the outer diameter of the rolls, which limits the use of these crushers only to the stage of fine crushing.

In order to improve the performance of roll crushers, it is recommended to use rolls with the wave profile of working surfaces [2], which have the following advantages:

- an increase in stress concentration at the contact of a piece with roll ledges due to the transition from a “flat” contact to a “linear” one, but without a significant increase in the wear of rolls, as it is in the case of toothed rolls implementing the principle of “point” contact; this also leads to a

decrease in the specific energy consumption of crushing, to a decrease in the yield of fines, and to a decrease in the loading on roll supports;

- an increase in the size of retracted pieces compared to the smooth rolls of the same diameter, which makes it possible either to use smaller rolls or switch to bigger pieces crushing.

In order to test theoretical conclusions and to identify the real characteristics of the crushers with wave profiled rolls, a series of experiments was carried out on the crushing of marble, quartzite and granite.

In particular, such indicators were determined, as the degree of reduction in the output of flaky particles, the relative size of the maximum retractable piece, as well as the coefficient of coarsening of crushed products size.

The latter indicator is the ratio of the size of the largest piece in crushed product to the size of the gap between rolls [3]. Its determination plays a significant role in calculating the technological parameters of quasi-static crushers.

The results of experiments on the crusher with a roll diameter of 260 mm showed that, practically regardless of the type of material studied, it provides stable retraction of isometric pieces up to 30 mm in size, and flaky pieces up to 70 mm in size.

This difference in size can be explained by the fact, that the minimum size of the piece (thickness) is of decisive importance during being retracted into the gap between rolls, while the division into size classes is performed mainly by the average size of piece (width).

In addition, the size of the retracted piece is strongly affected by the size of the gap between rolls, the increase in the maximum size is almost equal to the increase in the gap width, all other things being equal.

It has been established, that after crushing of materials of ordinary and improved forms, the percentage of reduction in flaky pieces content in products is 10-15% with a minimum formation of fines going to drop-off, which ensures the decrease in flakiness group number of the material by 1-2 positions.

The processing of cube-shaped or rounded materials does not lead to a noticeable increase in the quality of products in terms of reducing flakiness, therefore it is recommended only for the purpose of reducing particle size.

The most effective way to use crushers with the wave profile of rolls is processing in the so-called “shape improvement” mode, with a minimum degree of crushing, after preliminarily selecting most of the flaky pieces into a separate class. The higher the initial yield of flaky particles in the material is, the more this value will decrease in the crushed products. In addition, the processing of predominantly flaky pieces ensures the retraction of pieces with a maximum size of up to 20-25% of the roll diameter.

The results of experiments confirm, that the most rational area of application of the crushing process on wave profiled rolls is the processing of lumpy construction materials with increased flakiness in order to reduce the latter value. In this case, the degree of crushing should be minimal.

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CAUSES OF THE TITANIUM FILTER MESHES' DESTRUCTION IN TECHNICAL WATER FILTERS

Research and production enterprise "Oceanmashenergo" LLC (Dnipro, Ukraine) is a well-known developer and manufacturer of industrial modern automated technical water filters [1]. The company manufactures filters of various types and with a wide range of parameters and is characterized by a careful attitude to the special requirements of filter customers. In 2021, two automated FSC-600 filters were manufactured for one of the Ukrainian industrial enterprises using titanium wire ∅0,4 mm and cell size 1,45 mm as filter meshes.

The customer did not specify the brand and manufacturer of the mesh and wire, but agreed on the dimensions of the mesh and wire. A titanium mesh manufactured by Evek Gmbh (Germany) was chosen. The manufacturer of the titanium wire was not specified, presumably the wire was made in China. According to the certificate provided by the manufacturer, the grade of titanium from which the wire is made is Grade 2 ASTM B863, the chemical composition of the alloy is Ti - 99,77%; Fe - 0,28%; O - 0,18; C - 0,28%; N - 0,002%; H - 0,004; ultimate tensile strength 440-590 MPa.

Filters with such meshes worked for a year. During the regular maintenance, numerous bursts of nets were found over the entire area of the filter elements (Fig. 1).

Fig. 1. The rupture site of the titanium mesh

The urgent task is to determine the causes of the destruction of titanium meshes.

Possible causes of the destruction are as follows:

1. Bursts of mesh wires due to unacceptable tensile load when the filter element is clogged;

2. Cuts of the wires of the mesh by sharp and heavy objects in the wa-

ter pipe;

3. Corrosive destruction of the mesh material under the constant influence of technical water;

4. Inconsistency of the mechanical properties of the wire mesh with those specified in the certificate and standard.

Tensile load on the mesh wires is caused by the hydraulic pressure of water that is filtered through a partially clogged filter element.

The filter manufacturer limits the maximum allowable pressure on the mesh to 0,05 MPa, which, in terms of 1 wire, gives a tensile force in it of about 35-40 N. Such a force causes a tensile stress of 318 MPa in a ∅0,4 mm wire, which is less than the one declared in the certificate tensile strength limit 440-590 MPa. Thus, the normal mode of operation of the filter should not have led to a rupture of the mesh.

Examination of the torn edges of the mesh under magnification of 5^x and 63^x did not reveal traces of wire cuts, but revealed thinning of the wires in the places of destruction (Fig. 2*a* and *b*).

That is, it was established that the wires were torn under the action of a tensile force greater than the permissible one. The tip of a wire cut with scissors does not have a characteristic thinning at the point of the break (Fig. 2*c*).

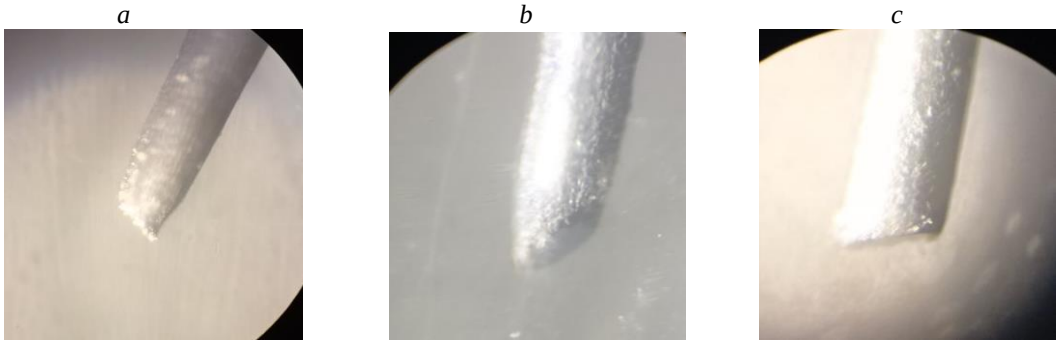

Fig. 2. The ends of the broken wires: *a* - mesh after their one-year operation; *b* - new mesh; *c* - wire cut with scissors (magnification 63 times)

The probability of chemical corrosive destruction of the wires due to the influence of technical water is low due to the absence of active reagents in the water in sufficient quantities that could destroy the titanium mesh material.

A comparison of the outer surface of the wires of the new and previously in use mesh did not reveal any traces of corrosion damage.

The experimental verification of the strength limit made it possible to determine the actual value of the tensile strength limit 390 MPa, which is slightly lower than specified in the manufacturer's certificate.

The chemical analysis of the mesh wires revealed some differences in the composition of the material specified in the certificate, namely Ti - 99,072%; Fe - 0,542%; Al - 0,386%. The presence of aluminum in the composition of the titanium alloy in general has a negative effect on its quality,

according to the ASTM B863 standard, the content of Al in the Grade 2 alloy should not be present at all, iron in the composition of Grade 2 leads to its strengthening.

Thus, it was established that the wires were not cut by sharp foreign objects, but were torn.

The main causes of wire breakage should be considered poor quality wire material and - possibly - accidental contamination of the filter mesh, which caused an increase in hydraulic pressure on the mesh and excessive tensile forces in the mesh (beyond its breaking strength limit).

