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"INNOVATIVE DEVELOPMENT OF RESOURCE-SAVING TECHNOLOGIES AND SUSTAINABLE USE OF NATURAL RESOURCES"

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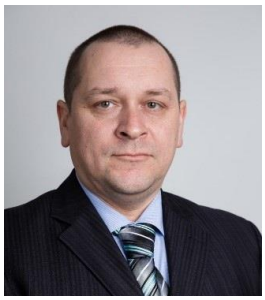

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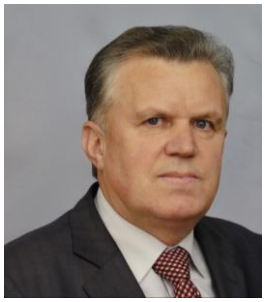

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Dear Colleagues,

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.

I am honored, together with my colleagues, that the University of Petrosani, also 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. 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 16 countries of Europe, Asia, Australia and Africa.

Valuable graduates are high educated by 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.

Together with the ucrainean and romanian graduates, teachers and researchers, at this conference 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, Russia

This wide opening to the contemporary world makes the National University of Water and Environmental Engineering a powerful center of scientific and cultural irradiation, well integrated in the circuit of international cooperation.

In this moment of a COVID 19 pandemic which could not permit us to present our scientific researches face to face, 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 IV International scientific and technical conference "Innovative development of resource-saving technologies and sustainable use of natural resources".

This year, our conference has a new status. The collection of scientific works has been awarded an international standard number of publication – ISSN. This has become possible due to joint efforts of Prof. Sorin Mihai Radu, Rector of the University of Petrosani and the staff of the National University of Water and Environmental Engineering. Authors are invited to publish their research papers in the collection of our conference, this being a stimulus for further cooperation between our universities.

The international status of the conference is confirmed by the Scientific committee of the conference which includes scholars and manufacturers from 16 countries of Europe, Asia, Australia and Africa.

Special gratitude should be expressed to Prof. Anatoly Bulat, Academician of the National Academy of Sciences of Ukraine; Prof. Khalidilla Yussupov, Corresponding Member of the National Academy of Sciences of the Republic of Kazakhstan; Prof. Vladko Panayotov, Corresponding Member of the National Academy of Sciences of Bulgaria; Prof. Oleksandr Krukovskyi, Corresponding Member of the National Academy of Sciences of Ukraine; directors of research institutes and leading researchers.

During 106 years of its existence, our University has been training specialists to be employed in Ukraine, Georgia, Azerbaijan, Turkmenistan, Russia, Belarus, Tajikistan and China, as well as the EU countries (Germany, Greece) and Africa (Morocco, Livia, Algeria, Tunis, Nigeria, Cameroon, Angora, Congo, Guinea). The scientific activity is essential for the University and it is an important component of training modern professionals.

We are delighted to watch our graduates' success when they are employed at large enterprises of various industrial branches that enhances their career growth and wellbeing.

Thanks to these efforts, our students actively participate in the conference together with their scientific supervisors.

Our conference provides an opportunity to get the participants acquainted with research achievements, advanced industrial technologies as well as establishing scientific and production ties with researchers and practitioners from other countries.

The four sections of the conference include over 80 abstracts from 58 research institutions of 18 countries.

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

I am absolutely positive that the conference activity is going to be effective and fruitful and provide significant results.

We wish you health, exciting work results and new business contacts!

Sincerely yours,
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WATER QUALITY OF "VALEA ARSULUI" TAILING DUMP LAKE

Tailings dumps are built for the purpose of storing residual elements resulting from the exploitation, processing and transport of coal. Most often they are located between mountain slopes, often exceeding 600-700 meters in length and 30-40 meters in height. In the vast majority of cases, tailings dumps affect and alter the landscape, waters, soil, flora and fauna of the environment. As a result of the actions of external factors and of abundant precipitations, the rocks at the base of the dumps they undergo erosion processes, thus causing landslides and compacted portions as a result of which accumulation lakes have formed. These lakes are formed as a result of meteoric waters, waters from melting glaciers, by clogging the waters of some underground springs or by blocking the courses of some surface waters.

In the Jiu Valley area there are the most numerous lakes formed inside the tailings dumps on the Romanian territory. This is due to the main industrial activities in the area, namely the mining industry.

The tailings dump is located on the edge of the Valea Arsului stream, being surrounded by hills both to the east and to the west.In the northern part the dump is crossed by a road that connects with the mining, and the southern part is delimited by the accumulation lake. This accumulation lake was formed following the deviation of the riverbed. The tailings resulting from the mining operations in the area are pushed directly into the lake waters, thus causing excessive contamination. At the moment, due to the water clogging, the dimensions of the lake are smaller and smaller, in the future it will disappear completely. This paper studies the water quality in the accumulation lake of the Valea Arsului dump. The study was conducted over a period of 10 months, but for this paper were selected only March, June and September 2021, because in these periods were the most fluctuations of pollutants. We collected water samples from different times of the day, samples that were subjected to laboratory tests. The research and analysis methods of the samples were carried out in accordance with the legislation in force. For this work, measurements were made on the pH, turbidity, level of zinc, calcium, sodium and oxygen in the composition of the lake water. The measurements are presented in table number 1.

Table 1

№	Quality indicator	March 2021	June 2021	September 2021
1	pH (pH units)	9.6	8.4	9.4
2	Turbidity (ntu)	23	15	35
3	Zinc (mg/l)	0.06	0.10	0.03
4	Calcium (mg/l)	42.3	125.6	98.6
5	Sodium (mg/l)	99.6	130.6	210
6	Oxygen (mg/l)	4.6	10.3	6.5

As we can see in the table above, all the measured elements register values that exceed the legal limits, which is why we can conclude that the water quality in the lake is very low, it is not drinkable, does not maintain life and can not be used for irrigation.

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USE OF ENRICHMENT WASTE FOR OBTAINING BUILDING MATERIALS

High volumes of waste of overburden, tailings and slags have been accumulated in the mining and metallurgical complex (MMC) of the Republic of Kazakhstan for many years. Millions of tons of harmful substances are released into the atmosphere and hundreds of millions of cubic meters of contaminated waste sewage are discharged into water basins. All this leads to serious economic, social and environmental problems.

Development of raw material base of building materials industry can be ensured not only by searching for new deposits of non-metallic minerals, but also as result of involving non-metallic raw materials in the production of technogenic waste. Technogenic raw materials, as a rule, require industrial processing and evaluation using effective methods and technologies that ensure their full use with maximum environmental preservation.

Industrial processing of technogenic raw materials (enrichment waste, overburden and wall rocks), which is close in composition to natural and used in traditional directions, substantially does not differ from industrial processing of natural mineral raw materials. Therefore, use of mining waste for production of building materials from them is undoubtedly critical task and priority. A large amount of research is carried out in this direction by staff of Satbayev University.

The largest stocks of waste are concentrated in tailing dumps. The need to involve tailings in production is dictated by the following circumstances:

- operating life of tailing dumps is limited, filling of many of them has already been completed or is coming to end in the coming years;

- tailings occupy vast territories and due to the fact that they have the form of dispersed and easily blown off material, they are source of increased environmental risk for operation regions of mining and processing complexes.

Since enrichment waste is fines that does not require additional grinding before use, this allows to reduce economic costs. In addition, in the process of ores enrichment, homogeneity of material is ensured both in chemical and mineralogical composition.

One of the enterprises where non-metallic rocks, tailings and waste water are formed is «test mine» of mining and processing complex.

Survey results of workings at the test mine (at quarry and underground horizons) showed that the largest number of falls are confined to fractured rocks, and falls volumes increase as the workings stand.

Workings observations driven through fractured rocks revealed that they are stable for month. After two -three months balmstones up to 10-15 cm in size are formed. Balmstoning and collapses develop within six months, roof collapse occurs in the form of domes. This dramatically increases volume and labor intensity of tunneling works, as well as costs of fixing and repairing workings.

Therefore, effective solution to the issue of fixing and controlling geomechanical properties of rocks is essential to adjacent rock mass of open pits and underground workings driven through fractured rocks [2].

In this regard, we investigated main characteristics of waste of the test mine deposit enrichment plant, the X-ray diffraction pattern and diffraction characteristics of which are shown in Fig. 1, from which it can be seen that they consist of calcite, therefore, the X-ray diffraction pattern shows reflections (peaks) characteristic of $CaCO_3$, with interplanar distances, d/n, Å: 3.8665; 3.3498; 3.0404; 2.8446; 2.496; 2.2847; 2.0952; 1.9127; 1.77; 1.6287; 1.60; 1.5236; 1.4393.

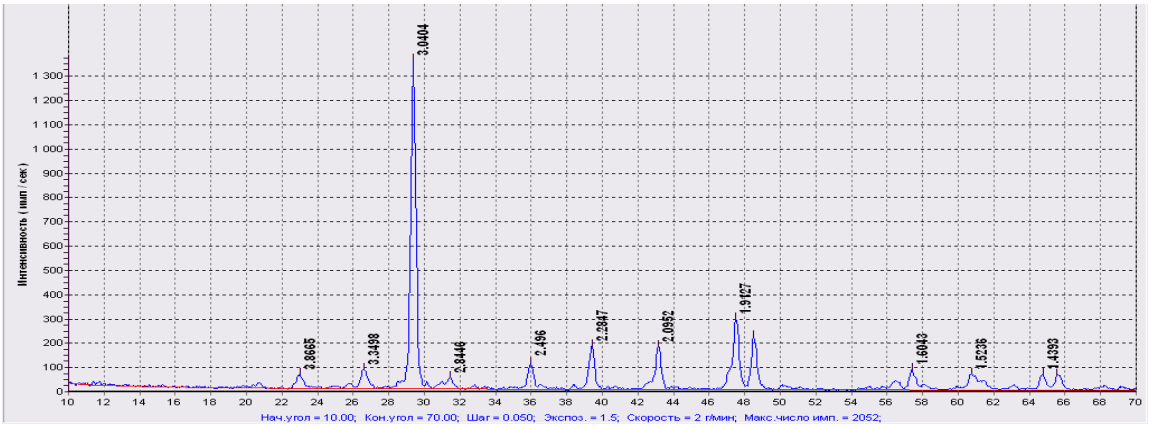

Fig. 1- X-ray diffraction pattern of the test mine tailings

Chemical analysis showed that mining waste mainly consists of %: CaO - 54,6; CO_2 - 39,4; SO_3 - 2,0; MgO - 1,5; SiO_2 - 2,5 %; Fe[S2 - about 0.18. Based on the results obtained, it can be stated that the non-metallic rock of the Akzhal deposit consists of limestone ($CaCO_3$) - about 95-97% and silica (SiO_2) - about 2.5-3% [3].

1. Analysis of mineral and chemical composition of the non-metallic rock of the Akzhal lead-zinc deposit shows that it mainly consists of calcite - $CaCO_3$ (about 95-97%) and silica - SiO_2 (about 2.5%); among them there are also impurity elements of magnesium, iron, aluminum, zinc, lead, barium, etc., which are not of industrial interest, since their total content does not exceed 1%.

2. Ore enrichment tailings of the test mine enrichment plant mainly consist of calcite and silica, the oxide chemical composition of which is represented by following individuals: CaO -54,3; CO_2 - 40,5; SO_3 - 2,3; SiO_2 - 1,5; MgO - 1,4 and Fe[S2] - 0,13 %.

3. Mine water and waste process water, respectively have following characteristics: alkalinity - 0.45 and 0.8; hardness - 11 and 12; pH -7.5 and 8.3. Moreover, mine is transparent, and technological one is turbid, which includes ore enrichment tailings, consisting mainly of calcite - $CaCO_3$.

Based on obtained results, we have proposed mortar for strengthening fractured rocks, containing filler, cement and process water. To reduce mortar cost as a filler, it is proposed to use enrichment plants tailings [2].

Additionally, dry superplasticized additive Neolit 400, which is produced by Neochim (Russia) with high water-reducing ability and makes it possible to reduce the water-binder ratio in systems by more than 20%. With decrease in the water-binder ratio, longevity and density of developed mortar increase, with simultaneous decrease in shrinkage and creep deformations during mortar strength. Additive is well compatible with port land cements, cement - up to 3%, tailings of processing plants - up to 52%, Superplasticizer Neolit 400 - 0.11-0.16 and rest is water.

Conclusions

It is possible to obtain break stone suitable for obtaining concrete M 100-M 300 (class: 7.5-B22.5) and highways foundations from the non-metallic rock of the test mine deposit, by breaking ; in addition, lime can be produced from it by firing, necessary for various branches of construction industry. Ore enrichment tailings can be used:

- for preparation of plaster and mortars with a strength of 2.5-20 MPa;
- to obtain fillers for introduction into the composition of strengthening mortars;
- for lime production (by burning). Mine water and waste process water are suitable for use as a water sludge in the production of mortar and concrete mixtures. Mortar was created for strengthening fractured rocks, based on mining and metallurgical waste with use of polymer powders, which has a low value, sufficient fluidity to fill small cracks and high strength.

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DEVELOPING SOLUTIONS IN TRANSMISSION ENERGY SYSTEM FOR ELECTROENERGETICAL SYSTEM DECARBONISE IN ROMANIA AS PART OF TRILEMMA ENERGY

The modern society shouldn't exist without a safety, clean and certain electrical energy supply as well as an affordable price. It is time to involve more people in making clean and just energy transitions happen.

The objectives of the energy sector in Romania, according to the energy and the environmental objectives set at the European level are the following: providing the security of the electricity to all consumers at the appropriate quality level through diversification of generations sources, increase of economic competitiveness and reduction of environmental impact [1].

Objectives of the Romanian current strategy is following the trilemma energy (figure1) as:

1. **Energy security**: critical infrastructure protection; increase of energy security by providing the necessary energy resources and limiting of imported energy dependency; diversification of energy resources and their transmission routes; increasing the adequacy level of transmission systems.

2. **Sustainable development**: increasing energy efficiency; promotion of electricity and heat in cogeneration plants; reducing the negative impact of the energy sector on the climate; rational and efficient use of primary resources;

3. **Energy accessibility Competitiveness:** development of energy services and accessibility for all people; liberalization of energy transit and provision of equal an continuous access of participants to transmission, distribution and international interconnections; reorganization and privatization process in the energetical sectors.

The world growth of electrical energy necessity more than 50% till 2040 is influenced by globalisation, demographic structure modification, increasing of urbanization level and electrification and will lead to major pressures above environment and efficient measures will be adopted for limiting greenhouse [2]. The innovative technologies can induce in reality the requirements for a sustainable development focusing on customers demands.

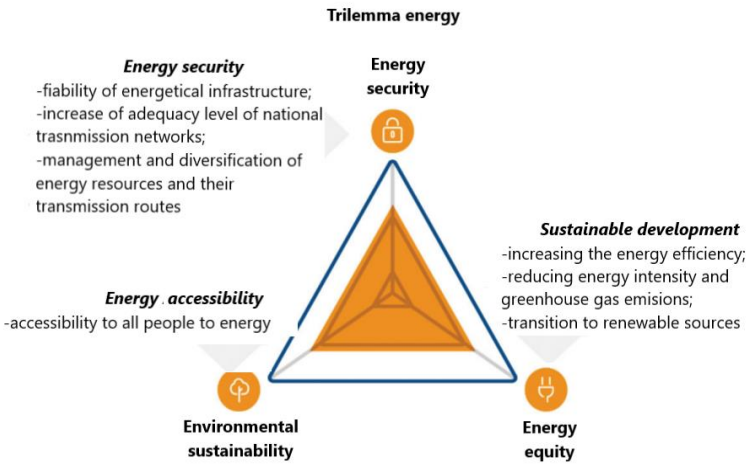

Fig. 1. Trilemma energy

To be successful in the future, standards and guidelines must be open on development, that means as changing framework conditions and new business models can be provided too: *Consistently digital description;Easy to install; Communicative and secure; Easy to operate; Autonomous and adaptable;*

Resource efficient

Energy and material usage can be adapted individually and precisely, as all the data required for intelligent management is available. This means that only the energy that is actually required is used.

Facts technology

The main definition of FACTS is the A.C. Transmission System which incorporate static commutates based on power electronics which improve the controllability and increase the transmission capacity. Flexible AC Transmission Systems (FACTS) technology helps utilities in reducing transmission congestion and in utilizing more efficiently the existing transmission system without compromising the reliability and security of the system. Their fast response offers high potential for power system stability enhancement apart from steady state flow control [3,6].

FACTS controllers based on line commutated converter technology have a long and successful technology. FACTS provide the necessary features to avoid technical problems in the power systems that increase transmission capacity and system stability very efficiently and they assist in prevention of cascading disturbances. They support the great access of renewable energy resources and reduce the transmission losses by optimization of power flows.

The power systems work with transmission alternative voltage lines 220kV, 400kV, 750kV and continuous voltage ±200kV÷±800kV.

The benefits of employing FACTS are many: improvement of the dynamic and transient stability, voltage stability and security improvement, less active and reactive power loss, voltage and power profile improvement, power quality improvement, increasing power flow capability through the transmission line, voltage regulation and efficiency of power system operation

improvement, steady state power flow improvement, voltage margin improvement, loss minimization, line capacity and load ability of the system improvement [4,5].

The new solutions for electrical energy transmission using FACTS technologies (Flexible Alternating Current Transmission Systems) using dynamic voltage control as STACOM equipment (Static Synchronous Compensator), SVC - Static VAr , Compensator UPFC (Unified Power Flow Control) , SynCon (Synchronous Condenser , are allowing the contitions for static and dynamic stability and a high energy quality for customers.

In Romania, the collaboration between Transelectrica and Siemens is allowing the adoption of efficiency solutions especially the digitalisation in reliability processes, high voltage and very high voltage power stations, for obtaining a control, monitoring and safety system for a better interoperation and maintenance and cost decreasing. In Bradu power station and Sibiu Sud power station are being to be installed FACTS systems and Gutinas, Suceava nad Rosiori power stations are in designing stage. An important role for evaluation of system stage is Unified Power Flow Controller in Rosiori, Arad, Gutinas, Resita, Cernavoda and Bucuresti voltage power stations. The new generation of digitalised voltage power station will assure the system security, ability and improving of energy quality growth. [3,7]

The International Energy Agency reflects the important role of the power sector in its scenario planning scenario, where electricity generation and distribution goes from the highest emitter to a negative emitter between now and 2070[8].

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RESEARCH INTO PECULIARITIES OF SEALING THE UNDERGROUND GAS GENERATOR DURING GASIFICATION OF ADJACENT COAL SEAMS

With the purpose of providing the energy independence of Ukraine, the country's leading scientists tend to search for alternative technologies in the development of hydrocarbon energy

resources, which include natural gas hydrate deposits and methane reserves in the mine fields of operating mining enterprises [1,2]. In world practice, in countries that possess significant hardcoal reserves, underground gasification of coal has become widespread as an alternative technology to traditional mechanized coal mining [3-5]. Underground coal gasification has become widespread in advanced developed countries such as China, USA, Poland, South Africa, Australia, etc. [6, 7]. When the fire face of an underground gas generator advances, as in the similar case of fully-mechanized coal mining, deformation processes occur in the roof rocks, which lead to fracturing and stratification of rocks. And as a consequence, technogenic cavities are formed in the mass, which need to be backfilled [8, 9]. Fractured mass and technogenic cavities cause heat loss during underground gasification, reducing the efficiency of this method of energy resources extraction. To solve the problematic issues of heat loss and increase the level of its accumulation in the underground gas generator, it is necessary to take measures of its sealing.

For the reliable georeactor system functioning, the sealing parameters (backfilling of cavities) are studied to increase the efficiency of the gasification process by reducing heat losses. The first stage of these studies includes the identification of areas of fracturing and the formation of cavities in the process of fire face advance using numerical modeling by the finite element method in the SolidWorks 2016 software in the “static” mode. For this, the mining-and-geological conditions of the mine field in the Zakhidno-Donbaska Mine (CJSC DTEK Pavlohradvuhillia) are chosen, where 50% of the coal reserves occur in thin-bedding seams (<0.8 m) and which it is expedient to develop using underground gasification technology. By statistical processing the data of mining-and-geological predictions, an averaged lithological composition of the rocks in the coal-bearing stratum of the mine field has been obtained, where its stress state in the process of underground gasification is studied. During modeling, a decrease in the strength properties of rocks under the influence of temperatures is taken into account. Analysis of the roof stress curves makes possible to determine the zones of fracture formation and the spacing of general roof rock caving with complete failure, as well as to substantiate the rational length of the backfill well above the georeactor system. During the second stage of the “thermic” mode, the distribution of the temperature field and convection in the roof rocks are studied to determine the rational location of the backfill well under the conditions of the mixture hardening. The temperature parameters of coal and rocks, as well as the thermal load on the seam and rocks, which is formed in the reaction channel, are specified in the model. The third stage includes laboratory studies of the filling mixture parameters, which must have heat-resistant properties and ensure tightness when exposed to a temperature field of heated roof rocks of at least 350°C. Blast-furnace slag and part of the sand are crushed in a laboratory mill, mixed with water at various proportions with the addition of technogenic limestones from the metallurgical plant, which contributes to the mixture expansion. Then the mixture is mixed and heated in a SNOL

type drying cabinet in the temperature range of 100-350°C to determine the optimal heat-resistant composition.

The location of the zones of fracturing of the seam roof rocks during the fire face advance of the gas generator and the optimal location of the backfill well have been determined. To substantiate the properties of the filling mixture, the dependence has been determined of the temperature field distribution vertically to the deep of the roof rocks and bottom rocks in the central part of the underground gas generator, where the transition occurs from the oxidizing zone to the reducing zone in the conditions of the C_8^u and C_{10}^u seams.

The optimal composition and formulation of a heat-resistant filling mixture have been determined for backfilling the cavities formed in the seam roof, which consists of finely ground granular slag, finely ground and ordinary quartz sand, technogenic limestone from the metallurgical plant and water with a W/C of at least 0.5. This formulation is capable of forming low-basic hydrosilicates in the structure of the artificial stone and promoting the expansion of the mixture, which contributes to its tightness.

With the ascending method of mining the suite of adjacent coal seams in the Western Donbass (h=10-15 m), underground gasification of each next seam makes it possible to achieve the effect of "double-sided sealing" of the underground gas generator both from the side of the roof rocks and bottom rocks. Moreover, in the bottom rocks, heat losses are eliminated due to a heat-resistant filling mass with low thermal conductivity.

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REUSE OF GRAY WATER AND RAIN WATER IN A RESIDENTIAL COMPLEX

Albania is a mountainous country with about 450 km of coastline and numerous water reserves, many rivers, springs and natural lakes. According to Stanners and Bourdeau (1995), Albania ranks among the first countries in Europe in terms of the amount of water per capita.

For environmental and economic reasons, water reuse is being considered today as a good opportunity to fill the gaps. Reuse is defined as the reuse of water used by buildings, water that can be collected from roofs, other surface and groundwater in and around buildings.

This paper deals with a residential complex and analyzes the possibility of meeting the demand for water, from the reuse of water from the building and the use of rainwater from the roof, along with the drainage water of the building. To determine these quantities and the way of use, in this facility has been designed the supply and disposal system for water to be used for drinking, removal of sewage, gray water, collection of rainwater from the roof and drainage water by object.

The building is designed for an area of 5,257 m^2 at the base and roof. Sewage effluents to be used for reuse are designed separately from wastewater. Also a reusable toilet flushing system is specially designed from supplies of other plumbing fixtures. The requirements for drinking water for the facility are estimated at 4.8 l/s, while those of discharge at the peak of utilization can range from 30-60 l/s.

The calculation of rainfall for a recurring period of 50 years with a duration of 3 minutes maximum will be 4 mm, which means that the maximum amount of water flow from the roof of 5,257 m^2 is 116.8 l/s while the load for a vertical is 4.8 l/s.

The maximum groundwater flow from the drain in and around the facility is estimated to be 7.5 l/s. From the analysis of the results of water quantities, the volumes that can be reused from gray water, rainwater and groundwater have been calculated:

From the reuse of gray water generated by the sinks of the facility it is possible to provide about 27 m^3 per day of water, which will be used for flushing the toilet.

From rainwater that can be reused and from groundwater these volumes are 1,260 respectively 54 m^3.

This volume would serve to meet the requirements for the maintenance of greenery around 1 ha and valid reserve for emergencies such as fire.

The results of the work show that it is possible to provide a valuable amount of water from the reuse of used water, the use of rainwater and drainage that will fill the lack of water. Also the use of these waters has a positive environmental impact and reduces the economic cost of water use.

This paper suggests the authorities dealing with the definition of construction criteria in Albania to consider the possibility of starting the application and the criteria for water reuse, especially in urban areas and buildings with large areas.

The results of the work draw conclusions arising from the analysis, calculation and options for water reuse for the object, taken into study:

- That through the reuse of gray water generated by the facility's sinks it is possible to provide about 27 m^3 of water per day, which will be used for flushing the toilet.

- From the collection of rainwater from June to September it is possible to use a considerable amount of water of 1,260 m^3 that would be used in the maintenance of about 1 ha of green area, cleaning of paved spaces and concrete spaces.

-Estimation of the amount of water that can be collected and used from groundwater around the facility are approximately 54 m^3.

- The optimal volume of the collection tank that would provide a fulfillment of daily requirements for toilet flushing, irrigation, surface cleaning and increase safety for the amount of water in case of fire is 160-170 m^3.

- That with the method of water use and the model of groundwater drainage, the possibilities of floods and the negative impact of water on the structure of the building are eliminated.

The results of the work enable us to draw some recommendations. Reuse of water used by large facilities such as collective, industrial and school, is a method that should be implemented and advanced in the conditions of problems of countries with limited water resources, in periods of drought but also in environmental and economic dispute.

In the study building it is necessary that the installations of pipeline and hydro sanitary infrastructure be adapted in accordance with the proposals arising from the study in order to enable the reuse of water.

The quality of the water to be reused for the purpose of flushing the toilets should be periodically monitored in order to maintain the parameters within the standards.

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STUDY OF THECHEMICAL COMPOSITION OF ORE-BEARING MINERALS OF THE BLACK SHALE PHARMACY OF THE SARYDZHAZ AREA OF THE "KURGAK" DEPOSIT

Summary

In the publications of scientists in the field of geology and mining, "black shales" are considered as a new promising and unconventional source of noble and rare metal raw materials. In the context of information, it should be emphasized that this work will make a feasible scientific contribution in the field of finding an economically profitable and environmentally friendly method of extracting valuable metals from mining ores.

Purpose of work: to establish the chemical composition of ore-bearing rocks of the black shale formation of the Saryjaz area of the Kurgak deposit to extract useful components from them.

The relevance of this work is to improve the process of extracting valuable components from mining ores, as well as to create the scientific foundations of highly efficient, environmentally friendly and cost-effective technologies for the extraction and processing of mineral raw materials, improving the environmental situation in the mining regions of the Kyrgyz Republic. In the course of the research, elementary, chemical, X-ray, microscopic and thermogravimetric analyses were used; optical and electron microscopy; X-ray spectral and X-ray diffraction methods of analysis.

Key words: ore-bearing rock, crushing, screening, fractionation, magnetic separation, scanning electron microscope, spectra, elemental composition.

Introduction

It is known that the intensive activity of the mining industries generates many environmental problems, both local and global. Therefore, the creation of more efficient and less energy-intensive grinding methods and technologies is an important and urgent task.

Research objects

The object of the study is an ore-bearing rock from the deposit "Kurgak" of black-shale formation of the Saryjaz area located above sea level of 3500 m. It has long been known that the preparatory process includes crushing operations aimed at revealing the valuable components of the material to the coarseness required in the process of enrichment

For the study, samples were prepared using the following methods: screening, fractionation, magnetic, separation, electrical conductivity, wettability. The imported pieces of the black shale formation from the Kurgak site were crushed in a ball mill to a particle size of 1.5-2.0 mm. Then the ore-bearing rocks of the black shale formation, crushed in the specified value, were subjected to further crushing, which is carried out on a non-standard crushing plant with a 3-phase electric motor 3000 rpm 2 kW, at a pressure of 30-60 atm/cm^2. According to the results of the granulometric

analysis [2] of the fractions obtained, the following are indicated by magnitude: TCF - the coarsest fraction; SM is a small fraction; TSF is the smallest fraction.

From the comparative table, the effect of the size of fragmentation on the increase in the percentage of elements, H is observed: at TCF Mn from 5-90; Ti from 3-20; Co from 0.3-0.5; Bi from 0.3-100; Au at SM and TSF from 0.5-5; at SM As from 3-15; Zr at TSF from 5-15. It is also seen that the increase in the quantitative content of elements by the same value, in all three fractions (TCF, SM, TSF) of fragmentation, H: W from 0.9->100; Pb from 20-120; Sn from 20 - 1000.At the same time, there is a decrease in the quantitative content of elements with a decrease in the size of the fragmented samples, H: Mn in SM from 90-50, and in TSF 50-30 decreases; Ti in SM from 20-15; and in TSF from 15-7; Co in SM from 0.5-0.4; and in TSF from 0.4-0.3; Bi in SM from 100-50, and in TSF from 50-30; Also the number of some elements remains unchanged as in the original sample V, Nb, In, Cd, Th, U, Sc, Ge , Y, La, Ta.

Thus, in order to increase the quantitative content of elements in the composition of the ore minerals of the Kurgak deposit, the optimal size of fragmentation for the elements Mn, Ti, Co, Bi is the size of fragmentation of the TCF; for metals Au and Zr, the size of fragmentation of small (SM) and the smallest fractions (TSF) can be considered; and for elements W, Pb, Sn, the sizes of all fractions of fragmentation (TCF, SM and TSF) are optimal.

The morphological structure and particle sizes of initial samples (IS), coarse (CF) and smallest fractions (TSF) of ore minerals were studied using a scanning electron microscope (SEM)

When studying the morphological structure of large particles of initial samples, 5X5 mm in size, coarse fracture, stepped structure and facets of quasiscola are observed on the surface of the material. Using SEM, the sizes of the listed fractions, including coarse fractions (CF), were determined. The studied CF material is a coarse powder of oval shape, particle diameter size from 1 mm to 1.5 mm, there are inclusions of particles of the same material with size about 50 microns. According to morphology, the surface of the particles is stone-like structure, brittle and quasi-brittle fracture. Further, the TSF material studied by SEM is a powder with crystalline particles, which average diameter of the main particles was 167,7 μm, the cross-sectional area of the crystalline particles from 879,65 μm^2 to 2664.51 μm^2

Conclusion

1. When studying the chemical composition of ore-bearing rocks of the Saryjaz area black shale formation from the deposit "Kurgak" are observed: (A) The effect of the size of the fragmentation on the increase in the percentage content of elements, H: at TCF Mn from 5-90; Ti from 3-20; Co from 0.3-0.5; Bi from 0.3 - 100; Au at SM and TSF from 0.5-5; at SM As from 3-15; Zr at TSF from 5-15; B) increase in quantitative element content by the same value, in all three fractions (TCF, SM, TSF) fragmentation, H: W from 0.9->100; Pb from 20-120; Sn from 20-1000.

2. To increase the quantitative content of elements in the composition of ore minerals for the deposit "Kurgak" the optimal size of fragmentation for the elements Mn, Ti, Co, Bi is the size of TCF; for the metals Au and Zr can be considered the size of fine (SM) and the smallest fractions (TSF); and for the elements W, Pb, Sn optimal size of all fractions (TCF, SM and TSF).

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APPRAISAL OF DATA PARTITIONING AND ITS EFFECT ON THE PERFORMANCE OF ARTIFICIAL NEURAL NETWORK MODELS

Information on groundwater level (GWL) fluctuation is very important for general planning and water resources management. In recent times, Artificial Neural Network (ANN) has been used as an alternative predictive tool to the existing physical-based models in groundwater level forecasting. This is because there is an underlining limitation associated with the use of the physical models because itsusage demand a proper synthesis of the aquifer parameters to describe the geospatial variability of the subsurface (Taormina et al., 2012). However, acquiring such information is very challenging and rarely available as it is marked by very expensive and laborious site investigations, especially in the case of collecting hydro-geophysical data. In developing countries where there is limited number of resources and funding coupled with data scarcity, getting accurate predictions from the application of physical-based models is difficult. Moreover, it is widely known that groundwater aquifers are intrinsically heterogeneous systems that are affected by the complexity of the hydrogeological settings with groundwater and surface water interactions at various spatio-temporal scales (Chang et al. 2016; Chang et al., 2015). Given that, scholars have proposed ANN as appropriate alternative to the physical-based models which can provide a more realistic prediction even when the data is insufficient and when the physical characteristics of the subsurface are not the focus of the study (Mohanty et al., 2015). The recommended ANN methods can produce results without the clear knowledge of the practical relations between the input and output variables. In line with the ANN merits, several scholars and field practitioners have used ANN for managing water resources systems and hydrology (Solomatine et al. 2008).

It is noteworthy that an important factor to consider when developing an effective and accurate ANN model is the data splitting, where the data can be divided into training (used to build the

model), testing (used to test the model) and validation (used independently to validate the model). It has however been found in the literature that data splitting techniques used in the majority of GWL forecasting studies are subjective. However, in other disciplines where ANN has been widely applied, data splitting techniques have been discussed (Shahin et al., 2004; Wu et al., 2012; May et al., 2010). For example, Shahin et al. (2004) discussed three different methods of data splitting techniques: random data division, data division to ensure statistical consistency of the subsets needed for ANN model development and data division using a self-organizing map (SOM). In their research, they proposed a new data division method using fuzzy clustering to predict settlement of shallow foundations on granular soils, where they concluded that the SOM and fuzzy clustering method are suitable approaches for data division. May et al. (2010) considered the variability in the quality of subsets that are obtained using different data splitting approaches. Their work compared a novel approach to stratified sampling, based on Neyman sampling of the SOM to random sampling, DUPLEX, systematic stratified sampling, and trial-and-error sampling to minimise the statistical differences between data sets. Findings from their research indicated that a multivariate stratified sampling approach based on the SOM seems to be suitably robust and consistently produce superior ANN prediction models. The DUPLEX on the contrary provides a benchmark for data splitting and generates representative datasets and low model bias. Bowden et al. (2002) presented two methodologies of genetic algorithm (GA) and SOM for dividing data into representative subsets and compared these two methods with the conventional approach commonly used (which involves an arbitrary division of the data). The outcome of their research suggests that the models developed using the GA and SOM data division techniques resulted in a 24.2% and 9.9% reduction in root mean square error of the conventional data division method. In ANN modelling, the most widely and successfully used data partitioning approach of the hold-out cross-validation has been a critical factor that affects the performance of the model.

This study is focused on evaluating and comparing the impact of different data size partitioning in groundwater level prediction using ANN methods. The study considered all the possible partitioning percentages for the train-test sets which are (90-10), (80-20), (70-30), (60-40) and (50-50). These five different partitions have been analysed and tested on 13 different boreholes (BHs) using Backpropagation Neural Network (BPNN) and Radial Basis Function Neural Network (RBFNN). The BPNN and RBFNN were selected because they are the most used methods in literature for GWL prediction. Hence, evaluating the data splitting effects on their prediction performance is worth investigating. The findings from the study indicated that 70-30 and 80-20 were the most dominant partitions to produce optimum GWL prediction models for the BHs. Overall, the 70-30 produced optimal results for five boreholes, the 80-20 partition produced four boreholes, the 90-10 and 60-40 produced optimal results for three and one boreholes respectively.

The study has demonstrated that the performance of the ANN method is heavily dependent on the partition percentage used in the model formulation. Therefore, the main contribution of this study was to bring to light how different data partitioning size impacts on the effectiveness of the ANN in GWL prediction.

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RAW MATERIALS AND PEATS AS CONVENTIONAL ENERGY SOURCES

The article presents a short description of coal raw materials used as energy fuels. Conventional energy sources are fossil fuels produced by natural processes that take millions of years. They have one thing in common: their resources are limited. The most commonly used raw materials are coal and lignite, natural gas, crude oil, peat and uranium. They are widely used to generate thermal energy (heating), electricity and to drive internal combustion and jet engines in means of transport [1].

Hard coal is a raw material made of organic matter that has undergone the carbonization process under the influence of biological, biochemical, geological and geochemical factors. Hard coal contains 75÷92% of pure carbon element (anthracite contains as much as 97%). Hard coal is

widely used as a fuel, but with the development of technologies for obtaining energy from renewable resources, its share in the fuel market continues to decline. The calorific value of the raw material strongly depends on its composition and depending on the ash, sulfur and moisture content it is 16.7÷29.3 MJ/kg [2].

Lignite is a sedimentary rock of organic origin, formed as a result of many years of transformation process of deposition of plant debris. The material was created as a result of biological, geological and geochemical factors. This raw material contains from 58÷78% of pure coal, while its calorific value is 7.5-21 MJ/kg. Lignite is a transitional form between peat and hard coal and belongs to the group of non-renewable resources. Poland is currently the fourth largest producer of lignite in the world, after Germany, the USA and Russia (no data from China) [3].

Peat is a sedimentary rock formed as a result of incomplete decomposition of dead plant debris. Peat has been formed over thousands of years as a result of anaerobic processes and under conditions of swampy soil. The result is a high content of undecomposed plant debris and unstructured humus. The composition of peat varies in each case and largely depends on the flora that formed it in the past. The only characteristic feature of the raw material is the low carbon content <60% and the acidic pH 4-5.5. Peat has been used as heating fuel for many centuries, but with the progress and development of mining and distribution technologies, and the distribution of much more efficient energy resources, its demand has decreased significantly. Currently, only Ireland and Finland use peat to produce electricity and heat. Despite the decline in interest in this fuel, peat is still considered an energy resource in the energy balance of many countries.

The advantages prompting the industry to use coal as an energy fuel include: abundant deposits of the raw material in the world, ease of transport and storage, and competitive price of the raw material [4]. The disadvantages of the combustion processes of coal and peat include the emission of the largest amount of gaseous and dust pollutants (carbon dioxide, sulfur oxides, nitrogen oxides, carbon oxides, solid particles) compared to other energy resources. By-products of the raw material combustion process have the greatest impact on the greenhouse effect and the formation of acid rain. Other products of combustion are ashes and slags that require disposal. In the case of coal raw materials, rising extraction costs and a high percentage of accidents in coal mines are observed. Municipal heating requires constant monitoring of the loading condition and furnace operating parameters. There should also be a place for storing coal reserves.

The negative environmental effects are of great importance [2]. During the underground mining of hard coal carried out using the caving technique, the terrain subsides and the ground surface is significantly damaged. Landscape degradation is observed in opencast lignite mining. Groundwater is contaminated. In each case, mining waste heaps are created and must be managed. There is a high cost of implementing waste gas treatment technology.

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BIOLOGICAL LAND RECLAMATION PROFILES CONSTRUCTION AND TESTING IN THE MINING REGIONS OF UKRAINE

Ukraine has some of most extensive areas of highly productive soils in the world. However, a substantial area of this rich soil has been disturbed by mining or by severe erosion. Active mines occupy 170,000 ha, and many more hectares have been left abandoned, or poorly reclaimed, with about 40,000 additional ha left abandoned each year. In addition to mineral mines in various places in Ukraine, there are thousands of smaller quarries where building materials are extracted. Unfilled pits lower the water table of surrounding lands, reducing crop yields for quite some distance from the mine. A large proportion of the mined lands in Ukraine have overburden replaced without stratification. Therefore, there is no topsoil replaced during restoration. Current mining operations remove and replace overburden by strata, with careful attention to preservation of topsoil. Return of this land to agricultural use is comparatively easy and environmental and health consequences in the surrounding area are minimal. However, earlier mining operations did not preserve the integrity of the topsoil and underlying soil horizons. Therefore, even after leveling, the resulting “soil” is actually mixed-overburden substrata. Six universal and special models of reclaimed lands are proposed by DSAEU.

First model is the simplest. It is consist of the substrate type that is most fertile and most favorable for crops apart from replacing the surface-stratum chernozem. It relies on phytomelioration from crop rotations involving a period of legume crops followed by legume-grass mixtures. Most commonly the substrate is loess (Quaternary), a mixture of red-brown loam and clay (Neogene-Quaternary period origin), or grey-green clay (Neogene). The macro- and microelements in these substrates are sufficient for high yields of alfalfa and sainfoin hay. High yields of grain crops can be obtained only after applying of phosphorus, potassium and especially nitrogen fertilizers. First model is used for soil restoration if there is a lack of chernozem, either from it not being present originally, such as where ore-excavation occurred on strongly-eroded slopes, saline

land, solonetz (sodic soil), or from failure to keep the chernozem layer separate, or because part or all of the chernozem was lost or mixed with subsoil during transfer and storage. Second and third models are two-layer models. These models use a fertile substratum underneath a chernozem layer 0.5 m thick (Model 2) or 0.70-1.0 m thick (Model 3). Second model is more widely used. The full range of crops used in the Steppe and Forest-Steppe zones can be cultivated on it. Production technology is the same as for ordinary (undisturbed) soil, except that after land replacement, it is first necessary to grow 5 years of alfalfa or sainfoin. Yield obtained on such soils is equal to that obtained on lightly-eroded chernozem. Third model provides an additional 10-30% yield, presumably due to better nutrient and moisture supplies. But it is not too popular yet due to the extra cost of transportation, placement, and leveling of the additional chernozem. All expenses for restoration of the soils are borne by the mining companies, so they prefer second model. Fourth model is used for orchards. Chernozem is embedded in holes or trenches in a fertile substrate. Experiments with fruit-trees (apple, pear, plum, apricot etc.) and berries (red currant, black-currant and vine) were successful. For example, during 18 years, the average yield was 11 to 15 T/ha of apples, depending on variety. The amount of chernozem necessary per tree and 0.7-0.8 m of chernozem gave yields of 1.9, 2.7 and 3.3 t/ha, respectively. Fifth model 5 has 3 layers. The deepest layer is a substrate which is phytotoxic or unfavourable for crop growth (coal-bearing substrates with a high content of pyrite, saline substrates). The second layer acts as a protective shield and consist of loess (0.5 m). The third is the layer of fertile chernozem (0.3-0.8 m). Sixth model consists of 3 layers: 0.5-0.8 m chernozem on top of 0.3-0.5 m loess-like loam on top of 0.3-0.5 m of a waterproof, non-saline substrate. Greater yields of crops are obtained with model 6 due to higher fertility of the soil and additional accumulation of 40-60 mm of available moisture per year.

After initial replacement of the substrates, significant subsidence occurs for at least 10-15 years, impeding normal crop management. Therefore, it is necessary to wait at least 10-15 years after surface leveling of the underlying layers before putting the chernozem on top. Therefore there is great practical and economic motivation to make agricultural production possible on replaced substrata using phytomelioration without replacement of the chernozem [1]. The current research priority is to determine the general management approach that provides the most is about one cubic meter. The current research priority is to determine the general management approach that provides the most vigorous and enduring growth of the legume-grass mix, resulting in maximum soil improvement in the shortest time, with the fewest number of years and cycles of re-planting needed before initiating field-crop production.

The scheme for reclamation of disturbed land in Western Donbass coal region was based on the study of the effectiveness of capping the mine dumps with different layers of black-soil mass (chernozem) both with and without a shielding layer of loess- like loam [2]. In this study the

following models (variants) of techno-genic edaphotops were used to look into the peculiarity of upward migration of toxic salts from the mine dumps: Mine rock (MR) + 30 cm of the bulk layer of black soil (30BS); MR + 50BS; MR + 50 cm of the loess-like loam (50LLL) + 30BS; MR + 50LLL + 50BS. Observations of the mine dumps in Western Donbass indicate the need to study the changes in physico-chemical properties of the mine rocks, establish the rate of removal of the weathered rock material, and study the vertical migration of toxic substances along the technogenic edaphotop of the reclaimed land. Thus, experiments suggested a long-term study of the effectiveness of the two- and three-layer reclamation models as geochemical barriers for blocking the upward migration of toxic salts from the mine dumps.

Lands damaged by open pit mining works (with exposure of overburden rocks born to the surface) have to pass a very long and complicated process of reclamation without artificial covering by soil mass which was preliminary removed. That is why, in such cases it is necessary to carry out focused reclamation including the activities to preserve upper fertile soil layer. In spite of this they use the technology which does not involve selective extraction of overburden rocks and separate dumping. As the result mechanical blending of above-ore rocks and forming complex technical mixtures take place. Then, flattening-out or reclamation leveling of the surface to serve as an undercoat base for a filling layer of soil mass is carried out.

It is assumed that using reclamation can help create the lands of special target purpose in technogenic landscapes (that can be achieved by varying the thickness of filling layer of black soil mass) crops, feed grains, feeding, reclamation and other directions. The sites dedicated for open pit mining works can have different thickness of artificial profile that defines various thickness of removal and different thickness of damaged soil mass laying. To determine optimal parameters and rational stratigraphy of reclaimed lands detailed study is required. To solve a set of economic, ecological and biological issues determining optimal thickness of covering soil layer and choosing favorable bottom have a strategic significance while planning the type of reclamation works. To some extent it is connected with the type of damaged landscape as well. Choosing the thickness of a covering fertile layer and a bottom has defining value in the case of planning to use for agricultural purposes the areas being subjected to mining and technical reclamation. The reclamation technology is a perspective one to avoid forming “dry beaches” on the surface of drying out slurry pits. The thickness of covering waste depositories by mining rocks (loess loam) or soil can be minimal. As a rule it is within 20-30 cm. Outside dam cuts are supposed to be fixed by planted land which helps avoid soil erosion and dust removing from cut surface.

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LOW TEMPERATURE SYNTHESIZED CONE STOVER ACTIVATED CARBON FOR ADSORPTION OF AQUEOUS CRYSTAL VIOLET SORBATE

1. Introduction

Industrial effluents containing dye are a major source of surface water pollution. Industrial dyes are toxic and harmful to the human health if ingested (Hao eta al., 2000). Crystal violet (CV) dye is a cationic triphenyl methane dye which is widely used in the industry for various colouring applications such as dying of cotton in the textile industries (Bertholini et al., 2013). The dye is well-known to for its unsafe, mutagenic and carcinogenic effects on human and aquatic lives (Bertholini et al., 2013). Activated carbon is the most commonly used adsorbent for treatment of dye contaminated water using adsorption process (Raghavacharya, 1997). Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or a liquid (sorbent), forming a molecular or atomic film (sorbate). Adsorption process is perceived as an efficient and admirable method to other technologies for the heavy metal wastewater treatment. It provides treated effluent with high quality. In this process, waste is transferred by physical or chemical interest into the active sites present onto the adsorbent used (Ojedokun et al., 2016).

2. Materials and Methods

Cone stover collected from farm was pretreated to remove debris and other impurities. The pretreated stover was sun dried and milled using a milling machine. Low temperature synthesis of activated carbon was carried out using phosphoric acid at varying activation ratios as the activating agent. The mixture of cone stover and activating agent was homogenized and heated in the oven at 120° C for 1 h. The activated carbon produced was washed with distilled water until the neutral pH was achieved. The washed activated carbon samples were dried in the oven at 110 °C for 1 h in order to remove the moisture content. Adsorption study of aqueous CV solution (sorbate) on varying samples of synthesized AC (sorbent) was carried out using 50 mL of CV sorbate at constant initial concentration of 15 mg/L. The adsorption process was achieved by continuous mechanical shaking action of a laboratory shaker. The percentage absorbance (%A) at equilibrium was evaluated using Equation (1)

$$\%A = \frac{C_0 - C_в}{C_0} \cdot 100 \quad (1)$$

where C_0 is the initial concentration of aqueous solution of CV and $C_в$ is CV concentration at equilibrium.

The adsorption capacity of the adsorbent, q_e (in mg CV/g AC) was determine by Equation (2).

$$qe = \frac{C_0 - C_e}{m} \cdot v \quad (2)$$

where m is the weight of adsorbent (g) and v is the volume of CV solution (L).

3. Results and Discussion

Fig. 1 shows the spectrophotometer absorbance of crystal violet (at wavelength of 565 nm) at varying concentrations of the aqueous crystal violet solution. A linear curve relationship between the sorbate concentration and the absorbance could be observed. The relationship was used to determine concentrations of the sorbate throughout the adsorption study. Table 1 presents the adsorption capacity of the varying AC samples synthesized. It could be observed that the 1:0 which is the inactivated sample of the cone stover had adsorption capacity of 79.25%. However, the adsorption capacity of the adsorbent improved by 6.1% after activation at 1:1 impregnation. Further impregnation of the adsorbent at 1:2 and 1:3 increased the adsorption capacities further by 2.5% and 3% respectively. The 1:3 sample was considered the optimum activation ratio as further increase in activation ratio at very high value as 1:6 had no significant improvement on the adsorption capacity of the adsorbent.

Table 1

%Adsorption for the various samples A

AC Sample	Ce (mg/L)	%A
1:0	3.113	79.25
1:1	2.194	85.37
1:2	1.817	87.89
1:3	1.346	91.02

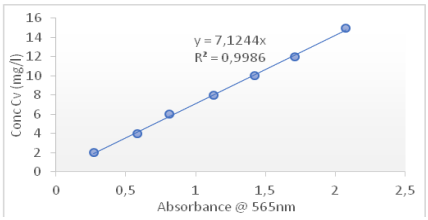

Fig. 1. Spectrophotometer calibration curve

Fig. 1 shows variation of the equilibrium concentration (C_e) of aqueous solution of CV against time. Starting from the initial CV concentration of 15 mg/L at time zero, it could be observed that the CV concentration dropped continuously as the adsorption time progressed until a stable profile equilibrium was achieved at around 240 min. Therefore 240 min was considered the optimum adsorption time. Fig. 2 shows the variation of the adsorption capacity of the sorbent for the adsorption process. It could be observed that the adsorption capacity increased progressively with time throughout the adsorption process until the optimum amount of 23.18 mg/g of sorbate per adsorbent was achieved at 240 min.

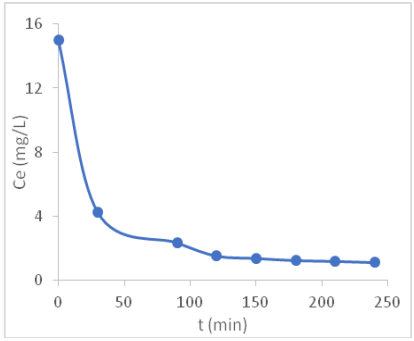

Fig. 2. Equilibrium conc. of CV against time

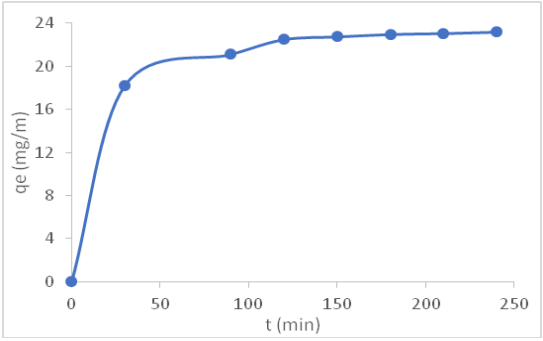

Fig. 3. Adsorption capacity against time

4. Conclusion

Activated carbon was successfully synthesized from agricultural waste cone stover via low temperature route. The synthesized activated carbon was effective for treatment of crystal violet contaminated waste water. The inactivated adsorbent had high percentage adsorption of 79.25%. Upon activation of the cone stover higher percentage adsorption of 91.64% was achieved for the optimum activated activated carbon synthesized at 1:3 activation ratio. The optimum adsorption time and adsorption capacity were determined as 240 min and 23.18 mg/g, respectively. Application of the synthesized activated carbon in industrial waste water treatment will not only be technically effective but will also be very economically advantageous and environmentally renewable as the raw material is from agricultural natural resource.

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LANDSCAPE TRANSFORMATION UNDER THE INFLUENCE OF MINING ACTIVITIES

This article presents the impact of mining activities on the environment on the example of the city of Olkusz (Poland). The influence of underground mining on the environment was analysed.

Olkusz was a mining town since ancient times. It owes its establishment and later flourishing to the local mining and huge deposits of raw materials. In the 13th century lead ores were discovered there, the exploitation and distribution of which brought the greatest profit. A very good location by the trade route from Kraków to Wrocław contributed to this. In the period of its greatest splendour, that is in the 15th century, 300 lead mines were active in Olkusz. Thanks to that, smelters smelting silver from ore developed around them [1]. In the last century the most important mining areas were the deposits of "Bolesław", "Klucze I" "Olkusz" and "Pomorzany". The "Bolesław" mine ended its activity in 1998, the "Olkusz" mine was closed in 2003. The Pomorzany mine ceased its mining activities on 31 December 2020. This mining and processing complex is currently being transformed into a metallurgical plant only, after a history of ore mining lasting almost 70 years [2].

The Błędowska Desert is one of the best examples of landscape transformation caused by mining activities. The formation of such a special type of landscape in the Błędowska Desert is a

result of the presence of metal ores in the vicinity. Due to shallow zinc-lead deposits, which were easily accessible already in the Middle Ages, the natural environment in the vicinity was transformed by industrial activities [3]. During the period of intensive mining activities, from the 13th century until the middle of the 18th century, there was a cyclic clearing of trees. The raw material was needed to fuel smelting furnaces, build mine shafts and adits. Degradation of the vegetation cover, grazing by cattle and the removal of litter started to reactivate the sand deposits. There was a decline in the groundwater horizon, resulting in the cessation of normal forest vegetation. A large area of sandy land of about 140 km^2 was then exposed. This is the greatest ecological disaster of its time [4].

The hoist and ventilation towers characteristic of underground mines have a huge impact on the landscape. In the area of Olkusz over the years 20 mine shafts were active: "Bolesław", "Olkusz", "Pomorzany".

In the Olkusz region, which is rich in zinc-lead deposits, many centuries of mining activities have left a particular mark on the landscape in the form of a huge number of pits, collapsed shafts, hills and spoil heaps. Post-mining spoil heaps pose a threat to the environment through dusting, contamination of underground water and water courses through high concentrations of zinc and lead. Apart from the bad influence on the environment, they become documentation and cultural objects that form monuments of the industrial heritage of the region [5].

The mines in the Olkusz area discharged huge amounts of waste produced during flotation for several decades. The heap leach pad in Bolesław is the most famous and the largest waste dump, which accumulates nearly 60 million tons of waste. The facility is causing a huge change in the landscape. It is an above-ground tailings storage site that covers an area of 110 hectares. Work is currently underway to recover zinc and lead from the tailings stored here. The assessment of the impact of mining activities shows that the lithosphere is the most vulnerable element of the environment. Exploitation of raw material from deep underground is connected with high impact on soils. Their acidification and increase in heavy metal content is possible, and this in turn may bring damage to agriculture. Strong pressure is observed in the hydrosphere, mainly in surface and groundwater. Soil drying up, disappearance of water courses, drying up of springs and wells and water pollution may occur in the areas belonging to the mine and situated in its vicinity.

Mining plants in the area of Olkusz provide valuable mineral resources enabling economic development. Despite a clear negative impact of mining activity on the elements of environment, one should try to reach a consensus between the sphere of economy and natural environment. This consensus is possible thanks to the application of the principles of sustainable development and introduction of new pro-environmental mining technologies which help reduce the negative impact on nature.

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DEVICE FOR EXTINGUISHING WASTE HEAPS CAPABLE OF COMBUSTION

The problem of today is the impossibility of utilization and temporary reclamation measures to prevent spontaneous combustion of waste heaps. In 1987, scientists from the Donetsk Polytechnic Institute Zborshchik M.P. and Osokin V.V. bulo proponated two patents for invention «A device for extinguishing burning dumps» -SU № 1332037 A1 and «Extinguishing device for waste dumps» - SU № 1298397 A2. The main commissioning of these devices consisted in the injection of an inhibitor (limestone suspension) deep into the body of the waste dumps, due to which penetration into the zone of the combustion seat took place and, as a result of a point effect on the combustion seat itself, its elimination. The vapors that were released during the extinguishing of the combustion center of the waste dumps through the system of suction pipelines were sent for use for economic purposes for heating the water for heating the premises, etc. [1].

Based on the advantages of such a device, there are also major disadvantages. Firstly, this is the impossibility of extinguishing waste dumps as a whole, which in my opinion is a very significant drawback, since the problem of complete processing of the dump mass with an inhibitor is not solved.

Based on the analysis of the work of domestic and foreign scientists, I proposed a device for the safe formation of rock dumps resistant to spontaneous combustion. The main difference of this device is the irrigation of the dump mass, which goes to the formation of rock dumps that are safe for spontaneous combustion with a lime suspension by irrigation using an introduced conveyor or through a cantilever spreader [2,3].

The device works as follows (Fig. 1). Water is pumped from the source through the suction pipeline 1, which consists of low-pressure polyethylene, the centrifugal multisection pump 2 through the discharge pipeline 3, which is connected to the tank 4, where the loading hopper 5 is

located on top, to which the components for preparing the limestone suspension are preloaded - hydroxide calcium Ca $(OH)_2$ and sandy-clay mixture at the rate of 30-50 kg/m^3 of water. Further, with the help of a 3-phase asynchronous drive motor 6, connected to a belt gear 7, which is connected by bearings to a frame mixer 8, the components are mixed to obtain homogeneous inert suspensions. Through the pipeline 9, which is combined, the inner wall of which consists of low-pressure polyethylene, and the outer shell of high-pressure polyethylene, by opening the automatic hydraulic valve 10 with an electromagnetic drive, the finished suspension is transported to the dispenser 11 on the tank and the dispenser there are hatches of revision 12, where the inner walls of the containers are cleaned and pressure gauges 13 are connected to control the pressure of the substance. A suction line 14 with a vacuum gauge 15 is withdrawn from the dispenser 11, through which the finished suspension enters the centrifugal multisection pump 16 from where it flows under pressure to the injection pipeline 17 through the receiving hopper 18, where the dump mass is loaded, which is combined through a high-pressure hose 19 with the injection pipeline 20, on which the nozzles with a full spray cone of a spray of dispersed liquid are installed. Both suction and delivery pipelines are adapted for transporting aggressive chemical substances (limestone slurry) and consist of a two-layer composition: the outer shell is high pressure polyethylene and low pressure polyethylene is the inner part of the pipeline. This ensures reliable, trouble-free operation of the pipeline when working in an open environment with temperature extremes and when transporting aggressive chemical working fluid. In the injection pipeline with irrigation structural elements there is an arrow of the introduced spreader, which consists of a receiving and a main transporting console, the working surface of which consists of conveyor belts 21 (shown schematically), on which the dump mass with different sizes of pieces 22 is transported to the unloading point [4,5].