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MODELLING OF STRESS-STRAIN STATE OF THE ONE LEAVER TUNNEL ERECTOR

Tubbing erectors - machines designed to reinforce horizontal mine workings with the help of lining (tubbings or reinforced concrete blocks) - are used in tunneling.

The tubbing erector manipulator (Fig. 1) connects the links of Lever arm *2*, Shoulder *3* and Section 4 with the hoisting device using rotational kinematic pairs.

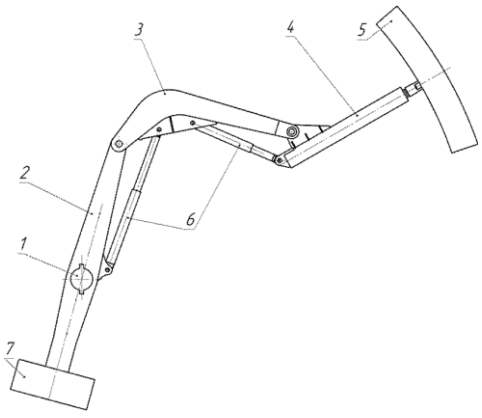

Fig. 1. UT62 tubbing erector manipulator design

The hoisting device is designed for assembling in the tunnel of Pin lining *5*. Lever arm *2* link with counter-weight *7* is set on the drive shaft of the hydraulic motor *1* (Support). Two power hydraulic cylinders *6* (Engine) control the links *3* (Shoulder) and *4* (Section).

By order of JSC Dneprotyazhmash, the scientific school of employees at the National Technical University Dnipro Polytechnic is engaged in the study of dynamic and static parameters for tubbing erectors [1].

For the dynamic analysis of such mechanisms, as a rule, methods of analytical mechanics are used, which, in the general case, make it possible to obtain forces in the drive along a given trajectory of the executive body movement.

But in order to calculate the stress-strain state of the mechanism links, it is necessary to perform a resource-intensive dynamic calculation [2].

The task is complicated by the fact that the mechanism links move according to a complex law of motion. Therefore, the authors in the work [3] restrict themselves to studying simplified dynamic models of the UTK-2 erector mechanism.

The UT62 erector main characteristics: tunnel diameter - 9,5 m; lining type - tubbings, blocks; tubbing or block weight is no more than 920 kg.

Based on the JSC Dneprotyazhmash initial documentation, a solid model has been constructed using the SolidWorks Simulation program (Fig. 1).

From the trial calculation of the lever arm with the default finite element mesh, it can be seen that an unacceptably high gradient occurs at the stress concentration points. In addition, the maximum aspect ratio in finite elements reaches 75,6, which is not acceptable in terms of the accuracy criterion. Therefore, the following measures are taken: 15 mm maximum size of the element is set; a mesh management tool is applied (1 mm is the element size, 1,1 is the ratio of the element size in one layer relative to the element size in the previous layer) on the edges, near which the maximum equivalent stresses occur.

A simulation case is accepted when the tubbing is placed in the vicinity of a horizontal plane passing through the axis of the tunnel with a diameter of 10.4 m. The tubbing weight (920 kg) and the gripping device weight for this tubbing (630 kg), applied to the axis of the Section link, are considered as the load.

Based on a simplified computational scheme, taking into account the gravity centers of each link and their masses (Fig. 1), an analytical calculation of the torque is performed. This result is controlled by directly measuring this parameter in the SolidWorks Simulation program, for which a special lever arm on the manipulator shaft is additionally constructed in the computer model (Fig. 1). The calculation in the SolidWorks Simulation program shows the reactive moment value by 10% higher than the value obtained by calculation.

The stress-strain state analysis (Fig. 2) obtained in the calculation shows:

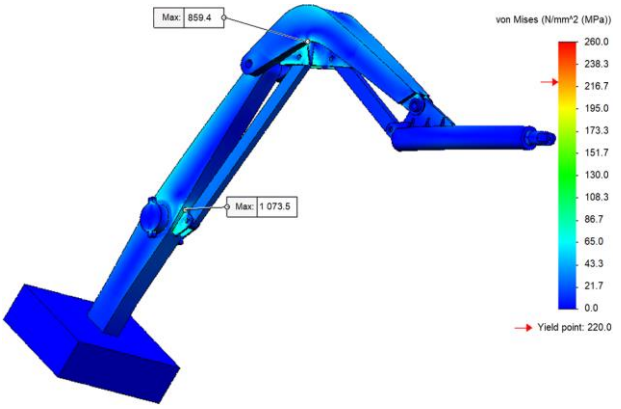

Fig. 2. Tubbing erector manipulator stress-strain state

- the most loaded places where equivalent stresses are in the places of attaching the beckets to the Lever arm link (1080 MPa) and in the places of attaching the edges of the beckets to the Shoulder link (860 MPa);

- the Section link is the least loaded - 8 MPa;

- in the entire structure of the manipulator assembly, the stresses, except for the above-mentioned places, do not exceed 50 MPa.

In addition, preliminary calculations show that the mechanism mass can reach 6000 kg.

To ensure the creation of a tubbing erector manipulator design with uniform strength, it is necessary to substantiate the method of computer analysis of the manipulator mechanism stress-strain state in the process of tunneling. In addition, it is necessary to set and solve an optimization problem – to determine the parameters of the tubbing erector manipulator, ensuring the delivery of tubbing to a given position according to the criterion of achieving the minimum mechanism mass and equivalent drive power.

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ANALYSIS OF THE IMPLEMENTATION OF INFORMATION TECHNOLOGIES IN THE PRACTICE OF SOLVING PROBLEMS OF AUTOTECHNICAL EXPERTISE OF ROAD ACCIDENTS

In recent years, information technologies have been widely used during expert research, which is typical in the investigation of various crimes. The following main ways of direct application of computer technology in forensic expertise were distinguished [1]: mathematization of individual elements of expert research; full automation of the analysis of material evidence; creation of dialogue systems. Computerized methods of researching the mechanism of road accidents, determining the place of collision of cars, comprehensive assessment of the traffic situation developed for the needs of autotechnical expertise. The beginning of the introduction of information technologies into the practice of autotechnical expertise were the modeling of road accidents, creation of complex software products, separate software for performing auxiliary calculations and forming expert opinions. Advantages of innovations: a much larger volume of calculations is performed; the likelihood of arithmetic errors decreases; the possibility of visualization of research results appears.

Modern information technologies of road accident research can be classified according to purpose, adequacy of reconstruction results, used mathematical apparatus, requirements for the performance of electronic computing machines, and the required level of specialist training [2-4].

All computer programs used for the needs of autotechnical expertise can be divided according to the following areas of application:

- photogrammetric programs: PC-Rect, PhotoModeler Pro, Photorect, their task is to correct the perspective, that is transformation of ordinary photos into an image in an orthogonal projection, used to perform all kinds of large-scale measurements of the location of objects at the scene of an accident;

- programs of spatial-time analysis of traffic of vehicles and pedestrians in the conditions of an accident: Sybid Titan, Cyborg Idea SLIBAR+;

- graphic editors, which allow to build large-scale schemes of traffic accidents: AutoCAD, Auto-Graf, Sybid Plan, MapScenes, software package «Cad Zone»;

- programs for determining the movement parameters of road accident participants in given conditions: AR Pro, Analyzer Pro, WinKol (Kollision), Crash, Rec-Tec, MonDiaFor «HADI-15» + Road Accident, and others (including those developed with the author's participation [5, 6]);

- systems of visual modeling of the traffic situation: SMAC, Sybid eSURV, CARAT, Sybid V-Sim, PC-Crash, «Road accidents expertise» and others.

According to the authors [1-4], the development of autotechnical expertise of road accidents is not possible without the use of automated digital systems for measuring and calculating various parameters at all stages of investigating the circumstances of traffic accidents:

- use of laser scanning of accident place, by results of which it is possible to automatically compile a digital scale scheme of accident and establish all the characteristic dimensions;

- use of EDR records (event data recorders), which record motor vehicle movement parameters before and after the occurrence of accidents and provide objective information to the investigation at the pre-expert calculation stage [7];

- use of special digital equipment to perform investigative experiments and applied software products to establish the mechanism of road accidents.

The automation of expert research is the basis for ensuring stable and high quality of autotechnical expertises of road accidents, increasing the productivity of experts, and significantly reducing the time of expertises [8].

Despite the fact that each modern method of expert investigation of accidents, based on the use of computers, has its own specificity and is oriented towards solving a specific problem during the analysis of various objects [1], they have a number of general properties.

1. These methods are based on the principle of systematic organization of the object of knowledge, the principle of using mathematical apparatus and quantitative certainty, algorithmic and functional approach to the process of object knowledge.

2. The element that precedes the formation and application of a certain research methodology, its methodological prerequisite is the mathematical modeling of the object and a comprehensive study of the algorithm of the process of its knowledge. In this context, modeling allows the creation of a model of a comparative analysis of features or a model of the object of analysis, and not only the construction of a model of a problem solution.

3. In the structure of each of the methods, it is possible to single out elements characteristic of them: defining the purpose and setting the research task; dividing the task into individual subtasks; definition of specific methods and means of their implementation; practical activity, consisting of a defined complex of operations; obtaining the result and its evaluation; making a decision.

4. No single method based on computers does not contain the entire process of solving an expert task. Their use in general automates and increases the objectivity of only a certain operation (group of operations), which can refer both to the evaluation of the obtained results and to the process of knowledge itself. Therefore, the use of information technologies in any case does not exclude the use of qualitative approach to the object of knowledge.

Currently, the system of autotechnical expertise of road accidents has, from the point of view of automation requirements and system requirements, many shortcomings, the fundamental reasons of which are:

1. Unsystematic development of current methods of expert research, its informational, mathematical and other types of support.

2. Absence of the corresponding scientific theory for the research of different types of road accidents, applicable to solving the actual issues of road accident analysis.

3. Delay of the level of automation of the existing system of autotechnical expertise from the level of development of registration and electronic-computing equipment.

4. Insufficient quality of specialist training in system perception of road accidents at all stages of their research.

A universal method of eliminating the indicated shortcomings is the methodology of system analysis, based on the principles of necessity and sufficiency of a set of functional elements [9]. It defines the boundaries of the researched system; transparency of the structure of inter-element connections and of each element, the form of transformed information; the physical essence of the system-wide criteria of the quality of functioning and the array of partial criteria, etc.

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RECYCLING WASTES OF ABRASIVE WHEELS IN A VIBRO-IMPACT GRINDER WITH AN INCLINED WORKING CHAMBER

Increase in industrial production is inextricably linked with an increase in the amount of industrial wastes, in particular wastes of abrasive wheels; and disposal and processing of such wastes is one of the most serious environmental problems. The existing multi-stage processing schemes, most of which include a crushing and grinding operation, use standard equipment with a low degree of crushing and poor control over the process of the original product disintegration. This predetermines the relevance of the task of creating small-sized equipment with implemented high degree of crushing (i>100) and obtaining a finished product with required specified characteristics.

A large amount of research carried out at the Dnipro Mining Institute (now the Dnipro University of Technology) made it possible for the first time to substantiate the possibility of using a vibrating jaw crusher with a vertically located chamber and a pendulum suspension of the jaws as an independent grinding unit for production of powder materials, as well as in production processes that require special technological regimes [1,2]. The high-frequency impact nature of loading of the material implemented in this research made it possible to reduce energy consumption and metal consumption of the installation, as well as to increase the degree of crushing. The vibro-impact principle of material destruction was further developed in the developed design of a vibratory grinder with an inclined working chamber and an expanded ability to control the disintegration process [3,4].

In general, the grinder (Fig. 1) includes a passive (lower) jaw 1 mounted on elastic elements (5) and simultaneously performing the function of the housing. The active jaw (3) is installed in the racks of the passive jaw by means of the suspension axis (2), relative to which it can perform rotational vibrations. In the determined neutral position, the active jaw is held by elastic elements (6).

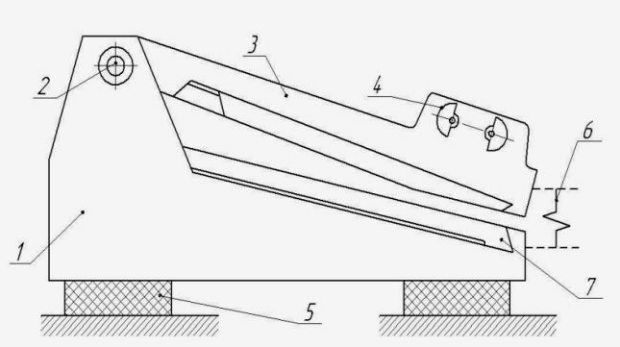

Fig. 1. Structural scheme of the vibro-impact grinder

Vibrations of the jaws are generated by a two-shaft inertial vibration exciter (4). Synchronous antiphase rotation of unbalance shafts is provided by external or internal gearing. Working surfaces of the jaws are lined with wear-resistant plates (7).

Technological tests for grinding abrasive wheels were carried out on an experimental sample of the vibro-impact grinder in an open cycle. The initial feed (Fig. 2) was presented as fraction of +40 mm, obtained after a jaw crusher.

As an example illustrating technical performance of the grinder, the results of grinding electrocorundum are considered. The grain composition of the crushed material is shown in Figure 3; the dimensions are given in microns.

According to the normative documentation [5], the upper limit of abrasive grain size is 2000 μm, and the upper limit of abrasive powder size is 125 μm. From the presented graphic dependence (Fig. 4) it follows that the crushed product (in one cycle) contains up to 70% of abrasive grain (*i*=20).

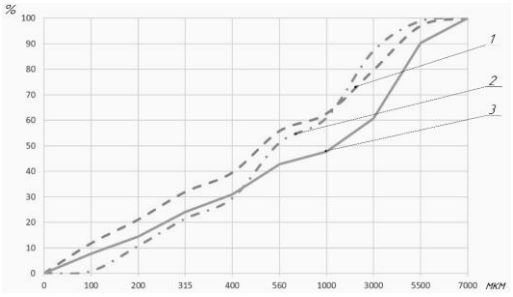

Fig. 4. Graph of the dependence of granular composition on the vibration frequency of the jaws: *1* - ω=14.17Hz; 2 - ω=16.67Hz; *3* - ω=19.17Hz

Content of abrasive powder reaches 15% at the degree of crushing equal to *i*=320.

The graph shows that vibration frequency of the jaws (ω) is a parameter that affects the granulometric size

composition of the crushed product. It is one of the features of the vibro-impact grinder; this grinder has a number of control parameters which when selected create a rational grinding mode for a particular material and produce a product with specified characteristics.

The presented research results show that vibro-impact grinders with an inclined working chamber can be effectively applied for the rational use of natural resources by means of grinding and converting industrial waste into commercial products.

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RESEARCH OF MANIFESTATIONS OF DESTRUCTIONS IN THE AUTOMOBILE CRANES

Topical problem of modern machine use is ensuring the reliability of machines. Reliability, to a great extent, determines work efficiency of any mechanical system over a long period of time, consumption of energy resources, as well as safety of their operation.

Indicators of reliability of machines are laid in the process of their design, provided during manufacturing period and manifest itself in the process of operation. Reliability isn't a constant value during the period of operation. Parts wear out, which leads to decrease in reliability of the construction.

According to the research of Bolotin V.V [1] main factors, which influence the reliability of metal structures, are:

- high tensions in stress concentration zones;

- insufficient plasticity of the metal of structural elements, related to chemical composition and initial structure of the steel or its change under the influence of technological and operational factors;

- presence of unfavorable geometric factors, such as structurally-technological and operational stress concentrators.

At the modern stage of functioning economy of Ukraine is characterized by low level of funding. This is one of the reasons for the average service life of productions equipment exceeds the standard. This situations leads to a significant increase in emergency situations, associated with the loss of operational efficiency of technical objects.

High-risk objects include cargo cranes, therefore their technical condition during operation process must be monitored periodically. Periodic evaluation of the technical condition of cranes, in particular automobile ones, promotes increase in their reliability and operational safety.