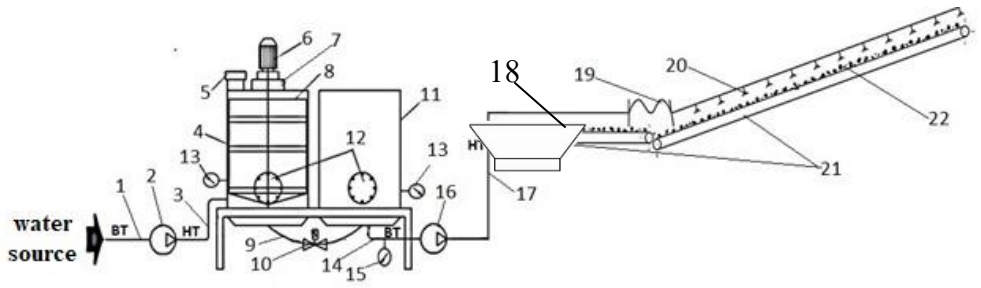

Fig. 1. Device for the safe formation of rock dumps resistant to spontaneous combustion

Conclusions

The efficiency of using the device can be obtained due to continuous operation, which is achieved by covering the dump mass with an inert mixture during transportation, this reduces the contact of the rock with the environment, which is an important stage in the formation of rock dumps of a particularly conical shape, reduces the cost of operation and maintenance for due to the formation of fire-resistant waste dumps, regardless of the influence of environmental conditions.

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QUALITATIVE ASPECTS OF SURFACE WATER IN ALBANIA

Problems related to water quality is often neglected, because in our country there were no lack of good quality water. Although water resources are renewable asset, feeded by rainfall, they come constantly being reduced as a result of pollution generated by the intensification of human activity, from chemicals used in agriculture as well as from industry development. This lead to the use of poor quality water.

Socio-economic changes of our country during recent years, demographic changes, population growth in the western lowlands, etc., have influenced the management of water resources in changing their physic-chemical characteristics, bringing consequently a complex of negative effects on aquatic environments.

The study aims to: evaluate the quality of surface water, determine the main pollutants of urban liquid discharges in surface waters in order to provide data to create a database for these discharges, and for an integrated management of water resources. In this study was monitored the quality of surface water, problems are identified and necessary recommendations are presented in the interest of preserving water resources. Monitoring of water quality in our country is based on contemporary methods that are applied today in many countries of the European Union. To achieve the objectives there are analyzed in the laboratory various parameters such as: pH, BOD_5, COD, dissolved O_2, NO_2^-, NO_3^-, NH_4^-, PO_4^{3-}, P_{total} and other microbiological indicators.

Sampling stations are located in Tirana, Durres and Elbasan cities, located mainly in the lower reaches of the rivers, making it possible to recognize the impact of urban liquid discharges on surface water quality. Surface water areas were assessed through two types of water areas with significant changes in the level of pollution.

- Water areas, not polluted by human activity, corresponding to the part of the river flow before entering the city.

- Water areas affected by urban and industrial water discharges of cities corresponding to the area, as rivers have crossed the city area.

Pollution of natural waters from urban liquid waste is a critical environmental problem with undesirable consequences for human health, its economy and the ecosystem in general. Today, in almost all countries of the world, work is being done to minimize the consequences of pollution and to prevent further degradation of the environment where we live.

One of the main sources of natural water pollution is urban water discharges, which contain organic matter that reduces the oxygen content in water, soluble phosphorus and nitrogen compounds, pathogenic bacteria and viruses, heavy metals and substances that spoil the appearance. of water, and give them a foul odor.

It is noticed that the water areas that correspond to the part of the rivers before entering the inhabited areas, meet the characteristics of the waters with satisfactory quality. The situation is more worrying in the river segments that pass in the most populated and industrialized cities of the country, where the city of Tirana is clearly distinguished.

Tirana is one of the cities with the largest demographic inflows, which has brought overcrowding of the city and peripheral areas and with it, the increase in the level of pollution in surface water as a result of increased discharges of untreated urban and industrial water. Surface waters quality, especially the Tirana river and Lana river, which later joined to become part of the Ishem river, are in a difficult situation both in terms of nutrient concentration (P) and organic matter load expressed through high BOD_5 values, COD or low values of dissolved oxygen, Class IV-V.

There is also a decreasing tendency of dissolved oxygen values in the stations after collector discharges. Upstream the river waters are clean and rich in oxygen. Oxygen depletion is a consequence of its consumption for the destruction of organic matter, the main source of which are urban discharges.

In terms of nutrients, phosphorus and nitrogen, the situation is problematic in terms of phosphorus. The natural content of phosphorus in pure rivers usually fluctuates in values less than 0.025 mg/l. When concentrations are greater than 0.05 mg/l this is due to human activity.

High values of phosphorus content are present in river stations after discharge of collectors, with values above the standards of satisfactory surface water quality, in the monitoring stations of Tirana, Lana and Ishem rivers.

For the protection of water from various pollutants, the effects of discharges of pollutants on them must be continuously controlled. The problem of water pollution is an exclusive responsibility

of everybody, in order to reduce emissions through improved management practices. Following recommendations are crucial to improve our understanding and ability to manage water quality:

- River flow measurements need to be made at the same locations as chemical water quality measurements, to enable the determination of pollutant loads.

- Increased measurement of nutrients is needed.

- Identification of high priority areas or 'hot-spots' which should be earmarked for the implementation of control policies.

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THE USE OF MODIFIED CLAY MINERALS IN THE PURIFICATION OF ORGANIC AND INORGANIC POLLUTANTS

A wide range of useful properties of clays and clay materials has been known for a long time, which explains the large-scale volume of their extraction and various fields of application. It is also well known that ignoring the numerous features of clay materials associated with the properties of raw materials and methods of their processing inevitably dooms to underutilize the high potential of these materials or to even more problematic situations. [1]

Cleaning the soil, water and other natural environments from various types of pollutions, including pollution from oil products can be carried out with the help of clay minerals due to their unique properties. Among them, first of all, should be called: (1) the ability to sorption substances, due to the high dispersion and structural features of the crystal lattices; (2) catalytic action in many

chemical reactions; (3), beneficial effect on the functioning of soil biota, including microorganisms - oil destructors.

To improve the sorption properties, natural clay materials are modified depending on the specific purpose of its further use. The modification is aimed at increasing the porosity and specific surface area of minerals, changing the structure of the interpacket space of labile minerals, as well as imparting hydrophobic properties to their surface. For this, various reagents are used: acids, bases, alkyl-ammonium ions and other compounds of quaternary amines, compounds of Al and Fe, which, under certain conditions, are capable of forming columnar structures of hydroxides in the interpacket spaces of labile minerals, and others.

The ability of clay minerals to adsorb non-polar organic compounds sharply increases upon modification with organic cations, which leads to an increase in hydrophobicity and organophilicity. These cations are, first of all, quaternary ammonium cations. Their influence on the sorption properties of organo-clays depends on many factors, including the length of the chain. When using quaternary ammonium cations with long chains, for example, hexadecyltrimethyl ammonium, they first partially and then completely occupy the interpacket space in smectites. It has been experimentally shown that with an increase in the chain length, the ability of organoclays to absorb phenols, trichlorophenols, and pentachlorophenols increases.

Clay minerals, mainly smectites modified with quaternary ammonium cations, are used to remove oils, lubricants and oil from water, as well as to remove toxins formed by cyanobacteria in watercourses and reservoirs. Even a small addition of modified clay minerals to conventional clay insulation barriers provides a seal against non-polar organic compounds for over 100 years. There are also known studies to assess the possibility of using clay minerals as sorbents for cleaning soils and grounds from petroleum products. [2]

Clay rocks and materials based on them can have a different granulometric and mineral composition. For the creation of engineering barriers, materials with a fine fraction (<2-5 microns) content of at least 30-50%, depending on the composition of clay minerals, are most preferable. Finely dispersed fractions are usually represented mainly by clay minerals with various impurity contents of feldspars, quartz and other minerals. In this aspect, only clay minerals possess useful qualities for the creation of engineering isolation barriers (ISB), which in their properties can vary significantly, which is determined by the peculiarities of their composition and crystalline structure. The main characteristics of clay materials as potential components of insulating anti-migration barriers are such indicators as filtration and diffusion coefficient, porosity, permeability, cation exchange capacity, sorption distribution coefficients of radionuclides, kinetic parameters, number and nature of sorption centers, crystallite size, specific surface area, index and swelling

pressure, etc. The structural features of clay minerals determine their physicochemical and mechanical properties. [3-5].

Electron microscopic images of the main clay minerals are shown in Fig. 1.

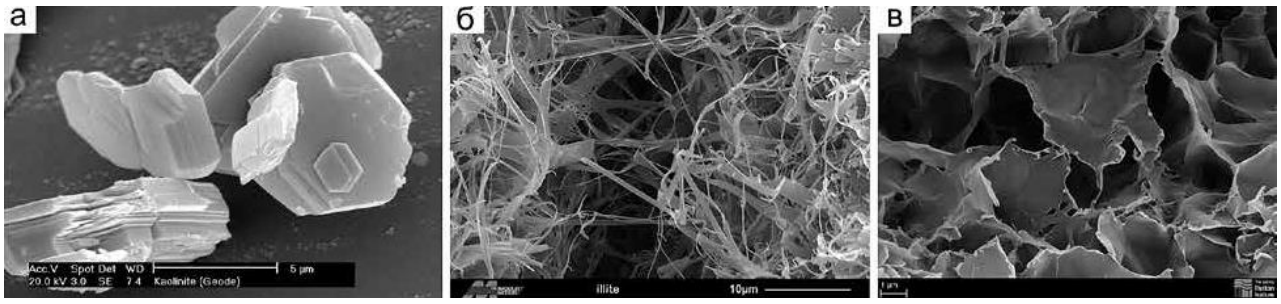

Fig. 1. Electron micrographs of particles of clay minerals: *a* - kaolinite, *b* - illite, *c* - smectite

In this work, bentonite of the Dash-Salakhli deposit was used as the object of research. It was found that the stability and coagulation of monocation-substituted forms of bentonite samples depends on many factors, such as the dispersion of particles, the magnitude of the forces of attraction and repulsion between particles, strength and elasticity of the structure, which is associated with the presence of exchange cations and interpacket spaces of bentonite [6].

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THE APPLICATION EFFICIENCY OF AGROCHEMICALS WITH IRRIGATED WATER

One of the ways to intensify irrigated agriculture is to combine irrigation with the use of chemicals, in particular with the application of mineral fertilizers (fertigation), herbicides

(herbigation), ameliorants and trace elements (Kiver and Onopriienko, 2016). In addition, modern irrigation equipment is suitable for equipping with tools that can work in the modes of spraying and pollination of crops.

Agrochemicals in solid, liquid and gaseous state can be used for chemicalization, but for the application of solid components the preparation of uterine liquors before their dosing into the flow of irrigation water is required (Kiver and Onopriienko, 2019).

The application efficiency of fertilizers and pesticides of soil action with water is determined by the correspondence between the intensity of water supply and water permeability of the soil at specific irrigation standards. Violation of this condition does not provide the required quality of soil moisture to a given depth. If the working solution of agrochemicals does not have time to be absorbed into the soil, then it accumulates on the soil surface, flows over the site, contaminates surface and groundwater sources.

During foliar fertilization, application of retardants, biological and chemical plant protection products, the method of sprinkling with an irrigation rate of 5–60 m^3/ha is used. To obtain a minimum layer of precipitation, special equipment that ensures the operation of sprinklers in the mode of spraying with accelerated rotation or frontal movement of multi-support machines is provided (King et al., 2009).

Using of mineral fertilizers with irrigation water radically solves the problem of uniform distribution of fertilizers in the active layer of the soil to the level of uniform distribution of irrigation water. In addition, the ability to apply fertilizers in small doses during the growing season without damaging the plants, both mechanically and through chemical burns is an important advantage of this method (Anna Biau et al., 2012).

Fertilizer irrigation as an independent technological measure includes a set of agronomic, organizational and economic measures for the rational use of nutrients to increase yields and improve its quality, increase productivity and the overall culture of agricultural production (Onopriienko, 2020).

The research was carried out over 3 years (from 2016 to 2018) of growing seasons in the private farm "Aist" in the Sinelnykovo district of the Dnipropetrovsk region, Ukraine. During the study period, the average annual temperature from May to October in the Sinelnykovo district was 17,2 °C in 2016, 17,9 °C in 2017, 19,4 °C in 2018. Throughout the vegetation period (May-September), 2016, 373 mm of precipitation fell, in 2017 it was 177 mm, and in 2018 it was 157 mm.

Middle - ripening hybrid corn DKC4351 (FAO 350) was sown in experiments with a density of 80 thousand plants per hectare in the field experiment. The technology of growing corn was generally accepted for this crop in the area of the northern part of the Steppe zone of the Ukraine. Irrigation was carried out with a wide-reach front-action sprinkler system produced by the Reinke company (USA,

System Serial No: 1212-54432-2065/2060 MAXI). The dosage of mineral fertilizer solution in the irrigation water was prepared by a special apparatus of the MILTON ROY company (USA, Manual No: 53873) with a maximum capacity of 416 liters per hour. The irrigation regime provided for maintaining minimum soil moisture in the active layer of at least 70-80 %. The irrigation rate was 2,100 m^3/ha in 2016, 2,400 m^3/ha in 2017, and 2,500 m^3/ha in 2018.

Solid mineral fertilizers were represented by nitrogen (urea), nitrogen and phosphorus (‘amophos’) and potash fertilizers (Kalium Makosh Company, Poland). The water-soluble fertilizer KAC-32 was used as a source of nitrogen. Liquid potash fertilizers with the K_{60} norm were applied with a self-propelled sprayer for pre-sowing cultivation. The doses of mineral fertilizers for the planned corn grain yield of 12 t/ha were calculated using the balance method, taking into account the content of basic nutrition elements in the arable soil layer. The calculated doses were $N_{200}P_{90}K_{60}$. The "Powerfol Zincate" fertilizers were applied annually by a sprayer with a dose of 150 ml per 100 liters of water in all variants of experiments in the 3-4 leaf phase to prevent chlorosis and zinc deficiency in plants. The "Elumis 105 od" herbicide was introduced in the phase of 9-10 leaves with a sprayer of 1,7 l/ha to protect crops from annual and perennial grasses and dicotyledonous weeds. The "Coragen Du Pont" insecticide was introduced with a self-propelled sprayer with a rate of 150 ml/ha to control the corn stalk moth in the phase of hair ejection.

The trials of the mineral fertilizers application are as follows: **A** - the control option - on irrigation, but without fertilization; **B** - application of fertilizers on irrigation before sowing for cultivation: urea - scattered with the rate of N_{200}, ‘ammophos’ with the rate of P_{90} for autumn plowing; **C** - application of KAC-32 on irrigation for cultivation before sowing with the rate N_{200} self-propelled sprayer, application of ammophos for autumn plowing with the rate P_{90}; **D** - urea fertigation retail with irrigation water with the rate N_{200} during corn vegetation period; **E** – KAC-32 fertigation retail with irrigation water with the rate N_{200} during corn vegetation period.

The total area of the field measures 120 ha, the sown area of the experimental plots is of 16,2 ha, and the examined area is of 12,5 ha, the repetition rate is four times. The $N\text{-}NO_3$ content in soil samples was measured in accordance with the potentiometric method by means of the ion-selective electrode. Seed samples were analyzed using the Kjeldahl method to determine the total nitrogen. The crude protein content was calculated by multiplying total nitrogen value with a coefficient of 6,25. The crude oil percentage was determined by means of the Soxhlet extraction technique, fiber - through the sequential washing method, starch - by the porarimetric method based on Evers’ principle.

The mathematical processing of the results was conducted using the ANOVAs statistical software with a calculation of the low sufficient difference LSD at a level of 95 %.

High efficiency of fertigation was established after three years of research on ordinary black soil in the production of corn hybrid DKC 4351, instead of traditional mineral fertilizing methods.

Nitrates are washed out of the root layer after spreading urea on the soil surface before cultivation in the spring. The nitrates content decreased in the soil before the period of intensive demand of maize plants for nitrogen (10-12 leaves) to 15,3 % and 41,0 % (in the phase of milk ripeness of the grain) in comparison with the period of 5-6 leaves. The nitrate content in the soil in the last two phases was 16-26 % higher than in the 5-6 leaf phase after applying the KAC-32 solution with a sprayer on the soil surface. The mass of 1000 grains was the highest after the urea application rate N_{200} retail together with irrigation water. The maximum yield of corn grain during three years of research was obtained by applying the urea norm N_{200} and KAC-32 with irrigation water during vegetation irrigation. There is a tendency to increase the protein content in corn grain during fertigation with urea and KAC-32. Retail application of these fertilizers with irrigation water has also contributed to an increase in the amount of protein per area unit.

The obtained data show that the combination of irrigation with the application of mineral fertilizers is an effective way to save energy and material resources, increase the yield and quality of the corn crop.

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GLOBAL GEOPARK HOLY CROSS MOUNTAIN-GEOLOGICAL AND MINING HERITAGE APPRECIATED BY UNESCO

The idea of preserving the geological heritage for future generations and the concepts of creating Unesco Global Geopark Holy Cross Mountain (Świętokrzyskie region) have extensive assumptions. Indirectly, they are based on clear, historically documented relationships between man and inanimate nature, expressed in the traditions of ore and rock mining.

On April 22, 2021, during the International Earth Day, Geopark Holy Cross Mountain was officially admitted to the UNESCO Global Geoparks Network. It includes geological objects

located in Kielce, as well as the neighboring communes: Chęciny, Morawica, Nowiny and Piekoszów. They created the Association of Communes "Geopark Świętokrzyski".

There are over 150 UNESCO-certified sites in the Global Geoparks Network, including one Polish-German. The Holy Cross Mountain Geopark is the first geopark located entirely in Poland.

The "European Geopark Charter" is a set of main criteria defining the term "geopark" and guidelines for new members (geoparks) applying to European Geopark Network (EGN) [1].

According to the records of "Charter...", the geopark is an area characterized by a special geological heritage, whose economic development is sustainable. This area must have a relatively uniform character, clearly defined boundaries and sufficient space to act as a stimulator of local economic development. Within the geopark, there should be a network of geological sites with significant values from the point of view of geotourism, education and science, as well as representing other, non-geological aspects (biotic, archaeological, cultural), making up the specificity of a given area as a region distinguishing in terms of nature and culture. An important aspect of the geopark's operation, as defined in the Charter, is a coherent strategy for the protection of geological sites, in accordance with the legal regulations in force in the given area.

Valuable natural areas associated with excavations of former quarries and ore mining sites located in the Chęciny-Kielce area operate in the vicinity of urbanized and industrial areas. Therefore, the main factors affecting the Geopark area are various anthropogenic threats to the natural environment and the cultural landscape resulting from direct or indirect human pressure on valuable natural areas. Natural factors that have a negative impact in the context of the protection of geological and mining heritage are associated primarily with the succession of vegetation and mass movements within the slopes and slopes of quarries. Both of these natural factors acting in conjunction lead to lowering the scientific and didactic value of exposures, as well as their availability and geotourism attractiveness [2, 3].

The effectiveness of activities related to the protection and conservation of geological and mining heritage in valuable natural areas remaining after opencast mining of rock raw materials or ores is the resultant of formal, legal, administrative, technical, technological and economic and economic conditions. The issue of managing such areas by entities capable of permanent, cyclical financing of conservation, conservation and investment activities is of key importance for the effectiveness of such activities. In addition to the aforementioned factors, a detailed, comprehensive inventory and valorisation of abiotic and biotic elements is a necessary condition, which is the basis for the development of protection plans determining the scope and direction of conservation and investment activities.

Examples of various conservation and investment activities carried out in post-mining areas under legal protection in the Chęciny-Kielce area also show that there is an urgent need to develop a

model of good practices, constituting a specific set of guidelines for the entities administering the abovementioned areas.

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USAGE OF HEAT PUMPS FOR REGULATING AIR TEMPERATURE IN RESIDENTIAL AREAS

Reliability of power supply is an index of effectiveness of economic policy in any government. The issues of global warming, rise of price for energy sources, growing addiction from fossil fuels demand alternative solutions of energy production. The field of housing construction especially needs new energetical technologies. Since the process of realization of water supply and heating arises the problem of providing the necessary energy.

Traditionally, fossil fuel (coal, oil, gas) was used for generating heat and separate system of air conditioning was used for cooling the buildings. The usage of heat pump which uses up to 75% of cheap low-potential energy extracted from the environment, might be an alternative solution to the problem of regulating temperature in the air [1]. Heating and cooling supply with the help of heat pumps relates to the sphere of energy-saving ecologically clean technologies and spreads more and more around the world. This technology according to the conclusion of a numerous authoritative international organizations, along with the other energy-saving technologies relates to the technologies of the XXI century.

Air-to-water heat pump can be related to the innovative projects of such type. This household appliance is able to heat the premises of any purpose and helps to provide the object with hot water. Also, one of his functions is room air conditioning during the warm season.

Operational principle of the ground-to-water heat pumps is accumulating and transporting dissipated solar heat, which is found in various natural sources, to the heating system. Besides the transporting

function, heat pump is also responsible for transformation of the heating energy through the converting the huge volume of low-potential energy into heat to cover the needs of the heating system.

Water-to-water heat pumps use the heat of ground-waters, opened water reservoirs or process cooling water. In Donetsk region, water from mines is considered as a low-potential source of heating, therefore a water-to-water heat pump is the most perspective for heating systems [2, 3].

Authors of this work substantiated the expediency of implantation the heat pump using pumpable to the surface mine waters to heat the settlements of residential area around functioning and non-functioning mines.

The parameters of the vapor compression cycle of heat pump with heat regeneration and an intermediate heat exchanger were investigated in order to achieve the set goals. The analysis of existing heat pump's constructions determined the choosing of the rational scheme of vapor compression heat pump with heat regeneration and an intermediate heat exchanger.

It was found that installing the heating system as a heated floor will allow to provide the heating supply of the object with heat pump unit during the whole heating period because of minor changes in temperature of ground waters during the year. During the heating period, the unit can also provide the heating of water in the hot water supply system.

Using heat pump just to boil water requires installing additional equipment. That is why after the end of the heating period, water boiling must be realized in a different way, for example by direct electric heating.

As a results of estimating the actual heat loosing during the transportation of the coolant, taking into account the technical condition and real terms of usage in heating networks, it was settled that the locating of the heat pump system is advisable directly near consumer, since it reduces heat loses.

Calculations of the options were made for the schemes of the vapor compressing heat pump, including versions with the heat recovery and sub cooler. It was found from the analysis of the energy efficiency indicators of calculated options, that the specific heat load of the heat pump characterizes the freon consumption, and therefore affects the cost of the compressor and heat exchangers. The compression ration determines its cost. The energy conversion factor and the specific primary energy consumption characterize the efficiency of the heat pump operation. The exergy efficiency shows the thermodynamic excellence of the process in the heat pump.

As a result of the conducted research was made the following conclusion: obtaining the cheapest by installing heat pumps requires large material costs; a significant reduction in the payback period is possible with the optimal design of heat exchanger in heat pump installations.

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RATIONAL MODEL OF THE MOTOR IN THE FORECASTING CONTROL SYSTEM OF DYNAMIC EFFICIENCY OF THE ASYNCHRONOUS DRIVE

It is known that the vast majority of mechanical energy in industry and everyday life is provided by electric drives. Meanwhile, today an important aspect in business activities are played by environmental and economic factors. Their impact depends on the cost of kilowatt-hours of energy, the tariff for which has a stable upward trend [1]. This forces manufacturers to seek a balance between energy efficiency, clean production and finance.

The direction of increasing energy efficiency by using highly efficient synchronous motors, which are excited by permanent magnets, has one significant disadvantage: their production requires rare earth metals, which can nullify any gain in the expected savings.

On the other hand, asynchronous machines are the most common motors in the modern industry, and their popularity is due to the simplicity and reliability of the design, low operating and investment costs and the ability to work in aggressive environments. As a result, in the upcoming decades, other motors will not replace machines of this type, and the issue of improving their efficiency in any operation modes is an important area of development.

The main principle of the motor’s power loss reduction is to supply its stator windings with the amount of energy required to perform the current process task. At present, a number of solutions have been proposed that implement the principle of energy saving in mechanisms operating in steady-state operation mode [2-4].

In the case of operation of industrial mechanisms in S2 or S3 modes (electric vehicles, elevators, lifts), with predominantly transient operation, the process of solving energy efficiency improvement problem is much more complicated. The problem can be solved using the procedure of finding the desired voltage and current levels of stator windings, which are obtained by mathematical modeling under the condition of the best compensation of the saturation effect of the magnetic circuit of an induction motor [5-7]. The result of the calculation is stored in the form of a look up table with its subsequent use as valid control signals for controlling the asynchronous drive.

In the calculation part of the research, it is permissible to use several variants of the motor model. The scientific task in this case is to find a rational variant of the motor model that cultivates the simplicity of calculation and quality of the control system, and provides the maximum desired energy efficiency during operation of the asynchronous drive in transient modes.

The search for a rational model is carried out for several variants of the equivalent circuits of the induction motor with different levels of detail:

- detailed Г-inverse equivalent circuit;

- model with constant iron resistance;

- model with neglected iron losses;

- model without taking into account iron losses and simplified constant value of the fundamental harmonic of magnetic induction;

- model with neglected iron losses and the moment of friction that allows to apply constant loading moment and the basic harmonic of magnetic induction.

Testing of the experimental setup is performed using the facilities at the University of Reutligen (Germany). It consists of: investigated asynchronous motor IE3-W41R 225 M4, 45 kW, loading machine, inverter SEMIKUBE SlimLine from SEMIKRON, controller dSpace DS5202 and power analyzer LMG671.

For each type of model, the optimal data is obtained, by simulating transient operation, which then are loaded into the control system of the real experimental setup. Evaluation of the quality of the test results of the real object makes it possible to give preliminary conclusions:

- the greatest effect of reducing power losses is shown by the control system, which is based on a detailed model of the asynchronous motor;

- detailed model of asynchronous motor has the most complex implementation, so it is necessary to determine the allowable limitations in order to obtain a rational model from the proposed list, that will provide the best balance of energy efficiency and complexity of the system.

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PECULIARITIES OF CULTIVATION AGRICULTURAL CROPS BY NO-TILL TECHNOLOGY

Violation, and in many cases, neglect of scientifically sound principles of land use and the basics agriculture lead to intensive soil degradation of Ukraine. Thus, obtaining a programmed harvest with the given consumer properties in the conditions of global climate change and high cost of material, technical and energy resources is possible only under the conditions of observance requirements of agrotechnics to terms and quality works.. It should, also be noted that climate change, caused by rising average annual temperatures, increasing frequency and intensity extreme weather events, including droughts, increases the risk land degradation, their desertification. Unsystematic acquisition of machine-tractor fleet of agricultural enterprises without taking into account the main factors influencing the efficiency of machinery leads to increased production costs.

In the conditions of insufficient moisture supply of soils the positive effect is provided by technology of sowing without preliminary processing of the soil (No-Till), according to agrar science this technology can be applied in Ukraine on area of about 6 million hectares [1]. However, production of agricultural products by No-till technology, both in the world and in Ukraine has a positive trend to increase the area of agricultural land occupied by this production, for example [1], the area of No-Till agricultural systems in world - 160 million hectares, of them: USA, Canada, Australia, Brazil, Paraguay - 95.0%; EU countries - 3.0%; Ukraine - within 2%.

The main features of No-Till production are: the field remains virtually intact from harvest to sowing, except for the introduction of nutrients; the fields are not plowed, and plant remains are left on the ground to provide protection against erosion; the narrow seed bed is prepared by the drill during the sowing operation, which ensures adequate placement of seeds and fertilizers; weed control is carried out with herbicides.

If we compare the most resource-intensive traditional technology (using plowing) with No-Till technology, the advantages of the latter are [2]: significantly saves fuel; reduced number of passes through the field. For No-Till - 3-5 passes of equipment on the field against 12-15 with traditional tillage per season; reduced equipment costs. As a result technical and economic assessment of technological processes and complexes of machines for production of crop products by No-till it established that in the structure of total operating costs: wages are 2%; fuels and lubricants - 6%;

maintenance and repair - 10%; depreciation of 16%; technological materials 55-66% [3, 4]; yield increases; the pressure of the equipment on ground decreases. Unploughed soil under the pressure of moving vehicles or animals is less deformed compared to tilled soil; deteriorating conditions for weed germination.

Plant debris accumulates on the soil surface. Under the action of bacteria, fungi and other microorganisms, they decompose into simpler organic ones. Mulch, by No-Till, delays the entry weed seeds into the soil, lowers the temperature at the surface of the field, creating unfavorable conditions for germination of weed seeds; the temperature regime of soil optimized. If mulch spread on the field surface, the soil has a lower temperature in summer and a higher temperature in winter.

Stubble keeps snow from blowing, which in turn provides effective thermal insulation of the soil and is able to maintain its temperature at 10-15ºC higher; soil structure improves. With the transition to No-Till technology, the natural structure of soil is restored and the strength of soil aggregates increases; content of organic substances in the soil increases.

To work on the No-till technology, the following equipment is required: a direct sowing seeder (stubble seeder), a sprayer and a combine with a device for even spreading of straw and plant residues.

The main link in No-till technology is the seeder. The direct sowing seeder must meet a number of specific requirements: minimal impact on soil structure; it easy to cut a surface layer of soil together with crop residues; ensure the necessary contact of seeds with the soil; optimally apply fertilizers; to control weeds effectively, the distance between rows should be as small as biological characteristics of crop allow; minimize moisture loss through groove that forms the opener. There are several types openers of seeder, namely: disc, anchor, paws and combination, which are used depending on climatic and soil conditions.

Desirable conditions of application of openers of stubble seeders:

- disk - for an arid climate and light or average soils;

- anchor, paw - for humid, cold climate and heavy soils.

Combined coulters allow you to apply locally liquid and solid fertilizers in a coordinated manner relative to the position of the seeds. It is now possible to apply fertilizers with seeds, under the seeds at different depths. This technology has made sowing more difficult, but it allows you to apply fertilizers to the soil exactly where they are needed. Applying fertilizers to seeds in each row has several potential advantages over spreading fertilizers, namely: friendly germination of seeds due to earlier access of roots to nutrients, which will later affect the harvest; advantage over weeds in the fight for nutrients - cultivated plants are the first to gain access to nutrients.

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RATIONAL USE OF NATURAL RESOURCES IN THE PROCESS OF CLEANING THE VENTILATION AIR

The Republic of Azerbaijan has unique reserves and variety of natural resources, developed industrial complex, powerful, a high proportion of export products, qualified workforce resources, an extensive network of educational and research centers.

With the development of scientific and technological progress, the burden on the environment is constantly increasing.

Air pollution by organic pollutants is observed almost everywhere. Removing these substances to meet regulatory requirements is complex and costly. The existing cleaning methods have both advantages and disadvantages, as well as differ in economic indicators. One of the most famous and widespread cleaning methods is adsorption. But it has disadvantages, such as the need for constant control of the sorption capacity of the sorbent, additional costs for regeneration, as well as the disposal of trapped substances and spent sorbent [1]. Natural zeolites are a new type of mineral raw materials and are characterized by sufficient acid resistance and thermal stability, which allows at high temperatures to carry out the process of cleaning gases, which include aggressive impurities: CO_2, H_2S, SO_2, NH_3, N_xO_y, etc.

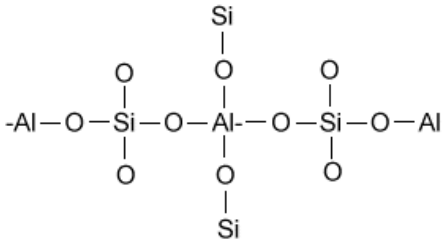
The high acid resistance of high-siliceous natural zeolites makes them irreplaceable absorbers of such aggressive gases as nitrogen oxides and others. These zeolites (clinoptilolite), both during the absorption of nitrogen oxides and during the regeneration process, do not undergo any structural changes and can be reused for gas purification. The selective adsorption of these compounds is explained not only by the molecular sieve effect, but also by the specific nature of the interaction between adsorbents and adsorbents [2].

In this work, we investigated the possibility of using the original form of clinoptilolite (Ay-Dag deposit) in the process of purifying air containing impurities of nitrogen oxides (NO_2 and N_2O).

When cleaning the ventilation air with zeolites from the vapors of various acids over time and especially at their increased concentrations, aluminum atoms are washed out from the zeolite crystal lattice [3]. At the same time, the course of ion exchange processes is observed, in which the ions of sodium, potassium, calcium, magnesium are replaced by the hydrogen of the acid [4].

To study the effect of vapors of sulfuric, hydrochloric and nitric acids on the adsorption capacity and crystal structure of adsorbents obtained on the basis of natural clinoptilolite in the processes of cleaning ventilation air from acid vapors, depending on the duration of work, a

derivatographic research method was used, which provides valuable information on changes in the physical chemical properties of zeolite samples [5].



Zeolite structure

And of received derivatograms natural clinoptilolite observed endothermic effects correspond to the polymorphic conversion of the mineral quartz, contained in the composition of zeolite-containing rocks. An increase in the number of hydroxyl groups and desorbed water molecules from zeolite micropores is also observed, indicating a partial replacement of exchangeable sodium, calcium, potassium, magnesium cations with acid hydrogen.

On the basis of the experimental data obtained, new methods have been developed for the preparation of effective adsorbents based on natural aluminosilicates for cleaning ventilation air.

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ENVIRONMENTAL PROBLEMS OF ENERGY AND WAYS TO SOLVE THEM USING RENEWABLE ENERGY SOURCES

With the intensive development of industry, agriculture and housing and communal services, more than 800 reservoirs were built, fresh water consumption and discharge of polluted wastewater increased significantly. For the needs of industry and agriculture, about 15 billion m3 of water is taken from the Dnipr every year and about 10 billion m3 of untreated wastewater is discharged into it. There are 5 nuclear power plants in the Dnipr basin. Sewage contains excess ammonium and nitrite nitrogen, petroleum products, phenol, heavy metal salts and organochlorine pesticides.

Natural gas is the most environmentally friendly type of fuel, but in this case nitrogen oxide, sulfur dioxide, gaseous products of incomplete combustion are released. Pollution from power plants is 22% of the total, which is one and a half times more than pollution from industry.

Methods of using renewable energy - solar, wind, geothermal, wave energy, tides, biogas energy, etc. - are being intensively developed. The sources of these types of energy are inexhaustible, but it is necessary to reasonably assess whether they can meet all the needs of mankind.

Hydropower is an important systemic economic factor that ensures the required quality of electricity in Ukraine. In addition to the unique energy component at a level sufficient to compensate for the peak loads of the energy system, hydropower also addresses issues: shipping, flood loads, water supply, irrigation, overcoming devastating droughts and dry winds, relevant climate change. National HPPs of the Dnipr and Dniester cascades play an extremely important role in ensuring the reliable operation of the integrated power system of Ukraine, balancing electricity during the day, as an emergency and frequency reserve of the power system. They are a mobile reserve of power system capacity. Moreover, the role of HPPs and PSPs is growing sharply in ensuring the reliability of NPPs and in the conditions of rapid development of wind and solar power plants with variable nature of electricity generation. Already, due to the lack of balancing capacity in the power system, the operation of wind and solar power plants is periodically limited.

Wind energy is used to produce mechanical or electrical energy. When using wind there is a serious problem: excess energy in windy weather and lack of it during windless weather. The use of wind energy is complicated by the fact that the wind has a low energy density, and also changes its strength and direction.

Solar energy is suitable either for the production of low-potential heat or for the production of electricity. In the first case the flat solar collectors which are not concentrating (the heat carrier - water, air, antifreeze) are applied. Electricity from light flux can be produced in two ways: by direct conversion in photovoltaic systems or by heating the coolant, which performs work in a thermodynamic cycle.

Geothermal energy uses the high temperatures of the deep bowels of the earth's crust to generate thermal energy. In some parts of the Earth, especially at the edge of tectonic plates, heat comes to the surface in the form of hot springs. In other areas, underwater sources flow through hot underground layers, and this heat can be removed through heat exchange systems. Iceland is an example of a country where geothermal energy is widely used.

Biomass is a fairly broad class of energy resources and includes wood, waste from the woodworking industry, agricultural and household waste. Biomass, which is grown regularly, and its use as an energy source is not accompanied by a decrease in the number of green spaces in the

region, is recognized as a renewable resource and is considered environmentally neutral (has a zero balance of carbon dioxide emissions).

Currently, combined systems are being actively implemented. For example, solar collector systems with a heat pump. The combination of heat pumps and solar heat systems can be implemented in different ways.

Option 1: The solar installation works on a large storage tank, and the heat pump covers peak loads in the coldest periods. This option is a fairly simple combination, but requires a significant volume of the tank. The efficiency of this solution is very high, as a significant share (more than 50%) of heat needs is covered by free solar energy. A great addition to this solution can be a photovoltaic system that will supply electricity for the heat pump.

Option 2: Solar energy is used to regenerate the geothermal field and store heat in the ground. The soil retains this heat for many months, ensuring high efficiency of the heat pump during the heating period. In this case, a heliothermal installation can be used, which heats hot water and supports the heating system, and discharges excess heat into the geothermal circuit. A separate solar system can also be installed to store heat in the soil.

Option 3: use of a solar absorber as a heat source for the heat pump. Even in winter, when the collector temperature is only a few degrees above the outside air, this solution increases the efficiency of the heat pump. Most often, the solar absorber is combined with another heat source, such as a geothermal horizontal collector and serves to raise the temperature of the coolant in the primary circuit. The solar absorber can have various forms: the absorber panels placed on a roof or walls of the building, a fence from absorbing pipes,an absorber arranged under the road surface or integrated into the bridge structure and others.

Option 4: use of phase transition heat to accumulate solar energy. This technology is better known as the ice tank (Eisspeicher). An ice tank is a container that is filled with plain water. The tank is placed in the ground, below the depth of freezing. Two heat exchangers are mounted inside the tank. The first is connected to a heat pump, the second - to a system of solar absorbers. The heat pump removes heat from the tank until the entire volume of water freezes. Then the tank is regenerated due to the heat of the soil and the heat of the air and the sun (using a solar installation). Due to the fact that water emits a lot of thermal energy during freezing (330 kJ / kg), the ice tank manages to accumulate a large amount of solar energy.

Renewable sources (apart from the energy of falling water) have a common disadvantage: their energy is very poorly concentrated, which creates considerable difficulties for practical use. The cost of energy from renewable sources (excluding HPPs) is much higher than traditional ones, but at the same time, only renewable energy sources can guarantee a certain energy and environmental security of Ukraine. International approaches, state support and the development of combining

methods are needed to achieve environmental and economic success in this regard. Research and use of combining methods is one of the areas that will help solve this problem.

In Ukraine, the only officially permitted case of overflow of excess capacity for sale or in the mode of "using the network as a battery" is the issuance of a "green tariff". The application of the "green tariff" usually includes the use of the following tools: 1) guaranteed access topower grid, long-term contracts for the purchase of electricity, 3) the establishment of relatively high purchase prices that take into account the cost of renewable energy sources. It should be noted that in a number of relationships it is beneficial for household consumers to allow zero tariffing of excess flows into the network and the absence of fines for it or accounting for it as consumed.

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IS BIOMASS ENERGY SUSTAINABLE? ANALYSIS OF SELECTED INDICATORS OF SUSTAINABILITY

The sustainable development of our planet is the integration of the economy, environment and society. In every aspect of life, indicators of sustainable development should be implemented, which define the direction of development of societies, the world economy and selfless care for nature. The demand for clean energy is currently a key global problem in which global ideas are realized through local actions.

Renewable energy means energy derived from natural processes, obtained from non-fossil energy sources. The resources from these sources complement each other in natural processes, which allows them to be treated as inexhaustible [1]. The European Green Deal [2], which provides guidelines for a sustainable ecological transformation, predicts that in 2050 Europe will be the first continent in the world without damaging the climate. The energy policy of the European Union countries assumes providing the society with a reliable, cheap and environmentally friendly energy supply. With the forecasted continuous increase in energy consumption, the energy sector should be transformed in the direction of minimizing the negative impact on the climate.

The use of renewable energies has many benefits, including reduction of greenhouse gas emissions, diversification of energy supply and independence from fossil fuel supplies. The development of renewable energy sources ensures employment growth in the green technology sector.

Solid biofuels include organic, non-fossil material that is used as fuel for the production of heat or electricity. Solid biofuel is firewood (briquettes, pellets and forestry waste), energy crops and organic residues from agriculture and horticulture (horticultural wastes, animal excrements, straw) [3].

A short analysis of the implementation of the assumptions of biomass-based energy for selected indicators of the social, economic and environmental pillars is presented below.

The indicator of the social pillar is the exposure of the urban population to the excessive impact of PM10 dust (domain: public health). Biomass contains 4 times more oxygen than steam coal and 2 times less carbon element, but also less sulfur, nitrogen and ash. In addition, it is characterized by a high content of volatile parts (65-80%) and high reactivity, which necessitate the use of appropriate technical solutions during energy conversion. The consequence is a higher proportion of emitted dust particles PM10 and PM2.5. Fly ash from biomass contains much less metal atoms (Ti, Al, Fe) in the elemental composition than coal dust [4]. In the economic pillar, attention should be paid to the eco-innovation index. An example of an eco-innovation process is the use of biomass in energy production. By using biomass in the energy sector, we prevent food surplus wastage, manage production waste from the forest and agricultural industry, and utilize municipal waste. However, Poland is one of the least eco-innovative countries in the European Union.

The environmental pillar is implemented through the indicator: greenhouse gas emissions in CO_2 equivalent (domain: climate change). Emissions are the total annual man-made greenhouse gas emissions in relation to the base year 1988 emissions of the Kyoto Protocol, excluding emissions from international aviation and international maritime transport, and land-use change and forestry. Greenhouse gas emissions are defined as the aggregate emissions of six greenhouse gases (CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons, SF_6), weighted with global warming potentials based on a 1988 base of 100. The equivalent of carbon dioxide is 1 Mg or the amount of other greenhouse gas equivalent to 1 Mg of carbon dioxide, calculated with the use of global warming potentials.

The arrangements made in Kyoto are considered to be one of the first steps of the international community to formalized action for effective environmental protection. The obligation to reduce greenhouse gas emissions in the first period (2008-2012) was fulfilled by Poland with a surplus (reduction by 29%) [5]. It happened thanks to the use of alternative energy carriers, including biomass, which has a great advantage: during its combustion, CO_2 emissions are equivalent to the amount of CO_2 taken during photosynthesis. The emissions of sulfur dioxide, nitrogen oxides and carbon monoxide are also lower than in the case of combustion of fossil fuels.

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TECHNOLOGY OF WATER USE ON THE EXAMPLE OF ZAPORIZHZHY IRON ORE PLANT

Most major water users do not implement effective water saving measures, there are no modern water-saving technologies that would help save Ukraine's water resources, and utility users do not think about the fact that water may stop flowing from the tap tomorrow. These issues in the context of climate change, last year's and this year's hydrological conditions are extremely relevant [1].

The most rational, from the point of view of ecologists, is the use of natural phenomena, namely evaporation. The two main components of the technological cycle are of the greatest environmental importance - the bookmark of the produced space and the utilization of mine waters.

So far, no domestic enterprise has solved these problems, except for the enterprise with foreign investment in the form of a private joint-stock company "Zaporizhzhya Iron Ore Plant" (PJSC "ZZRK"), the largest enterprise of the mining and metallurgical complex of Ukraine, which produces rich iron ore underground. by a bookmark of the made space by the mixes (a bookmark) hardening. Balance reserves of rich iron ores in the Belozirsky iron ore district are 581 thousand tons and 234 thousand tons of magnetite quartzite. The iron content in the mined ore is much higher than the quality of ores in the Kryvyi Rih region and other iron ore deposits in Europe.

Sewage from the industrial site is diverted to the filtration fields of PJSC «ZZRK» sown treatment facilities. After treatment, wastewater is not discharged into an open reservoir, but drained and evaporated in a drainage channel 13.5 km long. 266.9 thousand m^3 of wastewater was allocated to filtration fields. PJSC "ZZRK" emits greenhouse gases in the following quantities: methane - 0.188 tons, nitric acid - 0.001 tons, ammonia - 0.362 tons, oxide and nitrogen dioxide in terms of nitrogen dioxide (NO_2) - 15.17 tons. In total, emissions of nitrogen compounds amounted to 15,533 tons, and the total for the enterprise (excluding carbon dioxide) was 15,721 tons. Thus, the total amount of greenhouse gas emissions at the enterprise is 5,472.91 tons / year.

The main source of greenhouse gas emissions is the industrial site boiler house when using fuel oil as fuel for the heating season. The company is a leader in the use of naturally harmonized technologies in the extraction of iron ore. It uses a set of innovative environmental technologies for mining, which includes such key areas as: the system of field development with the laying of the produced space; conservation of water resources (use of mine water on the complex of the bookmark; minimal impact on the subsidence of the earth's surface and, as a consequence, the elimination of land flooding; no impact on the hydrogeological conditions of aquifers used for drinking water supply in the region; as well as the use of natural phenomena, namely evaporation, for the disposal of mine water); application of safe blasting technologies; complex mechanization of mining operations.

The use of these innovative technologies at the enterprise allows to achieve a significant environmental effect. In particular, to achieve: preservation of the stable state of the ore massif, the integrity of the earth's surface and aquifers; reduction of ore losses; mass utilization as a part of a mortgage mix of industrial wastes of metallurgical production, rocks of a dump, secondary resources of the industry and system of drainage of a deposit; surface water treatment and accumulation with the exception of discharge of fresh water into open watercourses; minimization of harmful gas emissions into the atmosphere; exclusion of unauthorized explosions; maximum reduction of harmful load on the health of workers; reduction of consumption of human, material and energy resources, etc.

In general, the impact of mine water discharge on the region's water resources at the plant is 46.8 times less than when using a chamber system with the collapse of ore and host rocks.

The technologies that are implemented and applied at the enterprise in terms of integrated environmental impact are 11 times different in the best way from traditional technologies for the development of deposits underground.

Treatment of a mixture of domestic and industrial wastewater from the industrial site of the plant is carried out in two stages. The first is mechanical, which includes: sand trap and two-tier settling tanks [2,3]. The second is biological in the filtration fields [4,5].

12.5 thousand m^3 of water was extracted from the well № 1031-U and received for desalination. After the desalination plant, 5.5 thousand m^3 were used for domestic and drinking needs, and 7.0 thousand m^3 of normatively clean return water was diverted to the Utlyuk estuary of the Sea of Azov.

Sewage from the industrial site is diverted to the filtration fields of PJSC ZZRK's own treatment facilities. After treatment, wastewater is not discharged into an open reservoir, but drained and evaporated in a drainage channel 13.5 km long. Over the last year, 266.9 thousand m^3 of wastewater was allocated to filtration fields.

The treated effluents, after filtering through the soil layer, enter the overdried drainage ditch through the system of drainage pipes. Discharge of treated wastewater from the drainage canal is carried out into the drainage channel and then into a closed reservoir - Verbova beam. Given the large length of the discharge channel, the treated wastewater does not reach the Verbov beam, but drains and partially evaporates on the way and therefore in fact there is no discharge into the beam.

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REDUCING ENVIRONMENTAL RISKS OF AQUATIC TECHNICAL FLUIDS

The risks of aqueous technical fluids are determined by the ingredients that are dissolved in water, namely, their danger to people and the natural environment. The dangers of aqueous technical fluids (HTF) are mostly latent in nature (chemicals dissolved in water, various oils, surfactants, etc.). However, such dangers as microorganisms that appear and actively develop in HTF during their operation can be identified without the use of devices, because the products of their vital activity, including gases, are determined by organoleptic methods visually and by smell [1].

HTF contains such substances: glycol; anionic and nonionic emulsifiers, fatty additives; organic and inorganic corrosion inhibitors; extreme pressure additives; polyalkylene glycols; industrial and

mineral oils; oil asidol; sodium hydroxide; bactericidal drugs – hexachlorophene, caustic soda, sodium sulfates, molybdenum disulfide, technical iodine, chloroparaffin and others. The most dangerous are pickling solutions and cutting fluids (CF) [2].

The environmental hazard of pickling solutions is determined by the presence of ions of chromium, cobalt and other substances in them, and besides this, the high aggressiveness of solutions is determined by their acidic or alkaline properties [3].

The presence of microorganisms in CF (sometimes in cleaning solutions), despite the fact that they are classified as hazard class 4, translates them into the category of hazardous and very hazardous liquids. Conditionally, it can be assumed that microorganisms can be attributed to the first class of hazard, because their concentration can be significant, especially in the coolant (10^7 - 10^9 bacteria per ml) and pathogenic bacteria can develop there [4].

The problem of liquid waste in production is not only environmental problems but also economic damage to the enterprise, due to the low coefficient of water use in technological processes. There can be only one solution to this problem, the improvement of technological operations with the inclusion in the flow chart of the process, devices that ensure the correction of the changing properties of solutions. The experience of using such technologies on the example of using EGT-type cutting fluids in technological operations has shown that a process solution can work for up to 5 years without deteriorating its quality indicators, and this is not the limit [5–7].

We investigated washing technological solutions, galvanic working solutions and rinsing water, condensate formed during the use of compressors, oily water and others. As a result of the research, well-known and widely used technologies and devices were tested, and new methods and devices were developed [5-7].

Lubricating and cooling liquids prepared on water must function for at least a year in production, this is achieved by: organizing their correct storage, providing protection against bacteria, removing mechanical impurities and oils; the correct organization of the functioning of solutions in the system of pipelines and containers; the presence of sensors that register changes in the number of bacteria in the solution and others. In order to ensure such conditions, we had to develop new, unparalleled devices that very effectively provide the required operating parameters. Naturally, no matter how long the liquid works in production, the question of its disposal may arise. And in this case, it is necessary to use a technology that allows, without the use of any energy-intensive and expensive influences, to separate the solution into water and impurities. Applying microbiological destruction performed on the raw materials of the enterprise, at minimal cost, a good result was obtained. The separated water is reused to prepare a new solution. It is necessary to pay attention to the fact that this water has a lower salt content, and therefore with better technological indicators [4].

Enterprises use a significant amount of cleaning solutions, which, as a rule, after their use, fall into the category of liquid waste. Studies performed on detergents with OP-7 showed that these

solutions after a while in their composition begin to resemble cutting fluids. In their composition there are detergents that contribute to the emulsification of the entering oils, mechanical impurities and after a while of bacteria. The technologies and devices developed by us also allow extending the time of application of cleaning solutions for a long period of time.

A significant problem for production is oil-containing wastewater. Such waters are formed during the implementation of various technical processes where water is used. Applying the designs of electrical devices developed by us, it was possible to provide cleaning from oil products with an initial concentration of 3000-5000 mg/l to 2-5 mg/l and less. The studies were carried out on an industrial plant and showed the promise of such technologies [8].

Condensate forms where compressors are used which then forms a stable emulsion when mixed with impurities and oils. Applying the technologies of electrochemical purification, we have achieved a high efficiency of oil extraction from condensate. The main problem was to provide purification of solutions with very low electrical conductivity but it was also solved.

Conclusion

In modern conditions, it is necessary to strive for the rational use of fresh water and minimization of liquid waste, using for this advanced scientific developments that will ensure the requirements put forward by the world community for production and technological processes.

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SOME ENVIRONMENTAL CHALLENGES OF THE SOUTH KAZAKHSTAN AND MANAGING THEM

The intensive development of the phosphorus industry in South Kazakhstanduring the 1960s-80s and the Karatau phosphorite deposit made the region the world leader in producing yellow

phosphorus and derivatives based on it. However, the positive economic development, the region experienced a significant impact on the deterioration of the environment.

The acidic method of processing (extraction by phosphoric acid, for fertilizers) involves the emission of fluoric compounds, sulfuric and phosphoric acid vapours that discharge into the atmosphere, and the storage of a vast amount tailings of phosphogypsum. The problem of utilization and neutralization of phosphogypsum has not yet been successfully solved anywhere.

The production of elemental yellow phosphorus (by electrothermal reduction from phosphorites) results in toxic gas emissions, solid and liquid waste, and large amounts of sludge. The phosphorus content in sludge varies widely from 0.1 to 40% and above.

Sludge with over 40% phosphorous content ("rich" sludge) can be processed into thermal process phosphoric slurry acid. However, it could be inferior in quality to thermal phosphoric acid based on elemental yellow phosphorus but suitable for producing products that are tolerant to some micropollutants.

It should be noted that the Karatau phosphorites has a smaller content of the main substance P_2O_5 and a larger content of impurities, including carcinogenic ones, in comparison, for example, with Kola apatites, or Moroccan, or Syrian phosphorites.

Fertilizers obtained from Karatau phosphorites do not fully meet the current requirements for environmental safety of production and consumption of agricultural products and environmental protection. At the same time, one of the main directions of increasing the fertility and protection of land resources is environmentally friendly fertilizers.

As, Cd, Hg, Pb, F, radioactive elements and their compounds, getting into the soil with fertilizers, then migrate to agricultural, fodder and food products, and, therefore, have a detrimental effect on humans. There is an accumulation of harmful substances in the soil layer (especially in the case of using fertilizers with prolonged action) and their gradual "leaching" into water bodies and rivers, poisoning the fish fauna and drinking water.

Agriculture cannot do without fertilizing the soil with phosphate, potash, nitrogen and other fertilizers, due to a decrease in the yield of various crops.

In the current conditions, we have prepared technical proposals for organizing the production of environmentally friendly chemical products and for the disposal of gas and liquid emissions at chemical enterprises of the Republic of Kazakhstan. Technologies for obtaining high-quality phosphorus-containing fertilizers from Karatau phosphorites have been developed. Thanks to the application of new purification methods, the resulting fertilizers are environmentally friendly. Their use in agriculture will increase yields and represent a promising direction in terms of protecting land resources and preserving the biosphere.

Two technological paths have also been developed to dispose of "poor" phosphorus-containing sludge with phosphorous compounds with P_2O_5<15-25% and phosphorus in the elemental state 0.1 to 3-5%.

According to the first option, the initial separation of yellow phosphorus is possible, followed by the sublimation of rare and trace elements at a high temperature. After cooling the sublimates of rare metals, they are treated with mineral acids to transform them into a soluble state, and the stages of extraction, re-extraction, separation and concentration are carried out, followed by heat treatment (redox roasting) of the obtained raffinates. The extraction step is carried out with alkyl phosphates, alkyldithiophosphates and tributyl phosphate. Kerosene or saturated hydrocarbons can serve as an inert diluent, and higher alcohols, for example, 2-ethylhexanol, can serve as active additives.

The second option for neutralizing the contents of sludge collectors of phosphorus industriesproposes the production of fertilizers only after the separation of elemental phosphorus (which is a self-ignitor) from the mineral part. This procedure is similar to the first method, where all elemental phosphorus is separated by heat treatmentprior to the processing of the mineral part with 17-18% P_2O_5. In the case of low content of elemental phosphorus in the sludge (0.02 - 0.5%), it is possible to treat it in the initial state with a mixture of nitric and sulfuric acids in the presence of phosphorite flour to increase the P_2O_5 content, followed by thickening of the pulp in the presence of a coagulant, drying and calcining the material to obtain fertilizers. However, the significant spread in the phosphorus content in the sludge makes this method of obtaining fertilizers less promising.

All proposed options for processing "poor" sludge from phosphorus industries provide for the complete utilization of gas emissions.

The contents of sludge collectors of phosphorus plants, in which not only elemental phosphorus and fluorine are accumulated, but also a whole range of elements, along with other technogenic wastes, must be considered as secondary raw materials for obtaining several valuable commodity products, in particular, high-quality mineral fertilizers that have practically unlimited demand in agriculture. The technical and economic indicators of the process can be significantly improved due to the associated extraction of rare earth elements from the sludge and the release of environmentally friendly building materials.

A comprehensive solution to the problem under consideration makes it possible to significantly improve the environmental situation in South Kazakhstan and thereby solve several social, economic and ecological challenges.

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INVESTIGATION OF CHANNEL PARAMETERS FOR REMOVAL OF DUST AND LIGHT GARBAGE IMPURITIES FROM THE PNEUMATIC SEPARATOR

During the separation of grain material into fractions, removal of light debris and dust together with part of the air on the DOC (dust outlet channel), bypassing the fractionation chamber, increases the purity and quality of feed fraction [1-3]. The DOC fractionation chamber of rectangular section has a curvilinear section, as well as a rectilinear part.

The air flow entering the curved section of DOC by inertia continues to move rectilinearly tangential to the inner wall of the channel towards its outer wall, which leads to formation of a zone of separation of flow in the inner wall and, consequently, to possible dust accumulation on surface channel walls. The accumulated particles can reduce the throughput of DOC, increasing the energy consumption of the grain cleaning process, or fall back into the zone of pneumo-separation, reducing the coefficient of light impurities, or carried into the sediment chamber, increasing the concentration of impurities and reducing the efficiency deposition. Therefore, the deposition particles on inner surface wall the DOC violates the quality of pneumatic separator.

To reduce or eliminate the deposition of particles in this area, the air flow rate should be close to a uniform cross-section the channel, which can be achieved by compressing the air flow by performing the channel on a curved section in form of a confuser and, accordingly, the ratio of h_{PSC2} areas to a depth of h_{PSC1} its input section is less than one.

For the considered channel made in the form of a confuser, energy losses will be insignificant and can neglected. The condition of Bernoulli's equation will look like [4-6].

At the same time, the equation of continuity of the air flow passing through the channel has the form [6].