Reliability - is a complex property of the automobile crane, which is formed from indicators of durability, maintainability and fail-safeness. Reliability of the crane changes during the entire period of operation. The tendency in decrease of reliability is explained by wearing down of the parts, both due to friction and under influence of corrosion. The decrease in the reliability of automobile cranes is significantly influenced by external natural and climatic factors and the variable nature of loads. In addition, to the loss of reliability contribute [2]:

1. Untimely conduct of control measures aimed at detecting defects;

2. Untimely performance of repair and restoration works. In particular, untimely restoration of paint coating of metal structures contributes to the formation of corrosion cracks.

3. Sufficiently high level of stress concentration.

Based on the results of research presented in works [3,4,5,6,7] we can assert that systematic experimental studies of the manifestations of defects in the structural elements of automobile cranes allow not only to obtain data on their technical condition, but also to create a database for predicting possible manifestations of defects under different operating conditions.

The need for such studies arises during the entire period of operations.

The analysis of statistical data for the period 2019-2021 is the basis of the study of the manifestations of characteristic defects of automobile cranes.

Research was conducted at enterprises in the city of Rivne and Rivne region. The research of conducted with the employees of «Expert and technical center of Rivne».

Ten 10t automobile cranes on the ZIL 133 GYA chassis with a hydraulic drive (KS-3575 A) were chosen as the objects of research, 1991-1992 years of production. We conducted an experimental study of functional and constructional elements of an automobile crane using the method of non-destructive testing.

Measurements of the coercive force Hc(A/cm) were carried out at points according to schematics provided by specialists of «Expert and technical center of Rivne».

Coercive force is such an external magnetic field, which must be applied to a ferromagnetic, that was previously magnetized to saturation, to bring its magnetizations or magnetic field inductions inside to zero« Coercitio» - retention in Latin is a characteristic of ferromagnetic materials.

It was coercive force that was used during the diagnostics of the automobile crane in order to determine the quality characteristics by the non-destructive method.

The device used for research - structurescope KRM - CK - 2M which was used to measure the coercive force.

Elements and components,that were subjected to control

1. Supporting frame, made of steel 09G2S - 12;

2. Crane boom, made of steel 09G2S - 12;

3. Supports, made of steel 09G2S - 12;

4. Rotation frame, made of steel 09G2S - 12.

The analysis of the obtained results revealed that the coercive force, Hc (average value) is:

1. On the supporting frame 4,4-7,4;

2. On the supports 4,4-5,1;

3. On the rotation frame: on the console 4,2-7,1; on the crane boom wall 4,9 -5,3;

4. On the root section of the boom 5,3-8,1.

The highest value of the coercive force was recorded on the boom walls in the middle of their width along the upper and lower belts.

The analysis of the typical types of destructions made it possible to establish the most common ones:

- cracks in the supporting and rotation frames;

- cracks and deformations of boom sheets;

- wearing down of the mechanical gears;

- wearing down of elements of lifting mechanisms (breakage and deformation of ropes, wearing down of the hook).

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PORTABLE DIGITAL SPECTROMETER GAMMA RADIATION FOR RADIATION IN THE FIELD

The level of development and application of radiation technologies is largely determined by the state of nuclear instrumentation. In a relatively short period of time, this industry went through several stages of development, and each of them was marked by emergence of various devices that register and measure the parameters of ionizing radiation: gas-discharge counters, scintillators, semiconductor detectors, and others. Their appearance and further widespread use was provided in the past by works from Crookes, Rutherford, Geiger and Müller to the works of A.B. Dmitriev, S.N. Perelman, V.G. Tchaikovsky, and V.G. Baranov, which are closer to us in time. I., Golbek G.R., Nemirovsky B.V., Yakubovich A.L. and many others. The basis for the progress of nuclear instrumentation was the simultaneous development of two areas - nuclear physics research and electronics. However, both directions at that time developed independently, without proper mutual connection.

The key problem of nuclear power - radiation safety - is solved by ensuring the reliability of protective barriers for the main objects of the technological process of NES functioning: fuel elements, fuel assemblies (FA), coolant transfer circuits, etc. The key problem of nuclear power - radiation safety - is solved by ensuring the reliability of protective barriers of the main objects of the technological process of NES operation: fuel elements, fuel assemblies (FA), coolant transfer circuits, etc. radiation reconnaissance in the field.

The new generation radiation sensors and measuring systems created in this work open up previously unknown possibilities in solving problems of nuclear fuel analysis, increasing the accuracy and efficiency of monitoring technological parameters and the state of protective barriers in nuclear power plants, creating means for IAEA inspections.

When considering methods of combating the illicit circulation of nuclear materials, it is necessary to reconsider approaches to the organization of control: today it is necessary to detect trace amounts of materials, and in many cases not to seize them immediately, but to establish the place of storage, processing, routes of movement, etc.

The structural diagram of the spectrometer is similar to that shown in Fig.1. In contrast, this device has two sensors. The second one is placed on a telescopic rod, which allows monitoring in hard-to-reach places with increased radiation hazard.

The BDPG-CZT detecting unit operates as follows.

An external voltage of +400 V is applied to the BDPG-CZT, which creates an offset on the sensor through the RD and a high-resistance resistor. When gamma radiation enters the detector, charge pulses are formed on it, which are converted by the PU into voltage pulses. These pulses are amplified by the op-amp and fed to the comparator and UZA.

The logic pulses at the comparator output are set to "1" by the latch trigger, the state of which is read by the MC. After detecting a logic "1" at the output, MC resets this flip-flop to prepare for receiving the next comparator pulse. The choice of the comparator threshold allows you to set the level of suppression of the noise component op amp signal when detecting radiation pulses, i.e. this threshold actually determines the lower energy level of the detected radiation.

The amplitude of the OA pulses is fixed in the analog UZA, the operation of which (reset-memorization) is controlled by the MC. The MC also controls the operation of ADC (trigger-read). The MC program works in 2 modes: calibration and measurement. The change of modes is controlled by an external PC via the RS-232 interface.

When the power is turned on and there is no external PC connected, MC automatically enters the measurement mode. In this mode, the MC reads correction and calculation coefficients from the nonvolatile memory of the EPROM, measures the count rate of radiation pulses (according to the comparator signal), determines their amplitude (radiation energy) and calculates the dose rate. Then MC records the code into interface corresponding to the calculated value of dose rate.

The interface generates the output signal BDPG-CZT in the form of pulses negative and positive polarity with an amplitude of 4,5 V, duration of 3 μs and a repetition rate proportional to the calculated value of the dose rate. These pulses enter the measurement channel.

The output pulses are continuously delivered to the measuring channel. Even if the BDPG-CZT unit does not register radiation, its output always contains pulses with a frequency of 0,3-0,5 Hz. This is used to check the functionality of the battery measurement channel.

A voltage of +6 V is applied to the "Blenker" input, due to this, the MC sets at the interface output pulses with a repetition rate of 1000 Hz.

In the calibration mode, initialized by PC, service information, correction and calculation coefficients are written into the microcontroller through the computer port interface. The microcontroller stores all this information in the non-volatile memory of EPROM. In the measurement mode, only this information is read.

MC conducts a series of measurements and analyzes the result. The first step is to measure the count rate of input pulses.

The maximum counting rate is limited from above by a value of 65536 imp/s, so a preliminary measurement is made at an exposure of 0,1 s and MC compares the obtained value with the number

6500 (10% of the maximum channel load). If the count rate exceeds specified limit, MC automatically sets the output pulse repetition rate of 65000 imp/s.

If the count rate is in range of values from 0 to 65000 pulses/s, then the MC conducts a set of pulses with subsequent averaging. So, at a count rate from 0 to 3000 pulses/s, the dialing time is 16 s. At a count rate of 3000 to 10000 cps, the dialing time is 4 s.

At the maximum counting rate, the dialing time is 1 s.

Conclusions

For the first time a portable digital gamma-ray spectrometer for radiation reconnaissance in the field was developed and created.

Distinctive features of such devices are:

- application of CdZnTe detectors with coplanar and quasi-spherical crystal geometry;

- the use of digital methods of filtering by the pulse shape, implemented in a digital spectrometer.

The manufactured sets of such gamma spectrometers have an energy resolution of 6 keV, which meets the requirements for assessing the isotopic composition of nuclear fuel.

A prototype of a digital gamma spectrometer using a multielement CdZnTe sensor has been developed.

On the basis of inexpensive CdZnTe-detectors, a prototype unit for detecting the power of air kerma with an average sensitivity of more than 120,000 s^{-1} at an absorbed power of 1 rad/h has been developed and manufactured.

The range of the measured absorbed dose rates was from 50 mrad/hour to 10 rad/hour with a crystal size of 5×5×1 mm.

The developed spectrometer meets the basic requirements for application in the program of international safeguards for the non-proliferation of nuclear materials.

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SUPERCAPACITOR AS A MEANS OF RECHARGING TRACTION BATTERIES OF MODERN ELECTRIC VEHICLES

Introduction

A significant disadvantage of modern electric vehicles is the duration of the charge of its batteries. Accordingly, this limits the custom properties of these cars.

The purpose of the work is to develop an original method for quickly recharging the battery of electric vehicles by using supercapacitors as part of the overall design of the power supply system as a means of intermediate energy exchange between the charging station and the battery.

The main content of the work. Traditionally, modern electric vehicles are equipped with lithium-ion sources, which must meet a number of requirements:

- minimum losses and voltage drops when operating in transient conditions;
- small influence of fluctuations in ambient temperature (winter-summer season);
- minimum self-discharge during the lengthy downtime;
- a large number of charge-discharge cycles;
- minimum weight and size;
- simplicity and robustness of design.

Existing batteries of electric vehicles have weight within 450-800 kg, a significant cost and a rapid drop in capacity. Therefore, according to Geotab company, 2015 Nissan Leaf car batteries, with active cooling, have a capacity reduction of 4,2% per year. Electric vehicles in countries with hot climate are especially prone to rapid battery degradation. Battery overheating also occurs when using high-speed charging stations. This significantly reduces their lifespan, increases the number of charges per trip and leads to a significant loss of battery power.

An analysis of publications of leading experts in the United States and Korea showed that today a method for high-speed charging of car batteries has been found. According to the Idaho National Laboratory, a battery charging up to 80% is possible in 10-20 minutes, although this technology will not be available within 5-7 years. For now, the process of charging devices of the first level up to 100% capacity lasts for days, and high-speed ones can charge up the battery to the level of 80% - from 30 to 60 minutes.

Supercapacitors can become an alternative for powering of electrical vehicles [1]. Unfortunately, the capacity of modern supercapacitors is not yet enough to completely replace the battery, and therefore it is rational to use them as an intermediate link for fast charging. The

advantages of supercapacitors include their rapid charge/discharge with a significant number of cycles and a service life that can reach more than 15 years. Today, tests of a car with a source based on a battery of supercapacitors have been carried out in China, the USA, Serbia, Bulgaria and other countries.

Systems of this type so far provide a travel distance of no more than 5-8 km. It is possible to increase the capacitance of supercapacitors by increasing the battery or using fundamentally new materials, such as graphene [2,3,4].

Their specific capacity is approximately ¼ of lithium-ion batteries, and the charge duration does not exceed 60 seconds.

At the same time, a lithium-ion battery with a capacity of 100 kWh is charged to a level of 80% from 5 hours or more.

The scientific novelty of the work lies in the development of an original method of recharging the battery by introducing an intermediate link in the form of a battery of supercapacitors into the power supply system of an electric vehicle.

It includes the possibility of its rapid charge from the charging station and long-term discharge to the battery, as well as the exchange of supercapacitor energy with the engine/generator of the electric vehicle [5].

Conclusions

Proposed method for rapid energy storage will allow the express exchange of energy between the charging station, the supercapacitor, the battery and the engine/generator of an electric vehicle, during normal driving as well as during peak load, braking and rolling of the car.

This will provide a gentle charging of the battery, which will contribute to its long and trouble-free operation.

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Section "Economics of natural resources use"

UDC 330

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FUNDING OF THE PROGRAM TO PROVIDE THE POPULATION OF UKRAINE WITH DRINKING WATER

In Ukraine, to solve the problem of providing the population with drinking water, the nationwide target program "Drinking water of Ukraine for 2011-2020" (hereinafter the Drinking Water Program) was implemented. Its main goal was to ensure the rights of citizens guaranteed by the Constitution of Ukraine to a sufficient standard of living and environmental safety by providing drinking water in the necessary volumes and in accordance with established standards. To achieve this, the Drinking Water Program was designed to ensure the implementation of state policy on the development and reconstruction of centralized water supply and drainage systems; protection of sources of drinking water supply; bringing the quality of drinking water to the requirements of regulatory and legal acts; regulatory and legal support in the field of drinking water supply and drainage;

The estimated volume of financing of the Drinking Water Program was UAH 9,471,7 million (in 2010 prices), of which UAH 3,004,3 million came from the state budget and UAH 6,467.4 million from other sources. Due to the lack of adequate funding during the 10 years of implementation of the Drinking Water Program in Ukraine, no significant positive changes in the provision of drinking water in the required volumes and appropriate quality 77 have taken place. Thus, as of January 1, 2020, about 1% of cities, more than 10% of urban-type settlements and almost 70% of Ukrainian villages (8,934 million people) are not provided with a centralized supply of drinking water in Ukraine. Almost every fourth citizen of the country is not provided with centralized water supply. The problem of using imported water covers at least 9 regions of the country, and on [1] directly affects at least 268 thousand people living in 824 settlements.

According to world standards for the quantity and quality of water, Ukraine is classified as a low-water country. In terms of the quality of drinking water, Ukraine ranks 37th out of 40 European countries. And over the past 10 years, our indicators have only gotten worse. And in terms of the amount of water per capita, Ukraine ranks 125th in the world ranking. At the same time, the national target program Drinking water of Ukraine is not being implemented and is not financed at all. The Drinking Water Program was last financed in 2018. Thus, as much as UAH 200 million was allocated from the State Budget of Ukraine for the Drinking Water program in 2018, while only

the enterprises of the water supply and sewerage industry of Ukraine submitted projects for a total amount of UAH 1,3 billion to the competition. Such activity of enterprises is caused by their unsatisfactory financial and economic condition, as well as the inability of local self-government bodies to provide the necessary support for the renewal of fixed assets from the funds of local budgets. In addition, it is worth noting that the procedures for obtaining grant and loan funds from international financial institutions are quite lengthy in the process and are associated with significant risks, therefore, obtaining state funds for the implementation of one or another infrastructure project was a desirable goal for each water utility.

During 2019-2020, the Drinking Water Program was not financed, and in 2020, its effect ended altogether. In order to continue supporting enterprises in the water supply and drainage sector, in 2019 the Ministry of the Regions of Ukraine developed and sent to the central bodies of executive power and specialized associations the bill "On Amendments to the Law of Ukraine "On the Nationwide Target Program "Drinking Water of Ukraine" for 2011-2020", which provided for the continuation of the Program for another 5 years. Interdepartmental agreement, coordination, consultations with the Ministry of Finance lasted for 2 years. Resolution of the Verkhovna Rada of Ukraine dated November 5, 2020 № 980-IX provides for the possibility and expediency of increasing/predicting expenditures and providing loans to the general fund of the draft state budget for 2021 under the budget program "Implementation of the State-wide target program "Drinking water of Ukraine" for the Ministry of Community Development and territory of Ukraine (instead of the Ministry of Regions). The Drinking Water Program of Ukraine will continue until 2025.