The new equations [5,6] sufficiently characterize the quantitative and qualitative side of air flow in considered channel. Narrowing the passable section of the curved section of the channel leads to equalization the velocity pressure of air to its depth, reduction of turbulence due to its movement with acceleration, at which the static pressure P_S decreases and the dynamic P_D increases. These circumstances lead to a decrease in deposition particles on the surface of inner wall of the curved section of the channel.

In addition, it should noted that when moving the particle along the channel, the velocity υ_P of air flow in the curved section is less than in the rectilinear part. Therefore, the rectilinear part the

channel in the structural relation towards the original section can made with an extension determined by the angle γ_{B1} of the inclination of its inner wall.

The zone of separation of an air stream arises at disturbance of smoothness of surfaces of walls of a channel and at sharp change of radius of its curvature. To eliminate or reduce the zone of separation of air flow from the wall of the channel, its inner and outer walls must be made in the form of circular cylindrical surfaces, and the tangent plane to the wall surface must continuously change the angle of contact.

It should also be noted that increasing the radii R_C and R_B of the outer and inner walls of the curved section of the channel leads to a decrease in the separation zone of air flow. However, the value of the radius R_C of the outer wall of the channel is limited by the height of the channel [4,5,6].

The largest radius R_{B1} of arc of inner wall of channel most effectively reduces the deposition of dust on it. Knowing R_C, h_{PSC1} and h_{PSC2}, you can find R_{B1} and the position of the point O'.

Analyzing the dependence [6], we can conclude that depending on the values of h_{PSC1}, h_{PSC2} and α_{PSC}, the radius R_{B1} of inner wall of the channel can be both larger and smaller than the radius R_C, its outer wall. This design of the inner wall of the channel contributes to a more uniform distribution of the spectrum of velocities υ_P of air over the depth of the channel.

To estimate the ratio of the values of $h_{PSC2}/h_{PSC1}<1$, we assume that the "core" of the air flow leaving the channel depth $h=h_{PSC1}$ in cross section M_1M, in the output section B_1B of curved section the channel completely fills it.

Dependencies [6] allow to substantiate the rational structural shape channel of separation chamber the pneumatic fraction separator. For the selected separation chamber with the height of the upper part Y=1.0 m, the angle of inclination of the PSC α_{PSC}=70°, the depth h=0.20 m and the height of its upper part H_{KR}=0.14 m when installing the leading edge of the inner wall (reflective plane) channel at a height of $Y(Y_{PSC})$=0.48 m and the distance h_{PSC1}=0.20 m from the outer wall of the chamber radius R_C rounding is 0.38 m, the value of h_{PSC2} for speed air flow (already in the form of some jet) υ_{PS}=5-7 m/s should be not less than 0.14-0.17 m, and radius R_{B1} of rounding - 0.27 m. Decreasing this value will increase the resistance the channel, as a result of which part the air with dusty impurities, bypassing this channel, will enter the separation chamber, causing a deterioration in quality of cleaning the feed fraction. Thus, in order to determine the conditions of effective fractional separation the components of the grain material, analytical equations are obtained to calculate the structural shape channel of the separation chamber, which allow to justify a rational scheme of machine design.

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ASSESSMENT OF ENVIRONMENTAL DAMAGES AND POSSIBLE CONSEQUENCES OF CROSS-BORDER GROUNDWATER PUMPING BY KHOTYSLAVSKY QUARRY

The development of the Khotyslavsky quarry, namely the extraction of chalk is carried out at a depth of about 12 meters from the earth's surface by the open method. The area of the quarry in 2009 was 10 hectares, in 2013 - 30 hectares, in 2019 more than 40 hectares. Predictive modeling of the development of the Khotyslavsky quarry, where water is pumped out for chalk extraction, shows that as a result of water lowering in the quarry of the groundwater (GW) level, a large-diameter depression funnel is formed around it in quaternary and upper cretaceous deposits, due to its GW being hydraulically connected. Similar hydrodynamic changes have been demonstrated in many studies of different extraction regions (Diachenko, 2013, Koščová M, 2018). Within the area of influence of the quarry, the water regime of the Rivers Rita, Malorita, Tursky Canal, Lakes Svyate, Dovge, Krymno, reservoir Turske, the hydrogeological conditions of the quaternary aquifer and, as a result, the water-air regime of soils will change during the projected drainage. All this will further reduce the productivity of agricultural land, reduce the growth of forest resources, disrupt the existing system of drinking water supply of settlements on the border with the Republic of Belarus (Diatel, 2018).

Given that the Khotyslavsky quarry is located at the watershed of the Baltic and Black Seas, the depression will remove water from the river basins of the Black Sea and feed the Rita river, which already belongs to the Baltic Sea basin.

The minimum losses that will be caused by inter-basin pumping of GW and the cost of pumping of a cubic meter of water is calculated according to the method of forming the cost of water supply services for irrigation, industrial and municipal needs (Romashchenko, 2012). Given

that we do not know the technological schemes for pumping water from the quarry, the number of pumps, their performance, electric power, and to simplify the calculations, we take the cost of pumped water about 1 UAH/m^3.

According to the official data of the Belarusian side, in 2009 the outflow (Q) from the quarry was 1500 m^3/day, 1200 m^3/day in 2013, 7176 m^3/day in 2015, 8836 m^3/day in 2016 and 10428 m^3/day in 2017 (Letter of the MNR of the Republic of Belarus 2016, 2017, 2018). We estimate that during the operation of the quarry at full capacity the drainage will be 27732 m^3/day and will be equal to the amount of water inflow.

Thus, due to the inter-basin transfer of water from the Black Sea basin, more and more damage is inflicted every year. Hence, at the beginning of operation, in 2009 and 2013, the losses amounted to about 500 thousand UAH/year. Starting from 2015, the outflow from the quarry is increasing, and therefore the amount of losses is increasing, which in 2015 amounted to UAH 2,619 thousand/year, and in 2017 - UAH 3,806 thousand/year. When the quarry is operating at full capacity, according to our calculations, the environmental damage will amount to UAH 10,122,000/year only due to the reduction of the water content of the Black Sea river basins.

In addition, there will be negative environmental consequences, which are difficult to assess in monetary terms, in particular, the quarry in the development will reveal the aquifers of groundwater and marl-chalk layer of Cretaceous sediments (a single aquifer complex). This will have unpredictable negative environmental consequences for Volyn Polissya. Possible disappearance of such reservoirs as lakes Svyate, Crymno. lake Svityaz and others will be washed away and the area of their water mirror will be reduced, and the shoreline will be swampy, which will lead to a decrease in recreational resources. It is possible to re-drain more than 40 thousand hectares of agricultural and forest lands. This will reduce crop yields by up to 50%. Numerous settlements will fall into the zone of influence, in the domestic wells of which water is likely to disappear, which will require additional financial resources to provide the population with drinking water. Unique ecosystems of alder and pine forests growing in the Polissya zone may be affected by the decrease in the groundwater level, and their bioproductivity will be significantly reduced. Various protected areas, reserves and forest monuments are also negatively affected.

Analysis of water exchange data (Gadzala, 2018) of the main lakes of Shatsk Park: Svityaz, Pulemetske, Luki, Lucimer, Pisochne, Ostrivne, Chorne Velyke, Somynets shows that in the lakes located at a distance of 12-18 km from the quarry, the water exchange has decreased by 2.6-5 times over the past five years, that is, the Khotyslavsky quarry already has a negative impact on this area and there is a danger of dehydration of the Shatsk National Park, especially in the context of global climate change.

The systemic environmental problems of the transboundary impact of quarry activities additionally include the fact that some types of hydrophilic flora and fauna may disappear when groundwater levels fall by even one meter. Increasing the filtration rate in the horizons of pressure GW can lead to intensification of karst processes in marl-chalk rocks and unpredictable consequences of changing the direction of GW and the emergence of karst dips, which will threaten the existence of lakes. Given the fact that most of the lakes of the Shatsk group are of karst origin, their shallowing will significantly affect the ecological condition not only of the park, but also in general on the recreational resources of the Shatsk NNP.

Due to such predictable environmental consequences in the area of impact of the quarry, it is necessary to apply environmental measures aimed at localizing the depression funnel, which is formed in the process of drainage, in order to prevent irreversible changes in the ecological state of the study area.

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AN EFFECTIVE WAY TO MAINTAIN THE LIQUIDATED MINES

In recent years in Ukraine, the functioning of the fuel and energy complex elements needs significant correction. This is due to the rapid development of renewable energy, both environmentally friendly and cheaper to produce. This trend, of course, is obvious, because such energy sources could in the future develop an active role in shaping the operation modes of the power system, i.e. to replace the shunting power designed to cover peak loads. Currently, the use of thermal power plants (TPPs) plays a

significant role as shunting capacities, the main fuel for which is coal and therefore their operation is environmentally unsafe. In addition, all existing TPPs have a service life of more than 20 years and, accordingly, outdated equipment, the efficiency of which is quite low. As a result, there is a question of the feasibility of further operation of thermal power plants, and with it the need to maintain coal mines for coal production. The main stages of the state "view" on the current situation are reflected in the latest version of the "Energy Strategy of Ukraine for the period up to 2035" from 08/18/2017 [1]. It envisages the decommissioning of fossil fuel power plants, which provide ~80% of current production (~20-25 GW), by 2035, without the possibility of extending the service life. They will be replaced by the design and construction of new facilities, including shunting - to balance the energy system. Such forced steps will be accompanied by measures to implement strategic goals in the coal sector, namely the reorganization of coal and other state-owned enterprises in the coal industry, restructuring of the sector, preparation of promising state mines for privatization, and liquidation/conservation of unprofitable state mines. In addition, during the conservation and liquidation of mines, measures should be taken to reduce environmental risks, among which the greatest threat is: landfills and burning waste heaps, possible landslides; violation of the hydrological regime and flooding of the soil surface with water; exit to the earth's surface of methane from closed mines. This is certainly the right approach in terms of the environmental situation, but in some ways limits the number of mines that are closed, the possibility of their elimination by so-called "wet" conservation. In this case, such mines are subject to "dry" conservation, which is more expensive than "wet".

"Dry" conservation means that the equipment for pumping mine water (main dewatering plant) is located inside the mine and must perform its function to prevent complete flooding, despite the closure of this mine. This in turn leads to forced unprofitable maintenance of such facilities. But the level of monetary costs for the operation of the mine dewatering plant can be minimized by regulating the modes of electricity consumption of the dewatering system [2].

In [2] the main approaches and algorithms for determining the most energy efficient mode of electricity consumption when applying a differentiated by zones of the day tariff for electricity are given. It can be possible by changing the operation mode of the electrical installation by transferring maximum power consumption to periods of minimum loads in the power system. Thus, such measures have a more global idea, as they are aimed at leveling the load diagram of the power system. As for consumers, this approach will not only save money, for example in paying for the maintenance of liquidated mines, but also to determine the most energy-efficient operation mode of the electrical installation, namely the mode with the minimum specific consumption of electricity.

Unfortunately, in Ukraine, from January 1, 2019, the decision of the National Commission Implementing State Regulation in the Fields of Energy and Utilities, differentiated by time periods (for non-household consumers) and the supply of electricity to consumers is now carried out at free prices.

However, if we analyze the current market for electricity sales, the price level corresponds to certain areas of the day and changes to them. That is, in the periods corresponding to the clearly expressed maximum load in the power system, electricity prices are the highest, and in the periods of minimum load (usually at night) the prices are the lowest. In addition, the periods of maximum and minimum loads are defined by the relevant National Commission Implementing State Regulation in the Fields of Energy and Utilities and correspond to only two periods of the day.

Conclusions. The maintenance of most of the liquidated mines is ensured by their constant maintenance in a "dry canned" state by pumping groundwater by mine dewatering plant. However, the application of regulation the power consumption modes by the main dewatering plant will reduce the cost of electricity consumed.

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DETERMINATION OF KINETIC CHARACTERISTICS OF THE SULFUR OXIDE(IV) ABSORPTION PROCESS BY A SOLUTION OF IRON(II, III) COMPOUNDS

The most effective methods of desulfurization of gas emissions are chemisorption methods, which are improved by using liquid-phase oxidation of sulfur (IV) oxide, for example, by introduction of oxidation catalysts (transition metal compounds: manganese (IV), iron (II, III), etc.) into the absorption solution [1-5]. The processes occurring in such solutions are poorly studied, the information about the rate of sulfur (IV) oxide chemisorption is mainly related to the processes of sulfur(IV) oxide absorption and oxidation by water objects in natural conditions.

The lack of a unified approach to the description of the processes occurring in the system H_2O-O_2-SO_2-SO_3-Fe(II)-Fe(III) causes the necessity of carrying out theoretical and experimental studies of these processes and determining the influence of different parameters on the speed and efficiency of sulfur (IV) oxide absorption by solutions containing iron(II, III) compounds.

To study the process of sulfur (IV) oxide absorption by a solution of iron (II, III) compounds, a gas mixture containing sulfur (IV) oxide concentration of 0.20-4.00 g/m^3 was used. For absorption of sulfur (IV) oxide, aqueous solutions of iron (II, III) salts with iron concentration of 10-84 g/m^3 were used. The choice of concentration of the absorbing solution was caused by the method of

obtaining solutions of iron salts in the diaphragmless electrolyser, as well as by inexpediency of using solutions with bigger concentrations because of high power consumption for their obtaining and possible return of the absorbent to sulfuric acid production. The temperature range of the absorption process research is 22-80 °C. The content of sulfur (IV) oxide in the gas before and after absorption is determined by photocolorimetric method.

To determine the kinetic characteristics of the absorption process, the dependences of the concentration of the absorbed sulfur (IV) oxide in the absorption solution on time were obtained. It was found that an increase of sulfur(IV) oxide concentration in the gas and the process temperature in the investigated range leads to an increase of the amount of absorbed sulfur(IV) oxide (Fig. 1).

Maximum possible amount of absorbed sulfur(IV) oxide is observed at initial concentration of sulfur(IV) oxide in gas 4.00 g/m^3 and temperature 80 °C [6,7]. Increase of an absorbing capacity of the solution at temperature increase testifies to occurrence of chemical reactions in a reaction volume. The kinetic curves have S-shaped form, the induction period of sulfur(IV) oxide absorption is clearly visible at the initial moment of time from 0 to 10 minutes.

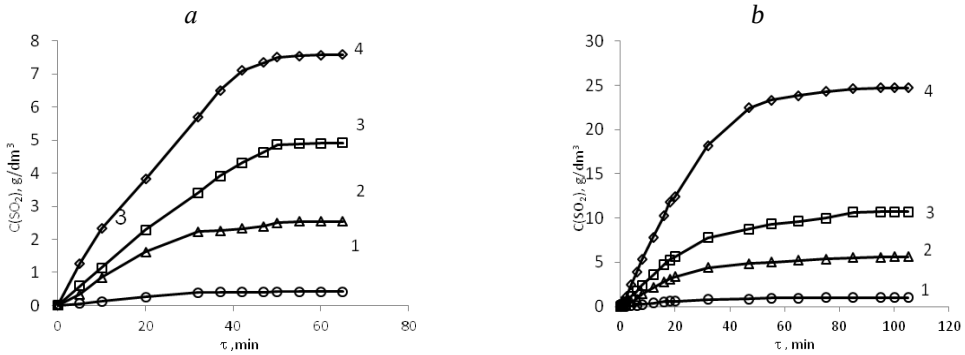

Fig. 1. Kinetic curves of sulfur oxide(IV) adsorption by absorption solution at different temperatures, °C: *a* - 22; *b* - 80; gas phase flow rate 1.0 dm^3/min initial concentrations of sulfur(IV) oxide in the air, g/m^3: *1* - 0,20; *2* - 1,10; *3* - 1,80; *4* - 4,00

The data obtained indicate the course of the process according to one of the following mechanisms: 1) the course of two consecutive reactions with close rate constants; 2) the course of several conjugated reactions; 3) the course of autocatalytic reaction. Under the considered experimental conditions (concentration of iron compounds in the reaction medium is approximately by 3 times of magnitude lower than the final concentration of sulfur (IV) oxide absorbed) - realization of the process by the 1st or 2nd mechanism is unlikely.

To determine the kinetic characteristics of the sulfur(IV) oxide absorption process the obtained dependences were processed in lgω-lg(C) coordinates. These dependences are divided into two regions characterizing two stages of the sulfur (IV) oxide absorption process described by different rate constants of the absorption procedure. For the whole range of concentrations under study, a decrease in the rate constants in time is observed after 32-37 minutes after the beginning of absorption. At the same time, the values of the rate constants of absorption at the beginning of the

absorption process are 1.2-1.7 times greater than the rate constants of absorption at the end of the absorption process-the first stage of the process. The temperature coefficient of the rate of the first stage of the absorption process is within 1.08-1.3, which indicates that the absorption process proceeds in the transition or diffusion region. The rate constants of the reverse reaction of the second stage of the absorption process are 1.6-3.5 times higher than those of the direct reaction.

Based on the obtained data (low absorption rate of the second stage of sorption and low share of absorption capacity of this stage - 20-22 % of the equilibrium capacity of the absorbing solution) as well as on operating conditions of absorbing units further studies of sulfur (IV) oxide adsorption process by absorbing solutions were accepted to be conducted only for the first stage of absorption. Processing of temperature dependence of rate constants of the process of absorption in the Arrhenius coordinates made it possible to determine apparent activation energy and a pre-exponential multiplier of sulfur (IV) oxide absorption: E=14.26 kJ/mol, K_0=0.05 s^{-1} [6,7]. The value of apparent activation energy is characteristic for the transition or diffusion region of the heterogeneous process.

In order to establish the kinetic parameters of the chemical reaction occurring during the absorption of sulfur(IV) oxide, the data obtained for the absorption rate of sulfur(IV) oxide were processed for several variants of chemical reactions based on the film adsorption model and surface renewal model. According to the obtained data, an instant irreversible oxidation reaction of sulfur(IV) oxide of the second order with partial orders of reacting substances equal to one and with apparent activation energy E=41.25 kJ/mol takes place in the absorption solution [6,7].

Thus, the absorption of sulfur(IV) oxide occurs in the diffusion region, and the process is limited by hydrodynamic conditions.

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THE QUALITY OF IRRIGATION WATER OF SOUTH BUG AND KAMIANSKA IRRIGATION SYSTEMS

A large part of Ukraine is located in areas of insufficient and unstable moisture, and therefore the food security of the population and the export potential of the state largely depend on the availability, condition and efficiency of irrigation land use. A factor limiting the development of irrigation in the South of Ukraine is the lack of quality irrigation water.

Agronomic quality of irrigation water according to FAO and other authors - is determined by several parameters (Ayers, Westcot 1994; Zaman et al. 2018; Bortolini et al. 2018): (1) content of water-soluble salts, the high concentration of which leads to salinization of soils, reducing the availability of water and nutrients to plants; (2) content of sodium cations, which leads to the degradation of the physical properties of soils, which, in particular, impairs their infiltration properties; (3) content of other ions that can accumulate in concentrations toxic to crops, which leads to a decrease in yield and product quality; (4) pH value.

The aim of our research was to study a set of agronomic criteria for irrigation water in the process of transporting it from the South Bug River to take to the lands of the South Bug and Kamianska irrigation systems. This assessment allows developing a system of reclamation and agro-technical measures aiming to improve the condition of irrigation water and soil. It also may help to improve the structure of sown areas, growing more salt-tolerant crops if necessary.

Soil salinization is dangerous because the aqueous solution supersaturated with salts has a high osmotic pressure, which prevents the absorption of water and nutrients by the roots, and this significantly reduces crop yields. A side negative effect of the presence of a high concentration of salts in the soil solution is the inhibition of photosynthesis. At the same time, more recent FAO estimates attribute such irrigation water to the average risk of soil salinization (EC_w (electrical conductivity) = 0.7−3.0 mS/cm). Such irrigation water has certain restrictions on use and may lead to reduced yields individual non-salt-tolerant crops (Ayers, Westcot 1994; Zaman et al, 2018; Nikolau 2020 etc).

Deterioration of physical properties of soil during watering is associated with the presence of sodium cations in the soil-absorbing complex. To assess the risk of deterioration of the physical condition of the soil, according to (Ayers, Westcot 1994; Zaman et al, 2018 etc.), the most informative is the SAR (Sodium Adsorption Ratio), which is calculated as follows

$$SAR = \frac{Na}{\sqrt{Ca + Mg/2}},$$

where Na, Ca, Mg - values of sodium, calcium and magnesium cations in irrigation water, mg-eq/cm^3.

FAO experts and other authors (Ayers, Westcot 1994; Zaman et al, 2018 etc.) assess the risk of degradation of physical properties of soils, including the rate of water infiltration into the soil, depending on the salt content, which, in turn, is a function of electrical conductivity. In such estimates, the risk of degradation of physical properties of soils and reduction of soil infiltration capacity during watering and precipitation will be greatest in conditions of relatively low total salt content in water and small values of EC_w accordingly. Conversely, when irrigated with highly mineralized irrigation water, the risk of deterioration of the physical properties of soils will be minimal even at high SAR values. From these positions, irrigation water with SAR values=3,2-4,8 and EC_w=0,9-1,1 mS/sm have medium risks of degradation of physical properties of soil.

The content of sodium cations does not exceed 2,0 mg-eq/cm^3 in the water of the Southern Bug. In the process of transportation after the passage of water through a number of reservoirs, the sodium content increases several times, reaching values of 5,4-6,6 mg-eq/cm^3. The main reason for this phenomenon is temperature changes of irrigation water. In the presence of excess carbonates during the evaporation of the solution, the process of formation of insoluble calcium carbonates ($CaCO_3$) and magnesium carbonates ($MgCO^3$), which precipitate from the solution. At the same time, increasing water temperature in reservoirs, especially in summer, increases the solubility of salts such as Na_2SO_4 and NaCl. As a result, the relative and absolute content of sodium cations increases, and with it the SAR value increases to toxic values for plants. According to studies of water quality indicators, no toxic effects of sodium were observed in May (SAR<3).September studies showed that the average risk of toxic effects of sodium cations (SAR=3-9). In the case of irrigation by sprinkling, the content of sodium cations exceeds 3,0 mg-eq/cm^3 for all observation sites, which is dangerous for all agricultural plants.Chlorides are almost always found in water used for irrigation. But the initial content of chlorine anions in the Southern Bug River and even a small increase in the content of this ion during transportation does not exceed the threshold value of 3,0 mg-eq/cm^3. This indicates the absence of a negative effect of this anion on crop yields.

The bicarbonate content is an important indicator of irrigation water quality. Their excess leads to the formation of insoluble calcium and magnesium carbonates and to relative sodium cations content increase in the water, which leads to an increase of this cation toxic effect on plants, especially in hot days, and the spread of physical soil degradation. The water of the South Bug contains 5,0 mg-eq/cm^3 of bicarbonate, so they dominate among all anions. The high content of bicarbonates is explained by the processes of chemical weathering as a result of dissolution of carbonate rocks such as limestone, marl, dolomite. In addition, a sufficient amount of precipitation in the upper and middle parts of the Southern Bug basin creates periodic leaching of soils in this area, which stimulates the ingress of HCO_3^- anions into groundwater and the formation of specific

ionic runoff of the river. Determination of irrigation water quality indicators showed that the HCO_3^- bicarbonate content ranges from 4,6 to 8,0 mg-eq/cm^3, which in some cases indicates the average risk of adverse effects of this anion on the soil solution and the plant.

The value of the hydrogen index (pH) in surface waters is usually formed within the carbonate-calcium system in the form of several components − calcium cations, carbonate and bicarbonate ions and carbon dioxide. This balance state of the system is determined by the temperature regime of water bodies, on which the solubility of CO_2 and the intensity of hydro biological processes depend. The pH value in surface waters increases with decreasing CO_2 content due to increasing water temperature or intensive photosynthesis of aquatic organisms, in particular blue-green algae, and decreases with increasing CO_2 content. In our case, the pH value is relatively stable both on the transport route and during the irrigation season, due to the presence of a large number of bicarbonate ions, which compensate for the reduction of CO_2 when heating water. The formation of carbonic acid, which determines the value of the hydrogen index, in this case is almost independent of the concentration of carbon dioxide, and therefore the pH value does not change. Thus, the range of 6,5-8,6, which was observed in water quality studies, according to regulatory values and data of other authors can be defined as safe for most crops**.**

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REQUIREMENTS FOR THE SIZE OF QUARTERS OF INDUSTRIAL WALNUT PLANTATIONS AND CALCULATION OF THE WORKING CYCLE TIME OF THE MACHINE-TRACTOR UNIT

Ukraine has significant natural advantages compared to neighboring countries for the highly efficient cultivation of walnuts, on its territory 424 thousand hectares of vacant land are suitable for growing this crop. At the same time, the level of domestic production does not reach a third of a

person's physiological needs, in particular, the average annual human consumption of nuts in Ukraine is 1.2 kg, and in developed countries - 6-8 kg. The main reason for this condition is the insufficient development of industrial cultivation and processing of nuts with a low level of mechanization of technological processes, especially harvesting [1,2].

The technological process of growing nuts includes: selection of varieties, places and schemes of planting, soil preparation and fertilizer application, planting, care of plantations, harvesting, storage and processing [3].

Of particular importance in the technological process of industrial cultivation is the determination of the location of the garden and the formation of optimal quarters with the condition of effective implementation of technological operations in semi-mechanized and mechanized methods. The planting scheme should provide illumination of the tree canopy and a sufficient feeding area.

Industrial walnut plantations should be formed in quarters with an area of up to 10 hectares with the formation of free inter-quarter ventilated strips. Due to the intensification of horticulture, thickened plantings are offered, but in the case of laying walnut orchards and determining the planting scheme, it should be borne in mind that walnut trees are durable and stable fruit for over 100 years, and the crown diameter can exceed 20 m. Trees grow quickly, especially in the early years, mastering the area of the garden. Therefore, the following planting schemes are recommended for industrial gardens: strong-growing trees - 17×15, 14×12, 13×11, 12×12, 10×10 m ($b_{bet.}$×a, where $b_{bet.}$ - row spacing, m; a - distance between trees in a row, m); medium-sized - 10×8, 10×7, 10×6, 9×7 m and undersized - 8×6, 8×5, 7×6, 7×5 m. If the feeding area of one tree is 100-255 m^2 per 1 ha, 40-100 trees are planted, 60-80 m^2 - 125-170 trees, 35-48 m^2 - 200-300 trees [3,4].

To effectively use the area, perennial walnut plantations should be formed according to the planting schemes of 8×8, 8×10 and 10×10 meters, respectively, for undersized, medium-sized and strong trees, and the density of plantings should be regulated by pruning.

Walnut plantings should be divided into quarters whose length ranges from 200 to 500 m and width from 50 to 250 m. The dimensions of the quarter can be 200×50 m (L_{rkv}×V_{kv}, where L_{rkv} is the length of the quarter; V_{kv} is the width of the quarter), while the area of the quarter is equal to one hectare, for the dimensions of 500×200 m - 10 hectares. It is inexpedient to make an area of more than ten hectares, because the perimeter of the site is growing, and therefore the length of the inter-quarter road and the time spent maneuvering the main or auxiliary, including transport units. That is, for the length of the quarter 400 m, its width should be 250 m.

In real production conditions, the length and width of the quarter will also depend on the planting scheme. That is, the length of the quarter should be a multiple of the distance between the trees and be L_{rkv}=n_{der}·a, where n_{der} - is the number of trees in a row, m; a – the number of trees in a row. Quarter width

$V_{kv}=n_{row}\cdot b_{bet}$, where n_{row} is the number of rows per quarter. The distance to the inter-quarter roads from the extreme tree in a row is $a/2$, and from the extreme row – $b_{bet}/2$.

That is when dividing the real area of the field, inter-quarter roads are provided across the rows on both sides of the quarter, the width of which must be at least 8-10 m to ensure the turns of the units during technological operations. Machine-tractor units are selected in such a way that they can carry out the gate at the end of the quarter on the inter-quarter road 8-10 m, it should usually be hinged, in extreme cases, semi-trailer units. Inter-quarter roads along the rows should be 4-5 m wide for the passage of units during maneuvering.

Taking into account the size of the field, the length L_{pol} and the width V_{pol}, calculate the number of trees in the series $n_{der}=(L_{pol}-n_{dp}\cdot b_{dp})$/a, where n_{dp} – number of transverse roads, taken from each other, or two if both; b_{dp} - width of the inter-quarter longitudinal road, m. The number of rows will be $n_{row}=(V_{pol}-n_{dv}\cdot b_{dv})$/a, where n_{dp} - the number of longitudinal roads, taken from each other, or two, if both; b_{dv} - the width of the inter-quarter longitudinal road, m.

The final values of the number of trees in the series nder and the number of rows in the quarter n series are obtained by rounding the calculated to a smaller integer.

The actual size of the quarter L_{rkv} and V_{kv} without taking into account the width of the inter-quarter roads is determined taking into account the values found n_{der} and n_{ryad}. The specified sizes of the quarter are used for a bookmark of a garden and calculation of productivity of performance of technological operations for real industrial conditions.

Determining the parameters of planting Wallachian gardens allows us to determine the productivity and time of the working cycle of the machine-tractor fleet. The first stage in the calculation of productivity is to determine the cycle time t_{ts}, which significantly depends on the length of the quarter L_{rkv} and consists of three times $t_{ts}=t_{rtz}+t_{hts}+t_{tzts}$, where t_{rtz},t_{hts},t_{tzts} - respectively, the operating time of the cycle, idling (turns), technological stop of the unit, with.

In turn, these times are $t_{rtz}=2L_{rkv}/V_t$, $t_{hts}=2_{Lh}/V_{pov}$, $t_{tzts}=2t_{tz}\cdot L_{rkv}/L_{techn}$, where V_t is the working technological speed of the unit, m/s; L_x - length of turn, depends on the type of turn, m; V_{pov} - average speed of the unit on turns, m/s; t_{tz} - total time of one technological stop, s; L_{techn} - stock of working stroke of the unit (employee) on technological capacity, m.

The working power reserve of the L_{techn} unit is taken as a multiple of twice the working length of the quarter L_{rkv}. During the calculations, we determine the number of passes of the unit before emptying the technological tank, and the resulting value is rounded down and specify the stock of the working stroke of the unit. To reduce the weight of the unit and soil compaction between rows,

it is advisable to calculate the number of consumables (fertilizers, pesticides, etc.), which are loaded into the process tank.

Quarter parameters and cycle time are the initial data for calculating the productivity of machine-tractor units in the quarter.

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MEASURES TO PRESERVE SOIL FERTILITY AND EFFECTIVE USE OF MOISTURE IN THE ZONE OF THE SOUTHERN STEPPE OF UKRAINE

In recent years in the world of Ukraine and its zone In recent years in the world, Ukraine and the zone of its Southern Steppe in particular, both climatic conditions and the main indicators of soil fertility change significantly. First of all, they reduce the content of organic matter, humus, soil compact, lose the number of basic nutrients. This is due to non-compliance with the basic laws of agriculture. First of all, this concerns a violation of the alternation of crops in crop rotation and the return of nutrients to the soil. Adverse phenomena have already led and in the future lead to an aggravation of the problem of rational nature management and a decrease in the sustainability of agricultural productivity.

In the current conditions of farming, when the use of fertilizers and especially organic has decreased dramatically, it is necessary to use all available types of organic matter more widely, due to which it is possible not only to positively affect the fertility of the soil, but also to significantly reduce the need for mineral fertilizers. It is advisable to use sideral crops and straw cereals.

Our preliminary research has established that their role is extremely important for the preservation of water-physical properties of the soil. Under these conditions, the water absorption capacity improves

and the number of waterproof units increases [1,2]. Thus, for an average of three years of research, unproductive dark chestnut soil was absorbed 14.72 mm/h of water, according to the background of green fertilizer, this figure increases by 16.3; 20.6%, and straw - by 22.8 and 34.6% respectively in the year of action and aftermath.

In the last period, unfortunately, the vast majority of soils are quite compacted. This has negative manifestations of moisture absorption and keeping it in the soil even after a significant amount of precipitation. They evaporate excessively quickly, that is, they are lost unproductively, plants do not use them fully.

Optimization of plant nutrition leads to more efficient water consumption and increased efficiency of soil moisture reserves for the period of crop sowing and vegetation period precipitation. We received such confirmation for growing many crops in the Southern Steppe zone of Ukraine. Studies have determined that even with optimization of plant nutrition on the basis of resource-saving moisture, they use much more economical.

For example, in studies with three varieties of chickpeas, which are considered to be a drought-resistant plant, conducted in 2015-2016, it was found that on average, 4160 m^3 of water was used by varieties in the control of 1 ton of grain of plants (for the treatment of seeds with water), and for the treatment of seeds and two fertilizers of sowing with biological preparations Biomag-chickpeas on the background of application to sowing $N_{15}P_{15}K_{15}$ indicator was 2663 m^3/t, or decreased by 36%.

For the cultivation of low-spreading oil culture of spring rigid variety Steppe 1 during 2014-2016 years. for the treatment of seeds before sowing and sowing plants in the main phases of vegetation, Escort-bio moisture was used 45.3% more efficiently compared to control.

Similar results were obtained in studies with winter barley varieties, which were grown during 2016-2019 years. and used for feeding modern biological products Azotofit, Mycofrend, Melanorysis and Organic Balance (Fig.1).

Figure 1 data also indicate that the water consumption rate varies depending on the conditions of moisture year and in the context of varietal features.

The positive impact of optimization of nutrition on the basis of resource saving through the use of modern regulating substances on the peculiarities of water consumption is determined by us in the cultivation of a demanding sunflower culture to the conditions of moisture.

This plant is considered drought-resistant, although with a lack of moisture and especially during flowering-budding, its productivity is significantly reduced.

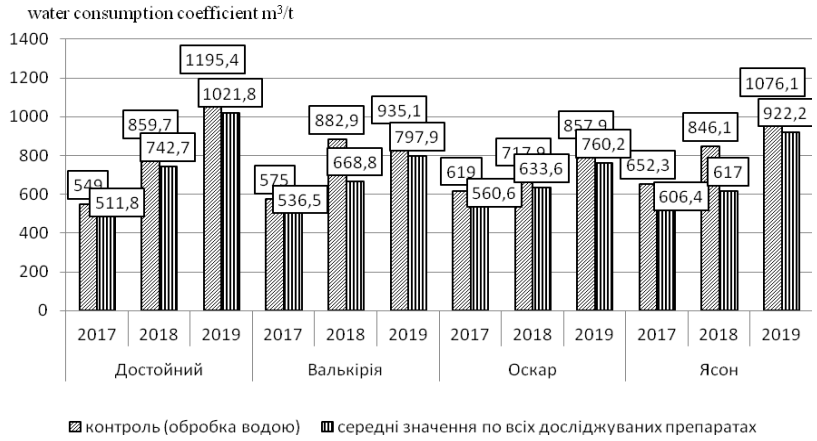

Fig.1. Coefficient of water consumption of winter barley varieties by plants depending on optimization of nutrition in years of research, m^3/t

The level of productivity and quality of sunflower seeds over the years of cultivation is significantly determined by weather and climatic conditions. We have determined that conducting foliar feeding with modern regulating preparation Fresh Energy (0.5 l/ha) contributes to the more effective use of moisture by plants during vegetation. In addition, it should be noted that the value of nutrition optimization is especially positive in drier years, compared with favorable moisture, illustrating Fig. 2.

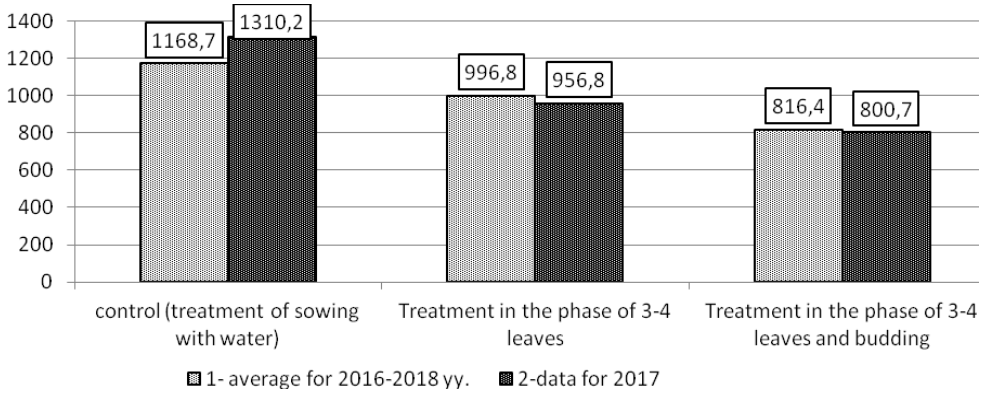

Fig. 2. Influence of foliar application of sunflower sowing with biopreparation Fresh Energy per water consumption coefficient, m^3/t

Thus, the main task of the agricultural industry at this stage of management is the issue of preserving soil fertility, their ability to accumulate, retain moisture and ensure the most complete use of its cultivated culture. In the conditions of the Southern Steppe of Ukraine, this issue is extremely relevant, because moisture in this region is the first limiting factor and determines the level of harvest.

In addition to the systematic enrichment of the soil with organic matter, it is necessary to optimize the nutrition of plants. Even the use of modern biological preparations and growth regulating substances for the treatment of seeds and plants during the main phases of growing season without fertilizers (with medium and increased soil availability by moving NPKs), or on the

background of their low doses, contributes to a significant increase in water consumption efficiency. This property is especially manifested in adverse years of cultivation. After all, biological products increase the resistance of plants to adverse environmental conditions, improve their growth processes and crop levels.

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INTERMETALLIC CATALYSTS DEVELOPMENT TO REDUCE EMISSIONS OF MOTOR VEHICLES THROUGH CATALYTIC DISPOSAL OF POLLUTANTS

Annual emissions into the atmosphere of Ukraine amount to more than 6 million tons of harmful substances and carbon dioxide. The environment is mainly polluted by industrial enterprises. However, with the increase in the number of cars on the roads, the number of harmful emissions into the atmosphere has also increased. Over the past few years, the amount of exhaust gases entering the air in large cities has increased by 50-70%. More than half of the toxic substances are released into the atmosphere by personal cars: 1.7 million tons of toxic substances were released into the atmosphere in 2019, while the total amount of all automobile emissions was 2.3 million tons.

Today, the pollution of the environment with harmful substances from the exhaust gases of internal combustion engines is the biggest environmental problem for people and the environment. Exhaust gases contain about 280 different harmful substances, among which carcinogens, nitrogen oxides, lead, mercury, aldehydes, oxides of carbon and sulfur, soot and hydrocarbons are especially dangerous.

The increase in air pollution by nitrogen oxides, carbon dioxide and hydrocarbons causes the formation of the "greenhouse effect" as a result of rising average annual temperatures and the process of global warming.

Environmental performance of vehicles can be increased through comprehensive measures to improve the design and modes of operation. Environmental performance is improved through increased efficiency, the replacement of gasoline internal combustion engines with diesel, the use of catalytic converters and many other measures.

The optimal composition of catalytically active intermetallic alloy for incineration of contaminants in the motor vehicle emissions was developed in order to reduce the vehicle discharges.

As the investigated catalyzers we used systems based on Fe-Al intermetallic of stoichiometric composition FeAl and $FeAl_3$ synthesized by thermal self-treatment [1, 2]. The intermetals were modified with different amounts of cobalt and manganese to increase the catalytic activity. In particular, FeAl and $FeAl_3$ catalysts with Co additives in quantities up to 15 wt.% were obtained [3, 4].

The catalysts obtained from iron-based intermetallic precursors exhibited sufficiently high catalytic activity. However, oxidation on them has a number of features that are not characteristic of other catalysts.

These catalysts have a higher specific surface area and, according to X-ray phase analysis, consist mainly of oxides. Let us consider in detail the process of CO oxidation on catalysts derived from $FeA1_3$ and $FeA1_3$-$CoAl_3$ precursors. All samples, except for the latter, did not undergo hydrogen peroxide treatment in the process of preparation, so a large amount of hydrogen is adsorbed on their surface. This explains their high activity in the first experiment. Hydrogen, burning out, gives a significant increase in temperature in the reactor. This is no longer observed in the second experiment, so the temperature of 100% conversion according to the above curves can be determined with a sufficient degree of accuracy. The sample Fe (100%) starts working only at 200 °C and full conversion of CO on it is reached at 500 °C. But when cobalt is added to the composition the activity of catalysts increases sharply. Already 5% of wt.% of cobalt give practically full conversion of CO at 350 °C. The sample with 15 wt.% cobalt shows the best result - full conversion of CO is reached at 250 °C.

Hydrogen peroxide treatment allows not only removal of hydrogen chemisorbed at leaching from catalyst surface, but also increases its activity. On the sample treated with hydrogen peroxide and containing 15% wt. cobalt 100% conversion of CO is achieved at 200 °C.

Propane conversion on this series of samples goes the same way as CO conversion with increase of activity depending on increase of amount of cobalt. The best result is shown by catalyst sample with 15% wt. cobalt treated with hydrogen peroxide. Propane conversion on it reaches 75% at 350 °C.

The peak of activity in the propane conversion curve on Fe (100%) catalyst may be related to the fact that hydrogen formed in the leaching process is more firmly bound to the catalyst surface and desorbed at higher temperature than on other catalysts.

Since the addition of manganese significantly increases the activity of intermetallic catalysts, it was decided to add it as well to the iron and cobalt catalysts. All catalysts were pretreated with hydrogen peroxide. The cobalt content in the samples was constant at 15 wt.% and the manganese content varied from 6 to 15 wt.%.

Such samples show activity in CO oxidation already at 100 °C, which is not typical for other

intermetallide catalysts. At the best sample containing 12 wt. % manganese a full conversion of CO is reached at 200 °C (Fig. 1*a*). Oxidation of propane on iron-cobalt catalysts with manganese content is more active with increase of its quantity up to 15 wt. %. The most active sample with 15 wt.% Mn gives 100% conversion of propane at 350 °C (Fig. 1*b*).

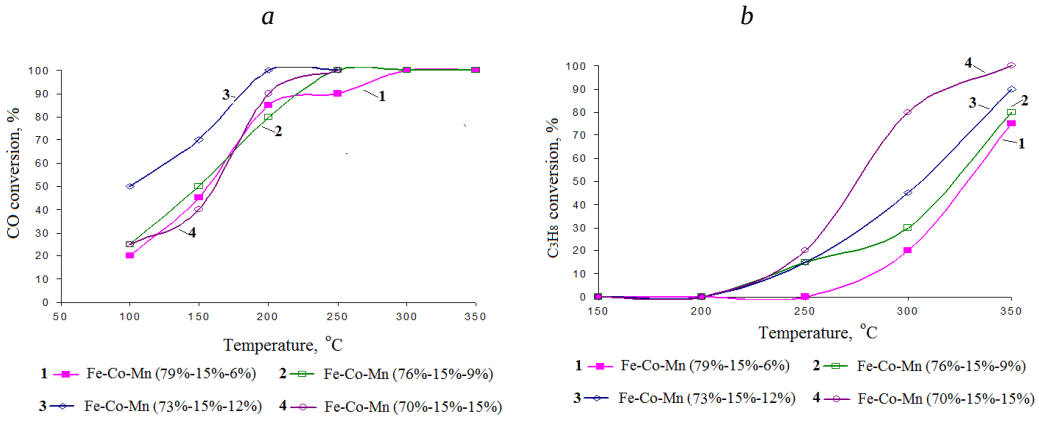

Fig. 1. Catalytic activity of Fe-Co system with Mn additives:
a - carbon monoxide conversion; *b* - propane conversion

A detailed study of a large number of iron-cobalt-manganese catalysts morphology of different compositions showed that the addition of manganese causes the formation of a specific structure on the surface. At the first stage of studies this structure is defined as fibrous formations with length >1 μm and diameter ≤100 nm. However, a more detailed study revealed that the surface nanostructure is formed mainly by hexagonal plates of the order of ≤100 nm thickness and 1-1.5 μm diameter. They can be oriented in space in different ways, but most of them are perpendicular to the substrate surface.

Microprobe analysis of the surface composition in the area of the nanostructures showed an increased content of manganese and oxygen, i.e., they are predominantly oxide or metal-oxide formations. With increasing manganese content in the samples, their surface morphology does not undergo significant changes, but the specific surface increases from 8 (Fe-Co-Mn (79-15-6%)) to 31 m^2/g (Fe-Co-Mn (70-15-15%)). The catalytic activity grows slowly until it reaches a plateau at the Mn content of 15%.

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LEVEL OF MODERN MAN-MADE IMPACT ON THE STATE OF THE INHULETS RIVER

The Inhulets belongs to the rivers of the Black Sea basin and, having a length of 549 km, is a surface water source for the population of Kirovohrad, Dnipropetrovsk, Mykolaiv and Kherson Oblasts. The river originates in Kirovohrad Oblast (Topylo village) and flows into the Dnieper as its right tributary 45 km before its mouth. The Inhulets has 9 tributaries, the main of which are the Saksahan, Bokova, Zhovta, Zelena and Vysun rivers. The total drainage basin is 14,460 km^2 [1]. According to the Water Code of Ukraine, in terms of annual runoff (0.36-0.82 km^3/year) and basin area, the Inhulets belongs to the medium-level rivers and should have a coastal protection zone on both banks of at least 100 m. Today, the riverbed is regulated by two reservoirs: Iskrivka and Karachuny. To increase the water supply for the population and industrial facilities of Kryvyi Rih, the Dnieper - Kryvyi Rih canal was built in 1957-1961, through which the water from Kakhovka reservoir is supplied to Pivdenne reservoir, which is connected to the Saksahan by canal. In 1988, in the upper reaches of the Inhulets riverbed, an additional canal from Kremenchuk reservoir of the Dnieper to the Inhulets near Svitlovodsk was put into operation [2]. This canal is designed to increase the reserves of reservoirs for high-quality periodic flushing of the riverbed for the purpose of ecological river restoration, as well as for more complete water supply to enterprises and population of Kryvyi Rih and farmland of Southern and Eastern Ukraine [3]. The actual area of lands irrigated with water of the Inhulets is now 62.7 thousand hectares, including 42.6 thousand hectares in Mykolaiv Oblast and 18.2 thousand hectares in Kherson Oblast [4].

Determining the significant water and economic importance of the Inhulets and the entire irrigation system created on its basis as a source of fresh water, it should be noted that the man-made factors of Kryvyi Rih and, in particular, Kryvyi Rih mining and metallurgical plant have a huge negative impact on the state of river.

In 1968-1972, the technical project *Drainage of Kryvyi Rih mine water outside the Inhulets basin* was developed [5], according to which a mine water storage pond was created in the southern part of Kryvyi Rih on the basis of Svistunov ravine. This allowed regulating the discharge of highly mineralized mine waters of 7 southern mines of Kryvyi Rih through a network of pipelines and pumping stations. However, the capacity of the storage pond is limited (up to 12 million m^3) and allows collecting only the annual volume of discharge water, so in fact there is no other way than to periodically discharge the collected mine water with an average mineralization of up to 38690

mg/dm^3 for 2005-2220 to the Inhulets. The developed system provides for the accumulation of sulfate-chloride-calcium mine water during the growing season (April - October) and its discharge into the river during winter period (November - March). To protect water users of agricultural enterprises in Southern Ukraine from saline water, special regulation has been developed for the supply of fresh water from Karachuny reservoir simultaneously with discharge of mine water. Firstly, it allows dissolving and reducing the concentration of dirty water by 10-12 times, and secondly, it provides flushing of the riverbed and pushing the "salt plug" to the mouth of the Dnieper and further into the Black Sea.

However, the implemented system of centralized drainage of mine water of part of Kryvyi Rih mines currently does not provide complete environmental protection of the Inhulets from the unauthorized man-made and domestic pollution.

We performed chemical analysis of water samples taken at various points along the part of the Inhulets riverbed that flows within Kryvyi Rih from North to South. The samples were taken according to the established procedure along the river waterway a month after completion of the next discharge of mine water from Svistunov ravine and cessation of riverbed flushing. The sample taken at the level of Iskrivka reservoir (the northernmost point of the river delta before it enters the city's sphere of impact) is taken as the derived level of water mineralization. The total mineralization was 640 mg/dm^3, the pollutants were composed mainly of carbonates (354 mg/dm^3), sulfates (167 mg/dm^3), potassium and sodium cations (105 mg/dm^3). At the level of Karachuny reservoir (the main source of drinking water for Kryvyi Rih residents), mineralization increased by a third and reached 998 mg/dm^3, which is probably due to filtration leaks from the tailings dumps of Pivnichnyi and Tsentralnyi Mining and Processing Plants (GZK). At the same time, the chemical composition of pollutants changed significantly: the main ones are sulfates, chlorides, potassium and sodium cations (725 mg/dm^3). The next water sample was taken at the level of residential area Pivdennyi GZK. At this point, the Saksahan, the largest left tributary, flows into the Inhulets, and there is also the point of discharge of the sewage treatment plants. The analysis showed an increase in the level of water pollution to 2538 mg/dm^3 mainly due to sodium and potassium chlorides and sulfates (2088 mg/dm^3). The polluted water of the Saksahan, which suffers due to iron ore quarries and large tailings dumps of Tsentralnyi GZK and mines of the northern part of Kryvyi Rih located in its basin, takes the lead on the increase of the Inhulets water pollution in this part of the riverbed.

Further, the Inhulets passes through the territory of Novokryvorizkyi GZK, where the quarries № 2 and № 3 and dump of oxidized ores are located, as well as at the distance of 6-7 km along the river there is a significant destruction of the natural landscape, including in the protected coastal zone. At this distance, the bypass canal of Arcelor Mittal-Kryvyi Rih metallurgical plant enters the river and there are significant outflows of polluted water from under Livoberezhnyi waste dump of Pivdennyi GZK. Near the dumps № 2 and № 3 of ArcelorMittal Kryvyi Rih quarries, the water outflows and waterlogging on the territory of up to 6-8 hectares are observed. According to the chemical composition, such water is mainly sulfate, sodium-calcium-magnesium, its mineralization

ranges from 2400 to 3800 mg/dm^3. Due to these outflows, the level of water pollution in the Inhulets increases to 3186 mg/dm^3, of which 2598 mg/dm^3 is caused by sodium and potassium chlorides and sulfates. The next section of the riverbed is characterized by the fact that on the left bank there are numerous outflows of highly mineralized water - filtrates of Voikovo tailings dump of Pivdennyi GZK and mine water storage pond in Svistunov ravine. In this section of the river, the water mineralization increases to 5000 mg/m^3, of which 4013 mg/dm^3 are sodium and potassium chlorides and sulfates. In the next section of the riverbed (below the mine water discharge point), the left bank is waterlogged for 8-9 km with numerous outflows of highly mineralized liquid (concentration 10800-15600 mg/m^3), the origin of which is due to the filtration of mine water from Svistunov ravine. The volume of such unauthorized outflows reaches 170-195 thousand m^3 per year. The level of river water pollution at this level ranges from 3436 to 3600 mg/m^3, of which 2984 mg/m^3 are calcium-chloride- sulfate impurities.

Thus, despite the established system of discharge of the main volume of highly mineralized mine water of most of the existing Kryvyi Rih iron ore mines from the Inhulets basin, there is still its significant unauthorized contamination by mining and metallurgical enterprises along the entire length of the riverbed within the city, as evidenced by the increase in total water mineralization by 3 times during the riverbed flushing, and in the period between flushing - by 6 times relative to the natural level.

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JUSTIFICATION OF ECOLOGICALLY SAFE APPROACHES TO RECULTIVATION OF TERRITORIES OF CLOSED COAL MINES OF WESTERN DONBAS

The amount of mining enterprises, which are planned to be liquidated in Ukraine, is constantly growing (for example, in the Dnipropetrovsk region, these are the coal mines of the Western Donbas). These liquidations are accompanied by a significant reduction of jobs and growing social tensions in the region. At the same time, these enterprises have a developed infrastructure, a production complex for

development of various types of resources, a network of ground buildings what allows placing innovative industries of various profiles, but they also have technogenically disturbed territories. The problem of recultivation cannot be solved entirely and effectively at the present stage without comprehensive coverage of all types of disturbances of natural ecosystems, without studying the specifics and dynamics of ecological conditions created by technogenic impact on natural complexes without predicting the changes that may occur due to technogenic factors. Unfortunately, in many cases, recultivation is reduced to the economic restoration of individual disturbed areas without considering their role as part of the overall chain of natural ecosystems, often without determining their correct ratio, most appropriate for a particular region, considering the zonal-climatic features and the balance of ecosystems [1-4].

Further development of the energy, agricultural and economic sectors of Ukraine is largely connected to a possibility of systematic liquidation of a number of unprofitable and old mining enterprises. At the same time, the priority problems that occur during this process include the emerging loss of jobs, the cost of maintaining hydrodynamic safety of closed enterprises, landscape disturbance in a large number of territories, degradation of fertile soil and a threat of environmental pollution [3-5]. With the current agricultural priorities of the country development, a large amount of lands disturbed by mining needs to be restored both in terms of relief and fertility, followed by monitoring using fundamentally new methods of recultivation. At the same time, the previously established approaches to transformation of mining enterprises are mostly general and do not focus on the specifics of domestic industry, which significantly limits their use and requires the development of new, more targeted methods of restoration and management of production facilities and territories, which are located at sites of closed mines and quarries. The factors required in the field of environmental security of Ukraine are: a high level of scientific justification of measures for green production, strengthening the control functions of government, using market economy model in the context of environmental security and European integration interests of Ukraine. Land recultivation after the deposites have been developed is responsibility of the mining enterprise, so recultivation funds should be considered as the final part of the production process, and the cost of creating reserve funds for recultivation should reduce the amount taxed, i.e. should be included in the cost. This approach is implemented in developed countries [6-8].

In connection with the aforementioned, the research planned in the article, aimed at developing a comprehensive system of restoration of a mining enterprise territory and creating a single system of various energy efficient and agricultural industries, help stabilize the environmental situation and forced unemployment in such regions, as well as strengthen energy security of Ukraine. There is no experience of complex re-profiling of closed mining enterprises into agro-industrial ones in Ukraine yet, so the concept of biological-technological restoration of territories with maximum use of available resources suggeted in the article is acutely urgent. The originality of research related to the development of agro-industrial

locations within closed mines and quarries is justified by development of specific recommendations for the re-equipment of their individual facilities into productions with high demand, with restoration of phytoagrocinosis of territories, considering their mining and biological features, which gives a significant socio-economic effect in contrast to the previously performed general description of prospects of recultivation measures [2-3].

Therefore, the purpose of the article is to develop a comprehensive and stage-by-stage model of biological-technological restoration of liquidated mining enterprises into new agro-industrial locations, which are represented by a system of modern recultivation technologies that will increase their energy efficiency and environmental safety by maximum usage of available land and human resources.

Obtained results and their discussion. Further development of economy and energy sector of Ukraine is largely connected to a possibility of systematic liquidation of a number of unprofitable and old mines and quarries. At the same time, the priority problems that occur during this process include the emerging loss of jobs, the cost of maintaining hydrodynamic safety of closed enterprises and a threat of environmental pollution. In this regard, the authors' research is aimed at developing a parametric basis for technical and biological restoration of territories disturbed by mining, which allows their integrated usage for industrial and agricultural sectors, increases the economic efficiency of such lands and reduces the negative impact of mining on environmental state of the Dnipro region, while helping strengthen the energy security of Ukraine.

To solve this set of studies, a number of tasks is set and solved.

1. Establishment of ranges and the sequence of changes in agro-technological parameters of territories of mining enterprises, which is necessary for their restoration and ensuring various types of production and creation of enterprises that meet the requirements of market economy and the European ecological standards. Analysis of options for using and adaptation of selected agro-ecological cycles of restoration of disturbed territories, with development of fundamentally new approaches based on the obtained data.

2. Assessment of changes in hydrodynamic state of disturbed territories for restoring soil fertility and their usage for new technological purposes with determining the impact of mining-geological conditions and types of deposit development on a mechanism and sequence for transforming their disturbed areas into a system of innovative agro-technological locations.

3. Creation of an ecological-biological complex of project modules for development of various types of restoration of territories, including a full cycle of restoration of soil fertility. At the same time, it is necessary to determine the most efficient energy crops, adapting to soil-climatic conditions of mining regions in order to further use raw materials as alternative energy sources (e.g. fuel briquettes, etc.) and develop universal schemes for restoration and relief planning of disturbed territories for different types of development of mineral deposits.

The primary practical value of the research is in development of the suggested comprehensive approach, the result of which leads to expected increase in economic indicators of the region due to the creation and full replacement of jobs, restoration of territories and minimization of a threat of environmental pollution.

When it comes to agricultural restoration, preference should be given to agricultural sector, although a cheaper type of biological recultivation is creation of complex forest biogeocenoses.

Thus, a selection of the most rational variant of further use of the disturbed lands should provide achievement of economically optimal and ecologically safe level of return from unit area of these lands, implementation of resource-saving technologies of land cultivation and agriculture.

The choice of optimal direction of recultivation of disturbed lands is a problem that must be solved on a basis of considering a range of political, social, economic, and environmental factors.

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ANALYSIS OF KNOWN TECHNOLOGIES OF AMBER MINING IN RIVNE-VOLYN REGION

The world stock of amber in Ukraine is about six percent. The main deposits of amber are located in Polissya - Pripyat amber basin (northern part of Volyn, Rivne, Zhytomyr and Kyiv regions). Industrial development is carried out in Rivne region at deposits in Sarny (Klesivske, Vilne) and Volodymyrets districts. Total reserves are estimated at about 100 thousand tons, which mainly occur in sandy and sandy-clay amber soils at a depth of up to 15 m [1].

The largest amber deposits in the Rivne region are "Klesiv", "Vilne", "Volodymyrets-Skhidny". Together they contain several hundred tons of amber raw materials, of which 128 tons have been explored in industrial reserves. Two of them are currently in operation: "Solar craft". In the state balance of reserves "Amber" there were four deposits - Klesivske, Volodymyrets-Skhidny, Vilne and Zolote (South-Eastern section). Balance reserves of deposits are: in category C1 - 63.61 tons, in category C2 - 162.87 tons [2,3].

The development of amber-containing deposits is carried out by mechanical and hydraulic methods, which have a number of disadvantages. The mechanical method involves the mechanical development of a mass of soil in an open pit or underground. This method includes the following stages: opening of the productive layer of soil, excavation work, transportation of rock from the place of development to the screen, where the separation of amber from rock by washing, land reclamation. The disadvantages of the mechanical method are: high operating and economic costs, removal of rock to the surface and the negative environmental impact on the environment.

The method of downhole hydraulic development of mineral deposits includes the opening of the productive horizon by wells along the contour of the production chamber, their casing, installation of hydro-mining equipment with a dispensing device.

There is also a connection between the wells, trimming the productive horizon and filling the cut gap with water. The next stage is the destruction of the rocks of the productive horizon in the undercut slit, hydraulic erosion of the rock in the flooded face and raising the pulp to the surface of the well by self-discharge due to the constant flow of fluid into the working area in the center of the production chamber.

Hydro-mechanical extraction involves the excitation of a mineral into a mobile state by the action of a mechanical organ, after which it is fed to the surface by a hydraulic mixture through vertical mine workings.

Further development of the extraction process is possible with the improvement of mechanical hydraulic extraction with vibration on the array, which intensifies the process by substantiating and choosing the shape and spatial diversity of the vibrator emitters of the intensifier.

There is another method of downhole mining, for example, using mixtures of different viscosities. Thus, a viscous antifreeze is fed into the prepared well, which forms a pulp with the soil mass and due to the difference in density, heavier fractions are lowered down the well, and lighter ones are carried out together with the soil mass by pumps that pump the pulp to the surface.

This method is used for extraction of materials from frozen soils, as well as for sorting minerals of different densities [4].

However, all these methods are accompanied by the removal of mineral soil on the surface of the field, do not provide complete extraction of amber from deposits, energy-intensive, lead to changes in soil structure, voids and, accordingly, have a significant negative man-made environmental impact.

Many years of research have made it possible to propose a complex method for the extraction of amber from amber-containing deposits, which includes a number of technological operations using various techniques.

This method includes layer-by-layer development of amber massifs with the use of technological equipment for overburden, mining and processing of rock mass at the development site. The use of a set of machines allows you to effectively remove the smallest fractions of amber.

The proposed technology of layer-by-layer amber mining has a number of advantages over the existing hydromechanical and well technologies, but for a full assessment of its economic efficiency it is necessary to determine a number of influential factors, in particular: necessary productivity, equipment - and water supply of the technological process, as well as the pricing policy of amber sales of different size classes.

Such data are taken into account during the project implementation of the new technology in accordance with its initial requirements.

However, a large fleet of equipment forces to make significant economic costs in the initial stages of development, which affects the cost of production.

Therefore, today amber mining requires the latest technologies and improved tools to intensify the extraction process, which achieves higher productivity and efficiency, as well as reduces the negative environmental impact on the environment.

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DEPOSITS OF CRITICAL MINERAL RAW MATERIALS OF UKRAINE. CONDITION AND PROSPECTS

Interest in critical (strategic) minerals is becoming crucial in the global economy due to their natural limitations. The country's supply (or region) with raw materials is a factor of economic security, autonomy and a means of insurance against global crises.

Mineral raw materials are needed not only to produce a wide range of everyday goods and services, but also for the development of innovations, particularly for the development of more efficient and environmentally friendly technologies.

The acceleration of innovative technological cycles and rapid progress of developed countries has led to the increased global demand for prevalent metals and minerals. Ensuring access to a stable supply of many raw materials has become a major challenge for regional, national, and local economies with limited production, which depends on imports of many minerals, including critical mineral raw materials.

Defining parameters and critical raw material management system are the product of the implementation of legal, geological, economic and socio-political factors governing the geological study and use of the country's mineral base. Criticality should be determined by parameters that take into account the methodological principles of the UNFC and UNRMS. It is noted that basic principles of resource formation and management in Ukraine correspond to the UNFC and are implemented since 1997, and, since 2019, Ukraine has adopted a classification based on the principles of the UNFC at the state level.

Based on the analysis of the mineral reserve balance and existing occurrences in Ukraine, it has been acknowledged that there are certain opportunities for the production of the vast majority of elements presented in the table of critical for the European Union positions (Study on the EU's list

of Critical Raw Materials (2020) Final Report), and they have been divided into three groups according to the level of supply risk:

- low level of supply risk: gallium, hafnium, magnesium, natural graphite, scandium, silicon metal, titanium;
- medium level of supply risk: barite, beryllium, bismuth, cobalt, coking coal, fluorspar, heavy and light rare earth elements, tantalum, niobium, phosphorite, phosphorus (apatite), lithium, strontium;
- high level of supply risk: antimony, boron, germanium, platinum group metals, tungsten, vanadium, bauxites.

It has been mentioned that Ukraine has production capacities in several sectors that use raw materials, which, when processed, allow it to concentrate on some raw materials that are critical for the EU. An additional opportunity for MSMEs to join the sphere of critical raw material supply could be recycling waste or processing used products. The state's plans to restore primary industries, such as aerospace, mechanical engineering, shipbuilding, chemical, military and energy industry, and develop the country's infrastructure will stimulate domestic demand, including critical raw materials.

According to the balance of mineral reserves and existing manifestations, which are presented in the Study on the EU's list of Critical Raw Materials (2020) Final Report, Ukraine has some opportunities to establish production of the vast majority of elements.

The main contenders for involvement in mining are such critical raw materials as titanium, lithium, beryllium, natural graphite.

Titanium is used as a structural metal in aviation and missile technology, shipbuilding, power engineering, food, medical industry and non-ferrous metallurgy. Ukraine produces ilmenite and rutile concentrates, titanium dioxide, titanium sponge, metallic titanium and its products. In Ukraine, 26 titanium ore deposits have been explored with different levels of detail and another 48 deposits are off-balance, and titanium reserves and resources have been estimated only preliminary. Ilmenite and complex rutile-zircon-ilmenite placers are the main mineral base of titanium. Bedrock ores are associated with olivine gabbroid intrusions. The content of ilmenite reaches 25 per cent, apatite – 12 per cent. Ukraine has the largest Stremyhorodske bedrock deposit in Europe, complex and contains 131 million tonnes of ilmenite. Ukraine is one of the seven largest producers of ilmenite and rutile in the world. Production, labour and environmental resources in Ukraine, which are necessary for the titanium industry, remain quite competitive.

Lithium is one of the critical raw materials. It is used to produce ceramics and glass, chemical power sources, lubricants, continuity of steel casting, oxygen regeneration, polymers, aluminium metallurgy, and pharmaceuticals. According to the explored reserves and prognostic resources of lithium, Ukraine can be considered the wealthiest country in Europe. It can fully meet its own needs and the needs of the European market in lithium raw materials. There are pegmatite deposits that have been studied at different levels: Shevchenkivske (spodumene ores), Polokhivske (petalite ores), Stankovatske (spodumene-pelitic ores), Balka Kruta (complex rare metal ores), as well as numerous ore occurrences of this type. Also, lithium

forms large accumulations in the Donbas region in the composition of mica minerals with a lithium oxide content in the range of 0.2-0.6 per cent.

Beryllium is used in metallurgy, aviation and aerospace industry, nuclear energy, X-ray technologies, electronics, optical devices, etc. The mineral raw material base is represented by one rather sizeable Perzhanske deposit of valuable genthelvin ores with good technological properties, characterized by the high quality of beryllium content and sound enrichment. Work is underway to put it into operation. There is also the beryllium mineralization associated with potassium feldspar alkaline rocks, granite pegmatites, complex rare-metal pegmatites of albite-spodumene type have been detected. Total reserves of beryllium oxide in Ukraine reach 66 thousand tonnes.

Natural graphite is used to produce aluminium by electrolysis; it is also used in electronics, in nuclear reactors, to produce refractory crucibles and lining plates, and as a lubricant. Crystalline graphite deposits form the Ukrainian graphite-bearing province, which includes four graphite-bearing regions. In total, about 100 deposits and occurrences of graphite have been discovered in the province. In Ukraine, as of January 1, 2018, 6 graphite deposits are accounted for, one is being developed. Accounted balance reserves of graphite amount to 17356.6 thousand tonnes. Graphite is flaky; its content in ores reaches 30 per cent. Graphite has been mined in Ukraine since 1931 in the Zavalivskiy graphite plant (Kirovohrad region). In recent years, the plant's capacity that exceeds 40 thousand tonnes of graphite per year is used only by 15-25 per cent. The plant consists of quarries for ore mining (graphite is distributed relatively evenly), an enrichment factory, workshops for chemical enrichment of graphite, colloidal graphite preparations, lubricating and cooling liquids, etc. Also, the Mariupol Graphite Plant in Ukraine (PJSC "Markograf") does not have its raw material base. Currently, work is being conducted to start developing the Balakhivske deposit in the Kirovohrad region and the Burtynske deposit in the Khmelnytskiy region.

Also Ukraine has production capacities in a number of sectors that use raw materials, which, when processed, allow to concentrate some raw materials critical for the EU. An additional opportunity for our country to join the sphere of critical raw material supply could be recycling waste accumulated during former production activities of enterprises or is currently generated at enterprises.

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ESTABLISHING THE GEOMETRY OF STERILE ROCKS DUMPS IN THE JIU VALLEY REGION TO ENSURE LONG-TERM STABILITY

In the Petrosani depression, over time, there have been several coal mines and quarries. Currently, there are 49 waste dumps in Jiu Valley that stores a volume of over 40 million m^3, occupying an area of over 270 ha (Faur et al., 2013). Due to a lower activity in underground coal mining, most of these dumps were closed, being in different phases of rehabilitation and/or

preservation. The dumps were built as a result of the underground or surface exploitation of coal, the waste rocks coming from opening works or from the coal preparation plants.

The deposited material consists of a mixture of rocks represented by clays, marls, micro sandstones, clayey sandstones, coal shales and fragments of coal and ashes resulting from the combustion of the coal fragments within the dumps.

The physical and mechanical properties of the waste material have been analyzed in many cases, especially when stability studies were required. As a result of these observations and analyzes, several general characteristics for tailings dumps have been established (such as the height and inclination of the dump benches, as well as of the benches system).

The moisture and the degree of saturation of the waste rocks show great variations, being influenced by the position of the sampling points, the presence of precipitation, the possibilities of infiltration, drainage and water retention by the rocks. The presence of water in the pores always has an unfavorable influence on the strength characteristics of the rocks.

Strength characteristics are used both in stability analyzes and in the design of the geometric elements of the benches, and therefore they must be determined and interpreted as accurately as possible. The resistance characteristics of the material from the dumps in the Jiu Valley were determined in the Laboratory of earth mechanics of the University of Petroşani (Rotunjanu et al., 2006).

As the values of these characteristics vary within very wide limits, the results of statistical processing must be taken into account when performing the calculations (see table below).

Specification	Volumetric weight, γ_v [kN/m^3]	Porosity, n[%]	Cohesion, c [kN/m^2]	Internal friction angle, φ [˚]
Minimum	13.60	23.90	4.00	6.00
Maximum	21.00	53.00	90.00	33.00
Average	17.68	35.08	27.81	19.75
σ	0.16	5.36	0.15	6.69
Average-σ	17.52	29.72	27.66	13.06
Average+σ	17.84	40.44	27.96	26.44

Initially, the stability analyzes were performed without considering saturation moisture, considering that the base land morphology, the waste dump's geometry, the nature and granulometry of the deposited material facilitates drainage of groundwater. Also, the designed geometric elements were not taken into account, but the real values of height and inclination. As a result of running the input data for each of the cross or longitudinal sections considered, there were obtained the values of the stability coefficients for slides through waste dump body, for circular sliding surfaces as determined by Fellenius method (Lazar, 2017).

For the first 2 sets of values in most of the cases the stability factor is below 1, meaning that the natural equilibrium is lost and the examined slope will slide. The stability coefficient is higher than 1 for the other two sets of values, exceeding in almost all cases the value of the safety factor (Fs=1.3), as presented in following table.

Waste dump	Cross (T) and longitudinal (L) sections	H, [m]	φ, [°]	Stability coefficient – Fellenius for values set:			
				Min	Average – σ	Average + σ	Max
Lonea 1	T_{4-4}	21.00	15.89	0.43	1.13	2.56	4.15
Jieţ	T_{2-2} western slope	11.22	36.41	0.42	1.06	2.65	4.51
Branch R-V Petrila	T_{4-4} northern slope	25.08	33.1	0.32	0.76	1.82	2.65
Maleia AS no. 2-3	T_{2-2} western slope	8.40	29.78	0.42	0.98	2.22	3.26
Livezeni preparation	L_{I-I} southern slope	20.10	26.58	0.38	0.93	2.21	3.29
Arsului Valley	T_{3-3} western slope	6.80	37.00	0.61	1.52	3.67	4.61
Branch 2 J.V.C.P.E.	T_{5-5} western slope	39.32	33.55	0.27	0.64	1.27	1.77
Branch 3 Lupeni	L_{I-I}	53.62	36.35	0.22	0.52	1.21	1.86
New Funicular	L_{I-I}	54.15	47.73	0.22	0.52	1.22	1.74

The design of the geometric elements of the tailings dumps is based on several considerations, among which the stability of the slopes and of the dump assembly is the most important. According to the literature (Priest & Brown, 1983), the minimum accepted values for factor of safety depends essentially on consequences of the failure and on the slope type, so:

- Fs=1.3 for not serious consequences and temporary slopes smaller than 50 m;
- Fs=1.6 for moderate serious consequences and permanent and semi-permanent slopes with the high between 50–150 m;
- Fs=2.0 for very serious consequences and permanent slopes higher than 150 m.

Considering that the tailings dumps in the Jiu Valley are permanent, with heights between 6.8 and 54.15 m, taking into account the fact that the most probable values of the resistance characteristics of the rocks are between „Average – σ" and „Average + σ", a resizing of the dome geometry is required so that the minimum value of the stability coefficient is 1.6. Resizing can be done either using graphical, grapho-analytical or numerical methods, or using stability analysis software. To establish the geometric elements of the dump under slope stability conditions, was used the graphic-analytical methods as E. Hoek (Hoek & Bray, 1973) which proved its viability in many cases, including for the many dumps in the Jiu Valley. As a result, the geometric elements of the dumps which ensures a value of the stability coefficient of 1.6 are height of 20 m and the slope angle of 25°.

For dumps with heights of over 50 m, it is recommended to build an intermediate berm at a height of 25 m and to reduce the slope angle below 25°.

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FORMATION OF UNLOADED ZONES IN HARD PRONE-TO-OUTBURST ROCKS NEARBY THE STOPE

In the case when thick layers of hard rocks lie in the roof and floor of the developed coal seam, the spacing of main roof breaks should be significantly increased. Besides, sections of the powered support in the longwall are often clamped between the seam floor and the overhanging rock console. One of the ways to shift the support, which is normally used in coal mines in Ukraine, is to rip the seam floor under the support with explosive charges.

However, the Ukrainian mines are distinguished by difficult mining and geological conditions, and coal seams and sandstones in many mines are hazardous in terms of outburst of coal, rocks and gas. According to safety requirements, blasting operations in the prone-to-outburst seams and sandstones can only be carried out in a zone unloaded from rock pressure, or by using a shock blasting mode, at which people should be taken away to a fresh air stream at a distance of at least 1000 m and winning operations should be stopped for a long period of time.

It is obvious that the second way is economically unprofitable. Therefore, the purpose of this work was to determine the patterns of formation of zones unloaded from rock pressure near the stope by using numerical modeling methods.

The process of rock mass deformation is described by the following equations:

$$c_g \frac{\partial u_i}{\partial t} = \sigma_{ij,j} + X_i(t),$$

where c_g - the damping coefficient, kg/(m^3·s); u_i - the displacements, m; t - time, s; $\sigma_{ij,j}$ - the derivatives of the stress tensor components along axis x and y, Pa/m; $X_i(t)$ - the projections of the external forces acting on the volume unit of a solid body, N/m^3.

To analyze the stress state of rocks, geomechanical parameters were used which characterize different components of the stress field (Q*) and unloading of rocks from rock pressure (P*) [1]

$$Q^* = (\sigma_1 - \sigma_3)/\gamma H; \qquad P^* = \sigma_3/\gamma H,$$

where γ - the averaged weight of the overlying mine rocks, N/m^3; H - the mining depth, m.

The initial and boundary conditions for the task set

$$\sigma_{yy}\big|_{t=0} = \gamma H; \quad \sigma_{xx}\big|_{t=0} = \lambda\gamma H; \quad u_x\big|_{t=0} = 0; \quad u_y\big|_{t=0} = 0; \quad u_x\big|_{\Omega_1} = 0; \quad u_y\big|_{\Omega_2} = 0,$$

where σ_{xx}, σ_{yy} - components of the stress tensor, Pa; λ - the side thrust coefficient; u_x, u_y - components of the displacement vector, m; Ω_1 - the vertical boundaries of the outer contour; Ω_2 - the horizontal boundaries of the outer contour.

To study the process of the unloaded zone formation, a case was considered when layers of hard prone-to-outburst sandstones were located in the roof and floor of a coal seam, Fig. 1*a*.

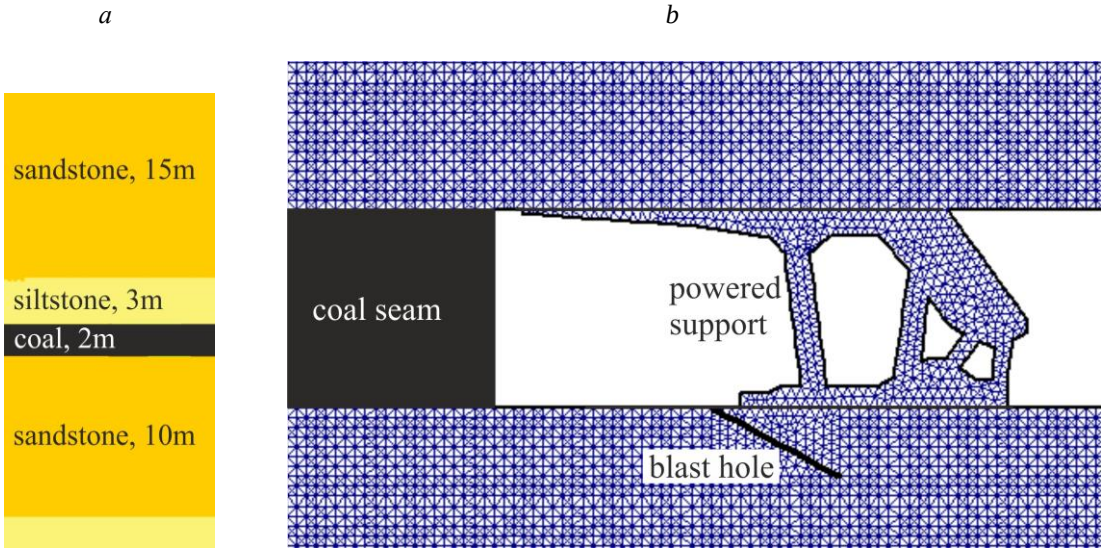

Fig. 1. Stratigraphic column (*a*) and central fragment of finite element mesh (*b*)

For the mathematical description of the process of rocks changeover into a disturbed state, the Mohr-Coulomb failure theory is applied. The problem is solved in an elastic-plastic formulation with finite element method, Fig. 1*b*.

According to the planogram of the works in zones prone to outburst, coal extraction should be carried out on compliance with a one-sided scheme, subject to observing the two-hour technological breaks between the extraction cycles.

Depending on various technological parameters and duration of the stope downtime caused by the clamping of sections of the powered support, the time period needed for unloading the floor rocks starting from the moment when the stope is exposed till the execution of blasting operations can reach several days.

The authors performed a series of numerical calculations of changes in the stress field. The distributions of the values of geomechanical parameters are shown in Fig. 2, and graphs of changes in the magnitude of the floor rocks unloading along the vertical line at the place of drilling a borehole for explosives are shown in Fig. 3.

As these figures show, zones of rock pressure relief and areas with great variety of the rock components around the stope are increasing over time. Zone of inelastic deformations in the immediate roof of the working, represented by siltstone, grows faster than in the working floor represented by the hard sandstone.

Steel structure of the powered roof support has a high concentration of stresses, but the support withstands the great load without any destruction.

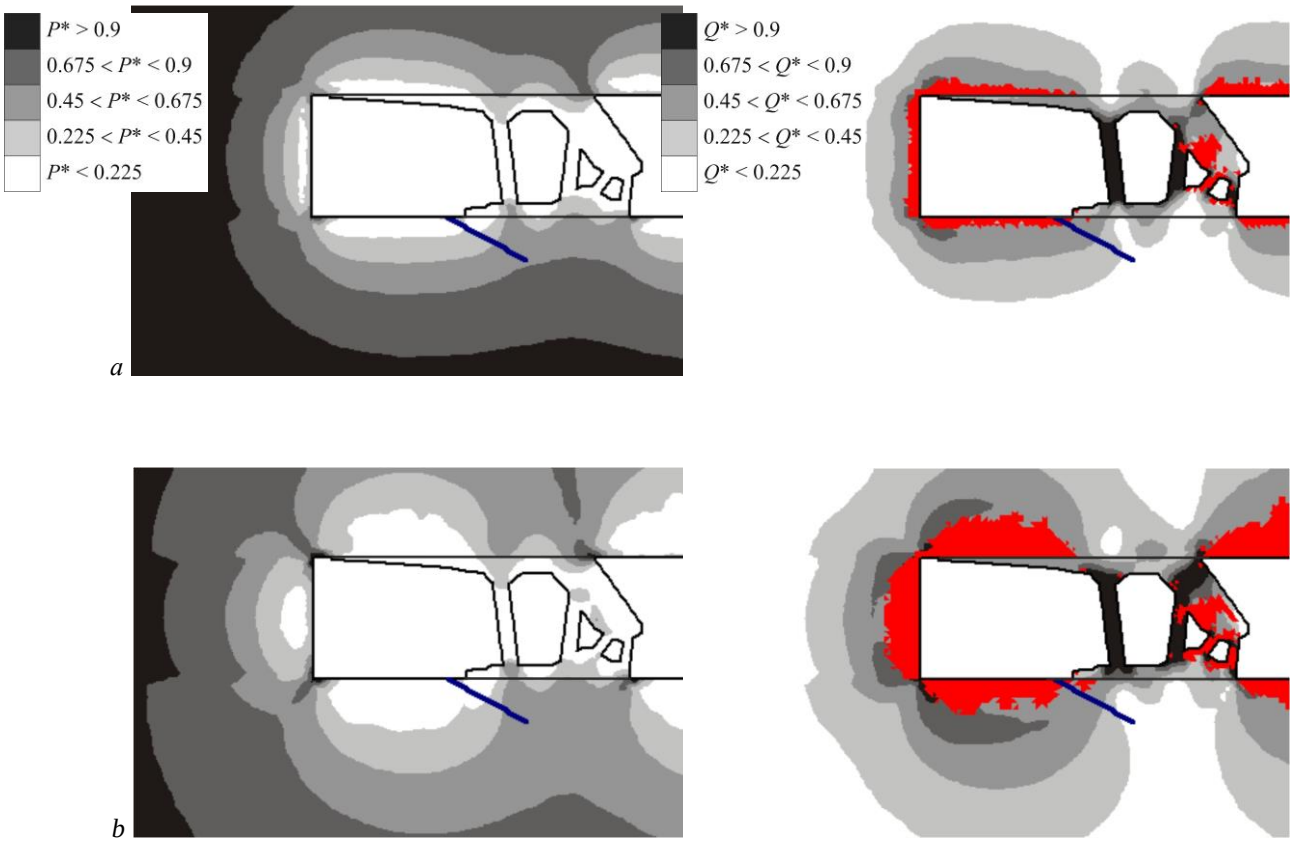

Fig. 2. Distribution of values of the parameter *P** (left), parameter *Q** (right) and zones of inelastic deformations (red) at the moments of time: *a* - *t*=5.4 *h*; b - t=27 *h*

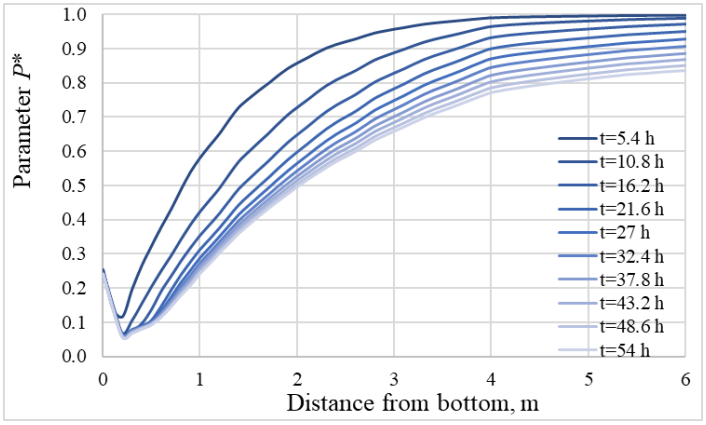

Fig. 3. Unloading of floor rocks (value of parameter *P**) at different points in time

From the graphs in Fig. 3, it follows that sandstone at a depth of 3 m is unloaded to a value of *P**<0.9 10.8 h after the wall advance (under the given initial and boundary conditions).

Conclusions. The results obtained make it possible to determine depth of the unloaded zone in the floor of the stope, in the place of drilling a borehole for explosives and at various points in time after advancing the stope; to estimate degree of outburst hazard of rocks in this area; and to ensure safety of the winning operations in difficult mining and geological conditions.

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METHODS OF MINING SEAMS OF THE KARAGANDA COAL BASIN

The development of the Karaganda coal basin reserves has been carried out from the moment of exploration to the present, mainly from thick and medium-thick seams, in which low-ash coking coals are found. In the Promyshlenny, Maikuduk and Saran areas these are coal seams k_7, k_{10}, k_{12}, k_{13}, k_{14}, k_{18}, in the Sherubai-Nura and Tentek coal-bearing regions these are seams k_7, k_{10}, k_{12}, k_{18}, $d_{10\text{-}11}$, d_6, t_1 and t_3. Such a tendency, given the actually uncovered reserves of thin seams lying within the mine fields, leads to premature depletion of reserves, irrational planning and preparation of mining operations, increasing the depth of development, the need to open deeper levels and as a consequence increasing the production costs, premature decommissioning of the existing production capacities of coal mines and the need to commission new ones to replace them. In the subsequent production, additional costs will be required for restoring and putting into development the reserves of thin seams [1].

Coking coals of the Zh, KZh, K, KO and OS grades can be obtained during the development of complex-structured, thin and contiguous seams of the Dolinskaya and Tentekskaya formations in the Tentek region at such mines of the Karaganda coal basin as the Shakhtinskaya, Kazakhstanskaya, Tentekskaya and Lenin mines; in the Karaganda formation at the Kostenko mine combined with the Stakhanovskaya and Karagandinskaya and at the Saranskaya mine combined with the Sokurskaya and Aktasskaya mines. There are 165.5 million tons of strata out of balance in terms of capacity. The balance reserves of coking coals in thin seams at the operating mines amount to 641.5 million tons, while the off-balance seams contain 165.5 million tons.

The introduction of highly efficient technological schemes with intensive excavation of thin and complex-structured coal seams is hindered by a number of reasons due to natural and mining-technical factors:

- reducing the size of excavation fields at the existing levels due to selective mining of mine fields and the complexity of the mining operations planning;

- complicating the mining-geological and mining-technical conditions of developing rock seams, developing difficulties for the use of traditional methods of coal mining;

- deepening the mining operations leads to increasing the costs of driving and supporting mine workings, ventilation, rock pressure control in working faces and decreasing safety of work;

- the outlined tendency of ash content growth, reaching 31 % in commercial coal and increasing

by 0.6-1.0 % per year.

In the Karaganda basin, the complexity of the problem of developing mining operations at deeper levels is associated with the fact that the main coal reserves are located at depths of 400-600 m and over 600 m, and the average depth of mines is 500 m.

The key tasks for the implementation of progressive development systems at deep levels are as follows [2]:

- developing methods of protecting development workings, ensuring their stable state behind the longwall during the time of the pillar mining, when a layer of rocks that are prone to intense heaving, is buried in the soil;

- developing methods of rock pressure control that neutralize the negative effect of depth on the state of the immediate roof.

Improving the technology of developing coal seams is one of the main trends of improving the technical and economic level of mines.

It is obviously impossible to solve the mining problem of increasing the technical and economic efficiency of the stoping faces only by means of equipping them with the best foreign models. Its solution should be based on the compliance of the implemented high-performance, reliably functioning equipment with preparation methods and development systems, planning schemes and cutting of mine fields.

The introduction of a new technical level, advanced technology and labor organization in stoping, preparatory work and transport equipment provided increasing the labor productivity, decreasing the share of manual and low-skilled labor.

The basic methodological principles of improving the technology of developing thin and complex seams are as follows: involving in the development substandard seams with a complex structure that have a high technological quality of individual coal packs separated by a rock pack removed selectively; developing technological development schemes with high productivity (5000-7000 t/day) and with the following parameters: the face length is 250-300 m, the extraction pillar length is 3.5-4.0 km; filling rock from driving, selective excavation and other sources into the goaf in the form of rubble strips, which provide reliable isolation of the goaf and mitigate geomechanical processes.

Implementation of the methodological principles of improving the technology of developing thin and substandard seams with complex structures will ensure high development efficiency and competitiveness of coal products in market conditions, as a result of which mining such reserves will become economically profitable.

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ENHANCEMENT OF INTEGRITY OF OVER 1000M DEEP MINE WORKINGS AT KRYVYI RIH IRON ORE BASIN

At underground mineral mining at great depths in various regions, including Kryvyi Rih iron ore basin, there arises a problem of preserving mine workings' integrity of mine workings during their sinking, especially during operation. [1,2]

Rigid, monolithic supports do not provide integrity of development and face-entry workings, since rock pressure processes are activated in the first days after their sinking. This is especially true when making workings in rocks with a low hardness coefficient. In such rocks, the rate of destruction of mine working contours reaches 1.0m per month, this entailing closure of such workings.

In these cases, a flexible arched support made of a special profile (universal collapsible support (UCS)) is the most effective. Such a support will provide a reduction in miners' injuries due to minimizing the distance of the support from the face. Flexibility of the support enables mining operations immediately after sinking.

To use the flexible support during sinking, the mine working contour is made the closest to the shape of the frame support of the UCS. The support is installed as close as possible to the rock mass with tight wood or reinforced concrete tiles lagging and voids backfilling.

However, with such a technology of supporting workings, interaction between the support and the rock mass is neglected with temporary manifestations of rock pressure when loads on the support are created by displacements of the mine working contour. These strains are taken up by the support along its entire perimeter. The support is subject to especially strong deformation from the sides where there are no elements of flexibility.

In practice, there are cases when this phenomenon makes the support undergo strong deformation even in hard rocks, despite the fact that destruction of the mass around the mine working stops and a stable vault is formed. This is the primary cause of quite early destruction of development workings.

Practice reveals that after retimbering of such mine workings, when part of the destroyed ore is drawn behind the support and deformed metal frames of the UCS are restored, mine workings continue to operate for a long time without visible damage to the support.

At underground mines of Kryvyi Rih iron ore basin, protective measures are widely used to enhance integrity of mine workings of various purposes during their sinking and operation at great depths. [3]

Main measures to protect mine workings from destruction include:

- methods for maintaining mine workings aimed at reducing loads on the support during the greatest destruction of the rock mass around mine workings by leaving compensation niches on the sides (developed by Kryvyi Rih Labour Safety and Ecology Institute and Kryvyi Rih Ore Mining Research Institute); support de-stressing in places of stress concentration by partially drawing caved rocks into the working;

- the developed frame inventory support with enclosing grid-type reinforced cards and elements of active influence on the surrounding destroyed mass.

The proposed measures to maintain integrity of mine workings at depths of over 1000m can significantly reduce costs of workings retimbering and enable continuous operation of mining equipment.

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PROTECTION OF MINE WORKERS IN EMERGENCIES

Rockslide, slips and falls into the mine workings, road blockage, unsatisfactory condition of the underground transport, falling mechanisms or tools, explosion of coal dust and fire are the main causes of emergencies that occur in mines among the others. To save employees in emergencies, it is necessary to establish the exact location of each person by the accurate positioning. The system of positioning and search of employees must ensure the detection of human location in all mine workings with the transfer of information to the dispatcher and to the command post of the object in real time.

In the work of M. Zhukov, [1] the manufacturers of equipment for positioning miners are represented. Most of the personnel monitoring systems are based on the RFID tags. It is used the "Nearest cell method" and records only the event of the appearance of personnel in the area of the reader at a distance of

up to 30 m. To more accurately determination of personnel position personnel in the mine one may use WiFi ("Granch"), NanoLOC ("Ingortech"). Positioning accuracy in such systems reaches 5-20 m. All these systems belong to real-time local positioning systems (RTLS - Real Time Location System). Such systems are being developed intensively both to increase safety in coal mines and for enterprises in other industries [2-4].

In accordance with the legislative standards, the error of positioning systems today is 20 m, therefore the development and implementation of systems of more precise and zonal positioning, which can be integrated with video surveillance systems to increase control levels, is an urgent task.

Tasks to be solved: control of miners' access levels; control of the location of miners in the mine workings; control of working hours and access levels of staff; emergency notification of miners; evacuation and identification of miners caught in the accident.

According to the general requirements for positioning systems [5-7]:

- the personnel positioning system must continuously display on the mine mnemonic the location of each employee who went down to the mine, with a resolution of ±20 m on a real time basis;

- availability of the general mine emergency warning system.

An analysis of available in the country's mines positioning systems shows that they do not meet the requirements of the standard because of:

1. Positioning is performed only "to the nearest section of the mine", which is significantly inferior to the parameter: "with a resolution of ±20 m";

2. Data on the location of personnel are provided to the mine control room discretely - when an individual mark enters the area of readers placed in the mine at a significant distance from each other at intervals that do not correspond to real time.

Improving positioning accuracy is required not only to fix the location of a person at the time of the accident but also to fence off the emergency zone in which workers may be, to warn personnel about vehicles moving in a certain direction, to warn the driver about the obstacles ahead etc.

This work analyzes the system of personnel positioning, transport and monitoring of mining equipment (SPPTMME) manufactured by LLC "SPBEK-Mining" [8], which has the following advantages over similar:

1. With the appropriate coverage of the mine workings by the readers of the system, the position of the personnel and transport is determined continuously with an accuracy of ±10 m.

2. Low power consumption of devices allows to create stand-alone devices with a long operating time from a single power source (up to 2-3 years).

3. Ability to transfer small amounts of data in the radio channel between devices and further via wired and optical interfaces to the upper level of the system.

Resolves the following problems:

1. To determine continuously the location of the system receivers in the mine workings with an accuracy of ±5 m and to display their position on the plan of mining operations in 3D with the possibility of scaling.

2. To create traffic control systems for underground transport (wheeled vehicles, electric locomotives) based on the exact positioning data.

3. To embed system receivers in other devices and transmit various data from them (equipment status, measurement results of various parameters, etc.)

The already mentioned SPPTMME [8] belongs to the class of RTLS-systems (Real-time Locating Systems - real-time positioning system). As a rule the mode of operation of all RTLS is based on measuring the distance between the mobile receiver of the system (label) and fixed "base stations" (readers) with known coordinates. In this case, to accurately determine the position of the receiver in the *n*-dimensional space relative to the base stations, it is necessary to have information about the distances to *n*+1 base stations. With such information the coordinates of the moving transmitter can be calculated.

Currently available on the market RTLS use various radio technologies (WiFi, UWB, ZigBee, NanoLOC etc.) and different ways to measure the distance between the receiver and the base station (ToA, TDoA, ToF, TWR, RSSI etc.).

The disadvantage of this method is the large variability of measurement results at short distances (up to 20 m), which is associated with an increasing in the ratio $(t_2\text{-}t_1)/(T2\text{-}T1)$ and the prevalence of signal processing time in the second receiver over time of radio signal propagation.

In addition to the TWR method, the RSSI (received signal strength indicator) method, which is a signal strength level indicator, is often used to increase the accuracy of short-distance measurements. This method allows to determine the location of the device based on the level of signal intensity received by the BS or vice versa. The RSSI method is convenient to use at close distances, as at these distances is the fastest relative attenuation of the signal and the device, which are almost always in line of sight. Therefore there are no structures that weaken the signal and make an error in the measurement accordingly.

The main practical difference of the proposed SPPTMME system from existing systems is increased accuracy of positioning which allows to determine the location of workers with the necessary accuracy not only in horizontal workings, but also when performing specific work, such as floors of tunnel or reinforcing regiment in the construction of vertical shafts. As a result it allows to make the most optimum decisions to help the victims during a fire and the liquidation of emergency situations.

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SELECTED ANNOTATIONS ON THE IMPACT OF BEDROCK VIBRATION ACCELERATIONS INDUCED BY UNDERGROUND MINING ON THE BUILDINGS

Keywords: mining tremors, ground vibration, acceleration, damage of buildings.

Mining of mineral resources causes the disturbance of the primaeval stress state of the rock mass and the propagation of its failures processes. Besides those static influences, such as the rock mass and the ground surface deformations (see e.g. [2,12]), the manifestation of these processes may be dynamic phenomena - tremors induced by mining activities (e.g., [1]). The major of them have a magnitude similar to that of minor earthquakes [6]. There is some similarity in the ability to describe earthquakes and mining-induced tremors [11].

The consequence may be ground vibrations influencing the ground surface and infrastructure. The response of buildings and their damage results from the vibrations of the ground [8]. The peak amplitude of the accelerations is correlated with the seismic intensity and the physical properties of the medium [5].

Pilecka and Szemier-Zaucha [7] compiled reports on the historical development of methods for assessing the impact of mining tremors on buildings. They referred to the macro seismic scales used since the 16th century to assess the effects of earthquakes. The natural development, as they write, was first the MSK-64 scale, and then the SWD scale, the empirical GSI scale, or the $GSIG_{ZWKW-2012-V}$ scale dedicated to the Upper Silesian Coal Basin. They also write about the applicable European standards, in which the assessment criteria are: vibration intensity, velocity and/or vibration acceleration.

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Intensive mining exploitation carried out in mining basins, regardless of the mining method, pillar or longwall, causes tremors generating accelerations and vibrations of the rock mass, which are transmitted to the buildings. The most frequently used calculation methods in Poland are based on the solutions of Mutke [6] and Dubiński. Examples of calculations of accelerations are, e.g. [10] and [9]. The phenomenon of the impact of vibrations also applies to special structures, not only as a result of exploitation [3].

Mutke [6] and Dubiński based, on their many years of research and analyses, proposed "Rules for the application of the mining seismic intensity scale [...]". On the website of the GIG Research Institute, we read: “The GSIS-2017 scale is used to assess the effects of tremors induced by coal mining on buildings and to classify dynamic resistance of buildings. The impact of the tremors is described by the degrees of seismic intensity, which are classified on the basis of the recorded or forecasted ground vibration parameters (such as velocity amplitude, duration and frequency). […] Many new solutions were introduced, i.e., the actual dynamic resistance of buildings subjected to mining tremors, assessment of the effects of vibrations depending on the type of building structure and its technical condition […]. [...] the degree of reliability of the assessment of the harmfulness of vibrations was also improved. [...] An important effect [...] is the standardization of the assessment of the impact of mining tremors on the surface in various mining regions." (source: WWW of GIG Research Institute, 10.10.2021).

The presented advantages of the new Mining Seismic Intensity Scale make it one of the best tools for assessing tremors, vibrations and their accelerations in the conditions of post-finished or driving underground mining.

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EFFICIENCY AND SEISMIC SAFETY OF CONSTRUCTION OF UNDERGROUND STRUCTURES IN A MASS OF STRONG ROCKS OF COMPLEX STRUCTURE

Increasing the volume of construction of underground structures and workings of large cross-section (distillation tunnels on railways and subways in cities, mining in deep mines and mines), especially in difficult mining and geological conditions, requires improvement of existing and development of new resource-saving technological solutions time of extraction and processing of minerals with underground cycles of works with the use of explosion energy.

It is established that mining in the massifs of strong tense rocks is a time-consuming process. This is proved by studies, both in the laboratory and in industrial conditions to study the mechanism of destruction of solid media by explosion energy, which are in a stress-strain state [1-3] and modeling of these processes by methods of discrete and finite elements [4]. They allowed to develop new highly effective technical solutions for their implementation in practice. It follows [3] that during the excavation of workings on the surface of the face in the massif of rocks are concentrated high stresses that are in an equal component stress state with one free surface, which leads to their fragile destruction under dynamic (explosive) load. Detachment or rash is the result of visible destruction during stretching under the action of high compressive stresses. Although the gap in the workings in the massifs of strong rocks is fragile in nature, which contributes to the release of large volumes of rock, which is usually found in crystalline rocks and in conditions where the collapsing massif has one free surface and is in volume. high-intensity stress.

Thus, during the construction of two parallel tunnels of large cross section [2], one of which served as an experimental site, drilling was carried out according to the newly developed parameters of blasting (BPD), and the other - according to the basic BPD passport. Both tunnels were led perpendicular to the subhorizontal tension of the mountain range. In the process of tunneling, seismometric monitoring was carried out against the explosion of charges along the section of the mine. He showed that the oscillations of the rock mass during the tunnel in the traditional way contributes to the instability and movement of the

seismic zone in front of the face in the course of production to a depth of 4.0 m. Detonation (GPA) in natural cracks with the subsequent weakening of their connections. The high deformation gradients around the part of the mountain massif torn off by the explosion were due to the velocity at which the seismic oscillations propagate with respect to the position of the tunnel face.

An effective method of controlling the seismic action of the explosion and reducing the level of its impact on surface objects for civil and industrial purposes is the shielding of seismic oscillations of explosive waves by forming a shielding zone along the contour of the work under construction.

Therefore, the development and implementation of new highly efficient and seismically safe technologies for the construction of underground structures of large cross section in complex mining and geological conditions at protected sites is an urgent task.

Tasks, methodology and presentation of the results research. To substantiate the rational parameters of the method developed by us to reduce the seismic action of the explosion during excavation in the massifs of strong rocks of complex structure, industrial tests were conducted in the conditions of distillation tunnels of the Dnieper metro under construction. Its essence is to determine in the bottom of the preparatory zone of rocks with different from the existing physical and mechanical properties of the rock mass, taking into account their structure and fractures, which is a determining factor influencing the nature of seismic oscillations in different directions from the explosion site.

Then on the marked areas in the cross section of the drilling machine NKR-100M drill exploration wells with a diameter of 75-100 mm, carry out the selection of cores using a core sampler, from which in the laboratory make samples and conduct research specifying the properties of rocks and type and direction of crack systems. Then in these areas drill holes to a depth equal to half the length of the hole, charge the cartridge industrial explosives and blow up.

The anisotropy coefficient is calculated from the obtained emission funnels, according to which the parameters of the blasting passport in these zones (distance between holes in a row and between rows of holes) are adjusted using the developed nomogram (Fig. 1). And the fracture coefficient is cracked from the obtained crack systems.

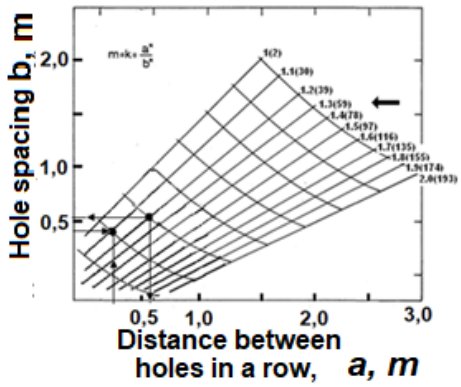

Fig. 1. Nomogram for calculation of parameters location of holes along the cross section of the mine in the adjusted passport of blasting operations

Next, adjust the parameters of the circuit charges and schemes of their location. To do this, in the area of the contour row drill one hole with a diameter not less than twice the diameter of the cartridge of industrial explosives to a depth equal to half the length of the inlet.

Then on the inner surface of the hole form symmetrical longitudinal cavities – incisions at an angle of 45° with a special device. The prepared hole is charged with cartridge explosives and blown up.

According to the system of formed cracks determine the radius of crack formation R_{crack} to the boundary of the flattening zone of the formed radial cracks. According to the obtained data of the radius of crack formation determine the rational distance between the contour holes, which should not exceed a=(1,5-2,0)R_{crack}.

According to the obtained reasonable parameters of the distance between the contour holes, they are marked on the surface of the face and drilled along the entire cross section of the mine. Next, in the contour holes along its entire length in the direction of the contour of the production make symmetrical longitudinal recesses - incisions at an acute angle. The prepared holes are charged with industrial explosives of the Anemix type - P32/250, initiators are installed, the mouth of the holes is sealed with stuffing, they are switched into the network and detonated with deceleration starting from contour charges with the formation of a shielding zone. on a section of working out.

Experimental explosions of the developed technological passports of blasting works were carried out in the conditions of the left distillation tunnel of the trunk №11 (15.06.2017, 04.07.2017) and the right distillation tunnel of the trunk № 14 (20.07.2017) of the Dnieper metro, which were evaluated by indicators seismic action of explosions on objects that are under protection. Seismic oscillations from the action of explosions in distillation tunnels were compared with reference oscillations for similar rock massifs, which did not exceed the current maximum permissible norms according to the DSTU of Ukraine.

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DEVELOPMENT OF THE TECHNOLOGICAL SCHEME OF ENRICHMENT IRON-CONTAINING ORE OF THE TEBINBULAK DEPOSIT

The leading industries of the Republic of Uzbekistan are mining and metallurgical, machine-building and petrochemical. Production in these industries is based on the wide use of high-

strength, wear-resistant, corrosion-resistant steels and alloyed cast iron. The creation of a stable mineral resource base of the steel industry based on a detailed study of local minerals, the assessment of the technological characteristics of the studied types of mineral raw materials and the justification of the presence of import-substituting varieties in the production of ferrous metals in the republic is a topical problem of the mining industry of the republic. It requires the study of genetic types, material composition, morphology and the degree of enrichment of iron ores, the main iron ore deposits of Uzbekistan. One of such deposits is the Tebinbulak deposit of titanomagnetite ores, which requires a special approach to the development of technology for enrichment and further processing.

The purpose of this work is to study the material composition of the ore sample and to develop an effective technology for the enrichment of titanomagnetite ore from the Tebinbulak deposit.

Based on the study of the material composition of the ore, the nature of the inclusions, the minerals composing them, as well as the study of the literature data and the experience of previously conducted studies similar in material composition, gravity is accepted as one of the main methods of enrichment. Electromagnetic separation has also been tested as the main classical method for the enrichment of iron-containing ores.

The ore was crushed in a laboratory ball mill of the 40ML brand with a Solid ratio:Liquid:Balls equal to 1:0.75:8.

Samples were subjected to electromagnetic separation, both in dry and wet form. Electromagnetic separation of ore and enrichment products was carried out on a dry electromagnetic separator of the 138T-SEM type and a wet magnetic separator of the EBM – 63/7 brand.

The results of the enrichment experiments were evaluated according to the data of chemical analysis for iron conducted in the chemical laboratory of the State Enterprise "NIIMR".

Gravitational enrichment was carried out in order to isolate relatively heavy particles of iron minerals from ores into a gravity concentrate. The ore with a grain size of -3+0 mm was further ground in a ball mill to the required size. In the experiments, the size of the material enriched on the concentration table varied from 1 to 0.15 mm in order to obtain the maximum possible extraction of iron and its content in the concentrate.

Table 1 shows the results of experiments on gravitational enrichment of an iron-containing ore sample.

Table 1

Results of gravitational enrichment of iron-containing ore

Size, mm	Enrichment products	Exit, %	Iron Content, %	Iron Extraction, %
-1+0	Gravioconcentrate	15,35	27,3	32,73
	Gravity Tails	84,65	10,24	67,27
	Ore	100	12,8	100
-0,5+0	Gravioconcentrate	17,37	33,6	41,15
	Gravity Tails	82,63	10,1	58,85
	Ore	100	14,18	100
-0,315+0	Gravioconcentrate	13,61	42,0	42,48
	Gravity Tails	86,39	8,96	57,52
	Ore	100	13,46	100

As can be seen from Table 1, during the gravitational enrichment of the ore sample of the Tebinbulak deposit, the best results were obtained when the size of the feed material was -0.315÷+0 mm. At the same time, a gravioconcentrate containing 42% iron was obtained when it was extracted by 42.48%.

The gravioconcentrate, gravity tails and the initial ore in dry and wet form were subjected to electromagnetic separation.

The ore with a grain size of -3÷+0 mm was further ground in a ball mill to the required size. In experiments on electromagnetic separation, the size of the material being enriched on an electromagnetic separator varied from 0.315 to 2 mm and the current strength in the separator windings was 0.25-12 A in order to determine the optimal operating mode of the separator and obtain the highest possible technological enrichment indicators.

The best results were obtained by magnetic separation of a thinner class of gravity concentrate.

The products obtained during the enrichment of the fineness class -0.315÷+0 mm at a current strength of 5 A were additionally analyzed for the gold content. In the magnetic fraction, the gold content was <0.1 g/t and in the non - magnetic fraction-0.14 g/t.

In order to extract the remaining iron, the gravity tails were subjected to wet magnetic separation. During the enrichment of gravity tails of class -1÷+0 mm at a current strength of 8 A, the non-magnetic fraction was further ground and re-enriched by wet magnetic separation. The results of wet magnetic separation of gravity tails of various sizes show that the best results were obtained with magnetic separation of a thinner class of gravity concentrate. The obtained products were additionally analyzed for the gold content during the enrichment of the fineness class -0.315÷+0 mm at a current strength of 5 A. In the magnetic fraction, the gold content was <0.1 g/t and in the non – magnetic fraction-0.14 g/t. During wet magnetic separation of gravity tails, concentrates containing 29.62-45.28% of iron were obtained while extracting 8.14-36.12% of it from the operation.

The enrichment of ore of various size classes on a dry magnetic separator did not give positive results. During dry magnetic separation, concentrates containing 14.14-40.95% of iron were obtained while extracting 57.35-96.2% of it from the operation. Dry magnetic separation should be used to isolate a part of the rock to improve the quality of the source material coming for further processing.

When ore of the class -1÷+0 mm and -0.5÷+0 mm was enriched at a current strength of 10 A, the non-magnetic fraction was re-crushed and re-enriched on a wet magnetic separator. The results obtained show that a concentrate with a yield of 10.38% containing 56.14% iron can be obtained from the ore at a grinding fineness of -0.315÷+0 mm, while extracting it 41.84%.

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RESEARCH AND APPLICATION OF SEMI-MECHANIZED MINING TECHNOLOGY FOR A FEW MINES OF DONG BAC CORPORATION IN QUANG NINH COALFIELD, VIETNAM

Semi-mechanized mining technology is a type of technology that uses shearer or plow with non-mechanized supports to extract raw coal block [1]. This type of technology has been been used in many different countries, especially China [2;3], where semi-mechanized mining technology applied to thin coal seams with gently sloping angle is also relatively effective. Currently, semi-mechanized mining technology for thin coal seams is still very new for underground mines in Quang Ninh coal basin, Vietnam.

At present, coal mines owned by Dong Bac Corporation are managing and exploiting mainly by underground method. With a small mining area, the annual mining output at the mines is not high. Excluding the Nam Khe Tam mine which is exploited by Company 86, Dong Bac Corporation also has underground sites such as: Bac Quang Loi, Tay Bac Khe Cham (790 Company); Tay Bac Nga Hai, Tay Nam Khe Tam (35 Company); Dong Ri (45 Company); Nam Khe Tam (86 Company); Khe Chuoi (91 Company); Ho Thien (618 Company); Dong Quang La and Tay Quang La (Thang Long Company) with a total geological reserves of about 66.9 million tons.

Depending on different geological conditions, Dong Bac Corporation has commanded and applied different mining systems as well as supporting and mining technologies. Up to now, the Corporation has researched and applied many different types of supports for each geological condition, such as hydraulic prop, moveable hydraulic support, moveable frame support, support "ZRY" and recently, a flexible mechanized support is being deployed at 35 Company, 618 Company and 790 Company. However, most faces in the Corporation are using mining technology of drilling and blasting method, which proves that coal mining technology has not been innovated and invested in this Corporation. The advantage of drilling and blasting technology is mobility and flexibility, which can be applied to all geological conditions. However, the disadvantages of this technology are low safety, interruption in technological chain, release of many harmful gases, as well as low labor productivity and mining output.

In order to eliminate the disadvantages of drilling and blasting mining method, along with the determination to modernize technology in underground mining, Dong Bac Corporation has cooperated with 86 Company to find suitable areas for the application of mechanized mining technology. The first problem is choosing the type of mechanization technology (semi-mechanized or fully mechanized), and the second is human resources to operate the equipment because the Corporation has no experience in applying such technology. Based on research results and consultation, as well as a practical study on application of semi-mechanized mining technology at some Chinese longwall faces for thin and gently sloping coal seams, the efficiency has been realized. Therefore, the Corporation decided to apply for the same conditions at Nam Khe Tam site of 86 Company [4].

From the above practical issues, the author also has researched and proposed a design for support plan and operation scheme for longwall face in a few mines of Dong Bac Corporation. On the basis of those documents, longwall face can apply and deploy in actual production to improve supporting and working efficiency of synchronous equipment in the longwall face, thereby increasing mining efficiency and worker productivity.

The selection of coal mining technology depends on many factors in which the geological conditions of mine are the decisive factors. According to preliminary assessment of geological conditions, the seam is relatively stable, and it is possible to use semi-mechanized mining technology. Currently, this technology is used in many different underground mines and has shown relatively good results. The application of mechanized technology at underground coal mines of Dong Bac Corporation has been approved by the Corporation's leaders based on geological conditions assessment of a few mines having suitable conditions. The application of semi-mechanized mining technology is to ensure the requirements of output as well as labor productivity and increase the level of safety [5].

+ Main synchronised equipment at the longwall face

The selection of synchronous equipment at the longwall face is influenced by many different factors and regulations. This selection is not only a problem of the technological system but also a problem of the most optimal combination. In order to ensure that the synchronous selection of equipment achieves the most suitable results for overall longwall face design, the equipment synchronization must be consistent with geological conditions of designed area, technical and economic factors of mines.

- *Shearer*

To extract coal in the longwall face, Dong Bac Corporation has chosen a China shearer MG125/150-WD. Cutting drum web: 1m; Number of cutting drum: 1 drum; Cutting drum diameter: 0,8m; Total weight: 8 tons; Outer Dimensions (Length x Width x Height): 6500 x 1600 x 700 mm

- *Roof support*

From analysis and comparison of different types of roof supports, the support selected for apply at the longwall face is a combination of single hydraulic prop DW22-300/100 and steel box bar DFB 2800/300. Max and min height of single hydraulic prop DW22-300/100 is 2240 and 1440 mm, the length of steel bar DFB 2800/300 is 2800 mm.

- *Transport equipment*

The transport equipment used in the the longwall face is a conveyor coded SGZ 630/2*90, which is synchronized with the shearer MG125/150-WD. Transport capacity: 250 ton/h; Conveyor length: 150 m; Rated power: 90×2 Kw; Dimensions of a plate (Length×Width×Height): 1500×630×190.

Support plan and operation scheme are two closely related technical documents. They must fit together in both time and space. These documents are prepared by professionals and are used to direct the production and management of the mine.

The support plan is a document that shows necessary information for viewer to use as a basis to build and install the roof supports, ensuring the safety of workers and equipment. On this plan, it shows the status of longwall face according to each extraction cycle, type of mining technology used, distance between supports, number of support, movement of shearer and support, as well as pressure control method in the face. In addition, the support plan also shows the progress of moving face in one day and the method for creating a room placing shearer.

+ Design basis of the support plan [6; 7; 8]

- Documents on the mine geology of design area; parameters on properties of roof and floor rock;
- Mining technology in the longwall face, technical parameters of equipment;
- Hypothesis to determine mine pressure (console beam hypothesis);
- Method of creating a room for placing shearer (head or tail);
- Method of controlling mine pressure in the longwall face;
- Skill level of workers;
- Requirements of actual production;
- Technical, safety and efficiency requirements.

The operation scheme in longwall face shows how to arrange the work to be done in a certain space and time relationship, and it also shows the number of people needed to complete each work to ensure that the longwall face moves on schedule to reach the designed capacity. It is extremely important to establish a suitable operation scheme for each different condition. This is what any manager wants because it determines the working efficiency of the selected synchronous equipment and ensures the safety for workers. Detailed research and calculation based on initial geological

data to establish a close relationship between technological stages is essential. This aims to maximize the working efficiency of shearer as well as other equipment at the longwall face. The operating efficiency of shearer is one of the factors affecting the economic efficiency in the mining process. In order to achieve high productivity in longwall face, it is necessary to arrange a reasonable operation scheme so that shearer can promote its advantages.

+ Design basis of the operation scheme [9; 10; 11; 12]

- Factors regarding characteristics of geological conditions of the design area;

- Technical and technological factors;

- The parameters directly affect the productivity of shearer;

- Movement speed of shearer;

- Tasks need to be completed in one mining cycle: cutting face, strengthening face, reparing face, operating face supports and conveyors...)

- Norms to complete each task;

Conclusions: This mining technology diagram which has been applied at Nam Khe Tam mine step by step shows the efficiency in exploiting thin and gently sloping seams. Thereby, it is recommended that Nam Khe Tam mine, 86 Company continues to report and evaluate so that this technology can be applied to other areas with similar geological conditions. At the same time, this is also a premise for Dong Bac Corporation to comprehensively evaluate other mines with thin, gently sloping seams in the corporation to put this technology into application

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INFLUENCE OF DRILLING MUD ON CAPACITY-FILTRATION CHARACTERISTICS OF CARBONATE ROCKS

The productivity of oil and gas condensate wells mainly depends on geological and petrophysical conditions and filtration and capacity properties of reservoirs. However, in the process of well construction there is a sharp, and in most cases irreversible, decrease in the filtration-capacitive properties of the reservoir. As a result, there is no potential flow rate, which leads to an increase in payback period and a decrease in the final hydrocarbon production factor [1, 2].