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ESTIMATING THE COST OF FORMING A REGULATORY AND LEGAL SPACE FOR ECOLOGICAL MODERNIZATION IN UKRAINE

In the acceleration of ecological modernization in Ukraine, one of the most important tasks currently includes the implementation of the legal norms of the European Union (EU) in the field of environmental protection (fixed in directives and regulations), which appear in the context of the Association Agreement with the EU. As part of the implementation of the goals of the said Agreement, which relate to the comprehensive institutional development of the environmental protection

sector, Ukraine, in fact, faces the need to form a single regulatory and informational space with the EU.

The central methodological issue is the meaningful procedure for assessing the value of such approximation and technical implementation. Such an assessment must be adapted to the specifics of the subject of assessment and requires the formation of an appropriate system of indicators.

According to the general prerequisites, methodical approaches to calculation can be classified as follows: 1. Estimates based on the use of macroeconomic indicators or on interstate ratios (rough and fast); 2. The category of estimates based on the use of specific (unit) cost indicators, or performance of works (unit costs approach); 3. Estimates are based on the use of special calculation models and corresponding software products. 4. Estimates based on calculations based on local (territorial) reference models; 5. Estimates based on direct surveys and investment calculations.

The first type of estimates is usually based on average indicators of expenditure per capita. Such indicators, summarizing the available calculation experience, appear, in particular, in a number of countries of Eastern and Central Europe, where European experts have carried out considerable relevant work. The same category includes estimates based on interstate comparisons of the situation and extrapolation of value indicators with certain caveats and corrections. The basis of the second type of estimates is the use of cost indicators per unit of services, works, etc. Among them, in particular, such as: UAH/1ton for waste removal, UAH/m^3 for drainage, UAH/m^2 for reclamation (landfills), UAH/kW for the cost of dust and gas treatment systems at thermal power plants. These are both capital and operating costs. The third methodological approach (use of software products) is considered the most adequate to the set goals. For its implementation, European companies have developed several special calculation models - Feasible (COWI, Denmark), MOSES, etc., in particular, for drinking water, for waste, for urban wastewater. Their application requires a comprehensive inventory of waste disposal facilities, water treatment facilities, sources of dust and gas emissions, etc. and, in addition, substantiation of the scenario for the development of new infrastructure and its cost estimates. In this regard, it should be noted that the large number of assumptions that accompany this process (and which are difficult to avoid) can significantly reduce the detail of the calculations. In our opinion, the construction of reference local (territorial) models belongs to methodologically close approaches. The latter are sometimes qualified as typical clusters, which makes it possible to extrapolate them according to value indicators to the entire territory of the country. The fifth type of assessment (by the method of direct inspection of objects) may be appropriate for a limited range of large pollutants of the environment. However, random examinations should be considered appropriate in all cases.

The array of sources of EU law in the field of environmental protection, subject to implementation in Ukraine in accordance with the Association Agreement, is very diverse in terms of content and scope of measures. Therefore, a methodical approach should be applied to each of them, which will take into account the specifics of the source.

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LEGAL BASIS FOR THE MANAGEMENT OF ELECTRICAL AND ELECTRONIC WASTE

The Waste Electrical and Electronic Equipment Act of 29 July 2005 defines this equipment as follows: "a device whose proper operation depends on the supply of electric current or the presence of electromagnetic fields, and which can be used to generate, transmit or measure electric current or fields and designed for use with an electrical voltage not exceeding 1000 V for alternating current and 1500 V for direct current"[1]. Electrical and electronic waste is all waste electrical and electronic equipment that once operated on electricity or batteries. For example, these are broken computers, electronic toys and gadgets, mobile phones, old washing machines and refrigerators, used fluorescent lamps, computer, office and telecommunications equipment, household appliances, banking equipment, audiovisual devices, power tools, consumer electronics, consumables, energy equipment, batteries and accumulators of all kinds.

Pursuant to the ordinance on the waste catalog [2], waste electrical and electronic equipment is included in group 16: "Waste not included in other groups". Group 16 02 13 "Waste equipment containing hazardous components" included accumulators and batteries mentioned in 16 06 and marked as hazardous, mercury switches, glass from CRT lamps and other active glass, etc.

The rules for dealing with waste electrical and electronic equipment containing hazardous substances are regulated by many national and international legal acts. These are i.a. three EU directives which were adopted by the European Parliament in 2003. They define the regulations concerning the collection, collection, treatment, recovery and recycling of waste electrical and electronic equipment (WEEE).

The first is Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment. According to her, the reduction of the amount of waste from waste electrical and electronic equipment directed for disposal takes place by supporting the re-use, recycling and other forms of recovery of this type of waste. The directive also introduces

the necessity for EU countries to adopt coherent legal regulations concerning the policy of managing electro-waste in order to protect the environment. Art. 8 and 9, because on their basis EU countries are obliged to pass laws that require electronics manufacturers to finance the costs of collection, processing, recovery and recycling of used equipment from households, enterprises and institutions. It also informs about the requirement of uniform marking of electrical and electronic devices with the symbol of a crossed waste container as information about the prohibition of mixing them with the municipal waste stream. Requirements for minimum recovery rates and minimum levels of reuse and recycling of electro-waste are also given.

On August 4, 2012, the WEEE 2 directive was introduced [3]. It was intended to replace the previous directive and to establish new minimum collection levels for electro-waste. From 2016, there is a collection of 40% of the weight of the equipment placed on the market in the three previous years, and from 2021 it will be 65%.

An important EU document is Directive 2003/108/EC of the European Parliament and of the Council of 8 December 2003 [4] amending Directive 2002/96/EC on waste electrical and electronic equipment. The change concerned the financing of the disposal of waste electrical and electronic equipment that came from users other than private households.

In order to adapt Directive 2003/108/EC to economic realities, the wording of Art. 9 of the previous Directive 2002/96/EC. It has been determined that the financial responsibility for waste generated by equipment from companies and institutions (i.e. not intended for households) is borne by the producers of the equipment in cases where the waste equipment is replaced by new products fulfilling the same functions or by new products corresponding to them. In addition, under the agreement, the equipment manufacturer and its user can transfer the obligation to finance the management of waste equipment to the user.

Another document is the Act of 27 April 2001 - Environmental Protection Law (as amended) [5]. This act defines the principles of environmental protection and the conditions for using its resources, with particular emphasis on the principles of sustainable development. In particular, it concerns the principles of establishing the conditions for the protection of environmental resources and the conditions for introducing energy or substances into the environment. It specifies the costs of using the environment, the obligations of administrative bodies and the principles of public participation in environmental protection. The Act of May 11, 2001 on the obligations of entrepreneurs in the field of management of certain waste and on the product fee, as amended, specifies the obligations of entrepreneurs who place on the domestic market packages and products in packages and products that pose a threat to the environment [6]. Products that are regulated by this Act also include discharge lamps, which are also subject to the provisions of the Act on waste electrical and electronic equipment. This document also specifies how to determine and collect product fees and

deposit fees. In addition, under this act, the task of public administration bodies is to keep records and reporting on packaging waste management.

An important legal act in Polish legislation is the Waste Act of December 14, 2012, as amended [7]. It defines the principles of waste management in such a way as to ensure the protection of human life and health as well as the protection of the environment, with particular emphasis on the principle of sustainable development. In particular, it concerns the principles of preventing or reducing the amount of waste and its negative impact on the environment. This act also defines the obligations of the owner of the waste, as well as the methods of their storage and storage, and the rules for the management of certain types of waste.

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IMPROVING THE FINANCING OF PROJECTS TO IMPROVE THE ENERGY EFFICIENCY OF ELECTRICAL NETWORKS

An important task is the formation of a balanced state technical policy for the implementation of the possibility of providing consumers with quality services for the supply of electric energy, demand management, as well as the ability to influence their own bills, as declared in the Law of Ukraine "On the Electric Energy Market".

According to the Energy Strategy of Ukraine for the period until 2035 "Security, energy efficiency, competitiveness", at the stage of reforming the energy sector , the main measures for the implementation of strategic goals in the field of main and distribution power networks were determined, in particular, increasing the efficiency and cost-effectiveness of the operation of distribution

power networks by transferring to a higher voltage class; increasing the share of installed SMART systems; ensuring the reduction of technological losses of electricity in the power grid from today's average of 11,5% of electricity supplied to the grid to 7,5% in 2035, etc.

Based on the analysis of the state of the main indicators of the reliability (continuity) of electricity supply for operators of distribution systems, the index of the average duration of long interruptions in the electricity supply in the system (SAIDI), the index of the average frequency of long interruptions in the electricity supply in the system (SAIFI) and the estimated amount of unreleased electricity (ENS) were determined across Ukraine. In 2021 , the total SAIDI indicator for Ukraine was 6 1 6 min., which significantly exceeds the forecast values stipulated by the requirements of the Energy Strategy of Ukraine for the period until 2035 "Security, energy efficiency, competitiveness", as well as compared to the values for EU countries.

The main reasons for such an actual value of indicators of losses in networks and the main indicators of reliability (continuity) of electricity supply are: -unsatisfactory technical condition of electrical network objects (the share of electrical networks that require capital repair, reconstruction or complete replacement is 52%); -the quality of maintenance of electrical networks.

According to the investment programs of distribution system operators approved by the National Commission that carries out state regulation in the fields of energy and communal services (hereinafter referred to as DSO), the current level of investment in distribution networks is UAH 2,8 billion per year on average. If we evaluate the amount of necessary investments in distribution networks from the point of view of perspective, then according to the Plans for the development of electric networks for 2016-2020, it is necessary to attract UAH 68,5 billion for the implementation of all measures provided for in the five-year plans. That is, on average per year - UAH 13,6 billion, which is UAH 11,0 billion more than the actual financing in distribution electricity networks. This leads to insufficient financing of priority and "pilot" projects. In order to carry out DSO volumes of complete replacement of network equipment, it takes about 40 years.

In the absence of additional sources of financing for repair and technical works at power grid facilities,, it is impossible to stop the process of their aging. In addition, DSO, in the conditions of their monopoly position, do not show interest in the implementation of "pilot" projects for the development of distribution electric networks without additional financial stimulation. Therefore, in this situation, coordinated interaction between all interested parties at the level of centralized policy regarding a unified managerial and technical approach to the practical implementation of projects to improve the energy efficiency of electrical networks is important, in particular, through additional financial stimulation of distribution system operators, including through investment programs. One of the ways to ensure sufficient funding for the practical implementation of projects to improve the energy efficiency of electrical networks is the transition to a new model of tariff formation - "RAB

regulation", the effectiveness of which has been proven in practice by many EU countries. The presence of additional financial incentives for operators of distribution systems will allow optimizing the timing of the implementation of "smart networks" in Ukraine, which should provide an opportunity for electricity consumers to take advantage of the reformed market to obtain quality supply services, manage their demand and, as a result, their own bill for the consumed electricity.

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DAMAGE COMPENSATION FOR FARMLAND REMOVAL FROM CIRCULATION

The carry out a qualitative land assessment before its disturbance and after its restoration is necessary for careful land usage which was removable to minerals extraction and for backing it in a high-quality further agriculture. At the same time, the material stimulation of rational farmland usage by those who have transferred it to the mineral raw extraction from the depths is very important.

We believe that material stimulation should be implemented through the land payment system. The land allocation by mining plants must be accompanied by significant compensation for obtaining farmland areas.

The compensation for the land depends on the reclamation works quality and the amount of preservation of the agricultural potential. If the mining enterprise has carried out high-quality reclamation work, which provides the agricultural enterprise with a gross collection of products at the level before the land was disturbed, then a certain amount of compensation for the land is returned to it, or taken into account in the next land removal. If the reclaimed land does not fully ensure the agricultural gross output, the amount of compensation for the land is partially returned depending on the quality of the performed reclamation (table 1).

Table 1

Compensation for land depending on the quality of reclamation

Soil impoverishment, %	Restored agricultural potential, %	Compensation for the land returned to the enterprise, %
up to 5	95	95
20	90	80
50	60	50
80	50 or less	0

Source: own research

According to this approach, mining enterprises will be interested in the preservation and rational usage of the top layer of fertile black soil and the reclamation works action in high-quality performance. In our opinion, it will contribute to the preservation of agricultural potential and the im-

provement of the socio-ecological environment. At the same time, the reclaimed land surface leveling with the application of the fertile soil layer on it becomes particularly important.

In line with our calculations, this process is the most capital-intensive, and the possibility of using agricultural machinery in the future depends on its quality implementation.

When farmland removal for mining it is obligatory to take into account the damage received by the agricultural enterprise directly from the land removal, as well as compensation of the buildings and structures values that are situation on the site (or the costs of their transfer and restoration in a new place), and the value of unused costs previously invested in the site (reclamation, fertilization, land management, etc.). It is also must be taken into account the damages caused by side effects (for example, a decrease in the productivity of agricultural crops on the surrounding landmasses due to the contamination of crops with dust, or the pumping of water from the quarry and, thus, a decrease in the level of groundwater and other costs, depending on the area specific).

The amount of costs for reclamation per one hectare of renewable land depends on their further usage direction.

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UDC 330

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EVOLUTION OF THEORETICAL AND METHODOLOGICAL VIEWS ON THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Violation of harmony between man and the world of nature is due to the rapid growth of the world's population; uncontrolled growth of consumption of natural resources by human civilization; unfair pricing of natural resources; uneven economic development in the world; excessive use of technology and technology that destroy nature and lead to an increase in anthropogenic pressure on the environment. The growth of this burden on the environment has led to global warming and climate change.

It is possible to change the threatening situation in the world today by searching for new theoretical knowledge and forming a new worldview. It is quite clear that the emergence of new theoretical concepts of economic development arises in the process of analysis and deep

understanding of the shortcomings and advantages of existing scientific theories. The concept of sustainable development claims to become such a new theory of economic development. The need for transition to sustainable development was proclaimed by the UN and the informal organization 'Club of Rome', which were concerned about the real threat of a large-scale environmental disaster in the world. To achieve this goal, in 1983 the UN established an independent World Commission on Development and Environment under the leadership of G. H. Brundtland. The Commission's goal was to fundamentally update the outdated concept of world development, which had exhausted itself due to the blind pursuit of economic profit.

The Commission proposed to humanity to move to the concept of sustainable development, which involves the interaction of economic, environmental and social spheres. That is, the previous concept of world development was supplemented with environmental and social components. Undoubtedly, the basic component of sustainable development is the environmental component, which reflects the relationship between man and the biosphere. The economic component is a kind of core of sustainable development, which reflects economic relations, their level of development and efficiency. The social component reflects social relations between all members of society, as well as relations between the state and its citizens.

The evolution of theoretical and methodological views on the concept of sustainable development in the world and national socio-economic thought took place over a long period of time, which led to the expansion of the range of views on the content of sustainable development. At the initial stage (1970s) [1], when this concept emerged, the issues of exhaustibility of natural resources were of primary importance; at the second stage (1980s) [2], the issues of environmental pollution and deterioration of the planet's natural resource potential came first; at the third stage (1990s), the main issues were social in nature.), the main problems were of a social nature; at the fourth stage (2000s) [3,4], the most important issues were economic culture and education; at the fifth stage (2010s) [5,6], the creation of a 'green economy' and biodiversity conservation became the priority.

Studying the semantic content of the category 'sustainable development' in the scientific literature, it is necessary to distinguish several approaches to the interpretation of this term. The economic approach to defining the category of 'sustainable development' is that the main cause of the global environmental catastrophe is the extensive type of economic growth. In turn, the intensive type of economic growth stimulates the STP, which is able to contain the negative consequences of economic activity of human civilization and promote socio-economic development of mankind. The ecological interpretation of the category of 'sustainable development' emphasizes that the threat to the natural world is man himself, or rather the ever-growing consumption of natural resources. Such unlimited exploitation of natural resources causes the growth of anthropogenic load. The social

interpretation of the category of ‘sustainable development’ draws attention to the fact that the greatest pressure on nature is exerted by the poorest stratum of the population, which is growing at an incredibly rapid pace and, unfortunately, is not able to meet even their physiological needs.