The reduction of the filtration-capacity properties of the reservoir mainly occurs during the initial opening of the reservoir, so it is necessary to use special technological fluids for their opening, which would not impair the natural permeability of the reservoirs, especially carbonate. Many special fluids have been developed, implemented and used, the composition of which depends on the conditions of productive horizons [3, 4].

To improve the quality of carbonate deposits of the group of deposits in the area of Zagoryanska Square, the formulation of the drilling mud was developed, which would not impair the filtration-capacity properties of the bottomhole zone of the formations at maximum repressions.

The influence of the drilling mud on the properties of carbonate rocks was evaluated according to the standard method on the UDPK-1M installation. The studies were performed on carbonate core material selected from the drilling interval 4935-5090 m well №1 Zagoryanska Square, which corresponds to the interval of St. №3, which must be disclosed.

The main direction of research was to determine the type of mud that will be used as a flushing, and at the same time will preserve the capacitive filtration properties of the pore space.

For this purpose, liquids of polymer-potassium low-clay type, liquids of clay-free polymer-magnesium type on polyacrylamide basis, and liquids of hydrogel-magnesium type were investigated. Prior to the study, the core was moistened with formation water of the chlorocalcium type ρ=1.18 g/cm^3, which is characteristic of the B24-25 deposits of the Zagoryanskoye deposit. The repression on the reservoir during the research was 250-300 atm, ie the conditions of the maximum repression on the reservoir at dynamic loads during drilling were modeled.

From the conducted researches it is possible to draw a conclusion that solutions of clay-free polymer-magnesium type on polyacrylamides have the greatest depth of penetration into a layer. However, they are characterized by a low rate of recovery of the formation after their application. In

addition, after treatment of the core with an acid solution, the formation of insoluble polymer structures, which almost completely clog the layer.

Although polymer-potassium solutions have a small depth of penetration, this effect is achieved by clogging the pores with a solid insoluble clay phase, which is part of these solutions. Due to this, the recovery rate of the formation after the application of such solutions is also low.

Solutions of hydrogel-magnesium type at a relatively small depth of penetration into the formation, are characterized, among others, by a high coefficient of permeability recovery. After application of such solutions and the subsequent acid processing the pore space of a layer is restored almost completely. Having sufficient density and viscosity, they do not contain an introduced solid phase that would irreversibly cloud the pore space. Carbonate blockers are formed during the preparation of this washing liquid and do not cloud the pore space.

However, according to some data, under the influence of process fluids based on bischofite, the filtration properties of the formation often deteriorate due to the formation of insoluble sulfate sediments in the pore space as a result of the interaction of filtrates and formation fluids [2].

Studies on the core material of the productive horizons of the Zagoryanskoye deposit have shown their high sensitivity to the action of formation waters in the presence of bischofite, which contains sulfate ions. It is noted that in the presence of sulfate ions in bischofite, the permeability and recovery of the formation in the presence of formation water is reduced by 11.53, and when using pure bischofite - only 1.29 times.

The results of research have shown that for the preparation of polymer-magnesium solutions it is necessary to use desulfated bischofite.

Based on the above, it can be concluded that the optimal drilling mud for opening layers of carbonate type, having a high coefficient of permeability recovery is hydrogel-magnesium liquids using desulfurized bischofite. Studies of drilling mud have revealed that the opening of productive strata on depressions using a solution of desulfurized bischofite allows to preserve the natural filtration properties of reservoirs and increase the efficiency of extraction of carbohydrates from the subsoil.

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INCREASING THE MINERS SAFETY IN THE UNDERGROUND COAL MINING

With the deterioration of mining and geological conditions of coal seams and increasing the longwalls load, various emergencies are increasingly occurring. Moreover, the analysis of the circumstances and causes of accidents indicate that increasingly their main cause is the human factor. However, this is not always the worker's fault. Sometimes it is difficult for miner to assess the situation in the workplace due to the presence of many distracting and masking factors, as well as his psychophysiological condition. Heavy and stressful working conditions, personal fatigue "provoke" the miner to simplify operations by disregarding the requirements of safety rules. Therefore, it is important to establish the interconnection between the level of miners injuries in coal mining and their physiological capabilities during of making the production operations.

Really, at implementation of productive process operations the mortgage of safe mining is accordance of power-hungriness of works to physical possibilities of miners. These possibilities can be estimated by the energy expenditure of the miners organisms. According to the amount of energy expenditure to perform certain operations over a period of time, we can set the intensity of energy expenditure of the body and assess the difficulty of work for a particular worker. That is, the total energy expenditure of the worker (E_T, kcal) when performing the operation or their combination, constituting a certain production cycle with a duration of t is determined by the expression (Nehrii et al. 2017)

$$E_T = \sum_{i=1}^{n} \left(N_i t_i \right), \tag{1}$$

where t_i - the duration of the i-th operation (sub-operation), min., and the weighted average energy expenditure for the production cycle (N_T, kcal / min.) taking into account the forced breaks, will be (Nehrii et al. 2017)

$$N_T = k_w \sum_{i=1}^{n} \left(N_i t_i \right) \Big/ \sum_{i=1}^{n} t_i \,, \tag{2}$$

where k_w - the coefficient of working time density.

The energy expenditure of the human body in different studies was determined in different ways: by determining the reduction of energy resources of the organism; by measuring heat production; by the magnitude of the oxygen demand; by determining the amount of work spent on the implementation of production operations; by heart rate. The most universal is the method of determining energy expenditure by heart rate, because it is faster, simpler and allows to quickly determine the condition of the worker.

According to the results of studies presented in (Zolina et al., 1983) and (Research Report, 1994), a linear dependence of energy expenditure of miners on heart rate, which has the form (Nehrii et al. 2017)

$$N = 10{,}4(HR - 71{,}6) \qquad W \tag{3}$$

(R^2=0,9; $t > t_{cr}$ (22,08>2,06); $F > F_{cr}$ (225>4,24))

To verify this dependence and determine the difficulty of the miners in performing certain operations, observations were made on the miners with the fixation of their physiological and ergonomic characteristics. 643 heart rate measurements were performed during various operations by different miners. Then from expression (3) the current energy expenditure was determined, and from expression (2) - the average value of energy expenditure of the miner's body during the performance of a particular operation. It was found that the heart rate of miners varies from 76 to 168 beats/min. (on average from 81 to 145 beats/min.), and, depending on the type of work performed, the energy expenditure of their organisms varies from 46 to 1003 watts (on average from 91 to 760 watts).

Comparison of the energy expenditure of miners with work schedules showed that the underground workers of the main professions during the shift experience increased physical activity. The body's total energy expenditure often reaches or exceeds acceptable values long before the end of the shift. They show earlier signs of fatigue. The total energy expenditure during the works was determined from expression (1) and compared with the allowable (290W) and optimal (174W) values of energy expenditure of the organism, which are regulated in the normative document (State sanitary norms and rules, 2014).

To assess the difficulty of work, an indicator was adopted (Nehrii et al. 2017)

$$k_в = \frac{N_T}{290}, \tag{4}$$

where 290 is the conditional limit of the difficulty of continuous work without rest for able-bodied men, W.

In cases where $k_в \geq 1$, working conditions are harmful (State sanitary norms and rules, 2014), otherwise - the worker performs his duties in a safe environment. Comfortable working conditions will be in the case when energy consumption will not exceed 174 W ($k_в$<0,6).

The study of accidents data at the mines of the Pokrovsky and South Donbass coal districts, consideration of work schedules related to an accident, allowed to establish the patterns of miners injuries during the main production processes.

Determining the energy expenditure of the miners' bodies affected by the production cycle operations that preceded the occurrence of the adverse event, led to the conclusion that before the injury, the performers worked in hazardous conditions due to the difficulty of work.

The comparison of accidents and the coefficient of severity of work, calculated from expression (4), indicated that most injuries were received at $k_в$>1 (mostly $k_в$ was in the range of 1.04-2.41). All

operations were regulated by the work organization schedule and were performed in strict compliance with it. That is, the implementation of regulated work was accompanied by injuries to workers. In this case, one of the ways to reduce the level of injuries may be by reduce the loading on the person by changing the improvement of the work schedule and optimize of the operations process. To do this, we can increase the duration of breaks for compensatory rest or increase the number of workers on labor-intensive operations. Then a break for compensatory rest is required for the duration of work t_w (min.) And can be determined from the expression (Nehrii et al. 2017)

$$t_r = \left(\frac{N}{4{,}2} - 1 \right) t_w . \quad (5)$$

Thus, it was found that accidents can be associated with employee fatigue, when the physical capabilities of miners do not correspond to the energy intensity of production operations that make up the work schedule. Therefore, it is necessary to further study the physiology of miners to ensure safe working conditions.

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EVALUATION OF MATERIALS FROM THE EXCAVATION OF THE OUENZA HEMATITE DEPOSIT (NORTH-EAST ALGERIA) BY GRAVIMETRIC ENRICHMENT

Abstract

Quarries and mines that exploit hematite ore Fe_2O_3 usually have a large quantity of waste rock with low iron content, stored in the slag heaps of quarries or mines without enrichment. This work consists in finding solutions to this product to make it more or less usable in industries. As an example of use, the Fe_2O_3 content in the clinker after grinding and homogenisation varies between 1 and 8%. Africa. After chemical and mineralogical analysis of the whole product, the large percentage of existing chemical elements is the hematite ore Fe_2O_3 which has a low iron concentration. To improve its iron content, it must be treated by chemical and hydro mechanical

processes that are economically viable. Since it remains in the product heap, it will be degraded in the open air of the quarry by atmospheric chemical reactions. A certain amount of this stockpile is sampled at different locations in a heap to distinguish the chemical elements of the dominant product. The search for good enrichment techniques of these materials after their homogenisation led us to choose among the main separation operations, those based on the difference of densities obtained by suspension in granulated Ferro-solutions composed of silicon and magnetite. From the results of the gravimetric separation, three fractions were obtained: an iron-rich fraction with a content > 45%; a medium fraction with an iron content of 45 to 10%; an iron-poor fraction <10%. The two fractions rich in iron and poor in iron are eliminated at the beginning of the enrichment operations. According to the magnetic properties analysis, as a semi-separated product, the medium iron fraction will undergo a new enrichment sequence by high magnetic field separation.

Keywords: separation; hematite; heavy suspension; magnetic properties.

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INDUSTRIES AT THE HEART OF THE CITY OF CONAKRY? WHAT ARE THE CONSEQUENCES ON THE ENVIRONMENT?

Summary

Nowadays, the climatic changes which are the basis of atmospheric disturbances are already having a negative impact on the whole country in general and in particular on the coastal region. In

Maritime Guinea (Conakry), most socio-economic activities are affected by these impacts. The discharge without adequate treatment of effluents from industries located in the capital constitutes a great threat to the environment. The aim of this research is to determine the concentrations of pollutants in these effluents and their impacts on the environment. This study made it possible to grasp the problem of the anarchic discharge of industrial effluents into the environment, their current management method and to foresee measures aimed at reducing their quantity and improving their management methods in order to protect our environment.

Keywords : Climate change, pollution, effluents, flooding, greenhouse effect; rainfall, atmosphere, environment.

Introduction

Air pollution in urban areas is generated by transport, industry and energy production.

- it is manifested by the presence of fine particles (aerosols, and in particular carbon).

- in the world.

❖ An Italian factory treating iron titanium of European origin (to extract the titanium dioxide necessary for the paint and plastics industry) released an average of 3,000 tonnes of residues per day in which 330 tonnes were effluents liquids rich in sulfuric acid, iron sulphate and muddy effluents, mainly containing iron and heavy metals such as titanium, chromium, etc.

All these industries located in Conakry and in the interior of Guinea produce waste whose quantities are not yet known, so by analogy with the figures cited above, we ask ourselves what is the current situation of Guinea in terms of industrial pollution?

These industrial emissions contribute to the accumulation of greenhouse gases , the composition of which is as follows:

❖ Water vapor: H_2O

❖ Carbon dioxide: CO_2

❖ Methane; CH_4

❖ Nitrous oxide: N_2O

❖ Certain organic compounds rich in chlorine and fluorine (cfc, hfc, sf6).

❖ Currently, nearly 50% of the CO_2 emitted into the atmosphere comes out of the carbon cycle and will remain in the atmosphere for 100-150 years.

Conclusion

➢ *Demographic growth and* industrial development *considerably affect the Guinean environment in general and more particularly in its coastal part where its capital Conakry is located, which* constitutes the industrial center of the country with a very high production rate of industrial effluents. Guinea *is one of the most* vulnerable countries, exposed *to the effects linked to*

the variability and disruption of the climate system *and affected by* climate change (especially flooding).

➢*he results on industrial pollution in Guinea in terms of* CO_2 *are worrying, so we asked ourselves the following question :* what will the concentration of CO_2 be in the coming years in Guinea with industrial development if adequate mitigation measures are not taken? are not taken?

➢ *We believe, that mechanisms to reverse the trend to return to equilibrium after the disturbances, must be taken into account by the* private *and* public *sector and especially at* the local *and* global leve.

This work made it possible to characterize the environmental impact of industrial effluents on the Conakry area. In order to achieve the objectives of this study, our efforts were made on the location of the sources of effluents, the measurement of their physicochemical parameters on the one hand and on the other hand the evaluation of their flows in the nature.

The analysis of these results obtained showed that the discharge of a high quantity of industrial effluents dangerously affects the environment and causes disruption of the climatic system and causes natural and man-made risks in the Guinean coastal zone.

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MODELING OF ROCK DESTRUCTION OF ASYMMETRIC LOADING WITH THE AIM OF FINDING WAYS TO REDUCE ENERGY COSTS

The existing mass technologies of rocks destruction have low efficiency (primarily energy): even the most advanced of them "use" for useful work less than 5% of the supplied energy [1].

For describe of process the disintegration are used diagrams "longitudinal stress - longitudinal deformation" obtained for prismatic samples under uniaxial compression [2]. Analytical

constructions of such diagrams are also used [3]. In real conditions of disintegration there may be other conditions, for example, in millstones or in cone crushers where in addition to normal, oppositely directed contact shear stresses act.

Based on the parameters of the diagrams mentioned, it is possible to determine the specific fracture energy E_f of the sample according to the well-known formula $E_f = p^2/2E$, where p - specific force on the bearing platform; E - elastic modulus of material.

The condition for the limiting state at the crack tip is the equality of the ultimate shear strength of the material to the active shear stress minus the losses for internal and contact friction according to the Coulomb criterion

$$k_n = |\tau_\alpha| - \mu\sigma_\alpha,$$

where k_n - limit strength of rock on shear at the top of the crack at TMESS (trajectories of maximum effective shear stresses) ξ; $|\tau_\alpha|$ - active shear stress on TMESS; μ and $\rho = \operatorname{arctg}\mu$ - coefficient and angle of internal friction; σ_α - normal stress at TMESS ξ. We consider that cracks develop along TMESS

$$\alpha = \frac{\pi}{4} + \frac{\rho}{2} + \beta_\xi. \qquad (3)$$

As the crack develops, part of the material comes from under the load. On the bearing part of the sample, for example, for rocks with a truncated-wedge fracture shape, there is a change in the distribution of the contact load and specific force, the values of which we need to calculate the specific energy of destruction.

Specific effort ρ at symmetrically directed contact shear stresses on TMESS (fig. 1, curve 1) grows from the ordinate of the crack tip (as the tip moves away from the upper contact plane).

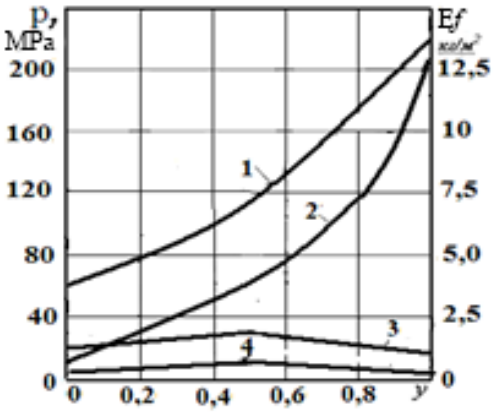

Fig. 1. Dependences of the specific force and specific fracture energy on the ordinate of the crack tip at k_n=10 MPa; ρ=45°; f=0,3, E=2000 MPa

With asymmetrically directed contact tangential stresses, compared with symmetrically directed stresses during fracture of the sample, it leads to a decrease in the specific force by up to 12 times

(Fig. 1, curve 3). To calculate the specific energy of destruction, we use the well-known formula [3], which takes into account the energy consumption during oblique shear,

$$E_f = 1/(2E)*(p^2+2(1+v)f^2\ p^2). \quad (3)$$

The specific fracture energy under asymmetric loading decreases 50-60 times (Fig.1, curve 4).

Conclusions

As a result of the development of mathematical models and analysis of the tension of the zone of interaction of the tool with the rock of destruction, it was established:

1. As the cracks develop, the specific force at symmetric contact tangential stresses increases all the time, and at asymmetric directional contact tangential stresses increases from the ordinate of the crack tip to the horizontal axis of symmetry, then decreases, while the maximum value of the specific force in the first case is 11-12 times higher.

2. The specific energy of destruction (for the example of a sample) at asymmetrically directed contact shear stresses in comparison with symmetric loading is reduced by up to 50-60 times.

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THE CAUSAL LOOP OF THE SYSTEM DYNAMIC MODELLING OF OCCUPATIONAL SAFETY SYSTEMS

There are many different accident prevention methods and techniques depending on the specifics and technology of the plant. Difference of the methods are based on the specifics of the accident, the nature of the accident, the recurrence nature, the frequency of the accident, the probability of occurrence and the risk of the accident.

Therefore, in order to reduce the number of accidents and the number occurrence to approach the accident, the main variables that affect occupational safety have been identified and how the level of hazard risk can be assessed by modeling the dynamics of the system.

The risk of occupational hazards is assessed to reduce accident occurrence in enterprises that have been performing based on mathematical statistics and probability theory. Therefore, we need more than practical and modern methods to assess the risk of hazards.

So, we have developed a new approach based on the theory of system dynamic modeling. The system dynamic model for assessing the level of occupational safety of the organization can be used to determine the current level, as well as realistically manage the factors and variables that affect the future level and it is more practical than current methods.

In the last 10 years, the number of employees in the light and heavy industry sector in Mongolia has increased due to the increase in the number of companies operating in the light and heavy industry sector. On the one hand, this will have a positive impact on the economic and social development of Mongolia, and on the other hand, it will cause significant harm to the safety and health of working people.

There is no common understanding or classification of industrial accidents in the world, and many scientists classify the causes of accidents as organizational, technical, workplace, and human. Internationally, occupational safety assessments are conducted by identifying operational hazards, followed by occupational safety assessments and risk assessments.

Probability theory and mathematical statistical methods such as fault tree analyses, failure mode analyses, and the fish bone method are used. Although these methods have contributed significantly to the development of risk assessment methodologies to the present day, they may give erroneous results due to the probability of an accident due to uncertainty and many specific factors.

Therefore, it is important to develop and implement a theory and methodology for risk assessment using dynamic modeling of the system of real responses to uncertain factors of accidents.

A detailed study of the many variables that affect the safety organization of the enterprise and the culture of occupational safety and the identification of key variables is the basis for establishing a causal loop in the dynamic model of occupational safety systems. The values of the other variables required to construct a dynamic model of an organization's occupational safety system need to be defined by determining the relationship between them.

The major purpose of safety risk analysis is to consider the dynamic characteristics nature of the risk whole process and operation of any industries , as well as the feedback frequencies that generate the risk impact. The next step in developing a loop and stock diagram is to build for system dynamic model, but it is important to determine the relationship between the variables. This operation can be performed with the special software, in example Vensim. In this way, the level of occupational safety of the enterprise can be assessed with the help of the main variables that affect it, and it is possible to predict the future.

The following conclusions can be drawn from the study of the possibility of establishing a causal loop in the dynamic design of occupational safety systems for enterprise:

1. In order to reduce the number of accidents and the number of occurrence to approach accidents, it is important to conduct regular risk assessments and to develop relevant methods and techniques in accordance with the specifics of the organization's activities.

2. Since workplace hazards, its aggravations, and accidents depend on time and a variety of adverse factors, it is possible to use system dynamic modeling to manage them in order to eliminate or reduce them in real time.

3. In order to ensure occupational safety, it is possible to effectively model all types of hazards by using object-oriented simulation techniques.

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INCREASING MINING PRODUCTIVITY AND EFFICIENCY IN THE FACE OF DEWATERING CHALLENGES AND INCREASED MINING DEPTH AT KONKOLA COPPER MINE, ZAMBIA

Abstract

Konkola copper mine in Zambia, is one of the world’s wettest mines. In order to sustain mining operations, the mine pumps between 350 000 m^3 to 400 000m^3 of water per day. The predominant copper ores mined are: chalcopyrite, chalcocite, bornite and malachite. In addition to the dewatering challenges, the mine has been experiencing reduced ore recovery of about 70% and high dilution of about 20 % in sublevel open stopping mining method with increase in the mining depth. The current mining depth is 1040 m level. The implementation of the dewatering plan has lagged behind due to financial constraints. The footwall aquifer at shaft № 3 is behind by almost 3 years while the hangingwall aquifer at shaft № 4 is behind by at least 13 years. This has resulted in most of the reserves being underwater. This paper explores the current dewatering challenges and methods used at the mine to accelerate the mining of deeper ore reserves and the empirical stability graph/numerical (Phase 2) methods used to optimise the stopes in order to increase ore recovery

from 70 % to 85 % and reduce ore dilution from 20% to 10% so as profitably sustain mining operations. It is anticipated that once the above methods are fully implemented, ore production would increase from the current one (1) million metric tonnes per annum to five (5) million metric tonnes per annum.

Key words: Ore production, Mine dewatering, ore recovery, Dilution, Stope optimisation
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GENERAL SCIENTIFIC AND SPECIAL METHODS OF COGNITION IN THE METHODOLOGY OF IMPLEMENTATION OF ENERGY EFFICIENT INVARIANT CONTROL BY BALL GRINDING-CLASSIFICATION OF ORES

Ore preparation in the first stages of grinding at concentrating plants is mainly carried out in ball mills (BM) operating in a closed cycle with a mechanical single-spiral classifier (MSSC). Domestic iron ore concentrate from concentration plants is distinguished by a higher cost compared to foreign counterparts due to significant overspending of electricity, balls and lining and the production of substandard product when grinding ore, especially in the first stages of ore preparation. One of the main ways to improve ore preparation is to improve the automatic control of this technological process (TP), since the automated control systems (ACS) of this TP, used at domestic ore processing plants, largely do not meet modern requirements. Therefore, the transfer of automated control of ball grinding of ore to a higher level is an urgent scientific problem, the solution of which can be based on a new methodology for the implementation of energy-efficient invariant control of ball grinding-classification of ores.

The methodology is based on a method - a system of rules and techniques for studying the object of research. According to the degree of universality and scope of application, the methods are conventionally represented in the form of four main groups: general or philosophical, general scientific, private and special. Special methods are used for specific sciences. In technical sciences, general scientific research methods are mainly used, which are represented by empirical research methods, theoretical research methods and general logical research methods. For empirical research in this work, the methods of experiment, comparison, description and measurement are most suitable. Among the methods of theoretical knowledge, the most suitable may be the hypothetical and the ascent from the abstract to the concrete. It is advisable to use general logical methods here most widely - these are analysis and synthesis,

abstraction, idealization, generalization, induction, deduction, analogy, modeling, system analysis, statistical methods.

The use of general logical research methods can be represented as follows. The method of analysis should be applied when studying the influence of factors on the wear of balls in a mill, the use of balls of different sizes, the influence of bed placement and spiral dynamics on the output of the finished product. The synthesis method should be used when combining the dismembered and analyzed parts of the BM and MSSC into separate aggregates and together in a grinding cycle. The idealization method should be applied in theoretical studies, where it becomes necessary to neglect certain facts and will not lead to distortion of the results obtained. This is the supply of crushed solid in the form of cubic or spherical particles, neglect of an insignificant amount of material when determining the volume of sands between the turns of the MSSC spiral. Generalization allows you to make a mental transition from individual facts to a more general concept or judgment. The analogy method serves as the basis for modeling, it is used together with other methods. In this work, it is advisable to apply it together with experiment. Then it has the name of a model experiment, which is advisable to perform when proving the adequacy of determining the volume of sands between the turns of the spiral using a theoretical approach. Modeling is also a method of studying objects on their models. At the same time, complex objects are replaced with models that are specially created and are more convenient. In the work of modeling should be used widely enough. Usually either the structure of an object or its behavior are modeled. Simulations provide reliable results when the model closely matches the actual object.

The systems approach serves as the foundation of systems engineering, studying the problems of analysis and synthesis of complex information and control systems based on computer technology. In this work, it is advisable to apply this method when creating a hierarchical system for ensuring the ratio of solid / water in BM, taking into account the initial feed, its size, liquefaction of sands of the MSSC. Statistical research methods should be applied when processing experimental data, determining the errors of information tools and control systems, bringing the models' adequacy to real processes. Empirical research methods - experiment, comparison, description, measurement should also occupy an important place in this work.

In technical facilities, there are two main areas for experimentation, conducting laboratory and industrial research. The results of experiments serve as criteria for the truth of theoretical knowledge. In laboratories, experiments are carried out on physical models, for example, between the coiled space of a spiral. According to the developed methodology, it is possible to conduct laboratory experimental studies of nodes that are not mathematically accurately

described. In addition, it is necessary to conduct experimental studies (tests) of the grinding-classification cycle in production conditions in order to obtain data for linking the results of a theoretical nature and modeling to real technological processes. After experimental studies, it is necessary to consider the issues of practical implementation of a complex of energy-efficient invariant control of ball grinding-classification of ores based on indirect predictive estimates of the characteristics of raw materials and equipment.

The comparison method in this work should also be widely used. It covers almost all units of the complex: ball loading, lining actuation, classifier bath, method for determining the volume of sand between spiral turns, sand trough of the classifier, information transmission channel, pulp movement along the mill drum and energy efficiency of ore grinding in BM. This also applies to the method of description, which is carried out by means of language, tables, graphs, diagrams, rows, indices, and the like. In work, it must be used almost continuously.

The measurement method should be used in all experimental studies of this work. In addition to experimental studies, measurements are also used in the control of objects. The analysis showed that in the transition to a qualitatively higher level of control and the implementation of energy-efficient invariant control of grinding-classification of ores based on indirect predictive estimates of the characteristics of raw materials and equipment, it is necessary to develop 21 new measurement methods, including MSSC sands, BM output parameters, pulp state in the mill, energy efficiency ore grinding, ore grinding and ball charging. Most of these parameters have never been evaluated promptly.

In addition to general scientific methods for researching technical objects, a wide range of so-called special methods should be used that are typical for this work. Among them there is a need to highlight the methods that are used for various sciences, that is, unified special ones. They should use the methods of decomposition and composition, bringing the adequacy of models and theory to real processes, system theory, theory of accuracy, method of approximating dependencies, method of transient processes, method of superposition, hydraulics of non-Newtonian fluids, algorithmic method, invariant method. Special special methods of this work are the methods of the theory of automatic control, the theory of the radio engineering method and increasing the accuracy of information tools. Among the methods of increasing the accuracy of information tools should prevail their own, related to the peculiarities of their structure, action and implementation principle. The methods of the theory of radio engineering systems cover the transmission and reception of radio signals at high frequencies. The methods of the theory of automatic control should be used widely. They should cover all technological units of the grinding cycle and the most important processes.

So, from the foregoing it follows that the proposed methods of cognition, including a number of general scientific and special, as well as the proposed methods, can solve the overwhelming majority of general issues on the implementation of energy-efficient invariant control of grinding-classification of ores based on indirect predictive estimates of the characteristics of raw materials and equipment. At the same time, the main nodal solutions are more related to invariance methods.

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IMPROVENEMT OF ORE DRAWING TECHNOLOGY AND MINED IRON ORE GRADE IN UNDERGROUND MINING

In underground mining, deterioration of the mined iron ore grade as compared with their natural one occurs due to many reasons, the main of which is losses of rich ores and their dilution with waste rocks.

Major ore losses and dilution are observed during breaking and subsequent ore drawing. Therefore, this work is devoted to investigation of losses and dilution of broken ore at its drawing from stopes.

When drawing broken ore, the largest ore losses remain on the footwall of the ore body [1,2,4,6]. These reserves can sometimes reach 25-30% of the total reserves of the stope. Their extraction requires significant costs for driving additional workings and other technical and technological measures. Again, such additional measures lead to deterioration of the ore grade [1,2,6].

Thus, development and improvement of the technology for broken ore drawing, especially from the ore body footwall, is an important task in developing modern technologies of underground mining of rich iron ores.

Fig. 1 presents the technology developed by the authors to draw broken ore from the ore body footwall.

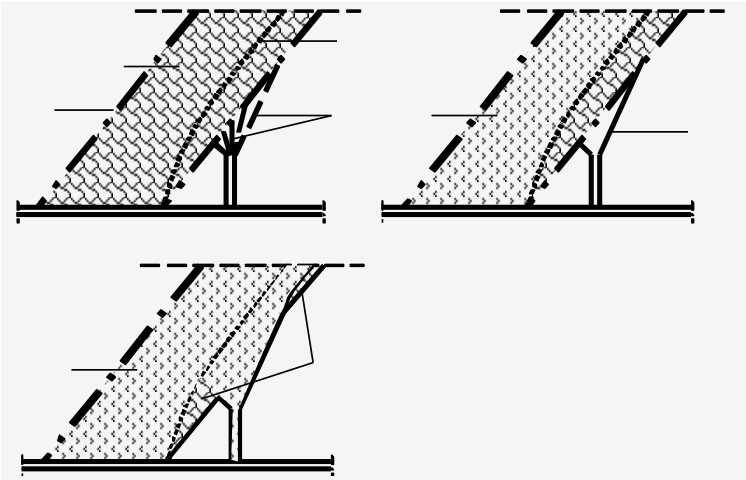

Fig. 1. Broken ore drawing from the dead area of the ore body footwall

As is known, to extract broken ore from the footwall, there are used drawing technologies that involve:

- footwall rocks blasting, their immediate drawing and subsequent drawing of the broken ore from the dead area of the ore body footwall [2,6].

The major disadvantage of this technology is significant costs for blasting, drawing, *haulage*, hoisting and waste rock dumping on the daylight surface, these resulting in significant rise of ore mining costs;

Fig. 1 - driving additional collecting levels (sublevels) in the footwall rocks.

The number of such sublevels depends on a level height and a dip of the ore body and includes driving a scraper drift in the footwall rocks, additional draw cones in the footwall rocks and additional discharge, ventilation-service and manway raises [6].

The major disadvantage of the technology of this type is a significant amount of work on driving additional collecting levels resulting in increased mining costs, retardation of stoping, reduction of concentration of operations due to introduction of additional sublevel stopes at different levels.

The proposed technology for drawing broken ore from the dead area of the ore body footwall is intended to eliminate the above-mentioned and existing weak points in current ore drawing technologies and is named “the technology of drawing ore through stope collecting cones”, Fig. 1.

The proposed technology is about the following. A raise is driven from workings of the main draw level in the footwall rocks.

Longholes drilled from the raise form stope collecting cones as is shown in Fig. 1.

Versus the current ones, the proposed technology provides for decrease in blasted waste rock volumes, reduction of costs for workings of additional collecting levels, for broken ore drawing and additional decrease of costs for waste rock hoisting and dumping on the daylight surface.

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EFFICIENT WORKING CONDITIONS OF STOPING FACES

The use of mechanized stoping complexes of a high technical level characterized by increased reliability, power-to-weight ratio and resource, necessitated the development of technological schemes adequate to them with design parameters that provide a favorable operating mode for such mechanization equipment with the full use of their technical potential to obtain the maximum economic effect from their use.

The main parameters that determine the dimensions of the extraction pillar are its length and the length of the stoping face. In recent years the average length of the extraction pillar in Germany and Great Britain has fluctuated between 1.1 and 1.3 km, in Australia it is 1,874 m, and in the USA 2,570 m. The longest extraction pillar in the world was mined in the USA at the Twentymile mine: 5365 m [1]. The parameters of the extraction pillar length are affected by the technical level of the longwall equipment. The productivity of Russian mechanized complexes begins to decline when the length of the extraction pillar is over 1.2-1.5 km, and for foreign complexes it is over 2.2-2.5 km. Taking into account the costs of assembling and dismantling the complexes, the efficiency of the mechanized complex is ensured when the pillar length reaches 2.8-3.0 km.

The world experience shows that the optimal pillar length, depending on the seam thickness, can be in the range of 3.5-6.0 km. The longer the length of the longwall, the lower the unit costs; and there is no optimal value. Considering that the service life of the equipment of the new generation of powered roof supports is 8-10 years, of shearers 5-7 years, of face conveyors at least 2-3 years, it is impractical to take the length of the excavation field that is lower than the last parameter. And since the scope of use of high-performance longwalls with optimal parameters along the length of the extraction pillar (up to 5-6 km) is very limited in the Karaganda basin, this value should

be taken from the service life of the face conveyors: 2.0-3.0 years. Considering the annual advancement of the line of stoping operations, technological and economic efficiency in the development of coal seams can be achieved with the minimum value of the excavation pillar size equal to 3.0-3.5 km.

Due to the technical improvement of longwall equipment with a larger available power of longwall drive stations, the length of the longwalls can be significantly increased. Therefore, in the limited field conditions for long excavation fields, it is necessary to optimize the preparation costs by using the longest faces possible.

When determining the parameters of the excavation site, three groups of methods can be distinguished, which differ in approaches to solving this issue:

- establishing the maximum possible length of the longwall in terms of technical and mining and geological conditions;
- establishing the maximum possible length of the longwall according to the ventilation conditions;
- determining the optimal parameters according to economic criteria, taking into account intra- and off-stock costs.

The disadvantages of these methods consists in that they do not in any way involve the principles that take into account mining operations safety, or at least somehow correlate with them.

The optimal parameters of the technological schemes of stoping operations can be determined by the criterion of the minimum current costs per 1 ton of coal.

The optimal value of L_{pillar} was determined by the method of finding the minimum criterion for the first derivative at $f(L_{\text{pillar}})'=0$. As a result, an algorithm was determined for the optimal length of the excavation pillar and the longwall given in [2].

As a result of the calculations, the optimal parameters of the pillar length were obtained according to the economic criteria depending on the seam thickness, stability of the side rocks, the length of the face, the load on the longwalls of the technological schemes of stoping operations.

The mathematical processing of the statistical material made it possible to establish the functional dependences of the each factor effect, to establish the regularities of the mining geological, mining technical, technological, organizational and socio-psychophysical factors effect on the safety of developing coal seams and to determine the effective area of stoping faces operation.

By correlating the optimal parameters of technological schemes obtained during implementation of the economic and mathematical model with the established values of the factor of safe stoping operations, the following recommendations can be formulated.

When developing a coal seam with the thickness of 2.0-2.5 m using the Glinnik complex (Poland) with a narrow-cut shearer KBB-2 (Russia) or SL300 (Germany), providing the daily load on the longwall of 5-7 thousand tons, as well as when using the complex of synthesized rational links of the technological scheme of the longwall mining determined according to the developed

expert system of selecting the optimal elements of the subsystem of "stoping operations", the safety of production processes in the longwall is increased by 2.0-2.5 times [3].

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EFFECT OF BENEFICIATION ON THE PHYSICOCHEMICAL CHARACTERISTICS OF DUGANI CLAY

1. Introduction

Clay is an abundant fine textured earthly powder produced by the weathering and disintegration of granite and feldspathic rocks Hassan., (2014). Clay minerals are a diverse group of hydrous layer aluminosilicates that constitute the greater part of the phyllosilicate family of minerals Huggett, (2015). They are commonly defined by geologists as hydrous layer aluminosilicates with a particle size 2 mm, or even 4 mm in at least one-dimension Huggett, (2015). They are an important constituent of soils, lake, estuarine, delta, and the ocean sediments that cover most of the Earth’s surface. Clay is used in a variety of industrial applications such as including paper processing, cement manufacturing, chemical filtration, water treatment, cement manufacturing, paint processing, agricultural soil treatment, ceramic processing, building and road construction, among others (Liu et al., 2017; Salahudeen, 2018). This study is aimed at determining effect of wet beneficiation on the physicochemical characteristics of Dugani clay.

2. Materials and Methods

Raw clay was mined from Dugani deposit in Gwarzo Local Government Area of Kano State – Nigeria. The GPS coordinate of the deposit is 11° 52.485 N, 007° 59.482 E. Tap water was collected from the laboratory water supply. Equipment used include weighing balance. pH meter, crusher, mortar and pestle and X-ray fluorescence machine (Model; SKYRAY-EDX3600B). Other apparatus used include density pottle, sieve of mesh size 200, stirrer, glassware and plasticware.

The raw clay was crushed and ground. Then ground clay was soaked overnight in water in a predetermined ratio of 0.1 g/L. The mixture was plunged by stirred for 3 h then left to settle for 1^{h}.

The supernatant water was decanted and the sedimented clay was sieved using mesh size of 200. The fine clay filtrate known as the beneficiated clay was dewatered, dried and ground. The residue known as the quartz impurity was collected and dried. pH analyses of the raw and beneficiated clay were carried out by preparing varying samples of clay-water mixture ratios of 1:1, 1:2,1:3, 1:4 and 1:5. XRF analyses of both the raw and beneficiated samples were carried out. The specific gravity of the clay was determine using Equation (1). Where W_1 is weight of the empty density bottle. W_2 is weight of the bottle plus clay. W_3 is weight of the bottle plus clay plus water. W_4 is weight of the bottle plus only water.

$$\text{Specific gravity} = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)} \quad (1)$$

3. Results and Discussion

Starting with 1500 g raw Dugani clay, 966 g of beneficiated clay was recovered. This implies 64.4 wt% recovery of the clay after beneficiation. The quartz impurity recovered after the beneficiation was 405 g. This implies that the quartz impurity in the clay was 27 wt%. The remaining 8.6 wt% of the clay was likely the organic impurities and soluble salts loss during the beneficiation process.

Table 1 presents the XRF chemical composition of the raw and beneficiated clay. The Silica-Alumina ratio of both the raw and beneficiated clay was 1.9. This suggests that the clay is a kaolinite clay as the Silica-Alumina ratio falls within that of Kaolinite (Salahudeen and Abdulkarim 2017). The CaO content was reduced by 12%. Similarly, there was 11.8%, 14,2% and 11.1% reductions in P_2O_5, SO_3 and BaO content, respectively. This was likely due to the effect of the impurities removed during the beneficiated process.

Table 1

X-ray fluorescence analysis of Dugani clay

Oxide (wt%)	SiO_2	Al_2O_3	Fe_2O_3	K_2O	CaO	TiO_2	MgO	P_2O_5	SO_3	BaO
Raw	47.82	25.70	11.31	5.74	4.00	1.61	1.50	0.59	0.49	0.36
Beneficiated	47.32	24.94	12.23	6.00	3.52	2.10	1.81	0.52	0.42	0.32

Table 2 presents the pH analyses of raw and beneficiated Dugani clay. It could be observed that the average pH of the raw clay and the beneficiated clay were 8.2 and 8.3, respectively. The pH values have shown that both clay samples were slightly basic this was likely due to presence of some mineral impurity phases present in the clay even after beneficiation.

Table 2

pH analysis of Dugani clay

Clay to water ratio	1:1	1:2	1:3	1:4	1:5	Average pH of Sample
pH of raw clay	8.2	8.2	8.2	8.2	8.2	8.2
pH of beneficiated clay	8.0	8.2	8.4	8.5	8.4	8.3

Table 3 present the specific gravity analysis of Dugani clay. Applying Equation (1) it could be observed that the specific gravity of the raw clay was 2.24. Effect of the beneficiation had resulted

into 6% reduction in the specific gravity of the clay. This is likely due to removal of quartz content of the clay during beneficiation as already supported by the beneficiation result.

Table 3

Specific gravity analysis of Dugani clay

Weight (g)	Raw Clay	Beneficiated
W_1	25.25	25.20
W_2	72.45	87.65
W_3	102.15	108.8
W_4	76.00	76.00
Specific gravity	2.24	2.11

4. Conclusion

Chemical analysis of Dugani clay suggests that the clay is Kaolinite. Wet beneficiation of Dugani clay resulted into 64.4% recovery of purified clay and removal of 27% of dense component suspected to be quartz. The clay was slightly basic having average pH values of 8.2 and 8.3 for the raw and the beneficiated clay, respectively. The specific gravity of the raw clay which was 2.24 reduced by 6% after beneficiation.

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INVESTIGATION OF THE FEATURES OF THE MATERIAL COMPOSITION IRON-CONTAINING ORES OF THE TEMIRKAN DEPOSIT

Based on the conducted studies on the study of the material composition of the ore sample of the Temirkan deposit, it was revealed that the industrially valuable component of the ore of the Temirkan deposit is iron, which is mainly in the form of magnetite-titanomagnetite, hematite and iron hydroxides. The associated components are titanium and vanadium. The main non-metallic minerals of the sample are pyroxenes, amphiboles (hornblende), plagioclases, less often olivine. Accessory minerals are apatite, sphene, rutile, epidote+zoisite.

The development of the material and technical base of the republic requires the search and exploration of a wide range of minerals, both ore and non-metallic. One of the urgent tasks of geological prospecting has become the problem of identifying the prospects of the subsoil of the Republic of Uzbekistan for iron.

Uzbekistan has significant reserves of titanium-magnetite ores at the Temirkan deposit in Karakalpakistan, hematite-magnetite ores at the Temirkan deposit in the Marzhanbulak region, Surenate in the Tashkent region, etc. To date, iron ores are not processed in the republic. The purpose of this research work is to study the features of the material composition of iron-containing ore samples from the Temirkan deposit..

The technological sample before the tests was prepared according to the standard method. Before crushing, samples were taken from the ore for mineralogical analysis, and medium samples were also allocated for semi-quantitative spectral, chemical, and phase analyses. The results of the chemical analysis of the average ore sample are shown in Table. 1.

Table 1

Results of chemical analysis of the average ore sample

Components	Content in the sample, %	Components	Content in the sample, %
SiO_2	39,82	K_2O	0,84
Fe_2O_3	11,93	Na_2O	1,46
FeO	7,27	$S_{общ.}$	<0,4
TiO_2	1,74	$S_{сульфид.}$	0,036
V_2O_5	0,06	SO_3	<0,01
MnO	0,14	CO_2	0,22
AI_2O_3	9,44	P_2O_5	0,13
CaO	14,84	$-H_2O$	0,2
MgO	10,0	п.п.п.	1,2

According to the results of chemical analysis, the iron content in the sample is 19.2%. Associated useful components - titanium dioxide - 1.74% and vanadium pentoxide - 0.06%.

The phase analysis was carried out on ore crushed to a fineness of 95-98% of the class -0.074 mm. In the table. 2 the results of the phase analysis of the average ore sample for iron are presented.

Table 2.

Results of phase analysis of iron samples of iron-containing ore

Forms of finding iron		
	Fe Content, %	Fe Distribution, %
Iron bound to carbonates and easily soluble silicates	0,92	6,81
Iron in the form of magnetite	7,94	58,81
Iron in the form of carbonates	0,41	3,04
Iron in the form of hydroxides	0,73	5,41
Iron in the form of hematite	2,67	19,78
Iron in the form of hardly soluble silicates	0,83	6,15
Total in ore:	13,5	100

As can be seen from the table. 2, in the ore sample of the Temirkan deposit, the content of extracted iron by magnetic separation is 58.81%.

To determine the distribution of iron by size classes, the initial ore with a size of 3-0 mm was subjected to a sieve analysis. The results of the sieve analysis of the average ore sample are shown in Table. 3.

Table 3

Results of the sieve analysis of the average ore sample

Size class, mm	Exit, %	Iron content, %	Distribution of iron by class, %
-3+2,5	8,73	10,5	7,23
-2,5+2,0	6,98	15,2	8,37
-2,0+1,5	7,48	15,2	8,97
-1,5+1,0	12,72	6,5	6,52
-1,0+0,5	21,45	14,7	24,86
-0,5+0,315	15,71	14,21	17,6
-0,315+0,15	14,96	14,1	16,63
-0,15+0,063	7,23	14,1	8,04
-0,063+0	4,74	4,76	1,78
Ore	100	12,68	100

Thus, based on the conducted studies on the study of the material composition of the ore sample of the Temirkan deposit, it was revealed that the industrially valuable component of the ore of the Temirkan deposit is iron, which is mainly in the form of magnetite - titanomagnetite, hematite and iron hydroxides. The associated components are titanium and vanadium.

The content of magnetite-titanomagnetite in the ore sample is 7.94%; hematite 2.67%; iron hydroxides 0.73%. According to the content of impurity elements in the chemical composition of magnetite, the mineral has several varieties:

a - titanomagnetite, where the TiO_2 content is from 4% to 13.89%;

b - nickel-manganese chromomagnetite, in which CrO_3 is 22.81%; NiO - 8.12%, MnO - 3.07%;

c - varieties rich in V_2O_5 up to 2.28%, MnO up to 4.47%, MgO - 2.48%, CaO - 1.59%, SiO_2 up to 5.81%, Al_2O_3 up to 3.92%.

Of all the minerals, magnetite and titanomagnetite are the most common in the samples. Hematite is one of the main minerals of the ore after titanomagnetite+magnetite.

Ilmenite is a product of the decomposition of a solid solution-magnetite (titanomagnetite). It forms plates, rounded inclusions and borders in the main ferrous mineral.

The main non-metallic minerals of the sample are pyroxenes, amphiboles(hornblende), plagioclases, less often olivine. Accessory minerals are apatite, sphene, rutile, epidote+zoisite.

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A METHOD OF PRODUCING RED OXIDE

The invention belongs to the technique of producing red oxide that can be used to protect external metal, concrete, and wooden surfaces against atmospheric corrosion in chemical, construction or mining industries as a colorant with a deep brown-red hue.

The technique being closest to the proposed one is the method of producing red oxide; it includes crushing with the following precipitation of harmful impurities, including formation of gas mixture in the form of vertical annular flow, and its further separation (author's certificate of the USSR 222866 BO2c 17/22).

Disadvantage of this method is represented by considerable vertical speed component along the height of a vortex chamber that cause insufficient heating of red oxide in the aerodynamic flow up to 150-200 °C; that will deteriorate the final product quality and result in separation of harmful impurities in red oxide, organochloride substances, up to 0.31%.

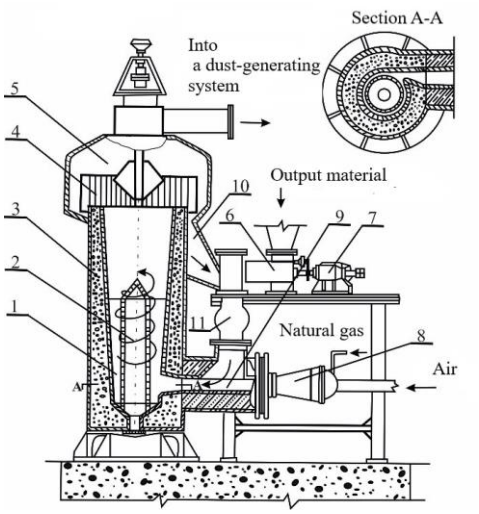

Fig. 1. General view of a vortex installation to produce red oxide

The invention is based on the task to improve a method of producing red oxide, which makes it possible apply the technological operations and parameters for more active elimination of harmful substances, especially chloride-containing ones, in terms of reduced number of multi-step stages. As a result, the final product is of higher quality along with the reduced costs.

It is obvious that during the process of catching and holding there arises a possibility to retain a characteristic thermodynamic state of a suspension, in terms of which mass-exchange interphase processes are being stimulated favouring active separation of chloride-containing impurities.

Combination of the operations of solid phase crushing and heating in a three-phase flow with the following holding during 1.5-5.2 hours stipulates the unpredictable result.

The figure represents a general view of a vortex installation that can implement this method of producing high-quality red oxide. It consists of vortex chamber 1, external 3 and internal 2 cases, vortex 4 and gravitational 5 classifiers, auger 6 and sector 11 feeders, electric motor 7, combustion chamber 8, and injection unit 9.

The input material comes from the auger 6 and sector feeder 11 into the injection unit 9; air and natural gas move along the pipelines into the combustion chamber 8 where it is heated up to 800-1000 °C. Next, the flow goes into the injection unit 9 where it is mixed with the input material and forms a dust-gas mixture, which is sent into a zone of red oxide crushing and heating up to 350-450 °C. The particles are crushed and heated in a vertical annular flow of a gas mixture that rotates between the external 3 and internal 2 cases in the vortex chamber 1. The red oxide particles rotate along the annular trajectories and move vertically into the vortex 4 and inertial classifiers 5. Due to decreasing vertical velocity, the uncrushed material move through the pipeline 10 and the sector feeder 11 and enter the injection unit where it is mixed with the output material to be further sent in to the vortex chamber for repeated crushing and heating.

The finished product heated up to 350-450 °C is sent into a dust-catching system where it is accumulated in the thermal insulated bunkers. It is stored there for 1.5-2.5 hours making it possible to reduce organochloride substances in red oxide from 0.31% down to 0.11% as well as decrease the amount of harmful impurities.

The method of producing red oxide in vortex installations will help produce red oxide characterized by sufficient level of covering capacity; the applied method is peculiar for its few-step stages of a technological process and no discharge water.

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THE RECORD OF HORIZONTAL NORMAL STRESSES IN METHODS FOR CALCULATING THE LIMITING STATE OF ROCKS

In methods known to us for calculating the limiting state of rocks horizontal normal stresses are not taken into account, although they play an important role in the management of the stress-strain state (SSS) of rock massifs. There are the most contradictory opinions regarding horizontal stresses: from the presence of some tensile ones to some compressive ones. These opinions apply to both massifs and rock samples. Many authors believe that the splitting of a part of the samples along the action of a compressive load is generated by tensile stresses [1] due to the occurrence of transverse deformation, although, according to the classical theory of elasticity, there are along this direction no normal and tangential stresses [2, p.113]. In the 60s, more advanced instrumental methods for studying the stress-strain state of a rock mass were created and a number of discoveries of high horizontal stresses exceeding gravitational were made. Many authors, taking into account the variety of hypotheses, concluded in conclusion that the anomalous stresses are caused by tectonic forces. The author [3], on the contrary, derived the formula for calculating horizontal stresses by the methods of the theory of elasticity of the form

$$\sigma_x = \frac{2(k+\mu\sigma_y)}{\cos\rho}(\sin\rho - \sqrt{1-b^2}) + \sigma_y, \qquad (1)$$

where k - material shear resistance; μ and ρ=arctg μ- coefficient and angle of internal friction;

σ_y - vertical normal stress;

$b = f\sigma_y\left(1-\frac{1-2y}{h}\right)/(k+\mu\sigma_y)$, f - coefficient of contact friction; y - ordinate of the considered point; h - object height

As you can see, the formula provides any values of horizontal normal stresses, including those exceeding the vertical ones that form them. The values of these stresses depend on the difference $(\sin\rho - \sqrt{1-b^2})$, ultimately, on the coefficient of contact friction. A.D. Tomlenov [4] developed a method the record of horizontal stresses to calculate their effect on the ultimate strength of plastic materials. But first you need to determine the value of the increment in the vertical stress C at the corner point. According to A.D. Tomlenov, the increment C at the corner point α is determined from the condition that the method of application of forces does not affect the distribution of stresses in sections that are sufficiently distant from the place of their application. This condition is

a propagation of the Saint-Venant principle of applied in the theory of elasticity to the stress state. In section x=0, free of load,

$$\int_0^{h/2} \sigma_x dy = 0. \tag{2}$$

Substituting the value of σ_x (1) into expression (2) at x=0 after integration, we find

$$C = \frac{1}{2} k_n \arcsin\left(\tau\left(1 - \frac{2y}{h_1}\right) \Big/ k_n + \mu\sigma_y \right). \tag{3}$$

Parameter $\left(1-\left(2y/h_1\right)\right)$ determines the level of attenuation of shear stresses with distance from the contact surface along the axis ordinate. To simplify the notation, we introduce the notation

$$d = \frac{1}{2} \arcsin\left(\frac{f\sigma_y\left(1 - \frac{2y}{h}\right)}{k_n + \mu\sigma_y} \right). \tag{4}$$

After that, the increment is $C=k_n d$. The experience of calculating the ultimate strength of specimens using the increment of the ultimate vertical load from the action of horizontal stresses showed that this increment increases the ultimate strength of the specimens at f = 0.3 of rocks at 8-10% [5].

Conclusions

1. In the known methods for calculating the limiting state of rocks horizontal normal stresses are not taken into account, although they play an important role in the management of the stress-strain state (SSS) of rock massifs and samples

2. D.L. Vasyliev is derived a formula for calculating horizontal stresses by methods of the theory of elasticity. For the first time, an analytical method has been developed for determining the ultimate strength of rock objects, taking into account horizontal stresses arising from contact friction.

3. A.D. Tomlenov developed a method the record of horizontal stresses to calculate their effect on the ultimate strength of plastic materials.

4. The experience of calculating the ultimate strength of specimens using the increment of the ultimate vertical load from the action of horizontal stresses showed that this increment increases the ultimate strength of the specimens at f=0.3 of rocks by 8-10%.

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DEVELOPMENT OF A TECHNOLOGICAL SCHEME FOR THE ENRICHMENT OF TUNGSTEN-CONTAINING ORES OF THE KOYTASH DEPOSIT

Based on the study of the material composition of these samples, it was found that only scheelite is noted among the valuable components in these samples.

Various reagents and laboratory installations, modern physical, physico-chemical and chemical methods of analysis were used in the research. Technological samples were taken at the points provided for by the sampling map, using samplers. After its completion, all samples were weighed, dried, their dry weight and mass fraction of solid were determined. The samples were separated according to the appropriate method. The flotation machines "Mechanobr" FL-1, FL-3, FL-5 were used as laboratory devices.

The scheme of scheelite flotation included the operations of basic and perechistnaya flotation, steaming of rough scheelite concentrate in a liquid glass medium, with a residual concentration of the last 3%, two or three perechistok. Concentrates were obtained.

The traditional scheme of enrichment of scheelite ores was used. The consumption of reagents varied: in sulfide flotation, lime 300-1200 g/t, xanthogenate 80-150 g/t, T-80-40-120 in scheelite flotation: soda 1500-4000 g/t, oleic acid 50-700 g/t, emulsion: oleic acid + tall oil-50-700 g/t and liquid glass 200-750 g/t. Based on the above, we performed experiments on the flotation of scheelite from: the initial ore, the tailings of sulfide flotation, from the rough scheelite concentrate after steaming it with 2 perechistkami.

In the flotation experiments, the consumption of soda varied from 1000 to 4500 g/t, liquid glass from 100-500 g/t and fatty acid collector-HOl or Emulsion HOl+tal.oils. The consumption of the T-80 foamer is 120 g/t in the main and 60 g/t in the control flotation operation. The fineness of ore grinding varied from 60 to 70% of the -0.08 mm class. Optimal reagent consumption: soda-2000 g/t; liquid glass-300 g/t; fatty acid collector-300 g/t. In the flotation experiments, the consumption of soda varied from 1000 to 4500 g/t, liquid glass from 100-500 g/t and fatty acid collector- Emulsion HOl+tal.oils. The consumption of the T-80 foamer is 120 g/t in the main and 60 g/t in the control flotation operation. The fineness of ore grinding varied from 60 to 70% of the -0.08 mm class. Optimal reagent consumption: soda-2000 g/t; liquid glass-300 g/t; fatty acid collector-300 g/t.

The traditional scheme of enrichment of scheelite ores was used for flotation. Experiments of preliminary sulfide flotation with variable lime consumption in dry form and in the form of a solution of xanthogenate and T-80 were carried out. The flotation time of sulfides is 3 minutes. The main reagents for the flotation of scheelite were soda and liquid glass. The results of the experiments show that with an

increase in the consumption of liquid glass, the quality of the concentrate increases, but the extraction of WO_3 decreases. The yield of the sulfide concentrate is small due to the significant oxidation of the ore.

When flotation of scheelite from the tailings of sulfide flotation (sample-1), the optimal consumption of the collector is HOl or Emulsion HOl+tal.the oil was 200 g/t; for the sample - 2, the optimal consumption of Emulsion HOl+tal.the oil was 100 g/t. In the rough concentrate, 86.11% of WO_3 is extracted from sample - 1 with its content of 2.91%; from sample - 2-95.2% with its content of 2.02%.

During flotation of the combined industrial product of the table, scheelite concentrates were obtained containing 1.25% WO_3 at the extraction of 65.8% (sample-1) and 1.37% WO_3 at the extraction of 58.7% (sample-2). Finishing of scheelite concentrates was carried out by cooking condensed rough concentrate (~50%) at a temperature of 85-95°C for 1 hour in a liquid glass medium. The WO_3 content in the final product was 59.8-67.56% (sample-1) at the flow rate of liquid glass of 7.8 kg/t in the control finishing flotation, at the flow rate of Emulsion HOl+ tallow oil is 50 g/t, and in the concentrate from sample-2, the WO_3 content was 41.4-48.0% WO_3 when it was extracted by 70.0-72.2%. According to the combined scheme, 82.2% WO_3 is extracted from the sample-1 into the concentrate from the operation with a content of 65.2% WO_3 in it. The extraction of WO_3 from the ore was 70.7%. 78.2% of WO_3 from the operation is extracted from the sample - 2 into the concentrate with a content of 47.9% WO_3 in it. At the same time, the extraction of WO_3 from the ore was 67.9%. The results of the conducted studies are shown in Table 1.