These approaches became the basis for our broader definition of the category of ‘sustainable development’. Thus, ‘sustainable development’, in our opinion, is a development accompanied by the emergence of qualitative and quantitative changes in the economy, which contribute to the simultaneous reduction of the technogenic load on the environment and increase the level of well-being of both individuals and society as a whole.

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INFORMATION BASIS FOR THE COUNTRY'S TRANSITION TO SUSTAINABLE DEVELOPMENT

Technogenic changes that have occurred in the environment have contributed to the emergence of a large number of environmental crises and disasters of a global nature and have become a serious threat to the existence of present and future generations. The transition of modern human civilization to a new, alternative subtype of economic development. Sustainable subtype of development is able to reduce or even neutralize the negative anthropogenic pressure on the environment of the planet.

The formation of a sustainable subtype of development occurs spontaneously with human intervention in the natural-historical process. Thus, with the help of knowledge and science, information and communication, new equipment and technology, which are inherent in the post-industrial stage of economic development, the earth's civilization is able to meet the needs of each individual without worsening the state of the planet's environment. Only at this stage can there be a qualitative growth of socio-economic indicators and a quantitative reduction of environmentally hazardous factors of influence on the natural world.

Each country in the world is obliged to develop its own way of transition to a post-industrial

model of economic development and, accordingly, to a sustainable subtype of its development. However, the process of transition to sustainable development in different countries is different. It is influenced by a number of different factors: the initial level of development; political situation; geographical location; availability of minerals and natural resources; the state and development of industry; prospects for the development of scientific and technical potential of the country; social, economic, environmental and structural policy of the state and other factors.

Transition to sustainable development requires significant efforts and involves a number of measures. These measures should include: improvement of environmental legislation; formation of a unified, global regulatory framework for the use of natural resources; adjustment of the tax system; reduction of energy intensity of the national economy; use of various environmental and economic instruments; construction and improvement of local, regional, national, international monitoring and control systems over the methods of implementation of this subtype of development.

The basis for the implementation of sustainable development is the study of changes in GDP per capita. According to the UN methodology, GDP is the most important socio-economic indicator of the level of development of any country in the world. At the same time, the direction of changes in GDP per capita will cause certain changes in the structure of the economy. That is, if GDP per capita grows, the primary and secondary sectors in the structure of the economy will decrease while the tertiary sector will increase. It is clear that we are talking about the post-industrial stage of development, in which the structure of the economy develops high-tech, knowledge-intensive industries that can neutralize the negative impact on the environment of energy-intensive, environmentally hazardous industries. In turn, the level of anthropogenic pressure on the environment can be measured by carbon dioxide (CO_2) emissions into the atmosphere.

The information basis for the study of these indicators is the statistics of international economic organizations such as the World Bank and the OECD. Their data make it possible to determine the starting opportunities and prerequisites for the transition of different countries to sustainable development. The starting point for comparing different countries were GDP per capita and carbon dioxide emissions. Our analysis allows us to make the following grouping.

By the level of economic development (by the level of GDP per capita) the following groups of countries were identified: 1) economically developed countries of the Group of Seven - Great Britain, Italy, Canada, Germany, USA, France, Japan (as of 2011, GDP per capita (PPP) in these countries ranged from 31,911 to 46,701 USD); 2) small highly developed countries (GDP per capita (PPP) in these countries ranged from 31,911 to 46,701 USD); 3) Western European countries with an average level of economic development - Ireland, Spain (as of 2011, their GDP per capita (at PPP) ranged from 31,905 to 40,490 international dollars); 4) Central European countries - Poland,

Romania, Slovakia, Slovenia, Spain (as of 2011, their GDP per capita (at PPP) ranged from 31,905 to 40,490 international dollars); 4) countries of Central and Eastern Europe with an average level of economic development - Belarus, Moldova, Poland, Slovakia, Russia, Romania, Hungary, Ukraine, Czech Republic (as of 2011, their GDP per capita (PPP) ranged from 3,100 to 25,251 international dollars).

Based on the study, it will be possible to identify the stage of development of each country in the world and what subtype of development is characteristic for it. Ultimately, this will allow to identify the level of readiness of these countries for the transition to a sustainable subtype of development.

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NATURAL RESOURCE MANAGEMENT AS A MODEL OF INTERNATIONAL ECONOMIC AND ENVIRONMENTAL COOPERATION

The objectives of this research are to determine the place of ecological and innovative factors in the development of international economic cooperation, to identify and to provide scientific substantiation of the essence of regional innovation processes, to develop well-grounded recommendations on improvement of methods of their management as a guarantee of economic growth of Ukraine and increase of its level of international competitiveness [1].

The current process of international cooperation is characterized by increasing interdependence of national economies and requires appropriate coordination of actions between the states.

The economic relations between the countries, in the context of growing interdependence and the actions of the factors of globalization, provide for the formation of a system of economic relations between the countries that would ensure a well-established, systematic, predictable and guided nature of their relations.

Thus, resource efficiency is a powerful economic argument with significant potential for cost reduction, which at the same time leads to two major consequences: Improved competitiveness and job creation.

Thus, natural resource management is an instrument of the "greening" of the country's economy.

The threatened state of use and deep degradation of natural resources and the limited natural resources in the spatial conthence became a precondition for allocation in the ecological management of the natural resource management.

Natural resource management is a qualitatively new model of natural resource management in a spatial context, which is aimed at ensuring rational use and preservation of natural resource potential on criteria of sustainable development and the dominant provision of national interests [2].

Conceptual principles of natural resource management can be considered: the principle of ecological and economic unity of interests in forming natural resource flows in the regional dimension; the principle of priority of environmental expenditures in the general system of budgetary expenditures; the principle of concentration of state financial resources on environmental protection measures in accordance with the established goals, and requirements for ensuring economic efficiency of their use, including at the regional level; these are the principle of synchronization of actions ("synergies"), which is manifested in synchronous implementation of certain ecological and economic reforms, which influence the socio-economic development of regions, coordination of priorities and actions of central and local executive bodies, local self-government bodies regarding regional and local development in ecological-balance context; the principle of obligatory revival of the lost natural resource potential by establishing permanent compensation payments; the principle of subsidiarity - distribution of power in the natural resource management system by concentration of material and financial resources at the appropriate territorial level of management; the principle of balanced development, which leads to differentiation of the state support in the area of environmental protection of regions, taking into account their potential of conditions, criteria and terms determined by the legislation; the principle of partnership, which provides for cooperation between central and local executive bodies, local self-government bodies, associations of citizens, economic entities in the process of realization of strategic ecological tasks, carrying out of ecological monitoring and assessment of possible negative consequences.

The target functions of natural resource management are: environmental planning of the necessary annual expenditures of the state budget, including for environmental purposes, which contributes to transparency, stability and synchronization in the policy of regional development; environmental programming, that is, regional development policy should be implemented on the basis of mutually connected long-term strategies, plans and programs of development both at the state and administrative-territorial level through the prism of ecological domino; ecological forecasting, provided through mechanisms of constant ecological monitoring of possible negative consequences of natural economic activity; environmental restructuring, which is based on the principles of transformation of existing powers, legislative base, organizational and administrative decisions [3].

The criteria of choice and provision of realization of optimal natural resource solutions in territorial dimension can be considered: assessment of the current situation regarding the management of natural resources in the spatial dimension; social mentality concerning formation of resource flows in the context of provision of the balanced development of regions; precurrency methodology of decision-making of ecologoriated management decisions; the state of the legislative and normative field regarding the realization of resource indicators of regional development; achieved level of resource conservation through introduction of cleaner technologies.

All the above-mentioned forms the essence of conceptual provisions of nature of resource management.

The need to overcome the acute resource-ecological crisis as quickly as possible, to improve the environment, to eliminate the causes of environmental disasters requires a fundamental improvement of the resource supply system, to save natural resources in all sectors and production sectors.

The effectiveness of public production in general, the pace of economic progress and growth of the people's living standards, as well as the volume of financial resources to solve the next socio-economic and ecological problems, depend to a large extent on this.

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