Table 1

Results of experiments of scheelite flotation of the initial ore

Name of products	Exit,%	Content.WO_3, %	To extract., WO_3, %	Reagent mode
				Zhid. glass-perem. expenditure
1	2	3	3	5
		Test №1		
Rough scheelite concentrate	11,3	2,91	59,1	Soda – 2000 г/т
Tails	87,7	0,26	40,9	Liquid glass 300 г/т
Source ore	100	0,56	100	HOl – 200 г/т
Rough scheelite concentrate	10,2	3,2	56,5	Soda – 2000 г/т
Tails	89,8	0,28	43,5	Liquid glass – 400 г/т
Source ore	100	0,58	100	HOl – 200 г/т
Rough scheelite concentrate	8,6	3,11	48,6	Soda – 2000 г/т
Tails	91,4	0,31	51,4	Liquid glass 500 г/т
Source ore	100	0,55	100	HOl – 200 г/т
Rough scheelite concentrate	6,8	3,39	43,6	Soda – 2000 г/т
Tails	93,2	0,32	56,4	Liquid glass – 600 г/т
Source ore	100	0,53	100	HOl – 200 г/т
Rough scheelite concentrate	16,4	2,44	78,6	Soda – 2000 г/т
Tails	83,6	0,13	21,4	Liquid glass – 300 г/т
Source ore	100	0,51	100	Emulsion HOl + tallow oil -200 г/т
		Test №2		
Rough scheelite concentrate	39,2	0,71	95,8	Soda – 2000 г/т
Tails	60,8	0,02	4,2	Liquid glass 300 г/т
Source ore	100	0,29	100	HOl – 200 г/т
Rough scheelite concentrate	39,4	0,57	77,1	Soda – 2000г/т
Tails	60,6	0,11	22,9	Liquid glass - 400г/т
Source ore	100	0,29	100	HOl – 200 г/т
Rough scheelite concentrate	60,4	0,31	65,4	Soda – 2000г/т
Tails	39,6	0,25	34,6	Liquid glass 500г/т
Source ore	100	0,29	100	HOl – 200 г/т

1	2	3	3	5
Rough scheelite concentrate	59,5	0,47	95,8	Soda – 3000 г/т
Tails	40,5	0,03	4,2	Liquid glass – 300 г/т
Source ore	100	0,29	100	Emulsion HOl + tallow oil -200 г/т
Rough scheelite concentrate	34,6	0,66	79,5	Soda – 3000 г/т
Tails	65,4	0,09	20,5	Liquid glass 300 г/т
Source ore	100	0,29	100	Emulsion HOl+ tallow oil -200 г/т

As a result of the research, a recommended scheme for flotation of tungsten-containing ores with the reagents soda, liquid glass and sodium oleate was developed, according to which the following indicators were obtained: - from sample № 1, scheelite concentrate containing 65.2% WO_3 when extracting 70.2% of the ore; from sample № 2, scheelite concentrate containing 48.0% WO_3 when extracting 68.6%.

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LUBRICANT ADDITIVES IMPROVEMENT OF DRILLING FLUIDS

One of the key factors affecting the success and efficiency of well drilling is the type and quality of the drilling fluid. The drilling fluid and the flushing regime should ensure the stability of the wellbore walls, cuttings removal, and the prevention of drilling tool sticking, the friction forces reduction, and the maximum preservation of the reservoir properties of the bottomhole formation zone.

A significant factor influencing the occurrence of complications during well drilling, mostly in the form of sticking, is the degree of lubricating properties of the drilling fluid. Consequently, the issue of developing new formulations of multifunctional lubricating additives is urgent.

Testing of various lubricating additives in the clay conditions as polymer and polymer clay free to drilling fluids showed that lubricating additives can be active components of the solution, that is, they can significantly affect to structural, mechanical and rheological, including thixotropic, properties of drilling fluids, as well as on fluid loss, which is explained by their adsorption on the surface of solid particles in solution.

Lubricating additives are a essential component for well flushing, especially when drilling deep and horizontal wells. In recent years, new types of reagents and their modifications have been

constantly appearing, which must be adapted to the conditions of drilling wells in specific mining and geological conditions. When selecting reagents, preference is given to environmentally friendly and cheap lubricating additives [1,3,5].

A promising environmentally friendly raw material for the production of lubricating additives are products of plant and animal origin. The main advantage of natural raw materials is its environmental friendliness. So, after entering the environment, oils are relatively quickly (about 5 days) exposed to the full schedule.

The main disadvantages of oils and fats are their relatively rapid aging during storage and operation. Due to aging, toxic constituents can form in them.

At the same time, complex chemical processes take place, as a result of which fatty acid raw materials acquire a specific, irritating, unpleasant odor [1].

For investigation, the following natural oils were chosen as lubricating additives: hemp, rapeseed, soybean, mustard, sunflower, corn and castor oils. In addition, the lubricating properties of products from the production of sunflower oil were determined: soapstock, hydrofuse, phosphate concentrate and fatty acids.

The experiments were done using the KTK-2 device, which allows measuring the angle of displacement of the load from the oily crust of natural oil and products from the sunflower oil production in degrees.

The coefficient of friction (friction and stickiness) K_{tr} of the “lubricant additive/metal” pair was determined on the KTK-2 device according to the generally accepted method.

The friction coefficient is the main criterion for evaluating the lubricating properties of lubricating additives; a decrease in this value reflects the effectiveness of lubrication [5].

As a result of experiments on the research of the lubricating additives friction coefficients at the interface "lubricant additive / metal", the following data were obtained:

- natural oils: hemp oil - coefficient of friction - 0.160; rapeseed - 0.240; soy - 0.118; mustard - 0.101; sunflower - 0.154; corn - 0.114;

- waste from the production of sunflower oil (studies were carried out immediately after the receipt of waste): soap stock-friction coefficient - 0.394; hydrofuse - 0.141; fatty acids - 0.194; phosphatide concentrate - 0.249.

The investigation results show that the best lubricating properties among natural oils when measuring the coefficient of friction (friction and stickiness) of the pair «lubricant additive / metal» mustard (K_{tr}=0.10), corn (K_{tr}=0.11), soybean (K_{tr}=0.12) and sunflower (K_{tr}=0.15) oils.

Among the wastes from the production of sunflower oil, the hydrofuse has the best values of the friction coefficient (K_{tr}=0.14).

When developing a formulation of a lubricant additive for drilling fluid, it is recommended to take into account the cost of this raw material and the main conditions for its production, as well as conduct research aimed at assessing the lubricity of these lubricating additives in the drilling fluid at the friction boundary «metal - filter crust» and on the verge of «metal - metal» using an OFI Testing Equipment (OFITE) Ultimate Pressure and Lubricity Tester in accordance with the API standard.

This technique, in which the lubricating properties of drilling fluids are determined by measuring the friction coefficient of a «metal-to-metal» pair while rotating a metal ring relative to an immovable metal block, allows simulating the rotation of drill pipes in a well.

The result of the research is the establishment of the lubricating properties coefficient of the drilling mud [3].

Subsequently, based on the analysis of the data obtained, it can be concluded that vegetable oils have good lubricating properties and can be used as components in the development of the formulation of a multifunctional lubricant additive for drilling fluids.

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THE NATURE OF HYDRODYNAMIC DRAG REDUCTION OF OIL FLOW IN PIPELINES BY POLYMER ADDITIONS

As a result of experiments it was confirmed the unfolding of molecules under wall-adjacent turbulence conditions, as well as it was proved that dynamic structure formation in polymer solutions is occured under the influence of supercritical longitudinal gradients of speeds. On the basis of data that characterize macromolecule dynamics in non-turbulence flow with stretching and the proved evidence of strong deformation effect on macromolecules in wall-adjacent turbulence, it

has been established the molecular-and-supermolecular mechanism of effect reduction for flow resistance when injecting soluble polymer additives in a turbulence flow. Understanding the mechanism of reducing drag flow of oil in pipelines by small polymer additions will allow to develop recommendations on the choice of rational hydraulic regimes oil pipelines, as well as to outline ways for the directed synthesis of high-performance polymer additions that reduce friction in the turbulent oil pipelines.

The problem of reducing the energy intensity of the oil-trunk pipelines by increasing their productivity remains one of the key problems of economic development of different countries. It is obvious that the task of improving the hydrodynamic characteristics of the oil pipelines is to find the ways to reduce the fluid flow drag - fluid friction. Among the known methods of artificial influence on the boundary layer, in order to reduce the hydrodynamic drag in oil pipelines, special place is taken by a method, based on the injection of polymer solutions. This method is the only one in the development that has certain practical progress.

Laboratory and field tests of the influence of small polymer additions to reduce the drag of oil flow in pipelines began conducting since the late 70-ye of the XX century. The design development of oil pipeline by using polymeric additions for turbulent drag reduction was justified, because the actual increase of the Trans-Alaska oil-trunk pipeline capacity has amounted 20%. However, the resulting friction drag reduction effects by applying polymer solutions in oil pipelines are far from the theoretically predicted. Therefore, the technical task of reducing the hydrodynamic resistance of oil flow in the pipelines by applying the polymer solution into the boundary layer needs to be resolved. This applies to all questions above regarding the nature of turbulent drag reduction by using polymer additions.

In the hydrodynamics of polymer solutions there takes place the transition from accumulating experimental information to understanding the physical essence and establishing main regularities of manifestation of memory and elasticity effects. Toms effect revealed as an experimental fact in the late 40-ies, up to now has been causing great difficulties when interpreting it from the point of view of modern ideas of the hydrodynamics of turbulent flow.

Among the attempts to explain the nature of effect Toms', lying in drag reduction by the polymeric components, special place is taken by a hypothesis, based on strong deformation effect of a near-the-wall turbulence on macromolecules. For the substantiation of this hypothesis experimental proofs of presence of large degrees of deformation of macromolecules in a wall-adjacent zone of a turbulent flow are necessary. The skepticism concerning strong deformation effect of wall-adjacent turbulence on macromolecules is stipulated yet by the fact that, as a rule, shift effects wall-adjacent a turbulence are analyzed, and not the, jet flows (“explosions”) with a longitudinal gradient of speed which arise in the wall-adjacent area. It is possible to hope, that the

way to understanding and describing phenomena reduction of turbulent friction by polymer additions lies through the study of hydrodynamic effects of big reversible (as well as non-reversible) deformations of molecular coils in flows with stretching.

Therefore the experiments proving the stretching of molecules in conditions of wall-adjacent turbulence have a fundamental character not only in point of developing the mechanism of drag reduction by polymer additions but also in point of more profound insight into the nature of turbulence itself [1, 2].

Comparison of concentration dependence of the Toms' effect and the data testifying to the formation of dynamic super-molecular structures in polymer solutions allows to state that in the vicinity of optimal concentration ($C \geq C_{opt}$), where the Toms' effect reaches its maximum, solutions start generating anisotropic super-molecular forms having the lifetime 10-20 times longer than θ_c. Further increase of concentration leads to conditions favourable for interaction between individual polymer molecules even without the hydrodynamic field effecting on them. The longitudinal hydrodynamic field effect in polymer solution gives way to the formation of dynamic super-molecular structures with lifetime significantly exceeding (in several factors) the temporal scale of the wall-adjacent turbulence. That's why unlike the super-molecular forms in semi-diluted solutions these super-molecular forms act as "stiff sticks". As an outcome of this the Toms' effect is decreased at a high polymer concentration in solution as well as at a high dynamic velocity.

On the basis of data that characterize macromolecule dynamics in non-turbulence flows with stretching and the proved evidence of strong deformation effect on macromolecules in wall-adjacent turbulence, and using data of model studies of turbulence peculiarities in a boundary layer there has been established the molecular-and-supermolecular mechanism of effect reduction for flow resistance when injecting soluble polymer additives in a turbulence flow. Mechanism of Toms' effect lies in the occurrence of auto-fluctuating mode of reversible processes of macromolecule deformation caused by longitudinal velocity gradients that quasi-regularly originate in turbulence boundary layer and in macromolecule deformation effect both on molecular (when $C<C_{opt}$) and super-molecular (when $C>C_{opt}$) levels on the wall-adjacent turbulence structure, i.e. as a result of macromolecule deformation oscillations and solubility of dynamic super-molecular forms brought about by the flow-with-stretching effect. All this leads to the increase of liquid ejection periods into the outer zone of the boundary layer and in consequence to the viscous sub-layer becoming thicker.

As an outcome of this generation of primary turbulence gets reduced and general level of turbulence dissipation in the flow becomes lower. In case of sufficiently big molecular masses and concentrations the viscosity growth caused by both "common" intermolecular interaction and dynamic structure formation leads to sharp Toms' effect decrease.

The developed approach of explaining the turbulent drag reduction mechanism fits well into the

general scheme of self-regulatory processes, which are dominated by negative feedbacks. It is typical for systems that can change their properties under the action of external physical effects, in this case, under the influence of jet currents ("explosions") with stretching which locally occurring in the boundary layer of the oil pipeline.

The considered experimental data prove the substantiation to transfer outcomes obtained during the study of macromolecule dynamics in non-turbulence flows with stretching onto jet currents of wall-adjacent ejections in turbulence flow, i.e. turbulence current (to macroscopic scale) is perceived as laminar one (to microscopic scale) when hydrodynamic field interacts with polymer molecules.

Understanding the nature of reducing drag flow of oil in pipelines by small polymer additions will allow to develop recommendations on the choice of rational hydraulic regimes of oil pipelines, as well as to outline the ways for the directed synthesis of high-performance polymer additions that reduce friction in the turbulent oil pipelines.

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ORGANIZATION AND OPTIMIZATION OF LOGISTICS MANAGEMENT OF MONGOLIAN COAL TRANSPORTATION

Since the beginning of the 1990s, when Mongolia's social-economic system changed, foreign and domestic trade has expanded. According to 2020 statistics, total exports reached USD 7,576.30 million and imports USD 5,293.90 million. An analysis of the volume of exports shows that, on average, more than 50 percent of the total over the last 10 years has been mining products. This clearly shows that the mining industry is a pillar of socio-economic development in our country. Demand for mineral resources, which is emerging in line with global population growth, is expected to increase three to five times in the next 10 years.

Mongolian government policy documents such as “Mongolia's Sustainable Development 2050”, “Mongolia's Development Concept-2030” and “State Policy on the Mining Sector” clearly state that natural resources should be fully extracted without waste, value-added, and exported as final products provisions.

Today, thermal and coking coal accounted for 46.5 percent of the mining industry by production and export capacity.

Between 1995 and 2000, coal was mined from state and local mines based on the Nalaikh, Shariin Gol, and Baganuur coal deposits, providing thermal power plants in Ulaanbaatar, provinces, soums, large urban heating plants, and household customers. At that time, our country's coal production capacity was about 3.5 million tons per year. In addition, more than 90 percent of Mongolia's electricity and thermal was generated by rail, which was the result of the government's prudent policy at the time.

As Mongolia transitioned to a market economy, the Gold Program was launched as a short-term solution to the crisis, with the private sector increasingly focusing on the exploration, mining, and processing businesses. As a result, the mining sector of our country has absorbed a large amount of foreign and domestic investment. In particular, coal and other mineral deposits in the Gobi region near China have entered the economy rapidly.

Therefore, a realistic assessment of the current state of coal transportation logistics and the improvement of its management based on system analysis and system dynamic modeling theory will be important for the development of research and production in the sector.

The purpose of this study is to develop a methodology for the efficient management of the transportation of mining products by establishing dynamic modeling of the logistics management system for coal transportation.

The study summarizes the current status of coal transportation at the Tavan Tolgoi group of deposits in Mongolia, transportation costs, location of the coal deposit, infrastructure, and transport logistics management. In addition, the stages of the Tavan Tolgoi coal transportation process, technical and technological evaluation of coal transportation machinery and equipment, work photography from the coal loading point to the unloading point, operational system analysis, and dynamic modeling and management model of the coal transportation management system were developed.

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DEVELOPMENT OF THE TECHNOLOGICAL SCHEME OF ENRICHMENT GOLD-BEARING ORES OF THE AUMINZOV DEPOSIT

A significant increase in the production of metals, the integrated use of raw materials, the involvement of new types of ores in the process of industrial production, reducing the cost of processing, increasing the extraction of metals from ores are the most important and urgent tasks in the development of efficiency and the development of mineral resources of the subsoil of Uzbekistan.

In the practical solution of these tasks, it is important to rationally and gradually involve the identified deposits with the maximum use of the local raw material potential for the benefit of the present and future generation of our people.

The purpose of this work is to develop an effective technology of enrichment using the methods of gravity and flotation of the ore of the Auminzov deposit.

When performing technological research, the primary interest was those signs of the material composition that most determine the technology of ore processing. Such signs are the presence in the ores, along with gold, of other useful components that have an industrial content; the degree of oxidation of ores; the presence in the ores of components that significantly complicate the processing technology and the nature of gold in the ores, primarily the size of gold particles.

Based on the study of the material composition of the ore, the nature of mineral inclusions, as well as the study of literature, the experience of previously conducted studies of ores similar in material composition to those studied, gravity, flotation of ore and their enrichment products as auxiliary methods were adopted as the main processing methods.

Ore enrichment studies were carried out in the following areas: collective flotation of gold and arsenic minerals; selective flotation of gold and arsenic minerals.

The evaluation of the enrichment results was carried out mainly based on the yields of the enrichment products and the data of chemical analysis for the content of arsenic and antimony and assay analysis for the content of gold and silver.

Gravity enrichment was carried out to isolate relatively large particles of native gold and sulfides from ores into a gravity concentrate. The deposition was carried out at the ore size of 3-0 mm. The heavy fraction of the jigging was further ground in a ball mill to the required size. In the experiments, the size of the material being enriched on the table varied from 1 to 0.1 mm in order to

obtain the maximum possible extraction of gold and its content in the concentrate. The results of the experiments are shown in Table. 1.

Table 1

Results of gravitational enrichment of a gold-bearing ore sample

Enrichment products	Exit, %	Content, g/t		Extract, %		Size, mm
		Au	Ag	Au	Ag	
The Daugyztau deposit						
Gravioconcentrate	4,1	47.2	103	45,39	51,94	-0,315÷+0
Industrial product	9,6	5,6	13,2	12,63	15,6	
Gravity Tails	86,3	2,07	3,06	41,98	32,46	
Ore	100	4,26	8,13	100	100	

During gravity ore processing, a concentrate with a yield of 4.1% was obtained, containing 47.2 g/t of gold, the extraction of which is 45.39 %. The optimal size of ore grinding for gravity enrichment is -0.315÷+0 mm.

Flotation experiments were carried out on the selection of the optimal fineness of the grinding of the initial ore at different fineness of the grinding of the ore. The lime consumption in the experiments was 1200 g/t (pH=8.0). The obtained experimental results show that the maximum extraction of gold into the concentrate was obtained by grinding the initial ore to a fineness of 82%cl. - 0.074 mm and is 87.0%. The extraction of arsenic into the concentrate is 83.2%, antimony -21.9%. In subsequent experiments, the ore was crushed to a fineness of 82% cl. -0.074 mm.

The floatability of antimonite in an alkaline medium at pH<8 is suppressed. The extraction of antimony into a gold-containing concentrate is 19.5-21.9%. In order to reduce the extraction of antimony into a gold-containing concentrate, experiments were conducted with various lime costs in the main flotation. The results of the experiments show that with an increase in lime consumption from 1200 to 3000 g/t, the extraction of antimony into a gold-containing concentrate decreases from 21.9 to 9.3%.

However, the floatability of pyrite and arsenopyrite is deteriorating. Gold recovery in the main flotation operation is reduced from 87 to 72.5%, arsenic-from 83.2 to 65.4%.

The analysis of the experimental results shows that 1200-1500 g/t of lime can be loaded into the main flotation. In subsequent experiments, the lime consumption in the main flotation was accepted as 1200 g/t.

To reduce gold losses, the control flotation operation was included in the scheme. At the same time, the aim was to reduce the floatability of antimony in the control flotation concentrate. To do this, various costs of lime and copper sulfate were loaded into the control flotation. The results show that with an increase in lime consumption up to 1000 g/t, the extraction of antimony into the chamber product of flotation increases from 80.5 to 93.5% of the operation. From the tailings of the main flotation, gold is extracted by 54.2% of the operation or by 7.2 % of the ore. Its content in the tails decreases to 0.4 g/t.

In order to increase the gold content in the concentrate, two re-cleaning of the main flotation concentrate were included in the scheme. Re-cleaning was carried out without additional loading of reagents. The results of the experiments are shown in Table. 2.

Table 2

Results of ore flotation experiments with two re-cleaning of the main flotation concentrate

№	Products	Exit, %	Content		Extraction, %	
			g/t	%		
			Au	As	Au	As
1	Concentrate	4,3	82	4,2	70	66,9
2	Industrial product	10,8	5,3	0,28	11,1	11,1
3	Industrial product	2,8	10,6	0,4	5,9	4,1
4	Industrial product	6,4	5,6	0,52	7,2	12,3
5	wastes	75,7	0,4	0,02	5,8	5,6
6	ore	100	5,04	0,27	100	100

After two purifications, the gold content in concentrates increases to 82 g/t when extracting 70.0% of the ore without taking into account the refinement of industrial products. The silver content in the concentrate is 87 g/t, its extraction is 39.9%.

Thus, based on the conducted studies, a two-stage scheme with selective separation of gold sulfide and antimony concentrates is recommended for the ore enrichment of the Auminzov deposit of gold-containing ore.

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INVESTIGATION OF THE MECHANICAL PROPERTIES OF PIPES FOR LONG-TERM COOLING SYSTEMS

Most of the metal equipment and tubular constructions of the oil and gas, chemical, food and agro-processing industries operate under difficult loading conditions under the influence of acyclic working and external environments, often causing irreversible physical and chemical changes in the material as a result of the occurrence of corrosion, sorption, erosion, cavitation and other processes, which lead to loss of strength and destruction of structures [1]. Increase of strength (resistance to destruction under the influence of external loads) and reliability (faultless operation of the structure) under the given operating conditions is based on increased stability, ie resistance to the effects of corrosive media. Therefore, it is important to study the stability of the metal equipment of agro-

processing and food industries in the context of corrosion-aggressive gas-liquid media, which lead to electrochemical corrosion [2].

The foregoing shows the importance of issues related to the corrosion-mechanical destruction of equipment, which requires an analysis of the common ways to increase the resistance of the material structures to destruction, the causes of destruction and methods for increasing the stability of metal equipment, especially shell designs (such as vessels, containers, pipelines) in specific technological environments [3]. In works [1-4], is established that during the long-term operation, especially at minus temperatures, there is a flood of the metal, which adversely affects the impact strength and plastic properties of carbon and low-alloy steels. Moreover, hydrogen not only reduces the value of impact strength, but also increases the tendency to cold brittleness. Its influence becomes noticeable with a sufficiently large content, varies for different steels ranging from 2 to 8 $cm^3/100$ g [1].

In accordance with the existing theories of hydrogen brittleness, the harmful effects of hydrogen are manifested in the significant increase in the energy of the cracked dislocation and the reduction of the force at which the nucleus fracture is formed, as well as in the interaction of hydrogen atoms with dislocations in the process of plastic deformation [4]. From works [3] it follows that flooding, especially at minus temperatures (to -60 °C), decreases the number of cycles to fracture of samples in the presence of stress concentrations, especially in conditions of low cycle fatigue failure. It is known [4] that with a decrease in temperature (to -20÷-60 °C), the impact strength and the deformation ability (ψ, δ) of the metal are reduced. The author [4] found that the destruction of samples decreased by 10-12 times when the temperature dropped to -70 °C. It was shown in [6] that cold-resistant steels with low hydrogen content (N_{dif} <3 $cm^3/100$ g) are less prone to overstretching at minus temperatures than steel with higher hydrogen content.

Also, the characteristics of crack resistance were determined - the parameters of the destruction viscosity of K_{1s} and δ_s, for which samples of standard sizes were prepared. The fatigue cracks in the samples were created using a hydraulic pulsator CDM-10 (Germany) at a load frequency of 10-15 Hz and a coefficient of asymmetry of the cycle r=0,1÷0,2. The tests for determining the parameters of the viscosity of destruction of K_{1s} and δ_s were carried out at UME-10 and "Instron" (UK) installations using standard methods.

The objects of research were samples from steel grades 3, 10 and 20, made from pipelines for transferring the refrigerant mixture (service life - from 0 to 30 years), and also from steel grades 3, 10, 20 shell-and-tube heat exchangers of refrigeration systems (service life from 0 up to 12 years) operated in fermentation plants. The basis for the preparation of samples served fragments of pipes, cut out in the process of forced or planned repair from emergency pipelines or tubes of heat

exchangers cooling systems. The results of tests for determining the parameters of crack resistance in a wide range of changes in minus temperatures are shown in Fig. 1-2.

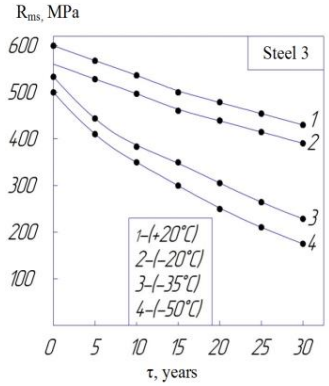

Fig. 1. Grapical dependence of steel microcleaving 3 on the lifetime of the pipelines for pumping the refrigeration mixture at the enterprises of the fermentation industry. Indication of the test temperature (in C):
1 - (+20); *2* - (-20); *3* - (-35); *4* - (-50)

Fig. 1 shows that, with increasing lifetime over the entire range of temperature changes from +20 to -50 °C, the magnitude of the stresses of the steel microcleaving R_{ms} 3 decreases, and this is noticeable for samples of pipes with a lifetime of 10 years or more and temperatures of -35 -50 C. So, for samples made of emergency reserve pipes, the parameter R_{ms} at temperatures of +20 and -20 C is equal to 580 and 560 MPa, respectively, and at -50 C this perameter has the following values: 400 and 460 MPa, respectively, that is, R_{ms} decreases in 1,2-1,45 times. At the same time, the parameter R_{ms} at temperatures of -35÷-50 C for non-extruded steel samples 3 has the following values: 530 and 500 MPa, and after 30 τ of operation, respectively, 250 and 200 MPa, that is, the value of R_{ms} decreases by 1,6-2,0 times. Moreover, such a tendency persists throughout the range of changes in minus temperatures and operating periods of pipe constructions.

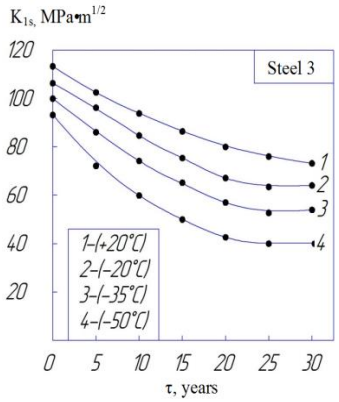

Fig. 2. Graphical dependencies of K_{1s} stress intensity factor on operation period of pipelines for pumping a refrigeration mixture at the enterprises of the fermentation industry. Indication of test temperature (C):
1 – (+20); *2* – (-20); *3* – (-35); *4* – (-50)

The negative effect of the test temperature reduction from +20 to -50° C on the parameters of crack resistance K_{1s} and δ_s, is observed throughout the term of long operation of the pipelines. Analysis of the data shown in Figs. 2 shows that the values of K_{1s}, and δ_s for unexploited steel at temperature +20 C are respectively 115 MPa·m$^{1/2}$ and 0,79 mm, and for steel pipe operation, for example, for 25 years such

the same parameters at the same temperature have the corresponding values: 74 MPa·m$^{1/2}$ and 0,39 mm, that is, 2,2 times (K_{1s}) and 2 times (δ_s) decreases the crack resistance of steels. For unexploited steel at -50°C, the values of K_{1s} and δ_s are 95 MPa·m$^{1/2}$ and 0,67 mm, while for steel with a lifetime of, for example, 30 years, the same parameters have the following values: 41 MPa·m$^{1/2}$ and 0,17 mm respectively, ie, they decrease by 2,3 times (K_{1s}) and ≈4 times (δ_s), that is, at minus temperature -50 C, the resistance of steel 3 against cracking significantly decreases with the subsequent destruction of the pipe structures directly in contact with the aggressive technological environment of fermentation production.

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TO THE QUESTION OF SELECTING INDICATORS FOR ESTABLISHING THE DANGEROUS PROPERTIES OF COAL SEAMS

The release of volatile substances during thermal decomposition of coal without air access (V^{daf}) is one of the main indicators for predicting the hazardous properties of mine layers during their development. It is used in regulatory documents to predict gas emission [1], gas-dynamic phenomena [2], dust formation [3], as well as in the development of measures to prevent and extinguish endogenous fires in coal mines in Ukraine [4]. According to these regulatory documents, it is assumed that the indicator V^{daf} characterizes the change in the properties and composition of fossil coals during their metamorphic transformation in the past geological periods of time. As a classification indicator of the degree of metamorphism V^{daf} was developed over the past several decades to characterize the consumer properties of coals and is now successfully used for these purposes in many countries in the interstate standard [5]. But the generally accepted definition [6] metamorphism involves the transformation of brown coal sequentially into coal and anthracite as a result of changes in the chemical composition, structure and physical properties of coal in the bowels, mainly under the influence of increased temperature and pressure.

Successful application V^{daf}, as a classification indicator of the consumer properties of coals, additional clarification of their properties with the involvement of nine more indicators contributed

[5]. The effectiveness of the integrated application of ten classification indicators in general for the assessment of consumer properties has been tested and proven by the experience of using coal on an industrial scale. Such a test of the effectiveness of the application V^{daf}, as the main indicator of the degree of coal metamorphism, it is difficult to predict the manifestation of the hazardous properties of mine layers according to the regulatory documents [1-4] due to the lack of the possibility of carrying out such experiments. The need and relevance of proof of the appropriateness of the application V^{daf} as the main indicator of the manifestation of the hazardous properties of coal mine layers, it is based on the following prerequisites:

- one of the main properties of solid fuels is the ability to decompose (degrade) their organic matter when heated without air access. In conditions of heating without air access, gaseous and vaporous decomposition products are formed - volatile substances. The release of volatile substances depends mainly on the heating temperature of the sample. The bulk of volatile substances is formed when coal is heated to 850-900 °C [7]. This indicates that the thermal decomposition of coals is, in essence, another artificial stage in the transformation of coals in laboratories, and is not directly related to the earlier metamorphic processes in natural conditions [8];

- index V^{daf} developed to characterize the consumer properties of coals [5]. According to the conditions of the methodology for its determination in laboratory conditions, it does not correspond to the natural state of coal during mining operations. In particular, as a result of preparing a coal sample for testing, moisture is previously removed from it and enrichment to an ash content of less than ten percent is performed [7];

- different forms of moisture in coals are associated with their metamorphic transformations. A significant role of moisture has also been established in the occurrence of endogenous fires. Determination of the moisture content of each form and assessment of their influence on the tendency of mine-seams to manifest hazardous properties are still unresolved problems of mining. The role of moisture and changes in the composition and properties of coals in the process of their metamorphic transformations have not been properly reflected in the current regulatory documents of Ukraine;

- the total amount of volatile substances released during the thermal destruction of coal, to a large extent, depends on their ash content - the higher it is, the more distorted the value V^{daf}. With the same degree of metamorphism of coal matter V^{daf} may differ by more than 20%, which corresponds to a difference of approximately one grade of coal and exceeds the permissible discrepancy between laboratory determinations by more than nine times;

- during the thermal decomposition of coals without air access, different amounts of volatile substances are released from the organic mass (their composition: CO_2, C_mH, O_2, CO, CH_4, H_2, N_2) and the mineral part (a pair of crystalline hydrate moisture H_2O, CO_2, H_2S and etc.) [12]. Index V^{daf}

reflects only the total amount of released substances without identification, which makes it impossible to consider in more detail their relationship with the hazardous manifestations of the properties of coal mine layers during mining.

The research consisted in checking the conformity of the gradation of mine layers into three groups according to their endogenous fire hazard, given in the normative document [9], to the actual conditions of accidents that occurred over the past twenty years during the development of 66 mine layers of the Donetsk basin [10]. The degree of metamorphism of coals of the considered mine layers, where endogenous fires occurred or they were absent, was assessed by the indicator V^{daf}. It has been established that for a comprehensive characterization of the hazardous properties of mine layers, it is necessary to consider in a complex the factors of three blocks:

1. Determined by the degree of coal metamorphism.
2. Mining and geological conditions of occurrence of mine layers.
3. Technological features of mining.

Conclusions:

- the method for determining the release of volatile substances on dry and ashless mass of coal in laboratory conditions does not correspond to the state of mine layers during mining operations, which does not guarantee the reliability of the results of predicting the hazardous properties of mine layers when using this indicator;

- the accidents that occurred did not confirm the special fire hazard of group I mines, established earlier in accordance with the regulatory document. Endogenous fires occurred only during the development of the II and III groups;

- the use of the release of volatile substances as an indicator of the degree of metamorphic transformations of coals does not make it possible to make a reliable gradation of mine seams according to the number of accidents that have occurred or assign them to different groups of fire hazard;

- the chemical activity of coals must be established taking into account structural transformations and changes in the composition of coals under the influence of previously occurring metamorphic processes. For these purposes, it is possible to use the previously obtained results of technical, elemental and petrographic analyzes of fossil coals;

- the occurrence of foci of spontaneous combustion, other things being equal, is associated with the content of oxygen, moisture and sulfur. In this case, the carbon content can serve as a criterion for the degree of transformation of the original organic matter.

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IMPROVING ECONOMIC EFFICIENCY BY MANAGING OPEN PIT EQUIPMENT OPERATIONS BASED ON BIGDATA ANALYSES AND MACHINE LEARNING

The main process of surface mine is performed by shovels or excavators and dump trucks. We made following conclusion based on the many years study about exploitation of equipment working at Erdenet surface mine and processing plant.

- For shovels' (type EKG from Russian) down times are caused by:
  - 41% technical,
  - 45% technological and
  - 11% organizational reasons.
- As for hydraulic excavator's down times are caused by:
  - 22% technical,
  - 45% technological and
  - 23% organizational reasons.

To observe the details of down times, operation of processing plant and surface mine's strong relation causes the down time as 7% exploding operation, 89% ore averaging, 4% moving of excavator. Down time caused by organizational reasons are; 55% enriching factory and 44% not having transportation.

So, indirect economic losses or hidden losses for Erdenet is created by above-mentioned causes of downtime. Maybe, in the future, indirect economic losses due to the above-mentioned reasons

are likely to increase due to the installation of in pit conveying and crushing system to the operation of surface mine and the re-equipment of the concentrator with modern advanced equipment.

Therefore, it is important to implement a strategy in order to improve the economic efficiency of the surface mine equipment operation by systemizing of mining equipment operation and the operation of the processing plant equipment through a comprehensive database analysis based on modern advanced methods and technologies within “Erdenet Industry” state-owned industry.

1.1. *To assess the exploitation level of mining equipment*

- Assess the current level of exploitation based on experiment on-site and system analysis and database that contains information of their exploitation for each type of machinery working at the surface mine and processing plant;

- Develop database management, comprehensive development, monitoring, and forecasting methodology that fully reflects the level of exploitation of mine machinery and equipment, depending on the factors influencing it.

1.2. *Planning, managing, and organizing of mining equipment*

- Develop a database analysis methodology to assess, plan, monitor, manage, organize and forecast the operation of each type of mine machinery and equipment;

- Modeling the operation of mine equipment and components based on system analysis and fuzzy logic theory;

- Develop a mathematical model to manage and monitor the operation of mine equipment and components based on advanced technology (machine learning and artificial intelligence networks);

Development of a simulation model for the operation of the process plant and the operation of the equipment.

1.3. *Strategic development of exploitation of mining equipment and machinery*

- Develop tactics for the operation and exploitation of mining machinery and equipment;

- Estimate the economic and other benefits of Erdenet mining.

Depending on the factors influencing the operation of the mining equipment, it will be possible to organize the operation of the mining process and plan in accordance with the advanced technology-based methodology and database.

Management, optimization, and strategic planning will be developed based on the level of usage of mining machinery and equipment, advanced technology, and comprehensive analysis of the database. It is possible to reduce the downtime of shovels and dump trucks caused by organizing by up to 60 percent.

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THE NEWS EXPLOSIVE TECHNOLOGIES OF THE DESTRUCTION OF STRONG ROCKS ON THE COMPLEX STRUCTURE

The problem of intensity increase of rocks crushing with the use of blast energy of explosive material is relevant for the experts dealing with destruction of rocky formations. The solution of this problem is inseparably associated with increase in explosion energy transformed to destructed part of the massif, which is directly adjacent to charge cavity (usually 2-3 radiuses of a charge) where the medium is over grinded that leads to losses of minerals in pits of non-metallic construction materials.

Determined [1] that, control of the size of the rock re-milling zone and reduction of fine fractional yield can be achieved due to both reduction of the contact area of borehole charge of explosive material (EM) with the destructed rocks, and creating of conditions providing reduction of explosion dynamic impact on charge cavity surface. It can be solved by regulation of value of specific energy of EM due to use of constructions of borehole charge of variable diameter [2].

From this, it follows that the increase in a role of tensile stresses in solid media destruction by explosion can be reached when using of extended charges of variable diameter.

There are some methods of extended charge formation of different configuration of both its length and cross-section. In particular, it is:

- creation of expanded sections, which diameter is bigger than diameter of initial cavity, in the drilled cylindrical cavities [3];

- placing inside the charging cavity of a continuous column of explosives in polyethylene shells of variable diameter, in the form of a cone with a step-down diameter to the wellhead and with a different configuration of the cross-section [4];

- layout of hollow figures from inert materials in charge cavities [5].

The above-mentioned constructions of extended borehole charges make it possible to create the multidirectional and multigradient field of stresses in the massif and at the same time, to reduce the dynamic impact of explosion on surface of charge cavity, due to reduction of the direct contact area of EM with rocks.

Therefore, the efficiency of breaking hard rocks of a complex structure with the use of new explosive technologies on granite ridges is an urgent task.

Tasks, methodology and presentation of the results research. For grounding of rational parameters of explosive failure of the rocks with complex structure (granites developed in pit

"Sivach" of PrJSC "Ukragrovzryvprom"), the industrial tests of the new blasting method [5], based on change of design features of a charge were carried out.

The rocks in pit are gray intensely water-flood end compact-grained granites with red inclusions of strength of *f*=12-16 grades on scale of the prof. M.M. Protodyakonov. Level of flowing waters in pit reaches 1.0-2.0 m in case of massif average water content of 15-20%.

In order to determine the main characteristics of fracture pattern of granite massif within mining lease of pit of "Sivach" of Uman Quarries Management using the method explained in paper [5], the stereo-photographic work of horizons free faces, which were selected for industrial tests of the developed method of blasting of rocks with complex structure (unit 01/12, mount. +56 and unit 04/11, mount. +68 m).

Processing of deciphered stereo pairs was maintained with use of standard programs of image processing "Photoshop" and "CorelDraw 11".

In order to determine the cracks influence on nature of explosive breaking of anisotropic massif along the face line, the blast-holes were drilled and exploded (diameter is 36-43 mm, depth is 1.0-1.5 m, EM - stick powder ammonite No 6 liquid hydrogen).

According to the specified sizes of big *a* and small *b* axes of breaking bell-hole caused by explosion of charge of EM and its orientation in parts of the world, coefficients of massif anisotropy were calculated according to expression $K = a/b$, which is equal to 1.14 on average.

With use of data of anisotropy coefficient, the nomogram was developed. Due to this nomogram, the parameters of borehole pattern of valid blast design in the experimental field of the unit (the borehole pattern is equal to 4.5×5.5 m instead of 5×5 m) were corrected. Its long side coincides with the direction of maximum values of vector of explosion energy flow in the destructed massif $\overline{F_{\max}}$.

According to the changed parameters of borehole pattern (*a*=5.5 m - distance between boreholes in trow and *b*=4.5 m - distance between rows of boreholes), and considering revealed zones of high jointing (focused orthogonally to the face line) in of experimental units, the boreholes of diameter of 150 mm and depth of 10.0-11.0 m with the subdural of 0.6-1.5 m were drilled according to valid blast design the massif in the shoulder of 12.0 m high.

After drilling-off, the boreholes were charged. The borehole multicharges were formed in the test area according to approved standard blast design for mass explosion for the unit. For this purpose, 2.0-2.4 m were left for tamping in the borehole, and another part of borehole was divided into two equal sections.

The mixed explosion of trotyl (hydrocarbon gas + granulated ammonium nitrate in a proportion 65/35) or emulsion EM such as Anemix were placed in the lower part of the borehole, the booster explosive of two trotyl blocks T-400 connected by wave guide with plain detonator by non-electric system of initiation "Impuls" or "PRIMA-ERA" was installed.

The mouth of borehole was encapsulated by tamping of stone screening dust (fraction of 3-5 mm).

Thus, in the block rock mass in the direction of the extended zones with pronounced local fracturing in the drilled wells, extended combined charges of variable cross section were formed.

The design of the developed variable-charge explosive of a variable cross-section is shown in Fig. 1.

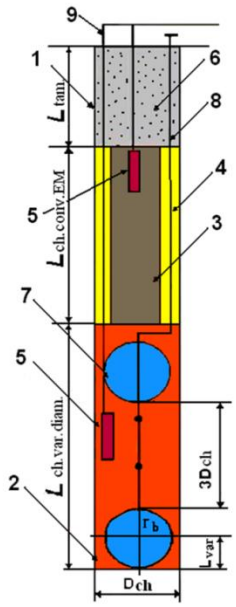

Fig. 1. Structure of the borehole multicharges variable diameter: *1* - borehole; *2* - charge of mixed EM - HG + AN; *3* - section of conversion EM - DKRP-4; 4 - pyroxylin powder; 5 - primed blasting cartridge; *6* - tamping; *7* - spherical cavities; *8* - binder for connection of spherical cavities; 9 - non-electric system of initiation «Impuls»

Conclusions and recommendations for further research. In course of industrial tests during 2017-2021, about 1600 ths. m^3 of mined rocks were blasted in granite pits of Private Joint Stock Company "Ukragrovzryvprom" according to the developed recommendations. The average economy of industrial EM in one borehole is 40 kg, thus, which is about UAH 30 thousand for one massive explosion.

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TECHNOLOGICAL PECULIARITIES OF IRON ORE PRODUCTION MANAGEMENT WHEN DEVELOPING THE OPEN PIT MINES ON A PHASED BASIS

The need to improve the methods for determining the iron ore production of open pit mines is arisen from the complication of surface mining environment. When reconstructing a number of open pits, the objective is to confirm the achieved level of ore production for the future open pit life and assess the potential for raising it. The best practice of iron ore open pit mining supports the fundamental correctness of basic provisions for determining the maximum production of an open pit in terms of mining potential [1,2].

The accumulated experience in the design and operation of deep open pits has not properly reflected and developed in the technological design standards [3]. A number of works [4] states the restricted methods based on analytical correlation between the rates of advancing and deepening the mining operations. The work [5] studies the dependence of the achievable iron ore production of the open pit on the technological potential of mining and transport systems involved in stripping operations.

The main idea used in simulation of the prospective development of mining operations is to represent an open pit field in the form of a set of pushbacks nested within each other and plotted at the maximum permissible slope angles of non-mining pit walls. The distance between adjacent pushbacks or their sections is taken to be equal to the width of the mining area or zero if two adjacent pushbacks have a common non-mining pit wall [7].

It is known that the ore production of an open pit depends on the mode of stripping operations. Let us consider the dependence of mining operations and the potential ore production of an open pit as a scaling function of stripping operations.

One of the main design problems is to find and substantiate the optimum technology concept that simultaneously meets the customer's requirements and regulatory documents governing the design engineering and operation of the mining company, and conforms to the current level of development of this industry. The search for an optimum solution should be carried out with the maximum use of modern achievements in the mining theory and practice, computer-based simulation methods and the potential of heuristic approach.

In the mining theory, when justifying the ore production of the open pit, both the mining and geological features of the deposit and economic factors that depend on the market environment and the prospects to maintain a steady demand for this type of raw material are taken into account. The maximum production in terms of mining factors is the upper production limit of the open pit. The actual production of the open pit in a specific period of its operation is determined by activity of mining operations. At the same time, technically possible production is not necessarily economically feasible, and conversely, economically feasible production is not always technically achievable [2].

The spontaneous use of temporarily non-mining pit walls in deep open pit mines has caused significant disruptions to the development of mining area. A long-term operation of the open pit with rated ore production and minimum stripping operations leads to an imbalance in the formation of exposed and prepared ore reserves, to a delay in the start of stripping operations within the next phased pit shells.

The practice of open pit mining has developed technique to deal with problems of delayed stripping operations. The main solution is to drastically intensify the reactivation of non-mining pit walls using the heavy-duty extraction and loading equipment. An increase in the performance of

stripping and transport equipment, an acceleration of deepening the stripping operations reduce the time required to prepare a new production zone.

The choice of mining and transport equipment in open pit mining has certain specific features. The shovels and dump trucks should be coordinated with each other in their operating parameters. One of the key factors for the rational use of mining and transport equipment is an optimum ratio of its operating parameters, in particular, of the shovel bucket capacity and dump truck body (loading a dump truck for 3-4 digging cycles). Analysis of the mining and transport fleet in the iron ore open pit mines [6] allows us to conclude that it is mainly represented by equipment being not optimum in terms of operating parameter ratio. The main dump truck is of 130 ton payload, the main shovel has a bucket capacity of 10 cub. m, the shovel performs 6-7 cycles to load the dump truck.

In order to intensify stripping operations, it is necessary to involve the shovels having 25-35 m^3 capacity buckets. This shovel (the rock weight in the bucket is 45-65t) cannot be used to load basic dump trucks of 130t payload. It makes sense to use the heavy-duty shovels if there is a fleet of dump trucks with a payload of 220-240 tons, for which haulage berms of up to 40m wide are required. This will result in an additional increase in stripping operations [8] and, accordingly, a decrease in a rate of deepening the stripping operations and an extension of time to prepare a new production zone. One of possible solutions to this problem is a mobile transfer hopper (for example, MMD's Fully Mobile Surge Loader) to conjugate heavy-duty shovels (25-35 m^3) and standard dump trucks (130 tons). A heavy-duty shovel unloads waste rock into a mobile hopper, the capacity of which is matched to the shovel bucket capacity. The basic dump trucks (130t) are loaded by a plate feeder of the mobile hopper. This technology creates conditions for stimulation of stripping operations. In addition, the rigid relationship between the parameters of the shovel and the dump truck is broken. The use of basic dump trucks will not result in an additional increase in stripping operations and will allow the formation of the maximum slope angle of the non-mining pit wall.

Thus, the problem of further studies is to develop the new methods of stripping and mining technologies that provide a high speed of reactivation of non-mining pit walls and an access to ore reserves.

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ON THE EFFICIENCY OF THE COMBINED METHOD OF FORMATION OF BLASTING WELLS AT THE PERVOMAYSKY DEPOSIT OF THE KRIVBASS

For increase the efficiency of underground mining of ferruginous quartzites at the Pervomaiskoye deposit of Kryvbass, a combined technology of drilling and blasting operations of a new level was applied based on plasma expansion units of blast holes with fundamentally new designs of charges of variable cross-section in various combinations.

The Pervomayskoye deposit has a complex structure with numerous tectonic faults of the strike-slip and of thrust nature. All rocks of the deposit are intensely mixing and brecciated. Metasomatic processes of various nature and intensity are widely developed. Alkaline matasomatites account for up to 81% of the rocks of the fifth and sixth ferruginous horizons in the area of intersection of the deposit faults.. Alkaline (aegirine and ritecote) metasomatites are found mainly in ferruginous quartzites.

At the "United" and "Pervomayskaya1" mines. after mining of uranium ores, mining of strong ferruginous quartzites was started. The block "Experienced" is located next to the ore body of the mine "United". Mineralogical-chemical zoning of metasomatites in the block has not been studied. It was decided to drill a 35 m deep core hole and study the core of the ore body. To make thin sections and anti-sections on the parent rocks, and then apply the combined technology of drilling the block. This technology consisted in drilling wells with a diameter of 105 mm using the NKR-100M machine, and then expanding the wells using the IPEW-V plasma installation with an electric arc plasmatron to a diameter of 350-400 mm. Four characteristic zones were identified in the ore body:

1 - breccia of magnetite-amphibole composition with pyroxene;

2 - silicate-carbonate-magnetite quartzite кварцит;

3 - shale-ore breccias;

4 - quartzite carbonate-silicate-magnetite. Strength of rocks on the scale of M.M. Protodyakonova f=10-12 places 16-20.

The speed while drilling the core varied depending on the heating of the core barrel. The operating parameters of the plasmatron varied depending on the rock strength and mineralogical composition (taking into account metasomatism). In breccias of magnetite-amphibole composition with spiroxene at a power of 170 kW, the rate of rise of the plasmatron was 1.2-1.1 m/h when the well with a diameter of 105 mm was expanded to a diameter of 450 mm, and in quartzites with carbonate-silicate-magnetite at a plasmatron power of 150-160 kW, the speed dropped to 0.6-0.7 m/h when the wells were expanded to a diameter of 300-270 mm. The destruction temperature for the former was 400-450 °C, while for the latter it increased to 700-800 °C and the destruction practically stopped.

In connection with the above, the IGTM NAS of Ukraine carried out a set of studies at various large-scale levels. The genesis, typomorphic features of minerals and the nature of the boundaries of zones of alkaline matasomatites were studied. The granulometric composition of the products of thermal destruction was studied. According to the results of sieve analysis, statistical processing of the experimental data was carried out in order to determine the average particle size by fractions, the root-mean-square deviation and the coefficient of variation,

According to the work [1], the fractions +7 and +10 in an amount of at least 100 pieces were subjected to deep analysis and study. For a quantitative assessment of the size and shape of the resulting particles, the corresponding coefficients were used, determined according to the method described in the work [2].

Methods of optical (microscope POLAM-R111) and electron microscopy (EVM-100 L) were used to determine the indicators of microfracture of quartzites, the nature of changes in structural characteristics (for example, the average size of grains and microparticles of quartz) during plasma heating of ferruginous quartzites. The calculation of the average size of grains and microparticles of quartz, the coefficients of their shape in the heated and initial samples were carried out on the above devices. For determine the value of the coefficient of heterogeneity of rocks by the size and shape of grains and microparticles of quartz, cumulative curves were plotted. The results demonstrating the nature of changes in the structure in heated samples and in comparison with unheated ones were presented in the form of a series of cumulative histogram curves. Determination of the material composition was carried out by the areal method.

Thermal analysis of rocks and products of plasma destruction was carried out on the device "Derivatograph". The difference between this device and other thermal installations was the identity of the research conditions. As a result of plasma heating of rocks, a number of crystals in a certain temperature range undergo phase transitions of the first and second kinds.

The crystal lattices of impurity systems of monoclinal alkaline pyroxenes and amphiboles, exhibiting the properties of substitutional and interstitial solid solutions, under the action of high temperatures are subject to various transformations associated with changes in the lengths of translation vectors, which leads to a change in the bond breaking energy, and ultimately affects the values of thermal energy destruction of rocks.

All studied samples were studied by thermogravimetric method. Roentgenostructural method was used if necessary. Thermograms were obtained under the same conditions in terms of sample size, recording speed and sensitivity. Analysis of thermogravimetric curves (TG, DTA, DTG) showed that the first stage of dehydration consists in the loss of approximately half of the structural water by rock samples. As a result of transformations in quartzites, the mass of matter changes. In the temperature range of 150-600 °C, complex transformations occur in magnetite quartzites: dehydration and dissociation, leading to the destruction of the crystal lattice; oxidation, causing the formation of new phases; reversible polymorphic transformations; complex mechanism of chemical reactions. And also the thermal expansion of minerals. In amphibole-magnetite quartzites, endothermic effects are present at 700-800 °C.

The mechanism of destruction of ferruginous quartzites under the influence of plasma flows on them was studied under the EPYTIP microscope in monitoring the development of the cavity in reflected light. . For this, we used anti-sections, the planes of which were strictly oriented perpendicular to the direction of the plasma action front. A series of four samples of approximately the same size in thickness, the selection of which was carried out after 10, 20, 30, 40 minutes of operation of the plasmatron. This made it possible to record changes in rocks during the development of the boiler. For more reliable analysis, 4 samples were placed in a metal holder. Epoxy glue was used as a cementing agent. Changes in rocks were investigated by monitoring the development of the boiler.

Conclusions

On the basis of petrographic studies, it can be argued that the entire direction and nature of changes in ferruginous quartzites occurs in increasing thermal influences. Under the influence of high temperatures, rocks soften. Even the formation of microvolumes of glass occurs due to the melting of silicates.

The performed complex of studies allowed a deeper study of the mechanism of plasma destruction of rocks and rationally choose the modes of operation.

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DETERMINATION OF THE LEVEL OF PRODUCTION NOISE OF MINE COMPRESSOR STATIONS AND MEANS OF ITS REDUCTION

Centrifugal compressors of various types and purposes are widely used in various industries of Ukraine, in particular in mines to obtain compressed air required for mining operations.

The advantages of centrifugal compressors over other compressors are compactness and low weight, reliability and durability, uniformity of compressed gas supply, the possibility of use with

high-speed motors. At the same time, high speed of rotation, reduction of metal consumption, complexity of maintenance of reliable dynamic balance are one of the reasons of the increased level of industrial noise at work of centrifugal compressors. According to the results of measurements performed with the help of the noise meter «EcoAcoustics-110A», the level of noise load on the service personnel of the compressor stations of Kryvbas mines reaches 103-106 dB at the normalized value of 80 dB.

On the territory of the compressor station of the mine production noise is created mainly during the release of air into the atmosphere and its level exceeds the normalized values at a distance of up to 15 m from the discharge system, as the air flow rate reaches 100 m/s. An additional source of noise load is the penetrating noise from the operation of the compressor, especially when the doors and windows are open in the warm season due to the low efficiency of the ventilation system.

In the premises of the compressor station, the noise load is created due to the total generation of industrial noise during the operation of air coolers, reducers, turbines and stimulators.

Constant exposure to intense noise above 80 dB causes a person with auditory nerve dysfunction of varying severity, which during a medical examination is manifested in hearing loss to the perception of whispered speech and hearing loss, as well as dysfunction of other organs and systems, manifested in changes in functioning central nervous system (there is apathy, memory loss, irritability), digestive system (there are changes in the secretor and motor function of the gastrointestinal tract), metabolic disorders [1, 2].

To reduce the noise load on the service personnel of mine compressor stations, the following should be provided:

- to reduce the level of industrial noise from the place of air emission - reducing the speed of air flow and the use of noise mufflers built into the air duct of the discharge system;

- to reduce the penetrating noise from the compressor room - increase the sound insulation of windows and doors, increase the efficiency of the ventilation system;

- to reduce the noise load during the operation of the centrifugal compressor - the use of soundproof panels for fencing air coolers, compressors and reducers, the use of thyristor converters or pathogens of closed design, the use of sound-absorbing coatings, use of mufflers and vibrators.

To effectively reduce the level of industrial noise from the place of air emission, it is necessary to reduce the air flow rate to 40 m/s, which will allow the use of an active type silencer. This can be achieved through the use of a special collector, which should be 1.5-1.6 times larger than the exhaust air duct, which will reduce the noise level by 18-24 dB.

To further reduce the noise level, an active type silencer should be used, which is built into the air discharge system. The efficiency of the muffler is ensured by compliance with a number of requirements:

1. The cross section of the muffler must be at least 0.3 m^2.

2. The length of the muffler should be at least 1.5-2 m.

3. The number of plates of sound-absorbing material, taking into account the sound-absorbing lining of the walls of the muffler must be at least 5 pcs.

4. The thickness of the plates, depending on the material is taken in the range of 60-80 mm.

5. The distance between the plates should not exceed 150 mm.

6. Plates and inner walls of the muffler are made of perforated sheet steel up to 2 mm thick with a perforation coefficient of not more than 0.3.

7. The design of the muffler must be collapsible to ensure periodic inspection and replacement of worn plates.

Therefore, the total reduction of noise load from the installation of the collector and muffler will be at least 38-44 dB, which will achieve the level of production noise in the compressor station below 80 dB.

Centrifugal fans C 4-70, the noise level of which exceeds the normalized values by no more than 5 dB, are mainly used for ventilation of the compressor stations of mines. To reduce the level of production noise generated during the operation of fans and their motors, it is advisable to install fans in soundproof chambers on vibration-insulating bases and equip inserts made of elastic materials between the fans and air ducts.

Sound-absorbing shelters made of hard materials or combined with the use of hard and soft materials are used to reduce the noise load from compressors and gearboxes.

The advantages of sound-absorbing shelters made of rigid materials include ease of manufacture, durability, reliability in operation, ease of installation and dismantling, the ability to provide effective ventilation of the compressor unit. The disadvantage of such shelters is the increase in noise level in the middle of the shelter, which can reach 15 dB in a wide range of frequencies, as well as the impact of structural vibrations of floors and foundations.

Combined shelters are widely used, in which hard elements help to increase sound insulation, and soft - can perform several functions:

- allow to reduce the level of industrial noise inside the shelter by 6 dB;
- provide vibration isolation of the shelter;
- allow to increase sound insulation of separate elements of shelter;
- allow to increase tightness of shelter.

The sound-absorbing cover is made of sheet steel up to 3 mm thick and should cover the area from the engine bearing to the turbine bearing.

The shelter is made of separate sections, which are mounted together when preparing the shelter for installation. Along the perimeter of the support on the foundations of the compressor unit and

the reducer, the shelter is equipped with vibration-insulating elements. In the joint area with a low-speed coupling, removable soft rubber elements are installed on the shelter, which are installed and fitted on site.

The side walls of the shelter elements are covered with sound-absorbing materials, which are placed in covers made of non-woven fabric or fiberglass and fixed with a mesh.

Ensuring the normal operation of the compressor unit with sound-absorbing shelter is achieved through the use of remote control of temperature, pressure, vibration of the compressor and gearbox bearings and the equipment of an effective ventilation system that maintains the gearbox temperature not higher than 45 °C.

The design of the sound-absorbing shelter should provide for the possibility of installing an additional fan above the gearbox to increase the efficiency of shelter ventilation.

The shelter has lighting and a remote control for connecting an auxiliary fan, mounted on separate racks not connected to the shelter. The shelter housing must be earthed.

To reduce the noise load from intermediate nozzles, air coolers and air ducts, their surfaces are covered with multilayer soundproof coatings, which may consist of:

1. A layer of mineral or glass wool up to 60 mm thick, which is fixed with a mesh.

2. A layer of mineral-cement coating up to 15 mm thick, in which vibration-insulating gaskets made of vapor barrier or soft rubber with a diameter of 20 mm are fixed.

3. External coating of sheet steel up to 1.2 mm thick, which rests on vibration-insulating gaskets.

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ENGINEERING METHOD FOR FORECASTING EARTH SURFACE MOVEMENT DURING COAL SEAM MINING

Carrying out cleaning works during the development of coal seams of low and medium thickness even at a depth of more than 1000 m in all cases leads to the formation of subsidence on the earth's

surface. Their parameters depend on the mining-geological and mining-technical conditions of the cleaning work. Initially, in the middle of the last century, the study of the formation of subsidence on the earth's surface was associated only with the solution of one problem - the protection of buildings, structures and other objects from destruction and the harmful effects of mine workings. Based on the results of these studies, several documents were developed and published that normalized the rules for the protection of structures and natural objects from the harmful effects of mine workings.

Calculation of displacements and deformations of the earth's surface and undermined coal-rock strata is a complex problem that has not yet received its fundamental solution. For this reason, in practice empirical calculation methods and separate analytical dependencies are used. This direction of scientific research is the most promising and relevant, since its implementation does not require long-term and labor-intensive observations, combined with each other, both on the earth's surface and in mine workings. The development of a sufficiently reliable forecast of the parameters of the formation of troughs on the earth's surface and the movement of underworked rocks using mathematical modeling methods is an urgent problem for mining, not only the protection of objects on the earth's surface, but and many engineering problems.

In the general case, the formation of displacement troughs on the earth's surface consists of two stages. The first is connected with the start of exploitation of the mining area and the removal of the working face from the split furnace. At this stage, the processes of displacement of the underworked rocks of the earth's surface are reached and a stationary semi-trough is formed above the open cut. The second is characterized by the movement of underworked rocks and the earth's surface above the moving stope.

In the current normative document, as in the well-known mathematical models, the formation of stationary and dynamic semimulds are considered independently of each other. For this reason, the logical transition of the change in parameters from one stage of the formation of the displacement trough on the earth's surface to another remains insufficiently studied.

A preliminary analysis of the results of processing by the least squares method of experimental data obtained in the same mining-geological and mining-technical conditions showed that with little change in the values of the thickness of the developed layer (m), the depth of the cleaning work (H) and the strength properties of the undermined rocks, subsidence of points on the earth's surface (η), both above the open cut and above the longwall, is described as being close to functional dependencies at both stages of development of the cleanup. Correlation ratios (R) for individual objects of observation were 0.995÷0.999. This gives grounds to consider the results obtained by processing the experimental data by the least squares method as the most reliable.

At the first stage, the trajectory of the points of maximum subsidence of the earth's surface is described by an exponential relationship, mm

$$\eta_m = a_1 - b_1 \cdot \exp(c_1 \cdot L_p) \quad (1)$$

On the second, the subsidence of the earth's surface above the working face corresponds to the logistic curve, mm

$$\eta = \frac{a_2}{1 - b_2 \cdot \exp(c_2 \cdot L)}, \quad (2)$$

where a_1, b_1, c_1 and a_2, b_2, c_2 - empirical coefficients determined by the least squares method for the same mining and geological and mining conditions; L_p and L - respectively, the removal of the working face from the open cut and the distance of a separate point on the earth's surface to the projection of the working face, m.

In addition to the least squares method, to determine the coefficients a_1, b_1, c_1 and a_2, b_2, c_2 equations 1 and 2, the results of the correlation analysis of their dependences on mining-geological and mining-technical factors were used.

To determine the maximum subsidence of the earth's surface (η_m) according to equation 1, on the basis of correlation analysis, empirical dependences of the coefficients (a_1^a, b_1^a, c_1^a) on mining-geological and mining-technical factors were obtained

$$a_1^a = 374 + 7.4 \cdot 10^4 \cdot \frac{m}{H}, r = 0.78; \quad (3)$$

$$b_1^a = 717 - 41 \cdot \upsilon_{оч}, r = 0.96; \quad (4)$$

$$c_1^a = \frac{1}{-0.5 \cdot H + 14.6}, R = 0.90. \quad (5)$$

In a similar way, using correlation analysis, the dependences of the coefficients (a_2^a, b_2^a, c_2^a) were established to determine η by equation 2

$$a_2^a = \frac{1}{(-2.64 \cdot 10^{-4} \cdot m + 1.54 \cdot 10^{-3}}, R = 0.881; \quad (6)$$

$$b_2^a = \frac{1}{(-0.14 \cdot \upsilon_{оч} / H + 0.19)}, R = 0.884; \quad (7)$$

$$c_2^a = 0.205 + 0.0148 \cdot \ln(\frac{1}{m \cdot L_л \cdot H}), R = 0.986, \quad (8)$$

where $\upsilon_{оч}$ - is the rate of movement of the working face, m/month; $L_л$ - lava length, m.

Using the known experimental data on changes in the maximum subsidence of the earth's surface (η_m) at the first stage of the formation of a stationary semi-trough and subsidence over the working face (η), these parameters (η_m, η) were calculated for several excavation areas using equations 1 and 2 in two ways.

The results obtained using the coefficients calculated according to Equations 3, 4, 5 and 6, 7, 8 were close to the results based on the application of the method of least squares. This allows us to recommend in engineering calculations to use a method for determining the parameters of the troughs of displacement of the earth's surface, based on the use of the results of correlation analysis.

The error in their determination in comparison with the least squares method does not exceed 10-20% for each of the considered objects.

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SIMULATION OF JOINT DUMPING OF OVERBURDEN ROCKS AND IRON ORE ENRICHMENT WASTE

After the enrichment of iron ores, waste remains, the so-called "tails", which enter the tailings for storage [1-2]. Recently, the problem of storage of enrichment waste has become more acute, as new landfills need to attract additional land, which is usually not enough. In this regard, scientists are developing new methods and technologies for storage of waste enrichment products, aimed at maximizing the use of tailings and reducing the storage area of "tails". One of the methods of solving the problem of waste storage is their placement together with empty rocks on the dumps. However, the formation of such dumps is difficult due to the different properties and conditions of storage of overburden rocks and enrichment waste.

Despite studies of the co-location of enrichment products and overburden on a single dump, issues of geomechanics, ecology, technology and economic feasibility remain unresolved. In this regard, special attention is paid to the problem of joint dumping of overburden and enrichment waste in dumps in certain mining and geological conditions, and the development of effective methods for placing waste of enrichment on quarry dumps is an urgent task.

They are usually stored in the tailings in a dry or wet way. The wet method of storage involves the installation of dams around the perimeter of the dump, and the waste in the tailings are placed in the form of pulp or pasty consistency. The technology of dry storage of beneficiation waste involves the addition of binders or chemical reagents that reduce sawdust from the dry sludge dump. The above methods of dumping show that none of them solves the problem of reducing the area of land that is involved in dump. Thus, this problem can be realized only by placing enrichment waste in the heaps of quarry rocks. Research on this issue is incomplete and limited, and the problem of reducing the area under the tailings is solved for specific conditions of the enterprise.

From the geomechanical point of view, the problem of stability of liberators, overburden rocks and enrichment wastes placed in them is also not fully investigated. Performing only modeling of the release behavior of overburden rocks in different mining-geological and technological conditions, in combination with the combined release of soils and rocks overburden [3-5].

There are two main methods of dumping of dry waste beneficiation on the dumps of overburden [3]: joint dumping of overburden and enrichment waste under the slope; in the cavity in the form of a triangular prism, which is formed between the mounds of overburden.

In the case of joint dumping of tailings and overburden by bulldozer dumping from the top of the dump under the slope, segregation will occur, ie the rocks of the overburden will slide down the tier, and smaller fractions of the rocks will be located in the upper tier of the dump [6]. This will reduce the stability of the dump.

When placing the enrichment products in the cavities in the form of a triangular prism, they will be limited on all sides by the overburden of the dump. In this case, the behavior of such a dump will be more predictable, and the simulation will be more reliable.

For the quarry conditions of the Horishne-Plavninsky iron quartzite deposit in the Plaxis 3D software product, geomechanical modeling of the behavior of the overburden with dehydrated enrichment waste was performed to establish the maximum allowable deformations and stresses that may occur during construction and the coefficient of stability. The basis of mathematical modeling is the Coulomb-Mora model [7], with the help of which, by the finite element method, it is possible to determine the deformations of both natural and artificially created rock massif and to establish its stability.

Geomechanical modeling was carried out in stages (layer by layer), starting from the construction of the 4th stage of the dump to the last stage, in order to determine the deformation processes and the stability of the dump. The simulation was performed from the 4th stage because 3 stage already exist [8]. In fig. 1 presents the results of modeling 11 stages of the dump. The last stage is modeled exclusively by overburden quarries without beneficiation waste to prevent sawing of the dump after its reclamation.

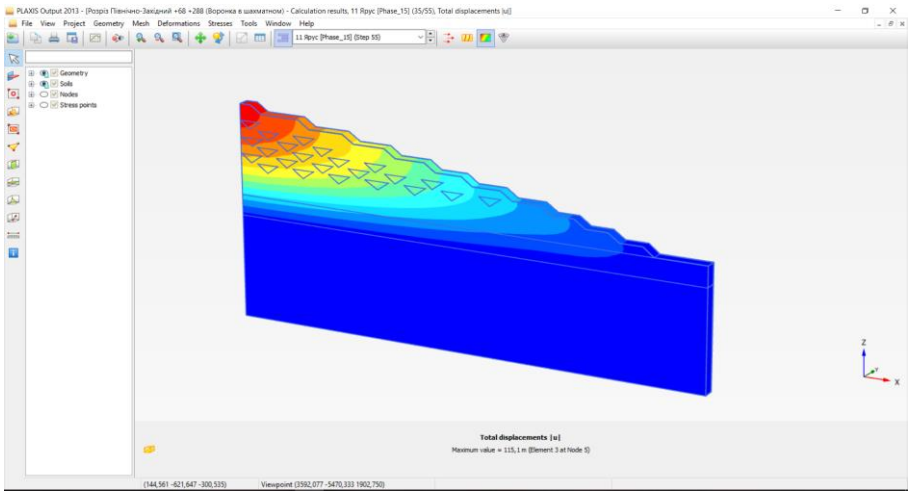

Fig. 1. Geomechanical model of completed dump

In fig. 2 presents the patterns of development of deformation processes in the dump as the construction of each tier in the joint dumping of overburden and waste enrichment in the funnels. The diagram of the change in deformation along the stages shows that the deformations are constantly increasing during the formation of each subsequent stage, but a clear pattern between the increase in deformation of neighboring stages s is not observed.

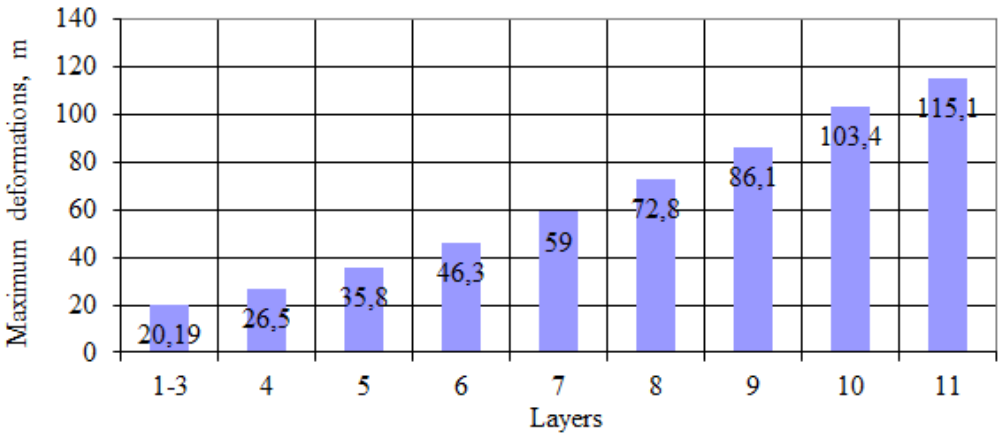

Fig. 2. Diagram of deformation of the dump in layers

Thus, as a result of geomechanical modeling, the predicted behavior of the joint dump during its service life and the value of the coefficient of stability of the dump after its formation, which is greater than the minimum allowable value (n=1,329>1,3). The obtained research results proved the prospects of scientific and research work in this direction, as the problem of storage of enrichment waste is very acute. Further research will be aimed at determining the optimal parameters of joint dumping for the maximum possible placement of tails, the behavior of dumps in difficult meteorological and climatic conditions and forecasting their stability.

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DEVELOPMENT OF GAS HYDRATE DEPOSITS AND STORAGE OF GAS IN THE FORM OF GAS HYDRATES

Today there are three main methods of extracting gas from hydrate-bearing formations: lowering the pressure below the equilibrium hydrate formation at a given temperature, heating the hydrate-containing rocks to a temperature above the equilibrium, as well as their mechanical destruction. At the same time, there is a physic-chemical technology of downhole hydraulic production (DHP), in which the hydraulic energy supplied through the well is used to destroy the rock, prepare the hydraulic mixture (pulp) and extract it to the surface [1]. Analysis of technological operations of SGV and the sequence of their implementation showed the prospects for the introduction of such a method for the development of gas hydrate deposits [2].

The method is carried out using jets of water flowing from the hydromonitors. A hydraulic production unit is mounted in the well, which is a combination of a downhole hydromonitor and a hoisting-and-transport mechanism of pulp extraction on the surface. The hydromonitor converts the static pressure of water into the kinetic energy of the jet, and as a result of reducing the cross section of the nozzle at a constant flow of water, its speed increases.

A method for the development of marine gas hydrate deposits [2] (Fig. 1), which provides: opening of the gas hydrate formation by horizontal wells 7; destruction of rock by high pressure jets of aqueous mixture and abrasive material (stream VII) by means of a hydromonitoring device 6; formation of water-hydrate-mineral pulp 2 as a result of mixing of crushed hydrogenated rock with a mixture of sea water and abrasive material (stream VII); gravitational separation in the working 1 portion pulp of the rock and, as a consequence, its enrichment with gas hydrate; the supply of water-hydrate-mineral pulp (stream I) from the workings 1 through the pulp intake 5, at a pressure higher than the equilibrium hydrate formation to the gravity separator 10 located at the bottom of the sea; separation in the separator 10 of the water-hydrate-mineral pulp into rock (stream III), gas hydrate (stream V) and gas-depleted pulp (stream II); supply of the separated gas hydrate in a mixture with water (stream V) in the form of the upper stream of the separator 10 by the pump 12 on the production platform 14; separation of part of the flow of depleted gas hydrate pulp (stream II) and supply under pressure to the hydromonitoring device 6 as a working mixture for the destruction of the rock (stream VII); discharge of the main part of the flow of depleted pulp (stream II) under the gas dome 13 above the upper limit of stability of the gas hydrate (ULSGH);

accumulation of gas under the dome 13 and its supply by pipeline to the platform 14 for technological needs.

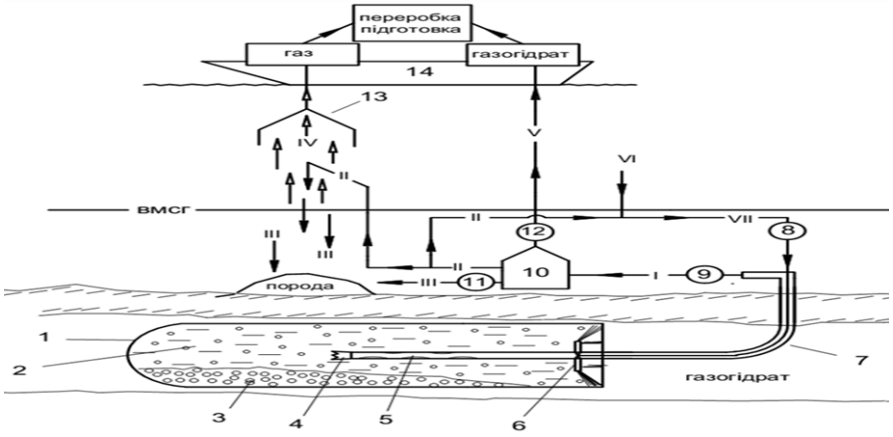

Fig. 1. The method of development of gas hydrate deposits [2]: 1 - development in the hydrate-saturated layer; 2 - water hydrate-mineral pulp; *3* - sediment of the rock*; 4* - bit*; 5* - pulp intake*; 6*- hydromonitor*; 7* - well*; 8, 9, 11, 12* - pump*; 10* - separator*; 13* – gas dome*; 14* - platform*;* flows*: I* - pulp*; II* - pulp depleted in gas hydrate*; III* - "empty" breed*; IV* - gas*; V* - gas hydrate*; VI* - sea water*; VII* - a mixture of sea water and depleted pulp for the destruction of the rock

At the same time, in recent years, a method of marine transportation of natural gas in gas hydrate form has been actively developed. A method of extraction and transportation of natural gas from gas or gas hydrate offshore fields is proposed [3] (Fig. 1), which provides: opening of a productive layer by a well; impact on the formation in order to extract gas or gas hydrate; production of gas hydrate from extracted gas; supply to the production platform of a mixture of gas hydrate, water and gas; enrichment of gas hydrate and increase its stability; formation of gas hydrate into blocks and preservation by a layer of ice; transportation and storage in terrestrial storages of gas hydrate blocks at atmospheric pressure and temperature, not higher than 278 K; dissociation of gas hydrate blocks due to solar energy.

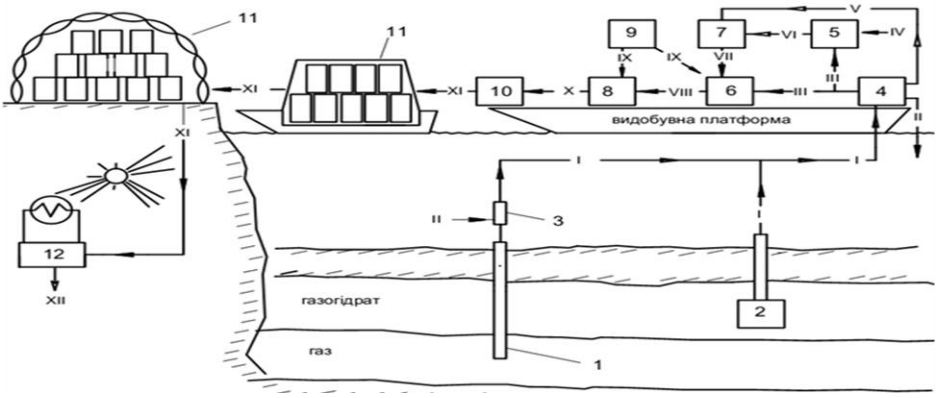

Fig. 2. Extraction and transportation of natural gas from gas and gas-hydrate marine fields: 1 – gas extraction; 2 – gas hydrate extraction; 3 – the formation of a mixture of gas hydrate, gas and water; 4 – separation of the mixture; 5 – melting of the gas hydrate to obtain high pressure gas; 6 – drainage of gas hydrate; 7 – gas compression; 8 – cooling of gas hydrate; 9 – cold production; 10 – formation of gas hydrate; 11 – transportation and storage of gas hydrate; 12 – dissociation of gas hydrate; flows: I – a mixture of gas hydrate, water and gas; II – water; III – "crude" gas hydrate; IV – heat supply; V – low pressure gas; VI – high pressure gas; VII – medium pressure gas; VIII – gas hydrate; IX – refrigerant; X – cooled gas hydrate; XI – gas hydrate blocks; XII – gas for consumption

The mixture of gas hydrate, water and gas in the development of marine gas hydrate fields is formed as a result of mechanical destruction of hydrate-containing rock and mixing of selected gas hydrate with water to prevent its dissociation in the formation and dissociation of gas hydrate in the pipeline, stability of the hydrate, in order to create the effect of a gas lift.

When developing a gas deposit, a mixture of gas hydrate, water and gas is formed on the pipeline connecting the well and the production platform with thermobaric conditions of hydration formation as a result of contact of the main part of gas and sea water extracted from the productive formation and heat dissipation through pipe walls. The content of gas and water in the mixture is regulated by the intensity of heat dissipation and the volume of water supplied.

The enrichment process of a gas hydrate mixture, water and gas on gas hydrate and increase the stability of the obtained gas hydrate mass is to carry out the following operations: separation of a gas hydrate mixture, water and gas into gas, water and a mixture consisting of gas hydrate, film water and water trapped between the crystals; melting in a limited volume of the gas hydrate to obtain high-pressure gas [4]; compressing the low pressure gas separated from the mixture; drying the mixture of gas hydrate and water by binding it to the gas hydrate in contact with the medium pressure gas flow and heat removal of the process; one-time cooling of the obtained gas hydrate mass taking into account the thermal balance of subsequent technological operations and processes until the moment of its dissociation before gas consumption.

The proposed method of extraction and transportation of natural gas from gas or gas hydrate offshore fields makes it possible to obtain a technical result, which is to minimize energy consumption as a result of integrated consideration of thermophysical properties and interaction parameters of the system within the developed deposit.

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MOBILITY OF THE METROBUS. WAYS OF IMPROVEMENT

The metrobus or the new Bus Rapid Transport (BRT) bus system is the result of the development of the public transit bus network.

The BRT system has several distinct advantages [6]:

- high passenger capacity and efficient payment systems ensure low-cost travel;

- high speed of movement allows the metrobus to carry a significant share of passenger traffic, which helps to reduce the number of cars on the city roads and, accordingly, to reduce exhaust emissions;

- an expanded information system informs passengers of the route.

The convenience, safety and organization of the road, which is inevitably improving, is far from being able to give passengers a high-speed bus system. In this system, passenger express buses move along specially designated lanes. They are separated from the carriageway and equipped with closed passenger stations with level platforms and subways.

The rolling stock used in the BRT system is of two types: the first is a classic, two-deck metrobus with an engine running on both diesel and gas fuel; the second option is a new generation metrobus with a hybrid electric-gas engine. These two variants are inherent in articulated buses, 18 and 24 meters long.

Studies conducted by domestic and foreign scientists found that the creation of a modern automobile vehicle (AV) with improved energy efficiency may be based on a hybrid power plant, but the unresolved issue of rational distribution of power between the internal combustion engine and electric motors implementation [3, 5].

In fact, a metrobus combines the benefits of a subway in a modern city with the relatively low cost of building such lines. Moreover, with the help of traffic intensity it is possible to adjust the passenger flow. In general, metrobus lines are suitable for areas that require transportation of (15000-18000) passengers per hour. However, there are many examples where they have generally replaced the metrobus in large metropolitan areas. For example, in Istanbul or Chinese Shanghai.

Another advantage of BRT systems is the speed of construction of such lines that can be used by existing highways in cities. Typically, such a line is built in (1-2) years, while the construction of the subway, tram lines can take (3-10) years.

The special development of the buses was with the advent of three-seater buses, which can carry up to 300 passengers against 180 passengers, in two-seater buses. Thus, having 3-lane buses that move at short intervals (up to 1 minute) the metrobus line can solve the transport problems of many Ukrainian cities, and in particular, completely eliminate the issue of transport connections of remote arrays.

New developments in the field of creation of multi-link AVs and methods of optimization of their designs are focused on minimizing fuel, energy consumption, improving mobility and controlling. Many theoretical data on the optimization of complex mechanical systems and multi-objective optimization methods are given in [1,4,7]. In [2] the circuit solutions and features of construction of vehicles with a hybrid power plant, electrical systems and complexes of a hybrid car are considered.

Mobility of AV is estimated by nine indicators, six of which are kinematic and three dynamic. However, for a three-lane metrobus, two kinematic unit mobility values should beconsidered as the main ones, namely:

• the overall traffic lane (OTL) equal to the difference of the radii of rotation of the points of the train, the farthest and closest to the center, that is, the difference of the overall radii of rotation - the outer (R_z=12.5 m) and internal (R_v=5.3 m);

• the ability to move backwards.

Given that the movement of the metrobus is carried out on dedicated lanes, the ability to move in reverse is not critical for him, that is, the maneuverability of the metrobus is advisable to determine by the OTL size.

When determining the maneuverability of the wheels of vehicles are taken as rigid in the lateral direction and elastic. The methodology for calculating OTL is based on determining the angles of assembly of the road train links and the offset of the driven links trajectories relative to the trajectory of the master. The discrepancy in the calculation of maneuverability when using rigid or elastic lateral wheels for two-lane highways can reach 13 - 15%, and for three-lane highway trains it can be even greater. Therefore, determining the mobility of a three-row metrobus will be carried out on models with elastic laterally wheels.

The results of our studies proved that:

• promising for big cities is the use of three-lane buses capable of carrying up to 300 passengers instead of 180 in two-lane buses. With such a capacity of three-lane buses operating at short intervals (up to one minute); the BRT system can be competitive with the metro line;

• in the one-way rotation of the trajectories of the trailer links are shifted with respect to the trajectory of the bus to the center of rotation, thus increasing the overall traffic lane, and the offset of the trajectories and the overall traffic lane increased with the increasing of the base of trailers;

• the standardized value of the overall traffic lane for the real design parameters of the three-lane metrobus, taking into account all its possible limitations (bus base, location of coupling points, trailer base, etc.) can provide a three-lane metrobus, both with unruled and driven second trailer.

• at the same time, for controlled second trailer OTL is mixed by (12-15)% and it depends on the location of the coupling points of the trailers with the bus and with each other.

• when performing an ISO maneuver at a 5 m/s highway speed, both the unruled and guided second trailer will fit into the normalized traffic corridor. However, a speed of 10 m/s, oscillations of the second guided trailer are already observed, and exceed the permissible ones, it can lead to loss movement stability of the metrobus.

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DETERMINATION OF TECHNOLOGICAL PARAMETERS OF THE CRUSHER WITH WAVE PROFILE OF ROLLS

The projecting of quasi-static crushers, such as jaw, cone and roll types, includes an obligatory substantiation for such an important technological parameter as the ratio of the discharge gap size and the size of crushing product. In practice, these two values usually do not match.

Either the maximum size of the pieces or their average size can be considered as the specific size of the product.

The ratio of the maximum product size to the gap size is called the product over-size factor. For traditional equipment, this factor is always more than one unit. Its largest values up to 3.0-3.5 are taken for secondary and tertiary cone crushers. It is explained by the large scale of fluctuations in the gap size (up to several times) when the cone moves.

Roller crushers are distinguished by the fact, that the gap size value is constant during their operation. However, the product over-size factor is still more than one unit and is about 1.5. The reason for this is the possibility of non-isometric pieces of material passing through the gap between the rolls by their minimum size - thickness, although its width and length are much larger.

In the production of cuboid crushed stone [1], it is more preferable to use wave profiled rolls [2], which substantially reduce the yield of lamellar-shaped pieces by their destruction under bending loadings between ledges of the staggered opposite roll profiles. This has a beneficial effect on the strength characteristics and service life of high-loaded concrete items produced from cuboid crushed stone. It is due to increasing the packing density of carcass particles, as well as eliminating the destruction of lamellar particles in the carcass under bending loadings [3].

The complexity of the geometry of the roll profile described in [2] makes it difficult to determine the ratio of the crushing product size to the gap size. Here, we consider the gap size as the shortest distance between the enveloping cylinders of adjacent rolls ledges. Therefore, to clarify the situation, an experiment was conducted to crush various marble fractions in the range from 10 to 32 mm. The pitch of the roll profile ledges was 10 mm.

Such values of the average product size have been obtained for the corresponding combinations:

1 - 12.6 mm for -32 +25 mm fraction and 10 mm gap size;

2 - 13.5 mm for -25 +20 mm and 10 mm;

3 - 10.5 mm for -20 +15 mm and 7 mm;

4 - 10.2 mm for -15 +10 mm and 7 mm;

5 - 7.9 mm for -20 +15 mm and 5 mm;

6 - 8.4 mm for -15 +10 mm and 5 mm.

Thus, it is concluded that the average product size d_{av} is approximately 1.6 times more than the gap size b and doesn't depend on the feed material size.

The yield of particles smaller than b in the product was from 12 to 26 percent, that corresponds to the crushing degree value from 1.2 to 2.2. Small values of the latter value correspond to the operation of crusher in the mode of particles shape improvement with minimum of excessive grinding.

The second studied technological parameter has been the grab angle of the crusher associated with the ratio of the outer roll diameter to the maximum size of loaded piece.

In this experiment, a laboratory crusher with rolls of D=260 mm diameter was used. The crusher retracted confidently the marble pieces of size d_{max}=25 mm. The pieces of size d_{max}=32 mm corresponded to the ultimate grab angle when, with a further increase in the size of a piece, it is rubbed on its surface, but cannot be pulled inside. Thus, the limit ratio (D/d_{max}) was 8-10 units, which is better than for the smooth rolls case, and approximately corresponds to the case of corrugated rolls.

The results of the analysis confirm and refine the characteristics of crushers with a wave profile of rolls. They will be also useful for technological calculations of the stone raw materials processing.

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WAYS OF DISPOSING OF METAL WASTE FROM THE AUTOMOTIVE INDUSTRY

End-of-life vehicles are an excellent source of many valuable secondary raw materials, and their disposal is not only cost-effective but also beneficial for the environment. With the right processes, it is possible to produce raw materials that do not differ from conventional ones. One example is the technology for disposing of metals at the end of a vehicle's useful life.

When dismantling a vehicle, metal scrap is sorted into magnetic fractions (i.e. steel, cast iron, cast steel) and non-magnetic fractions (e.g. aluminium alloys, copper). A separate group is formed by catalytic converters due to their precious metal content.

Ferrous metals. In cars, steel has the largest share among ferrous metals, to a lesser extent cast iron. Steel sheets are used for car body, and structural elements are made of steel with increased strength [1]. Once the parts that are to be reused or recycled have been removed from the vehicle, the remaining parts are left in the wreckage. These remnants are then compacted or sent to a shredder. In this device, they are shredded using an impact device (hammer or ring) on a rotating

rotor. The process continues until the residue falls through the grate. Usually the size of these fragments does not exceed 200 mm. After shredding, the pieces are sent for segregation to obtain ferrous metal, non-ferrous metal and light metal fractions [2, 3].

Steel is very recyclable. The most common way to recycle steel is to melt down the scrap in steel mills. This yields a new product that can be used in both the automotive industry and other industries. Before steel can be used in metallurgical processes, it must be dezincification. The purpose of galvanising steel is to protect the vehicle against rust. Zinc accumulates in dust and sludge, making the process economically unviable.

Non-ferrous metals. The largest group of non-ferrous metals used in vehicles is aluminium and its alloys. Other non-ferrous metals (copper, zinc, lead) are used to a lesser extent. After the shredding process, a non-ferrous metal fraction is separated, which is sorted using magnetic properties, density difference and electrical conductivity. Light foams, paper, textiles and other non-metallic fines are separated from the pre-sorted material. Using eddy currents, the remaining electrically conductive particles are also separated. As a result of these processes a non-magnetic metal concentrate is obtained, containing 30-95% metal by weight. The obtained concentrate requires enrichment in heavy liquids. It is sold to specialised plants [2]. The sorted aluminium alloy fragments can be remelted. In the case of fragments contaminated with varnish or moist, they are subjected to thermal treatment in low-temperature rotary furnaces. The remelting can take place in rotary furnaces and induction furnaces. During remelting, fluxes are added to prevent oxidation and to absorb impurities. Then the liquid metal is blown with argon or nitrogen (refining). The next stage is metal filtration and the whole process ends with casting it into moulds [1]. A very important element of aluminium remelting is the separation of its alloys, which are divided into cast and ductile. Thanks to research works, a method was patented, which allows to obtain 95% of plastic alloy and 80-90% of cast alloy [2, 3].

Precious metals. The recycling of precious metals makes it possible to obtain these rare and expensive elements very favourably. The energy input for their recovery is significantly lower compared to their extraction, and there are also fewer emissions of pollutants. The recycling of 2 tonnes of reactors or 0.5 tonnes of catalytic carriers makes it possible to obtain 1 kg of precious metals, mainly platinum and, to a lesser extent, rhodium and palladium. Despite the high cost, these treatments are cost-effective. Recycling of a catalyst starts with the separation of its casing from the inner part containing the precious metals. These metals are then recovered by hydrometallurgical or pyrometallurgical processes.

The hydrometallurgical method uses leaching with strong acids. The metals are then segregated by precipitation. Another way is to melt the entire carrier and extract the metals from the liquid by extraction. This method causes large losses of precious metals and generates large amounts of

waste. During the indirect pyrometallurgical process, the precious metal carrier is added to another molten metal, such as iron or copper. Anodes are then cast from this alloy, which in a further step undergo electrolysis (final refining). Precious metals in the form of a precipitate are processed in the final stage by electrolysis. The raw materials obtained in the above processes require additional chemical purification. Only then can they be used in industry [2].

Every part of a worn-out vehicle is reusable. Some parts may end up as spare parts for other vehicles. Using some parts as replacements for brand new parts can significantly reduce repair costs. Parts that cannot be used in this way should be recycled and used as materials, even outside the automotive industry. Some parts of a worn-out vehicle are highly toxic, so how to recycle them properly is very important.

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IMPROVEMENT OF CONTROL SYSTEMS FOR HYDRAULIC DRIVES OF TECHNOLOGICAL MACHINES

The widespread use of a hydraulic drive in almost all sectors of the national economy is due to its advantages over other types of drives. One of the main advantages of a hydraulic drive is its high energy consumption, i.e., the ability to obtain high power with small dimensions. Energy consumption is estimated by the ratio of mass to power, for a hydraulic engine this indicator is about 0.2 kg/kW. For comparison, for an electric motor, this figure is approximately 10 kg/kW.

However, the existing disadvantages, such as: the complexity of the individual elements of the hydraulic drive; high requirements for the manufacturing technology of individual elements of the hydraulic drive; rather high complexity of high pressure communications; whimsical operation; high requirements for the personnel servicing the hydraulic drive and high cost, significantly limit the scope of its use. At present, the use of a volumetric hydraulic drive is limited to the use in machines and equipment of high power: metal-cutting machines, presses, in control systems of aircraft, ships, heavy vehicles, mobile road construction equipment, in systems of automatic control and regulation of hydraulic turbines [1]. In the hydraulic drive, various types of valves and distributors are currently used

to switch (connect and disconnect) hydraulic lines. The most widely used spool valves are four-way, three-position valves, differing in nominal diameter and type of control [2].

In addition, according to GOST 24679-81, such distributors are produced according to various line connection schemes in each of the positions. There are several dozen such schemes. Such a variety of valve circuits significantly complicates the control circuit and reduces its reliability. Since there is no interchangeability. Two-way on-off valves (2/2) are currently not widely used and are mainly used to block (shut off) the flow of liquid in automation systems.

Despite the seemingly significant differences between electric and hydraulic drives, there are many similarities between them. Some concepts and operation of an electric drive are sometimes explained using an analogy with a hydraulic drive, and a hydraulic drive using an analogy with electrical networks and drives. This method was first proposed by Maxwell [3, 4]. Its essence lies in the fact that, in the general case, the electric voltage is equivalent to the hydraulic head (pressure), and the electric current is equivalent to the hydraulic volumetric flow (supply), that is, the volumetric amount of the flowing fluid in time. Therefore, the hydraulic circuit can be represented as an electrical circuit, replacing hydraulic components with electrical equivalents (analogs). So, for example, a hydraulic analogue of a diode is a check valve, which passes the liquid in the forward direction and does not allow it to flow in the opposite direction. An analogue of an electrical resistor in a hydraulic drive is a throttle, which resists the movement of fluid. An analogue of an electrical contact or thyristor (controlled semiconductor valve) can be a two-position, two-way valve, which, under the action of a control signal (mechanical or electrical), connects or disconnects two lines, allowing or inhibiting the movement of fluid. And an analogue of a four-way hydraulic valve is a relay that simultaneously switches four lines.

But unlike electric ones, hydraulic elements have much larger dimensions and weight. This state of affairs can probably be explained by the fact that despite the fact that hydraulics as a science was formed much earlier than electrics, the hydraulic drive in today's understanding was formed relatively recently at the beginning of the 20th century, and the electric drive, despite its relative youth (the first electric machines appeared only in the 19th century) developed rapidly and from the point of view of theory, machines and element base, is now far ahead of the hydraulic drive. This determined the widespread use of electric drives and microelectronics in almost all sectors of the national economy.

The main (elementary) control element in an electric drive and electronics is a contact (valve) or a logical element, which at a certain moment, when certain conditions are met or under the influence of a control signal (electrical, mechanical, pneumatic, etc.), are connected or disconnected separate sections of the chain. Thanks to the development and improvement of these elements, the development and improvement of the electric drive and electronics in general takes place. For

example, massive and large contacts in a contact-relay drive, replaced a thyristor drive based on compact thyristors.

Obviously, in order to simplify the hydraulic circuits and increase the reliability of operation, in accordance with the electro-hydraulic analogy, it is necessary to develop a small-sized two-line contact / valve. On the basis of which it will be possible to compose compact relays / distributors for switching a large number of hydraulic lines [5].

For example, by grouping 4 2/2 valves together, they will work as one 4/3 directional valve controlled by one power control element (electromagnet). They can also be placed separately in different (more convenient) places in the circuit.

It should be noted that unlike the commonly used four-way, three-position valves, four 2/2 valves can be used to assemble a 4/3 hydraulic valve according to any of several dozen schemes presented in GOST 24679-81. Moreover, it should also be noted that all 2/2 valves are interchangeable. In addition, 2/2 valves have a simple design and, accordingly, higher reliability, and during mass production, the cost of their manufacture is minimal.

The research carried out allows us to draw the following conclusions.

1. A method has been developed for constructing control schemes for hydraulic drives of technological machines based on elementary switching valves.

2. It is advisable to construct rational control schemes for hydraulic drives by analogy with electric drives based on simple designs of valves of type 2/2, which will improve the reliability of operation, provide simplicity of design and reliability of operation with a significant reduction in the cost of their manufacture.

3. For the successful application of the proposed control systems for hydraulic drives of technological machines based on elementary switching hydraulic valves, it is necessary to refine and study the design of the simplest elements (valve / distributor 2/2) in order to increase their compactness, simplicity and reliability.

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MONITORING THE NOISE LEVEL PRODUCED BY ROTOR EXCAVATORS

Excavators are machines for digging earth and extracting ballast, sand, broken stone or other materials from quarries or hard-to-reach places. The excavators are of several types, and in this paper we study the rotor excavator.

Excavators differ in chassis design, with models made on tracks or tracks. In the case of the studied excavator, the buckets are placed on a large wheel (rotor), ensuring the work of the soil in the optimal direction. If a surface layer is generated, the rotor rotates clockwise. When working with the bottom layer, the rotation is in the opposite direction. In addition, the cups can be rotated vertically or horizontally [1].

The rotor is the moving part of an electric motor, electric generator or alternator. The rotor is located on a telescopic or stationary arm. The change in the position of the arm in space is due to the winch, whose cable is passed through the mast of the chain hoist.

The position of the arm is adjusted using the installed counterweights. Each rotor excavator is equipped with a unloading container, has an autonomous rotation system provides a deviation of the arm by 270-300 degrees, relative to the horizontal plane. The average size of the rotor is about 20 meters in diameter.

The volume of the bucket is about 12 liters, the depth of development can reach 20-25 meters, while the working height is 50 meters. Such specifications ensure the car a capacity of up to 10,000 cubic meters per hour [2].

This paper studies the operation of excavators and the level of noise produced. Its purpose is to determine whether prolonged exposure to work with these excavators can endanger human health.

Thus we performed measurements of the noise level produced by them both at rest and during execution. The measurements were performed in different periods of 2020, and for this paper were presented the values recorded in January, June and December. These values are presented in table number 1. The measurements were performed in accordance with Romanian legislation so as to obtain accurate and quality data. These were made using the noise level measuring device provided by bruel and kjaer type 4448.

Table 1

№	January 2020		June 2020		December 2020	
	at rest	in execution	at rest	in execution	at rest	in execution
1	60dB	95dB	63dB	120dB	68dB	150dB
2	58dB	85dB	58dB	140dB	60dB	110dB
3	64dB	120dB	62dB	85dB	58dB	95dB

As we can see in the table above during rest, the noise level produced falls within the legal limits, but during execution, depending on the working mode, the noise level exceeds the legal limits. Thus we can say that a long exposure without protection produces negative effects on human health

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ANALYSIS OF METHODS OF SORTING NON-FERROUS METALS AND ALLOYS IN VEHICLE UTILIZATION TECHNOLOGY

The amount of cars on the roads of Ukraine is growing. This process occurs due to the following factors: the expansion of opportunities for the import of used cars from Europe and the United States, the COVID-19 epidemic, in which individual vehicles began to be used more intensively and public transport for safety purposes. Imports of used cars and the rapid aging of the Ukrainian car fleet will eventually lead to the accumulation of a large number of end-of-life cars that will need to be disposed of. Today, the number of cars that have already fallen into operation and are subject to disposal is about 170 thousand per year. Given the current pace of such processes, the number of cars that could go out of service in 10 years could double. In such conditions, effective high-tech car recycling systems are indispensable.

Modern car consists of 75-80 percent of ferrous metals, 6-8% - non-ferrous metals and alloys, the rest - plastics, glass, rubber and other materials [1-3]. Non-ferrous metals, although they make up a relatively small share, are a valuable raw material for further processing. In modern technologies of shredder utilization of cars non-ferrous metals are removed after the release of ferrous metals, mainly by electrodynamic separation on eddy current separators. This allows you to remove a mixture of non-ferrous metal particles and alloys from the shredder residue of end-of-life vehicles. Next, to separate the particles of metals and alloys by type, you need to use other methods, such as heavy separation, X-ray sorting and others. A mixture of non-ferrous metals and alloys on the market can be sold at the price of the cheapest component, which reduces the cost-effectiveness of shredder recycling technology [4, 5].

The aim of the work is to develop a classification of methods for the separation of non-ferrous metals and alloys and to analyze the possibilities of these methods, the use of which will increase the economic efficiency of shredder technology for car recycling.

Methods of separation of non-ferrous metals and alloys can be divided into two groups: methods for separating a mixture of particles of all non-ferrous metals and alloys and methods for separating non-ferrous metals by type. The first group includes methods of electrodynamic separation and induction sorting. The second group includes methods of heavy-medium separation and X-ray sorting methods (using X-rays). Under the condition of uniform size of non-ferrous metal particles and their alloys, electrodynamic separation can be used to separate aluminum particles.

Electrodynamic (eddy current) separation is the most common method in shredder technologies for automobiles, designed to separate non-ferrous metal particles and their alloys from the shredder residue after removal of magnetic metals [4-5].

The principle of operation of electrodynamic separators is the occurrence of eddy currents in the electrically conductive material of the particle under the influence of an alternating magnetic field. The main separating feature used in the process of electrodynamic separation is the electrical conductivity of the material of metal particles. It can be effectively used to separate particles of non-ferrous metals and alloys with sizes of 3–100 mm. With a homogeneous composition of the product in size and shape of the particles can be used to separate non-ferrous metals by type.

Induction sorting is a relatively new method of separation and is designed to extract metals and their alloys from bulk products. The principle of operation of induction separators is to pass the product on the conveyor belt between two coils (induction sensors), one of which is connected to an alternating current source and creates an alternating magnetic field, and in the other this alternating electromagnetic field induces electric current. When non-ferrous metal particles get between these, the signal in the receiving coil weakens due to the creation of circular currents in the electrically conductive particle. This signal change is recorded and transmitted to actuators, preferably pneumatic nozzles, which blow the identified particle with an air stream from the main product stream. Induction separators are manufactured by Steinert (Germany) [6].

The main separating property used in the induction sorting process is the electrical conductivity of the particle material. Induction sorting makes it possible to remove particles of metals and their alloys with sizes of 1-20 mm.

X-ray sorting is a modern information method of separation, designed to separate non-ferrous metals and their alloys by type, based on the use of X-rays. It makes it possible to identify the spectra of metal atoms and their alloys. The product is fed to a conveyor belt on which X-ray irradiation is performed, resulting in a signal in the form of spectrograms of each particle. After identification of the metal or alloy particle, the signal is fed to the appropriate pneumatic nozzle,

which blows this particle from the main product stream. One metal or group of metals, such as aluminum and its alloys, can be removed in one separation. The separating property of X-ray sorting is the energy of the atomic spectrum. X-ray separators are manufactured by Redwave (USA) [7].

Heavy-medium separation, designed to separate products by density in heavy suspensions based on magnetite or ferrosilicon, allows you to separate most non-ferrous metals and their alloys. This type of separation is widely used in the enrichment of coal and polymetals. Heavy-medium separation is performed mainly in wheel separators and heavy-duty hydrocyclones.

The distinguishing feature is the density of the particle material. Particles with a size of 3–150 mm can be effectively separated. The main disadvantage of this method is the need for constant preparation and regeneration of the heavy suspension.

Thus, the paper proposes a classification of methods of separation of non-ferrous metals and their alloys, which are already used and can be used in the technology of car recycling in the future. This classification includes, in addition to traditional methods of separation, and new promising efficient technologies.

Wider use of methods of separation of non-ferrous metals by types will increase the economic efficiency of car recycling technology through the sale of each metal separately at higher prices.

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RESULTS OF FIELD STADIES OF QUALITI OF SOIL CULTIVATION WITH A BIONIC LANCET PAW

Tillage working bodies for the most part cannot be classified as complex in design. But the problem is that they have to be constantly adapted to new technologies for growing crops.

For example, among the latest significant innovations is the organic farming system. The consequence of the introduction of which system is to reduce soil consolidation.

At the same time, the main machines of both surface and deep tillage are adapted to the conditions of the supporting cut, which, in conditions of underestimated consolidation, leads to a deterioration in the quality of the technological process.

The possibility of the emergence of other completely new farming systems cannot be ruled out. Thus, constant work is required to adapt the working bodies to the new needs of technology.

The use of bionics methods is promising in this regard. In [1] the method of using the structure of the body of the Californian stingray as a biological analogue in the design of a soil-cultivating paw of high streamlining is argued. In further studies [2], a method is proposed for adapting the formed cutting perimeter of the paw to work in real soil conditions.

In order to confirm the adequacy of this area of research, we performed a number of field experiments using paws performed according to the proposed scheme.

In order to confirm the adequacy of this area of research, we performed a number of field experiments using the paw performed according to the proposed

Dimensional characteristics corresponded to the reasoned ones [2]. For comparison, a serial swept paw was also studied using a unified technique.

The width of capture B=270 mm is taken as the basic size. The experiment fully confirms the working hypothesis that an increase in streamlining leads to a decrease in traction resistance. So, with a specific adhesion of soil particles of 2.2 kN/m^2, the traction resistance of the serial share is 860 N, the experimental one is 780 N, with a specific adhesion of 3.8 kN/m^2, respectively, 920 N and 850 N.

It should be noted that the bionic paw cuts the root system of plants almost completely, while the serial paw cuts off 70-75%

The quality of crumbling and loosening is practically the same for both paws.

This is explained by the fact that the design changes concerned only the cutting perimeter, while the working surfaces remained unchanged.

Namely, the working surfaces provide crumbling and loosening.

As a whole, the cultivator equipped with experimental paws performed the technological process steadily, technological failures were not noted.

The studies were carried out in the mode of shallow (12 cm) tillage at a speed of up to 7 km/h agrophone - barley stubble

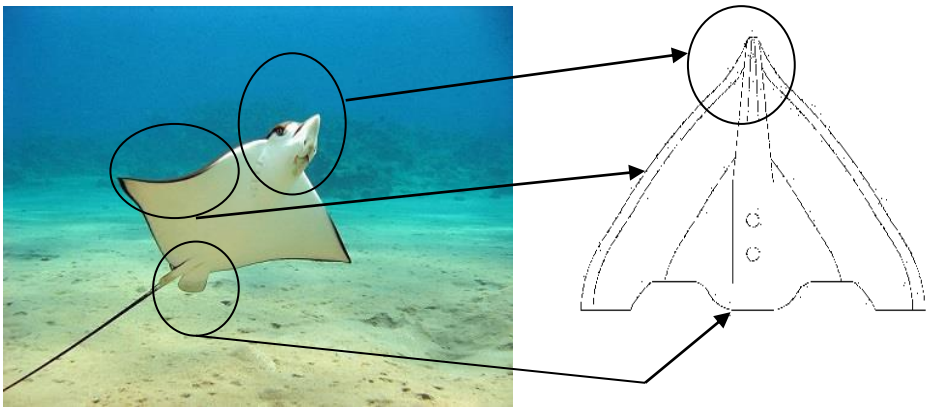

Fig. 1. The principle of formulating the constructive scheme of the paw[1]

As a conclusion, it is necessary to note the directions of further research.

First of all, it is necessary to study the possibility of using other biological analogues, including for deep tillage. Develop an analytical technique for modeling work surfaces

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IMPROVING THE QUALITY OF THE SURFACE LAYER OF DETAILS BY VIBRATION PROCESSING

In modern mechanical engineering, the share of finishing and cleaning of parts with granular abrasive media in the processes of grinding, polishing, preparation of surfaces for coating, removal

of burrs and rounding of edges, cleaning surfaces from contaminants is steadily increasing. Such processing contributes to the intensification of technological processes, increases the level of automation of operations, economic efficiency and productivity [1].

Heat treatment of parts associated with heating and cooling of steels in the air or in the products of fuel combustion, is accompanied by the formation of gas corrosion - scale. Its presence on the surfaces of parts reduces their properties: aesthetic, technological, operational. There are various methods of cleaning parts from scale using a granular abrasive filler, but not all of them allow to obtain the desired surface quality. Therefore, the creation of appropriate equipment, the choice of efficient and affordable working environments and process fluids requires a study of the processes of destruction of scale under the action of vibration forces.

It is known that scale consists mainly of three layers - FeO wustite, Fe_2O_3 hematite and Fe_3O_4 magnetite. The sequence in the location of the layers of different phases in the scale corresponds to the sequence of phases on the state diagram of "iron-oxygen" [2]. Adjacent to the metal is a layer of festoon of FeO, then - in the direction of the gaseous medium - is a layer of magnetite Fe_3O_4, and the most oxygen-rich hematite Fe_2O_3 is located at the boundary of the phases "scale-air". The results of metallographic studies confirm the above data on the structure of scale. At the boundary between these phases of the sublayers, the scale is relatively easily separated from the metal base.

Oxidation of metals has characteristic features, because the oxide film as it grows more and more insulates the metal from oxygen, so its growth rate is often not controlled by a chemical reaction, and the movement of metal outward or oxygen inward (through the solid film), ie physical process - diffusion of charged particles through the crystal lattice of solid phases of scale: cations are directed to the outer surface, and anions - to the inner [2].

Scale formation is accompanied by a significant increase in volume, so the oxide layer is in a compressed state. This leads to the detachment of oxide films from the metal base (with significant strength of scale and its weak adhesion to the metal) or to their cracking (with low strength of scale and its strong adhesion to the metal base). At slow cooling from high temperatures to room temperature the scale has insignificant disturbances of continuity owing to sintering of oxides.

Since the various factors associated with the occurrence of compressive stresses are difficult to quantify, it is impossible to predict their effect. However the violation of its integrity was mainly observed in the form of cracks.

Cracks occur as a result of the difference between the coefficients of linear expansion of metal and scale, components of scale (including hematite and magnetite), their location and as a result of temperature stresses that occur during rapid cooling of high temperature parts.

Bulk scale defects (bubbles) are formed mainly at temperatures above 800 °C due to the burning of carbon from the surface layer of the metal and the formation of rounded cavities that

connect with each other. In addition, rounded microscopic cavities (pores) and larger bulky defects are often present in the scale.

The strength of scale and its adhesion to the metal base play an important role in cleaning parts. On the one hand, strong adhesion of scale reduces oxidation during heating and subsequent processing, on the other - makes it difficult to remove scale during processing.

As the scale thickness increases, the adhesion decreases, falling for pure iron from 9.8 MN/m^2 (h_{ok}=0.09 mm) to 1.5 MN/m^2 (h_{ok}=0.325 mm) [3]. For St3, oxidized at 1000 C, the adhesion force of scale with the metal decreases almost from 3.2 MN/m^2 (h_{ok}=0.2 mm) to 1.9 MN/m^2 (h_{ok}=1 mm).

Surface cleaning is the removal of dirt from it to a certain level of cleanliness. Each of the cleaning methods is based on a certain method of destroying contaminants and removing them from the surface. The law of scale destruction in general should express the dependence of the rate of its destruction on [3]: force and kinematic parameters, parameters of the abrasive filler, parameters of the scale layer, presence of chemically active liquids in the working zone.

The destruction of scale in the medium of freely oscillating granules is the result of the simultaneous action of microcutting (viscous fracture), fragile destruction, plastic deformation, hydromolecular destruction. When removing scale the fragile fracture, which occurs as a result of repeated shock interaction of the working medium ingredients is predominant.

The destruction begins with changes at the microscopic levels. In scale, where microscopic violations of continuity are already in the initial state, even with a slight increase in external actions, the size and density of microdisorders increase rapidly and destruction can occur. The places of the greatest curvature of microcracks are stress concentrators, the values of which can be hundreds of times higher than the average values of stresses. As a result, the destruction of scale can occur at a relatively small value of the average voltage. The energy supplied to the scale is converted into the energy of deformation, which accumulates in the material, and into the surface energy of the crack. When a certain critical length is reached, the crack will propagate spontaneously. Cracks, spreading and joining together, form a macrocrack that loosens scale.

The final stage is the growth of one of the macrocracks, which absorbs the neighboring ones, forming a main crack and a fracture surface. Fragile destruction of scale is possible by microcracking, splitting and uprooting of its individual particles.

Since the processes of microdeformation take place in the microvolumes of scale, and the fracture itself originates in the zones where the probability of combining the largest stress increase and strength decrease is the highest [4]. This leads to a probabilistic interpretation of the process of brittle fracture.

To conduct research of vibration descaling, an experiment was conducted to clean heat-treated samples on an installation, the working chamber of which has performs complex angular oscillations.

Under their action working environment carry out intensive circulation, which creates conditions for highly productive processing. Abrasive molded PT 15×15 and abrasive natural "Baikalite" were used. A 2% soda ash solution was used as the process fluid.

Technological parameters were the angular amplitude (2-7 degrees) and frequency (17-22 Hz) of oscillations, processing time. The criterion for the productivity of the process is the weight removal of scale. The amount of scale removed was recorded using electronic scales every 15 minutes for up to 60 minutes of processing. Samples made of steel 45 of cylindrical, prismatic and cubic shape were used for research.

The samples underwent quenching (840 °C, cooling in water) and high tempering (620 °C, cooling in air).

With small amplitudes, the change of granules and details is even smaller, so the scale visibility is insignificant.

With an increase in the amplitude the growth of the granules and parts is undoubtedly. Protect the sutta for an increase in amplitude, and even the contact of the granule with the part will become shockable, so that the strength of the surface and the dynamism of the surface is pushed to the drive. In the range of 5-6 degrees of centering and changing the storage forces of granules for a part, they are balanced and set up the optimal mind for the precise processing of parts.

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IMPLEMENTATION OF SUSTAINABLE DEVELOPMENT GOALS IN URBAN TRANSPORT IN KRAKÓW (POLAND)

At the initiative of the United Nations in Rio de Janeiro in 1992, a document defining the Sustainable Development Goals (Agenda 21) was adopted at the Environment and Development Conference. On 25 September 2015, the document was replaced by the resolution Agenda 2030, which was signed by 193 UN member states. The new document includes 17 sustainable development goals and 169 tasks, under the three pillars of sustainable development: economic, social and environmental [1].

The article discusses selected areas of action in the field of urban transport in Krakow (Poland). Efficient and pro-environmental development of public transport will allow the implementation of selected eco-development goals [2].

Access to clean fuels

Access to clean fuels is one of the action areas that has a direct impact on the environment and improvement of the quality of life of the inhabitants. This indicator is included in:

- Goal 7, which recommends ensuring access to stable, sustainable and modern energy at affordable prices,

- Goal 9, which recommends building stable infrastructure, promoting sustainable industrialisation and supporting innovation. This objective includes numerous social and engineering activities carried out in an innovative manner,

- Goal 13, which addresses the urgency of combating climate change and its impacts. This objective aims to limit climate change, which is currently being felt in all countries.

The City of Krakow has taken a number of measures aimed at realising these goals. The bus fleet is gradually being replaced by hybrid or fully electric vehicles. Due to the number of vehicles, Krakow has "eco-lines" where 100% electric buses are used [3]. The city has several chargers located mainly in the city centre for fast charging of electric buses. In addition, residents driving alternative fuel vehicles are promoted. Owners of electric cars are exempted from paying fees in the paid parking zone, can travel in bus lanes, and have parking spaces reserved specifically for electric vehicles. These parking spaces are also often equipped with free chargers.

Reducing CO_2 emissions

Reducing carbon dioxide emissions is one of the key objectives of the City of Krakow. Due to the significant air pollution especially during the winter period, the city places great emphasis on ecological means of transport. This indicator is implemented in terms of:

- Goal 9, which was discussed above,

- Goal 13, which addresses the issue of urgently combating climate change and its effects. This objective aims to reduce climate change, which is currently being felt in all countries.

The city has undertaken promotional activities to promote healthy lifestyles and therefore more walking or cycling [4]. Numerous investments have provided the inhabitants of Krakow with a rich network of cycle paths and pavements. Moreover free bike check-ups are carried out. Reducing journeys made over short distances reduces carbon dioxide emissions from vehicles. Car pooling, a system that makes the private car similar to and compatible with public transport, is also promoted. It consists in increasing the number of passengers during car journeys, mainly by matching commuters on the same routes to work or study. It is developed in situations where it is uneconomic to run organised public transport lines due to low traffic volumes. Increasing vehicle capacity results in a

reduction in the number of vehicles on the road, thus reducing the production of harmful carbon dioxide. During winter, in case of bad air conditions, public transport within the city area is free of charge [5].

One of the pillars of sustainable development is sustainable passenger transport. It consists in efficient transit of people living in a given city area using other means of transport than the passenger car. Other means of transport include e.g. public transport, bicycle, scooter, walking trips. Walking is a form of physical activity that contributes to the improvement of a person's physical and mental condition.

Nowadays, more and more attention is being paid to the improvement of transport services offered in urban areas. On the example of the city of Krakow this can be seen in the replacement of the bus fleet with vehicles complying with the Euro 6 standard and the adaptation of communication for the disabled and people with reduced mobility. Bus stops are equipped with passenger information boards, providing real-time information about the current timetable. The buses have been equipped with voice systems announcing the names of the next stops. All buses and a significant part of the tram fleet are low-floor vehicles.

Sustainable transport consists of planning elements. On the example of the city of Krakow we can observe numerous actions aimed at closing particular areas to car traffic. One example is the first ring road of the city. It has been excluded from car traffic in almost 90%. Traffic of municipal transport and cycling is allowed.

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ENERGY DEPENDENCES IN VIBRO-IMPACT OPERATION MODE OF A VERTICAL VIBRATION MILL

At present, vibration mills are used in most cases to obtain fine powders. The grinding chambers in them have the shape of a cylinder and, depending on its design orientation, the mills are divided into horizontal and vertical ones. The grinding chamber of a vertical vibration mill (MVV) vibrates along an axis in a vertical plane. The main advantage of MVV is the possibility of implementing the vibro-impact mode of interaction between the chamber and the technological load (grinding bodies) in them. In this way, friable materials are effectively crushed and, in some cases,

activated. The purpose of this study is to determine the energy of the grinding chamber interaction with the grinding bodies in the vibro-impact mode of the MVV operation.

In papers [1, 2], a vertical vibration mill is considered, for which the mass of the grinding chamber is of the same order of magnitude as the mass of the balls. The technological load is relevant to a system with discrete and distributed parameters. Equations of motion for the technological load at the stages of joint motion both with the working body and that with detachable from the working body have been created. An amplitude-frequency characteristic of the load motion inside the chamber has been plotted and the forces in the drive have been determined. The presented materials are of theoretical importance, but they are not easy to use for engineering calculation as far as the mill operation mode is concerned. The obtained experimental data show the presence of an obvious vibro-impact mode of interaction between the grinding chamber and the ball loads [3]. Therefore, the author proposes an approach to calculating the modes of MVV operation from the standpoint of vibro-impact systems [4].

The following assumptions have been made. The chamber moves according to the harmonic law with amplitude a and frequency ω along the vertical axis. Interaction with the load does not affect the motion of the chamber. The load is represented as a unit weight. Its interaction with the lid and bottom of the chamber is characterized by the velocity recovery coefficients R_l and R_b, respectively. Neglect the impact time. Motion in the vertical direction is carried out from the middle position of the chamber. Take the starting point of time at point *0,* which coincides with the moment the load collides with the bottom of the chamber – this is the initial phase φ. The weight of the load G and its friction force against the walls of the chamber F are taken into account.

For the implementation of the vibro-impact mode, the key parameter is a technological gap S – the distance between the load and the lid of the grinding chamber in a static position. Thus, consider two stages of movement of a single load: upward movement until it hits the chamber lid and downward movement until it hits the bottom.

Problems of this type are solved in dimensionless coordinates. Time, coordinates, velocities and force parameters in this case are reduced to dimensionless quantities.

Write down the equations of chamber movement and load in Y and y coordinates, respectively. Velocities are determined as derivatives of these values. When the load interacts with the chamber, its impact velocity u and rebound velocity v are related by the impact equation.

Assume that the vibro-impact mode of motion and interaction of the load with the chamber is periodic, and the period is of 2π. The first stage corresponds to the movement of the load from the bottom of the chamber upward until it hits the lid. The second stage of the movement is the movement of the load downward until it hits the bottom of the chamber. Further, "matching" the

movement of the chamber and the load on the interval 2π, obtain the phase equation, which includes the parameters S and φ.

From the phase equation, determine the range of permissible values of S, the fixed values of which are taken in further calculations. Next, set the values of φ in a certain range and determine expressions for the velocities of interaction between the load and the chamber. Hence, determine the dimensionless energy dissipated during the impact.

Plot on the graph the dependence of the energy of impact interaction E with the lid and bottom of the chamber. The curves obtained qualitatively characterize the efficiency of grinding the material in the mill.

Practical experience in grinding various materials has shown the following specificity. Under the influence of vibration, light materials are distributed uniformly throughout the chamber. This makes it possible to recommend modes corresponding to the high energy of interaction of the load both with the lid and the bottom of the chamber.

For heavy materials, the grinding of which takes place in the lower part of the chamber (zone of the vibro-boiling layer), modes with the maximum interaction energy of the load with the bottom of the chamber should be chosen.

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FORMING HEAD PRESS OF VEGETABLE MATERIALS WITH COMBINED WORKING SURFACE

At the present stage of energy production from agricultural materials is an important area in ensuring the energy independence of farms of different capacities. In particular, a promising area is the processing of plant mass into solid fuel briquettes (pellets) for their further use as fuel cells for various industries and needs.

This solves the problem not only of energy independence of the economy, but also the disposal of waste from basic production. Therefore, the issue of reducing the energy consumption of this process is relevant and needs more research.

The review and analysis of literature sources shows that the process of compaction is significantly influenced not only by the design parameters of the auger, but also the features of the molding head (shape, additional elements, length) [1,2].

The molding head provides for the compaction of the material, giving it shape and relaxation of the product. Currently, their designs and functional significance are quite diverse.

Vegetable mass with certain input parameters is fed to the press: particle size, humidity, temperature, pollution, density.

Due to the technological action of the "press" on the material, the molding head receives a mass with certain parameters: density, temperature, humidity (intermediate parameters of the system).

In the molding head, the plant mass, due to the structural shape and elements of the head is compacted, takes the form of the output channel, sintered, relaxed and excreted into the environment in the form of a finished product, which in turn also has certain quality indicators (output parameters - density, humidity). To ensure all these processes, the head must have certain design and technological parameters.

In our opinion, the best shape of the hole will be the surface formed by rotation around the axis of the tract. The proposed curve is the so-called "natural curve with the lowest resistance".

The inner surface of the forming head with the forming path 2 (see figure) will allow to distribute more evenly the reactions of the walls on the mass to be pressed. And also will reduce the resistance to movement of the compacted material due to the distribution of friction forces along the head.

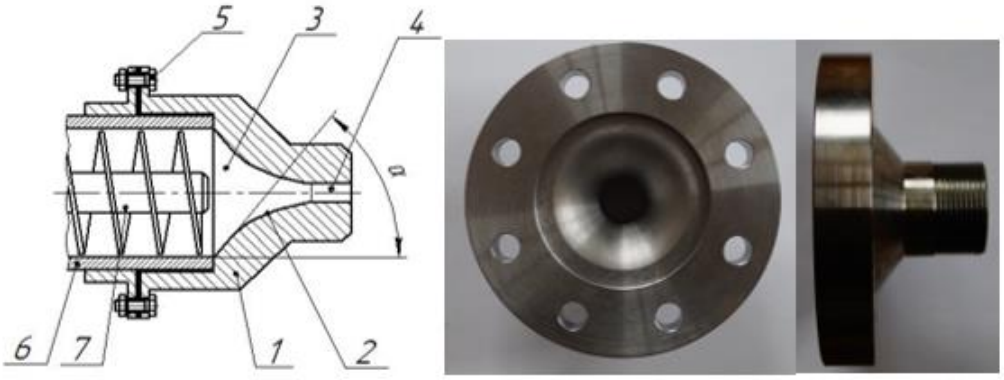

Fig. 1. Scheme and general view of the molding head with a combined inner surface: *1* - molding head; 2 - curved section; *3* - working chamber; *4* - outlet; *5* - threaded connection; *6* - auger body; *7* - auger housing

The rectilinear section of the inner working surface corresponds to the angle of friction of plant materials on the steel and is from 17° to 25° depending on the plant. This section allows you to

smoothly move from the working area of the screw seal to the working area of the molding head seal with the least resistance when moving.

The length of the channel of the molding head will depend on the density to be given to the material and the diameter of the auger (the initial diameter of the working channel of the head) [4]. Using parametric equation (2), we performed a constructive analysis of the working channel and constructed the relationship between the ratio of the diameters of the auger and the outlet of the working channel of the head $\lambda = D/d$ (D is the diameter of the auger; d is the diameter of the outlet of the working channel of the forming head) and its length l. [3,4]

This molding head will compact the plant mass and due to its curvature gradually reduce the resistance to movement of the mass along the length. Due to the features of this curve, the proposed design of the head can be used for different materials and industries.

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ENVIRONMENTAL THREATS CAUSED BY HUMAN ECONOMIC ACTIVITY AND TRANSPORT

Anthropogenic impact is any conscious or unconscious, accidental and deliberate stimulus on the part of man, causing a reaction from the natural environment. In nature, completely new, previously unknown interactions are noted (e.g. artificial lighting that changes the daily cycle, introduction of new organic chemical compounds into circulation). The forms of impact on the natural environment transform the landscape over very large areas (e.g. cultivation of land) or cause very profound changes in the landscape on small areas (e.g. urban buildings, industry). The effects of human activities in the environment can be classified according to their duration (long-term, short-term), frequency (cyclical, continuous, repetitive, vanishing), nature (synergistic, cumulative),

scale (regional, global, local), reversibility or irreversibility, randomness or effects on renewable resources. Anthropogenic disorders differ from natural disorders in scale and frequency [1].

The influence of industry on the natural environment of man. Industrial plants discharge liquid wastes containing poisonous substances into surface waters. The wastewater of the metallurgical and chemical industry is particularly dangerous, as it contains heavy metals, which are very dangerous to living organisms. Wastewater from food industry plants (breweries, sugar factories, dairies) favor the growth of microorganisms. Deep mines, which are not buried after the extraction of raw materials, cause crunches, i.e. vibrations of the earth's crust. The consequence of this process is mining damage, which is responsible for cracking the walls of buildings and road surfaces. Particularly dangerous for the natural environment is the emission of ashes from thermal power plants and heaps made of metallurgical slag, because poisonous chemical compounds are washed out and blown away from them. The polluted and saline groundwater is pumped out of the mines and then discharged into streams and rivers. The life of organisms in inland waters is threatened by saline mine waters. The development of industry leads to the combustion of more and more energy resources: lignite and hard coal, natural gas, crude oil. Gases and dust are released from steelworks and power plant chimneys. Dust from the non-ferrous metallurgy of lead, cadmium, mercury and zinc also get into the atmosphere, and accumulate in the human body, causing diseases. The energy industry is the source of thermal pollution. After leaving the turbines of the combined heat and power plant, water vapor is cooled by water, and released into lakes and rivers, which increases the water temperature by several degrees. Algae thrive in such waters, reducing the oxygen content. Man has learned to use nuclear energy, thus creating the most dangerous pollution called radioactive waste. This waste is the cause of radiation sickness. The problem of radioactive waste management has not been properly solved [2].

The impact of transport on the environment. The impact of transport on the natural environment of man. The exhaust fumes from motor vehicles are the most harmful to the natural environment, mainly in large cities in highly developed countries. There are nitrogen oxide compounds, carbon monoxide and hydrocarbons in the exhaust fumes. The health of people living near busy roads is at risk. Inland and sea shipping also significantly contributes to the weakening of the values of nature. Greases and oils endanger the life of aquatic organisms. First of all, attention should be paid to the sewage discharged into the sea from the cleaning of tankers' tanks. The greatest tragedy for the environment is the failure of large tankers. By covering the water surface, crude oil deprives fish and other organisms of access to air. Birds whose feathers are taped are also massively killed. The diesel or steam railway transport has a negative impact on the environment. Aviation communication, apart from vibrations and noise, emits exhaust fumes through aircraft engines. High-altitude flights upset the balance of the ozone layer, as do rockets and satellites launched into

orbit. The broadly understood communication is associated with electromagnetic contamination, incl. TV links and transmitters, radars, or radio navigation devices [3].

It should be emphasized that along with the increase in the threat to the environment by human economic activity, there should be an increase in the ecological awareness of the society.

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ENERGY EFFICIENT ASYNCHRONOUS DRIVE FOR PUMP AND VENTILATION PLANTS

It is known that the economic component of any production is directly related to the cost of energy. Usually its share in the cost of production can reach 40% of the total price. As a result, the desired level of profitability of enterprises can be achieved, in particular, through the implementation of energy saving technologies. Based on this, the development of new ways to save energy is definitely in demand in the manufacturing sector.

Among the powerful industrial mechanisms, pump-ventilation plants have become quite widespread, which, due to the specifics of use, do not always operate in modes close to the nominal ones. Naturally there are intervals of operation of centrifugal systems with the reduced efficiency. Accordingly, this is accompanied by significant non-productive financial losses on electricity consumption.

The experience of previous studies has shown that to solve the problem of reducing non-production costs it is possible with a comprehensive approach to the implementation of energy saving measures [1]. Their list usually includes links of the power channel, static voltage or frequency converters, electromechanical link and machines for the technological task.

Rational adjustment of the energy channel involves conflict-free operation of local and centralized reactive power compensation systems. Although, as for this case, we should consider as the priority the local filter-compensating devices that do not let the consumer-generated reactive power into the network, and most importantly contribute to the provision of acceptable switching of control switches operating on active-reactive.

Study of the use of thyristor voltage regulators as a relatively cheap equipment compared to frequency converters, showed the ability to ensure efficient operation of the motor, but with a significant

loss of power at the conversion link due to the phase method of valve control. It was possible to increase the power factor of the converter by using transistor converters with control based on the principle of pulse-width modulation. The stable operation of such equipment is achieved, in particular, through the use of local RC circuits connected in parallel to the phase stator windings of an induction motor [2].

Traditionally, non-controlled electric drives are used in pump and ventilation systems, this does not allow controlling the energy flow during the entire working period. The main idea of [2] is to supply the motor with sufficient power that does not exceed the required to overcome the current load. The research results show the possibility of saving up to 47% of active and 51% of reactive power when the load falls below 60% of the nominal.

As for the possibility of increasing the efficiency of the machine to perform the technological task, then the search direction is related to the regulation of the speed of rotation of the impeller. Unfortunately, previous projects of voltage regulators have almost no effect on the speed of the working machine. Therefore, the further direction of research is related to the development of a frequency converter with a step control method [3], which is not significantly complicated, and accordingly with cost slight increase.

The final stage of research was aimed at developing an integrated automatic start and switching modes "nominal" and "economic" [3]. Digital simulation of the desired modes on the model confirmed the efficiency of the system. Although the step system of transition from the "nominal" to "economic" mode has not shown sufficient perfection, which requires additional research in order to obtain higher values of the efficiency of the asynchronous drive of centrifugal mechanisms of long-term operation.

The performed research complex made it possible to draw the following conclusions:

- local filter-compensating devices give the best results in compensating the reactive power generated by the motor while guaranteeing switching of control switches of the converter;
- to provide rational consumption of power by the working machine it is possible for power supply of the motor from the step converter of frequency with the simplified circuit decision and accordingly low prime cost;
- it is experimentally proved that the integrated mode switching system works stably and in accordance with the specified algorithm;
- the final test of the integrated control system did not show the perfect results, which requires the additional research.

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EFFICIENCY OF USING V– AND U– SIMILAR DEEP RIPPERS IN THE CONDITIONS OF SOIL MELIORATION AND RECULTIVATION

According to the definition melioration is an improvement of the natural soil condition, mainly through irrigation and drainage. Recultivation respectively is the restoration of human-caused disturbed soils by performing cultural and technical work. In both cases the necessary tools can have an impact on both arable and subsoil layers. Traditional shelf plowing which today is perhaps the most common method of basic tillage in most farms in Ukraine causes the creation of a compacted subsoil and thus the deterioration of moisture and air exchange in the fertile layer.

Spherical disks of disc harrows, cultivators, disc harrows during interaction with the soil have even more intense effect on it. As a result, the degree of structural elements grinding increases which accelerates the destruction of agriculturally and technically valuable units. It is the mechanical action of these working bodies that has led to a tendency to reduce yields and a significant impact of precipitations on the yield during the growing season. Therefore, the issue of destruction of the subsoil and carrying out the main tillage without damaging agriculturally and technically valuable soil units under the conditions of resource and saving technologies is relevant.

Soil compaction occurs under the action of its own weight, plants and water on the surface of the field and as a result of drying of the soil. There are not only internal factors but also external ones: compaction by mobile units and working bodies. As a result, the density of the soil increases, the micro soil porosity decreases which leads to a deterioration of infiltration properties. In general, soil compaction is a cumulative process that is accompanied by an increase in density, a decrease in porosity, a decrease in aeration which negatively affects the development of the root system and the biological activity of microorganisms. Reducing the infiltration of moisture through the soil contributes to water erosion and leads to flooding of agricultural land for a long time. The content of humus in the soil is the main factor that determines the degree of compaction and its level in the arable soils of Ukraine decreases every year. According to the definition, chisel tillage is a deep tillage without rotation of the layer with its undercutting on the width of the capture and the formation of intact ridges at the bottom of the furrow. The fundamental point is that the ridges are formed without direct contact with the working surfaces of the tool that is due to the spread of chipping lines. It is known that deep rippers are single-rack and double-rack or three-dimensional action. A number of experimental studies [1,2] on the effectiveness of the use of two-rack deep rippers *V*- and *U*-shaped have been conducted, Fig. 1. The fundamental difference of the constructions is that the *V*-shaped has angles of convergence of the side risers which intensifies the compression of the cut soil layer and automatically eliminates the possibility of its use on soils with high stickiness but improves the quality of crumbling and

especially loosening on dry hard soils. The advantages of these types of soil rippers in comparison with single-rack ones are that they process arable and subsoil layers with different intensity at the same time. Another difference is that undesired objects that exceed the size of the formed soil lumps are carried to the surface. This makes machines based on them indispensable for the recultivation of human-caused disturbed soils.

a *b*

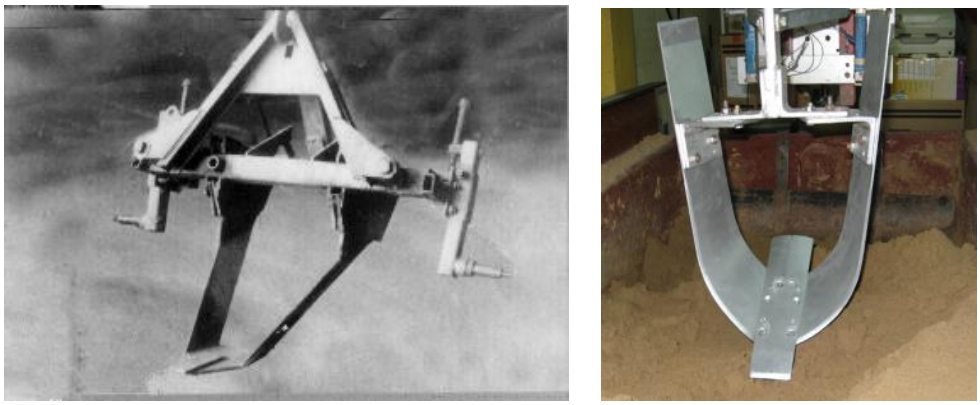

Fig. 1. General view of deep rippers: *a* - V-shaped; *b* - U-shaped

Previous analytical studies [1] have determined that for the tools of this design it is rational to have a working depth a=0.42-0.45 m and a grip width B_P=0.25 m. Therefore, working bodies with such design parameters were made for the research. In the course of strain gauge studies it was found that the traction resistance of the U-shaped is on average 7-10% lower. At the same time, the presence in the surface layer of agriculturally valuable units of 0.25-10 mm in the *V*-shaped working body is lower by 5-10%. The latter is a consequence of the fact that the process of moving the split soil prism in the spacing space is accompanied by a more intense bending of the layer and small particles fall into the lower horizons. The fractional composition of lumps in the layer below 20 cm in both tools is almost the same. Thus, a *V*-shaped tool can be more effective in combating air erosion. At the same time, *U*-shaped for lowering water, digging up roots, uprooting shrubs, removing undesired objects. In general, units based on these working bodies constantly perform the technological process, but require overlapping width of 5-10 cm. Rational working speed V_P=3.0-3.5 m/s. The limitation is related to the increased probability of clogging the space between the racks with a decrease in working speed and spouting of the soil with its increase.

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EXPRESS ANALYSIS OF BASIC PARAMETERS OF ACCUMULATOR BATTERIES

The world experience in the development of vehicles and alternative energy systems expects the presence of modern chemical energy sources in their composition. Taking into account the scale and development prospects of this direction, the importance of express determination of the main parameters of accumulator batteries, allowing to use them more efficiently and reliably, cannot be questioned [1-7].

In power systems of this type, acid traction and starter, lithium-ion and other energy storage systems are widely used. The operation of them can be carried out under various conditions, which requires them to comply with certain conditions such as:

- stability of voltage maintenance in modes under load, which will reduce the number of discrete elements, simplify maintenance and reduce cost;
- small currents of internal and external self-discharge;
- long-term performance due to a significant number of charge-discharge cycles;
- acceptable weight and dimensions, especially for mobile and transport devices;
- strength and simplicity of construction.

For the end user, the most important are the requirements for the failure-free operation of the battery without the need for additional recharging. In practice, the service life of energy storage devices is mainly determined by the conditions of their operation.

The natural aging process reduces the capacity of accumulator batteries, as a result the device has to be charged more often and its peak power decreases. In the future, the low efficiency of the power system provokes its automatic shutdown, which can be an unpleasant surprise for the consumer.

To establish the fact of the end of operation resource of accumulator batteries, in most cases, it is sufficient to estimate the value of their maximum residual capacity. For this purpose, it is necessary to measure the following parameters periodically: residual charge (determined by the ratio of the current capacity to the capacity of the new battery); peak voltage when operating under load; internal resistance of the battery, rate of discharge to final voltage and temperature of individual cells.

Currently, the development and application of effective methods for determining the residual capacity of various types of batteries, and, as a result, determining the duration of operation of batteries, are quite acute.

Authors has studied the modern experience of national and foreign battery manufacturing companies. On this basis, a set of studies was carried out in laboratory conditions of the Renewable energy sources Department, "DUT". The bench testing unit included:

- devices for charging and discharging of various types of accumulator batteries;

- devices for measuring of current, voltage, power and temperature. Devices for latching the signals of changing the main electrical parameters in time;

- load resistors, etc.

The test results led to the following conclusions:

- the method of storage accumulator batteries testing using conductivity testers does not provide an assessment of the effectiveness or time of critical failures;

- test of car batteries using discharge testers or monitoring of its voltage does not allow assessing the duration of their normal functioning;

- measurement of the residual capacity during a cyclical charge-discharge of batteries takes a significant period of time and involves disconnecting the batteries from the power system;

- it was found that method for determining the residual capacity of batteries when removing the voltage curve during the process of maximum heavy loading is the most informative.

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THE JUSTIFICATION OF THE DESIGN OF A LABORATORY FACILITY FOR EXPERIMENTAL MEASUREMENTS OF THE RESISTANCE FORCE OF A BRUSH CLEANER MOVING ALONG A STRAINER MESH

Industrial water used at the industrial enterprises for cooling heat exchangers, eliminate industrial waste, clean products, feed boilers, move material, etc. Industrial water should not contain

large mechanical particles (impurity) with the size determined by the parameters of the devices consuming industrial water. To remove large particles from industrial water, at the industrial plants mesh filters with brush cleaners used frequently [1].

For the experimental study of the processes of cleaning the strainer mesh from particles and for improve selecting the brush cleaner parameters, depending on the mesh parameters, it is necessary to develop a laboratory facility.

Laboratory work should allow studying the following:

- The resistance force at the start moving;
- The resistance force during moving with the constant velocity;
- Removing impurity particles from mesh cells.

The brush cleaner parameters to be experimentally studied to justify the effectiveness of the removal of the impurity mesh by the brush cleaner:

- Bristle penetration depth in the mesh;
- Bristle inclination angle;
- Bristle length;
- Brush bristles count.

Previously published the results of experiments to determine the brush moving resistance force [2] over the clean mesh with the size of 5×5 mm. It was found that bristles in the brush works as a set of individual bristles.

However, this laboratory equipment [2] has a number of disadvantages:

1. Not a constant bending radius of the mesh, which led to an uneven force of resistance to the movement of the brush.

2. The mesh was hooked on flexible stretchable suspensions, which led to an inconsistency of the mesh bending radius, which led to a change in the mesh bending radius and the mesh trajectory.

3. Due to the movement of the mesh along the radius, it is impossible to measure the linear force, since the measuring device must always be perpendicular to the radius of the path of movement.

4. Measurements were carried out using a digital dynamometer that gave an average result, therefore, it was impossible to determine the resistance force of the brush movement along the mesh from the stasis and the resistance force changes during the brush movement.

A new laboratory facility has been created to avoid of the indicated disadvantages, the schema of which is shown in Fig. 1, and the real design in Fig. 2. The laboratory facility consists of a spring dynamometer 1 connected to a movable trolley, which is installed on a horizontal surface 5 and a fixed brush 2 which rubs along a mesh. Trolley is a metal frame with mesh 3 and four rollers 4 installed on it (2 symmetrically on each side).

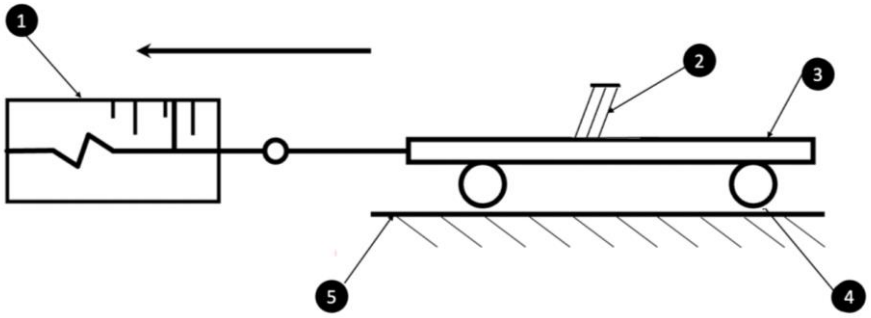

Fig. 1. Schema of a laboratory facility with a dynamometer. *1* - spring dynamometer; *2* - brush; *3* - frame with mesh; *4* - roller; *5* - horizontal surface

The trolley moved along horizontal surface 5 using a spring dynamometer. The spring dynamometer allows measuring the instantaneous values of the force required to move the trolley. This is necessary to measure the force:

- At the initial moment of movement;
- Movement of the trolley in a steady state;
- Arising from the removal of particles of impurity from the mesh cells.

Instant dynamometer readings should be recorded by high-speed video recording

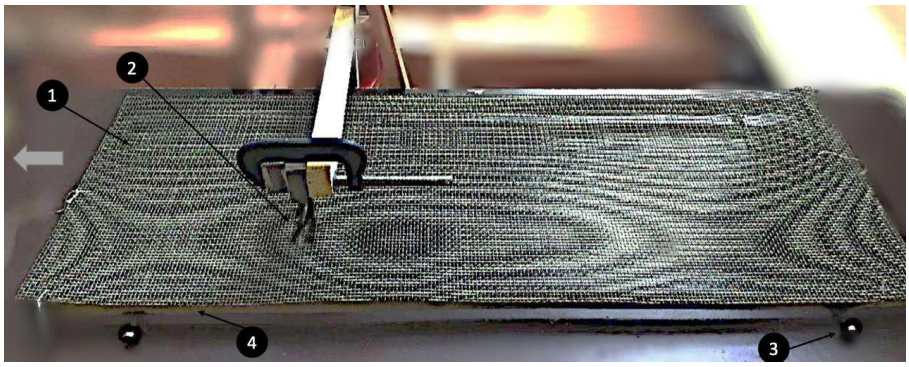

Fig. 2 . Designed laboratory facility photo: 1 - strainer mesh; *2* - fixed brush; *3* - frame

The parameters have been justified and a laboratory facility has been created for experimental measurements of the resistance force of a brush cleaner moving along a strainer mesh. It allows to experimentally study the processes of cleaning the filter element from impurity particles and to choose the design parameters of the brush cleaner depending on the mesh parameters.

Preliminary measurements have shown the efficiency of the laboratory facility.

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DEVELOPMENT OF STATISTICAL SIMULATION MODEL OF MAINTENANCE PROCESSES

Complex technical objects in modern society are extremely important. We are talking primarily about various radio-electronic complexes for military and special purposes, radar stations, automated control systems (air traffic, energy facilities, etc.). The state's defense capability, economic security, and the lives of hundreds and thousands of people depend on the level of reliability of such facilities.

Such objects belong to the class of recoverable objects of long-term repeated use. They tend to be expensive and costly to operate. To ensure the required level of reliability during their operation, maintenance is usually carried out, the essence of which is timely preventive replacement of elements that are in a pre-failure state.

A characteristic feature of complex technical objects for special purposes is the presence in their composition of a large number (tens, hundreds of thousands) of different types components parts that have different levels of reliability, different patterns of their wear and tear processes. This feature requires a more subtle approach to the organization and planning of maintenance during their operation.

The problem is that during the development of such facilities, all issues related to maintainability and maintenance should be addressed already at the early stages of facility design. If you do not provide in advance the necessary hardware and software for built-in monitoring of the technical condition (TC) of the object, do not develop and “embed” the maintenance technology into the object, then it will not be possible to realize in future a possible gain in reliability of the object due to maintenance. Since all these issues must be resolved at the stage of object creation (when the object does not yet exist), mathematical models of the maintenance process are needed, with the help of which it would be possible to calculate the possible gain in level of reliability facility due to maintenance, to estimate the cost costs required for this. Then, based on such calculations, make a decision on the need for maintenance for this type of objects and, if such a decision is made, develop the structure of maintenance system, choose the most acceptable maintenance strategy, and determine its optimal parameters.

The developed simulation statistical model (SSM) is designed to obtain estimates of reliability indicators and the cost of operating an object, taking into account its composition, structure and reliability characteristics and taking into account the maintenance. The model should reproduce (imitate)

the process of technical operation, which is formally described by a graph of states and transitions.

In the process of modeling, all elements of the array are periodically "reviewed" and the smallest of planned points in time is determined. The found minimum value is taken as the current model time, and corresponding event - as current event. Then the current event is “processed”, which consists in imitating the actions that make up the essence of this event.

The model simulates (and processes) three types of events: “failure” (transition 0→1), “control” (transition 0→2) and “maintenance” (transition 0→3). After processing each event, the time is planned for the next occurrence of an event of the corresponding type. If the current event is "failure", then a random operating time of the same (failed) element is generated until the next failure. If current event is "control" ("maintenance "), the time of the next corresponding event is scheduled. The received new values of the scheduled time are recorded in event calendar instead of their previous values. The described process of analyzing and modifying the calendar of events is repeated cyclically throughout the entire simulation period.

After each processing of the next event, there is a "advance" of the model time. This process continues until the value of model time reaches the set value of duration object's operation.

The process of processing and replanning events when the model time changes from 0 to the specified value of the operating time is one implementation of modeling process. As a result of repeated repetition of such implementations, the necessary statistics are accumulated to obtain estimates of the resulting indicators.

1. In this work, an SSM is developed, designed to predict the reliability indicators and the cost of operating a complex technical object, depending on the parameters of the selected maintenance strategy. The SSM implements algorithms for simulating maintenance processes for three variants of maintenance strategies:

- maintenance of condition with constant monitoring frequency;
- maintenance of condition with adaptively changing frequency of control;
- regulated maintenance.

The mode of modeling regulated maintenance was introduced in order to ensure the completeness of the analysis possible maintenance strategies of the designed facility and to predict the possible gain in reliability and cost of operating the facility through use of strategies for maintenance.

2. MS of complex technical object is built into SSM algorithms, due to which the model implements the dependence of simulated maintenance process on the parameters of structural and reliability structure of the object.

Before starting modeling, the user must specify a subset of the restored and potentially maintainable elements by selecting (marking) them in the structure tree of object. The generation of

random values operating time to failure of individual elements subordinate to DN distribution is carried out using a random number generator developed in [8].

3. SSM verification was carried out as follows. The correctness of algorithms for simulating the process of failures-recoveries was checked by comparing the simulation results with exact calculated mean time between failures obtained for a single element.

The instrumental accuracy of the model obtained in this way, estimated by the value of relative error, was less than 1%. The correctness of algorithms for simulating the maintenance processes was checked qualitatively (according to the consistency of obtained simulation results).

The methodological accuracy of SSM is determined by the following factors:

- initial reliability of the object (given indicators of the reliability elements);
- number of realizations (duration) simulation;
- specified duration of operation facility.

Of these factors, the first is most significant. In most cases of practical interest, the relative error of simulation results does not exceed 10-20%.

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TO DETERMINE THE STABILITY OF THE METROBUS IN UNSTABLE DRIVING MODES

The last time many cities in the world began to introduce so-called buses or BRT systems, that have become a cheaper alternative to the subway and other rail transport, in particular trams. BRT transport is already operating in more than 200 cities around the world.

Therefore, we consider it appropriate to study this experience and the advantages of the urban transport system, possibility of implementation in Ukraine. After all, the appearance of the

metrobuses will help to evolutionarily displace the minibus from Ukrainian cities and switch to a more progressive model of urban transport functioning.

Metrobus line is usually plying buses of a particularly large capacity and length (18, 22, 24 or 25 m). Their main difference from the usual city routes is that the metrobuses run in a separate dedicated lane with short intervals. Also an important component of the BRT system are stops, which are special terminals (stations) equipped with turnstiles where fares are paid [2].

Safe movement of any vehicle, including the metrobus is largely determined by its dynamic properties, and to a large extent its stability and road handling [6].

The manoeuvrability and stability characteristics of a motor vehicle are known to be determined by a combination of the operational, mass-geometric and structural parameters of its modules (for metrobus it is bus and trailers) and their control systems. In general, the desired messages of the above parameters in terms of stability, even for the same vehicle, vary over the range of operating loads and speeds. As a result, it is difficult to obtain, in the early stages of the development of motor vehicle, precise design parameters and quantitative indicators for the sustainability of its movement. Success in solving such problems depends on the success of the mathematical model and its essential parameters describing the behavior of the dynamic system in different modes of motion.

The work [3] has developed differential equations of plane-parallel motion to determine manoeuvrability and stability, but these equations can only characterize the stability of a motor vehicle in straight motion. Their use to assess the stability of a motor vehicle in the transitional traffic modes may lead to significant errors. The purpose of our scientific research is therefore to determine the stability indicators of the metrobus in the transitional traffic modes, in particular when performing such manoeuvres as «steering wheel jerk» and «shuffle».

When researching the stability of road train movement, they are usually considered plane-parallel motion of links. At the same time, it is believed that the normal reactions of the support surface to the wheels of the starboard side are the same. Under this condition, traffic stability is considered for a flat road train model. The paper [3] obtained a system of differential equations, which describes the plane-parallel motion of the links of three-link swing-jointed bus.

Manoeuvring in the traffic limits and moving the metrobus in the designated lanes at a high speed can lead to a significant change in the reactions of the support surface on the wheel of the links of the road train. Therefore, in addition to the horizontal movement of the road train, as described by the differential equations of plane-parallel motion, it is necessary to consider the movement of the road train in the longitudinal vertical and transverse planes. The communication between the undercarriage and the unbreakable masses of the real structure of the road train is carried out by means of flexible and damping devices, and between the unbreakable masses and the road - by means of tyres which are characterized by both resilient and damping properties. At

relatively low speeds of the road train under manoeuvring conditions, it can be assumed that the movement of lean and unsprung masses is synchronized. The suspension elements and the tyres shall be supposedly subjected to static compression with little resistance of shock absorbers [5]. Under such circumstances, it can be assumed that the spring-loaded masses oscillate on the elastic elements with the given rigidity.

In this case, the interaction forces in the coupling and traction couplings do not affect the redistribution of loads on the sides of the road train links. Therefore, a fairly complex system - three-links metrobus can be considered as three systems - a bus, the first trailer unit (semi-trailer) and the second trailer unit (trailer) which is rolling independently. The heel axis of each link is also considered to be parallel to the supporting surface, and the movement of the metrobus links in the vertical plane along the angles of halopilation (tangage, trim) and heel influence lateral motion, primarily and mainly by changing the vertical loads on the wheels, thereby changing the vertical reactions of the supporting surface. In accordance with this concept, a distinction has been drawn between lateral, longitudinal and transverse motion [1].

In the work [1] a system of equations is obtained describing the loading and unloading of the sides of the road train when it performs various manoeuvres. This system with some correction can be applied to the metrobus.

In determining the stability of buses, including articulated buses, it is considered that the bus is fully loaded, the mobility of the passengers is absent, and the whole spring mass is a solid body [4].

The resulting roll angles and bearing angles are based on the calculation of the correction of the wheel withdrawal resistance coefficients of a buses and trailers in order to further calculate the parameters of stationary motions, the critical speed of straight motion and the turning radius of the metrobus.

It has been established that the stability of the metrobus in the performance of typical manoeuvres such as «steering wheel jerk» and «shuffle» it is useful to define by integrating the system of equations, describing the three-link metrobus in the vertical plane together with the equations describing its plane-parallel motion. Under this condition, the folding angles of the metrobus links are defined.

As the steering wheel angle of the bus increases, the difference in the folding angles of the bus also increases, with the second folding angle being significantly greater than the first, especially considering the roll of the metrobus body. It has been established that the greatest rolls and loads of the metrobus axles are those of the last trailer, which is the limiting factor for the critical speed. For example, the coefficient of increase of lateral acceleration of the metrobus body, if the roll of the body is taken into account, is increased by 22.2% in comparison with its absence, and this must be taken into account in the analysis of the structure of the metrobus, in particular the running part and the suspension.

The lateral accelerations of individual metrobus links and their yaw velocity when performing the manoeuvre «steering wheel jerk» and «shuffle», show that both the bus and the second trailer link are a limiting factor when performing various manoeuvres, but the acceleration value does not exceed the permissible value of 0.4g (acceleration of gravity), that is, its stability under these conditions is ensured.

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MANAGEMENT OF RUBBER WASTE FROM THE AUTOMOTIVE INDUSTRY

Due to the ever-increasing number of vehicles on the road, the number of used tyres is constantly growing. It is difficult to determine their exact number because they are scattered and no records are kept. In reality, they account for around 80% of rubber waste. This proportion is maintained both in Poland and in other European Union countries [1].

The problem of waste car tyres is solved through three types of recycling. Material recycling is the reuse of a material or product for the same purpose (e.g. tyre retreading). If their technical condition allows it, they can be placed on the market directly; if not, they need to be remanufactured. Raw material (chemical) recycling consists of recovering chemical waste and putting it back into production (e.g. using car wrecks in steel plants). Energy recycling allows energy to be recovered from automotive waste.

Apart from tyres, other rubber components are recovered from passenger cars, which account for only 34.5% of the total weight of rubber in such a vehicle. These include timing belts and V-belts, shock absorbers, suspension elements, body sealing elements, hoses and pipes ensuring the flow of liquids and gases [2]. Over 90% of the mass of rubber components in a passenger car are tyres and body

seals. They are easy to disassemble, which makes it possible to recycle them. The same cannot be said for the remaining rubber components, as they are not reusable due to the ageing of the rubber [2].

The number of used tyres is not proportional to the number of end-of-life vehicles, as statistically each car uses at least four sets of tyres during its lifetime. This means that there are 2.5 million tonnes of waste tyres per year in the European Community countries. In view of such a large mass of rubber waste, appropriate action should be taken so that it does not pose a threat to the natural environment, but is instead a source of valuable raw materials and materials. Processing of rubber waste is also supported by the fact that landfilling waste tyres in landfill sites is prohibited, as their spontaneous combustion and land contamination may occur [3].

The collection of waste tyres is hampered by their wide dispersion. Tyre owners are not obliged to deliver them to collection points, and the process of tyre return is problematic.

The selective collection points often impose limits on the number of tyres that can be returned free of charge, and garages are not always willing to accept them. A significant number of garages charge a fee for accepting used tyres. A separate problem is that the Selective Waste Collection Points only accept passenger car tyres, so there is a problem with lorry or tractor tyres. The cost of transporting whole tyres is significant because they have a disproportionate volume in relation to their weight [2, 3].

Retreading of used tyres is most beneficial in terms of saving material, labour and energy input, but this is not possible for every tyre. Used tyres that cannot be retreaded due to age or casing damage are waste, which must be managed in an environmentally safe way.

Used tyres are a very calorific material, so the heat energy released during their combustion in special furnaces can be used [2]. As much as 60% of energy recycling goes to cement plants, where it can be burnt in its entirety. A significant proportion of cement plants abandon hard coal firing in favour of an alternative fuel containing up to 20% of tyres, because used tyres produce ash and the amount of harmful substances emitted during combustion is negligible. Cement plants built nowadays are oriented from the beginning towards the use of waste rubber as fuel. Such installations meet environmental requirements and the combustion process is constantly monitored [4].

The problem of managing used car tyres is still current. The number of vehicles on the roads is still increasing all over the world. Rubber waste properly used brings financial and environmental benefits. It is not without reason that it is called rubber raw material.

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ECOLOGICAL TOOLS FOR DIVERSIFICATION OF SUSTAINABLE DEVELOPMENT OF RURAL AREAS

Technological progress, development of industry, and agriculture increase the amount of waste every year. Gases, liquids, solid waste, household waste, and wastewater have a detrimental effect on the environment - its pollution sometimes reaches dangerous levels. Ukraine is one of the countries with a high level of development of the energy-industrial complex, agriculture, consumption of various products of industrial and agricultural origin.

We believe that achieving the main goals of diversification of sustainable development of rural areas is possible through the involvement of regulatory, organizational, economic, institutional, and environmental instruments [1, 2, 3].

The main tools for the diversification of sustainable rural development in the environmental sphere include environmental audit, environmental standardization, environmental certification, environmental monitoring, environmental certification of rural communities and enterprises that promote the development of biotechnology, the spread of organic production, and reducing the destructive impact on the environment [4, 5].

During the study, V. Rybak proposed a method of environmental audit [6, p. 227], which contains a systematic analysis of such blocks of information as cartographic information; climatic conditions that are specific to the territory; land resources; aquatic resources; condition of drained agricultural lands; bioresources; complex indicators of transformation of territories; economic indicators. We believe that the application of the proposed methodology in assessing the level of environmental safety, condition, and functioning of land will help to obtain a complete database of the object of study, which should be used to predict crop yields, assess the value of the land when buying or selling agricultural land, taking into account the degree their environmental safety, feasibility and uses.

The accumulation of industrial and household waste in urban and rural areas poses significant environmental risks not only in Ukraine but also around the world, especially for its components such as air, surface and groundwater, soils, vegetation, and more. We believe that one of the

environmental tools for diversification of sustainable rural development is environmental standardization, ie establishing requirements, standards, and means of determining them regarding the state of individual components of the environment and the allowable impact of anthropogenic pressure on the environment set out in environmental standards [7, p. 6].

Expanding cooperation of Ukrainian companies with foreign ones, as well as Ukraine's accession to the World Trade Organization requires increasing the environmental attractiveness of domestic goods and services. Therefore, compliance with the requirements of international environmental standards for products and their relevant certification is of great importance. The presence of a certificate of environmental quality of goods and services from the manufacturer increases the level of trust of the potential buyer and the prestige of both the company and the country. There are environmental certifications of products, enterprises, homes, land, certain activities, and services [6, p. 18].

For example, in order to supply organic products to the territory of the European Union, domestic exporters must meet the standards of the importing country. An uncompromising condition for organic production is the quality of products, which is monitored throughout the life cycle. Each stage of production is under the strict control of an accredited certification body, which certifies compliance with the requirements and standards of organic production by issuing a certificate. The process of certification of organic production is a procedure that allows the manufacturer to confirm the compliance of the methods introduced on the farm with the requirements of organic standards and allows access to the market of organic products at a premium price [8, p. 12-13].

The existing environmental monitoring system is based on the performance of distributed functions by its subjects and consists of subsystems subordinated to them. Each subsystem at the level of individual subjects of the monitoring system has its own structural-organizational, scientific-methodical and technical base. The functioning of the state system of environmental monitoring is carried out at three levels, which are distributed on a territorial basis: the national level, which covers the priority areas and tasks of monitoring throughout the country; regional level, covering priority areas and tasks in the territorial region; local level, covering priority areas and tasks of monitoring in the scale of separate territories with an increased anthropogenic load.

The diversification of sustainable rural development is undoubtedly linked to the development of agricultural activities and the agro-sphere in general. This relationship is manifested in the following: with the rational conduct of agricultural activities and nature management, agricultural landscapes are favourable for production needs and for the livelihoods of the rural population; production of ecologically clean agricultural products attracts tourists and vacationers to rural areas; ecological safety of agricultural production is a guarantee of the same condition of rural areas [9].

Based on this, the quality of agricultural products, agritourism products, and related services must meet both national and international quality standards.

The above can be achieved through the implementation of environmental certification in rural communities. Ecological passport is a normative document developed to ensure state registration of objects that adversely affect the state of the environment, control over the state of ecological safety, prevention, and elimination of the negative impact of economic and other activities. The ecological passport of communities and enterprises allows determining the degree of use of natural resources, conducting an ecological assessment of territories and land plots, as well as to establish appropriate norms and rules for the rational use of natural resources and agriculture.

Thus, ecological audit, ecological standardization, ecological certification, ecological monitoring, ecological certification of rural territorial communities and enterprises contribute to the achievement of ecological goals of diversification of sustainable development of rural areas, including ecological safety in rural areas, reduction of destructive impact on the environment, potential.

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PRECOLONIAL AND MODERN ARTISANAL MINING IN GHANA

The paper provides a basis for an understanding of the micro processes associated with indigenous and modern artisanal small-scale mining in Ghana. Through a review of primary and secondary data, the paper establishes that there have been a remarkable degree of continuity between precolonial gold mining and modern artisanal mining. Additionally, it documents that unlike precolonial mining, modern artisanal small-scale mining has caused enormous damage to local ecosystems in Ghana. The paper concludes by providing new evidence that artisanal small-scale mining continues to flourish in Ghana because it serves the interest of a wide range of actors who are covetous and avaricious. Moreover, the paper emphasise that the bane of illegal mining has endured in Ghana and will eternally remain so as long as Ghanaians with some measure of clout continues to support illegal mining directly and indirectly.

Keywords: Ghana, Gold mining, Artisanal mining, Galamsey

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ASSESSMENT OF ECOSYSTEM SERVICES IN THE LOWER DNIESTER BASIN

The aim of "Assessment of Ecosystem Services in the Lower Dniester Basin" study were to introduce mechanisms for integrated water resources management in the Dniester River Basin to ensure its sustainable development and to identify ecosystems and evaluate their services using the methodology of the GEF Guidance Document on the Economic Assessment of Ecosystem Services using the example of the Lower Dniester wetlands. The paper uses the results of international studies on the assessment of ecosystem services, data on wetlands prepared by Ukraine within the framework of requirements of the Ramsar Convention, scientific articles, statistical information and data provided by the Lower Dniester National Natural Park.

The main reason for the degradation of ecosystems is the underestimation of their real economic value, the value of natural resources and services in general. In cases where the financial resources necessary to solve serious economic problems are limited, payments for ecosystem services (PES) can provide additional resources for the improvement of environmentally friendly technologies that create incentives for investment and increase the involvement of business in environmental protection.

“Ecosystem services” are the many and varied benefits that people get free from the natural environment and functioning ecosystems. Development of the PES system includes: identification of ecosystem services, assessment of ecosystem services, identification of potential sellers and buyers, identification of compensation mechanisms, creation of markets for these services [1].

The first stage is the identification of services provided by ecosystems related to one of the four broad categories: providing (food, raw materials, water), regulatory (climate regulation, air quality regulation, water purification, pollination of plants), cultural services that directly affect people (educational, aesthetic, spiritual, cultural heritage, recreation), supporting services necessary for the preservation of other services (soil formation, photosynthesis) [2].

Ecosystem services can be also divided into "use values" and "non-use values", according to the concept of the "Total Economic Value" (TEV). The TEV is a common approach in the field of environmental economics that aims to create a single monetary metric that combines all activities within an area and to express the levels of each activity in units of a common monetary measure, such as US dollars. It is a useful tool for exploring what types of values each ecosystem service provides. This helps in determining the valuation methods required to capture these values [3]. Broadly defined, the TEV includes:

Use Values: *Direct use value:* Individuals make use of a resource in either a consumptive way (e.g. the fishing industry and agriculture) or a non-consumptive way (e.g. cooling water). *Indirect use value*: Individuals benefit from ecosystem services supported by a resource rather than actually using it (e.g. watershed protection for flood mitigation, cycling processes for agriculture or carbon sequestration).

Non-Use Values are associated with benefits derived simply from the knowledge that the natural environment is maintained. By definition, non-use values are not associated with any use of the resource or tangible benefit derived from it, although users of a resource might also attribute a non-use value to it. Non-use value can be split into three basic components: *Altruistic value*: Derived from knowing that contemporaries can enjoy the goods and services the natural environment provides. *Bequest value*: Associated with the knowledge that the natural environment will be passed on to future generations. *Existence value:* Derived simply from the satisfaction of knowing that ecosystems continue to exist, regardless of use made of them by one self or others now or in future.

In general/globally, the existing projects for the introduction of a payment system for ecosystem services are still not enough despite the available positive examples of the development of markets for ecosystem services in individual countries. This applies even more to Ukraine. Causes are ecological inadequacy of traditional models of the economy, lack of institutional infrastructure,

imperfection of regulatory, legal, and methodological framework in the field, lack of systematic education among stakeholders.

Economic approaches to assessing the value of wetlands and their ecosystem services are based on: market valuation, rent, cost approach, alternative cost, total economic value [2]. Not all proposed approaches are well developed, they contain contradictory issues, however, based on them, it is possible, at least in the very first approximation, to assess the economic value of wetlands.

The methodology included: *a* - identification of ecosystems whose services will be assessed, *b* - determination the size of the territory in which these ecosystems are located, *c* - definition of ecosystem services potentially supplied by these territories, *e* - search for reliable information about the volume of services supplied and their possible assessment (the most difficult stage), *f* - identification of which ecosystem services can be assessed directly via (local) market prices, and which need a benefit transfer, *g* - assess the values of provisioning services via local market prices, *h* - assess the values of other ecosystem services using the simplified the Benefit Function Transfer approach proposed in the Repository of Economic Valuation Studies (https://iwlearn.net/valuation/the-repository-of-economic-valuation-studies). Repository is containing information on studies considered directly usable for benefit transfers, i.e. studies with values/benefit information that can be transferred to another area - our project area, in this case. It is the result of an extensive search, screening hundreds of valuation studies and selecting the some of it that are directly usable. The Repository is structured in such a way as to allow one to easily identify the studies available for the transfer to project area, to select the most appropriate ones, and to have all information at hand to perform any adjustments to the values cited that might be necessary.

While most ecosystem services are not traded on markets, there are some that are, i.e. products that are derived directly from the ecosystem (food, raw materials etc.), and some other services (e.g. tourism). As these products are directly traded on markets, or in a certain way replace products usually obtained in a (local) market or store (e.g. in case of building materials), their value is best assessed using the local ***market prices*** that would need to be paid for the replaced product.

The Lower Dniester ecosystems provide a number of provisioning ecosystem services that can be valuated at market prices. However, the lack of data on ecosystems such as area, quantity of products received and their price do not allow to fully assess the ecosystem services. Only some of them (water, reeds, recreation) have been identified and estimated.

The total value of the ecosystem services selected in Lower Dniester including water supply and irrigation, tourism and recreation, reed, climate control and water purification amounts to 29 million EURO per year. This is only an extremely insignificant percentage of the benefits provided

by the ecosystems and can be seen only as an initial valuation at the very lower end. Valuation the remaining ecosystem services will require considerable effort. For comparison, the cost of all water protection measures carried out in the Dniester basin in Ukraine in 2017 was 3.7 million Euros [4].

A global study conducted by Robert Costanza for inland wetlands allows a very rough estimate of the value of the wetland ecosystem services of the Dniester sites, using a benefit transfer method. The total value of ecosystem services presented in Constanta research is US$16,500 per hectare per year [5]. The value of all ecosystem services of the three sites in the Lower Dniester can be roughly estimated 2.2 billion EUR per year. Even a small proportion of these funds could contribute to the growth of the well-being of the local population and the improvement of the environmental situation in the territory of the Lower Dniester.

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PECULIARITIES OF DETERMINING TECHNICAL AND ECONOMIC INDICATORS IN SUBSTANTIATION OF EXPEDIENCY OF OPERATION OF GROUNDWATER DEPOSITS IN UKRAINE

Today, there is a worldwide trend towards wider exploitation of groundwater, Ukraine is no exception, as groundwater has a number of significant advantages over surface water, including better quality and efficiency of water treatment. However, given the vulnerability of groundwater, this issue needs strict control by the state.

The main tools for regulating groundwater production are administrative and economic methods: issuing special permits, setting rent payments and fees. In contrast to Ukrainian legislation, which focuses on an environmentally friendly approach to natural resources, European legislation considers groundwater as an integral part of the ecosystem, and the policy is aimed at their protection and rational use.

Accepting the European way of development as a non-alternative, Ukraine faced the need to reform the state environmental monitoring system taking into account international experience and

the requirements of relevant EU directives, as well as to adapt its own regulations, including those related to water regulation.

Feasibility study of the feasibility of industrial development of deposits is a mandatory requirement for the preparation of geological and economic assessment of drinking groundwater reserves. Feasibility study for drinking, technical and mineral groundwater is performed for each deposit or subsoil area in the process of geological and economic assessment at different stages of exploration. The feasibility study should provide a comprehensive geological and economic assessment and promote the rational, restorative and economically safe use of operational groundwater reserves.

When compiling the feasibility study, the so-called expected static and dynamic technical and economic indicators of field operation are calculated. The calculation of the expected technical and economic indicators of operation of the drinking groundwater field is performed on the basis of:

- decisions on the method and technology of field operation;
- actual indicators of research and industrial development of deposits;
- the current regulatory framework for taxation;
- other initial data of the business entity.

When compiling the feasibility study, it is important to make calculations of technical and economic indicators with maximum accuracy and give a forecast for the life of the project (25 years). But the unstable economic situation in Ukraine has a negative impact on the development of groundwater production, new deposits are not actually put into operation. If we consider the dynamics of production, profitability and profitability of groundwater enterprises in recent years, we can conclude that their main regulators are the Tax Code of Ukraine and the discount rate of the National Bank of Ukraine (*Methodical instructions ...,* 2010). But there are a number of inconsistencies.

According to the Tax Code of Ukraine, the rent for the use of subsoil is defined as a percentage of the gross value of finished products or income of the enterprise from the sale of marketable products, ie volumes of groundwater sold or used by the enterprise. In essence, this tax largely duplicates the income tax. It does not depend on the cost of geological exploration, the complexity of the conditions of occurrence, formation, development of the field and only to some extent takes into account the value or market value of the mineral (*Shevchenko,* 2017).

In practice, business entities for the extraction of groundwater are actually subject to a double tax - for the use of subsoil and for the special use of groundwater. If we take the European experience as an example, according to Polish legislation, groundwater (except for medicinal, brine and thermal) is not a mineral, and therefore is not regulated by Geological and Mining Law (Prawo

geologiczne i górnicze). Thus, there is no rent for the use of subsoil from the economic activity of groundwater production in Poland (*Luibchyk*, 2018).

The structure of payments for the special use of groundwater in Ukraine and Poland also differs significantly. If in Ukrainian legislation the tax rate depends on the administrative position of the object, in Polish - on the type of water consumption and method of treatment (*Luibchyk*, 2018).

In general, the Ukrainian business entity pays on average much more for groundwater extraction than the Polish one. This means that the subsoil owner (the state) gets more. However, as a result of significant tax expenditures, businesses in Ukraine are not able to invest in the development of new deposits, so, as a rule, only explored ones are developed deposits.

It should also be noted that the rates of rent for the special use of groundwater are increasing every year, and the calculation of dynamic technical and economic performance of the field is performed for a period of 25 years. For example, in 25 years the rent rate for the special use of groundwater in Kyiv may increase 5.8 times, which will significantly affect the results of technical and economic indicators (*Luibchyk,* 2018). But when compiling the feasibility study, the rent is taken as a static indicator at the time of compiling the report of geological and economic assessment. Thus, the objectivity of the results of calculations of technical and economic indicators raises significant doubts. The structure of payments for the special use of groundwater in Ukraine and Poland differs significantly. If in Ukrainian legislation the tax rate depends on the administrative position of the object, in Polish - on the type of water consumption and method of treatment.

An important external factor influencing the assessment of profitability and profitability of the enterprise for the extraction of groundwater is the discount rate of the National Bank of Ukraine. The results of the calculation of dynamic indicators (net discounted cash flow or net discounted value of the deposit, internal rate of return, profitability index, discounted payback period of investments) depend on the discount rate of the National Bank of Ukraine.

The Ukrainian business entity pays much more for this type of activity than the Polish one. At the same time, this means that our domestic treasury receives more. Such an advantage should be reflected in the improvement of the environmental situation in Ukraine, but in fact this is not the case, which indicates problems in the allocation of the budget for environmental needs.

According to the authors, the existing results of the calculation of technical and economic indicators in the preparation of the feasibility study of the feasibility of developing groundwater deposits are not accurate enough. Improving the accuracy of calculations requires changes in government regulation, such as the differentiation of payments taking into account the operating conditions of groundwater deposits, their quality, the depth of the aquifer and the direction of use of extracted water. It is also advisable to review the mechanism of formation of rent payments. Under

the concept of sustainable development, the issue of ensuring the needs of mankind with natural resources while preserving the interests of future generations, requires a systematic approach. The implementation of such a systematic approach is the creation of international standards and directives.

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