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Session 10. INNOVATIVE METHODS FOR PROSPECTING AND EXPLORATION OF OIL AND GAS DEPOSITS

Session 11. ECONOMICS OF SUSTAINABILITY AND GLOBAL INVESTMENT TRENDS

Session 12. INFORMATION TELECOMMUNICATION TECHNOLOGIES AND DIGITAL TRANSFORMATION

Session 13. INNOVATIONS AND PROSPECTS FOR THE DEVELOPMENTS OF MINING MECHANICAL ENGINEERING

Session 14. ENERGY EFFICIENCY AT THE ENTERPRISE OF THE MINERAL RESOURCES SECTOR

Session 15. SUSTAINABLE DEVELOPMENT OF REGIONS AND ENVIRONMENTAL SAFETY

Session 16. WASTE MANAGEMENT UTILIZATION, WATER TREATMENT, OFF-GAS TREATMENT, AND LAND RECLAMATION

Session 17. TOPICAL ISSUES AND CONTRADICTIONS OF MODERN SOCIETY DEVELOPMENT

Session 18. CURRENT ASPECTS OF ARCHITECTURAL AND URBAN ACTIVITIES

Session 10. INNOVATIVE METHODS FOR PROSPECTING AND EXPLORATION OF OIL AND GAS DEPOSITS

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PROSPECTING FOR HYDROCARBONS IN THE NIGER DELTA BASIN BASED ON BASIN MODELING

Basin modeling is the dynamic modeling of geological processes in sedimentary basins over geological time. [1]

Simulation of petroleum systems is applied at the basin scale to assess hydrocarbon potential, migration and trap formation. The result of basin modeling is the determination of the location of hydrocarbon deposits, data on fluid composition, data on the evolution of the basin and the distribution in the basin volume of the values of many petrophysical and geochemical parameters in the course of development history. [2]

The purpose of this work is to assess the prospects for the oil and gas potential of the Niger delta basin based on the results of modeling generation- accumulation systems in the Petromod software package.

The Niger Delta is one of the world's richest hydrocarbon provinces in the world. It is composed of rocks of the Mesozoic and Cenozoic age and has an extremely complex structure. Its structure is determined by listric faults under the outer part of the shelf, clay diapirs and ridges under the upper part of the slope. [3]

This is one of the largest regressive deltas in the world with an area of about 300 thousand km^2, a volume of sedimentary filling of 500 thousand km^3 and a sediment thickness of more than 10 km in the depocenter of the basin.

In terms of proven reserves, the province ranks 12th among the largest geological provinces in the world and contains 2.2% of the total world reserves of explored oil and 1.4% of the total world reserves of explored natural gas. The province has discovered about 4.83 million tons of recoverable oil reserves and 11.94 trillion cubic meters of natural gas. Commercial oil and gas content is associated with the Akata - Agbada tertiary oil and gas system. [4]

The collection and critical analysis of the data required for the modeling was carried out. Seismic lines 4350 (western zone of the delta) and 5350 (eastern zone of the delta) were selected with interpretation and identification of reflecting horizons.

After calculating the models, summary tables of accumulations obtained on profiles 4350 and 5350 were compiled with the key accumulation parameters for planning geological exploration: the estimated volume and mass of hydrocarbons, the average density of the fluid in the accumulation, and depth from the bottom surface. The assessment of the oil and gas potential was carried out on the basis of the historical-genetic method, which includes 5 analyzes:

- Tectonic analysis
- Paleotectonic analysis
- Lithologic-facial analysis
- Geochemical analysis
- Thermobaric analysis

In the process of solving this problem, basin modeling was carried out along two seismic lines (4350 and 5350), including:

- study of the geological structure and neftegazonos nose tee delta of the Niger River Basin
- geometrization of geological models and their structuring into a system of cells
- simulation of hydrocarbon generation based on the established GAUS parameters

- analysis of the evolution of catagenesis of oil and gas source rocks of the Akata formation, as well as the degree of its production, the order of migration of generated hydrocarbons and their further accumulation

It is proposed to include 9 vertical and one multilateral directional wells in the project for further prospecting works, 5 along each of the modeled profiles.

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IDENTIFICATION OF PROMISING DEPOSITS OF THE BT-9 LAYER OF FIELD NO. 1 OF THE WEST SIBERIAN OIL AND GAS PROVINCE

The West Siberian oil and gas province is one of the largest provinces in terms of hydrocarbon reserves. Its area is about two million square kilometers and extends both on land and on the shelf of the Kara Sea. One of the most promising fields in the West Siberian Province is field No. 1, which is located in the Yamalo-Nenets Autonomous Okrug of the Tyumen Region, in the Tazovsky district. The field was discovered in 1962, the oil and gas was found because of emergency gushing of exploration well No. 1P. The field has a multi-layer structure; the main interest is the Cenomanian gas deposits, as well as the underlying oil rim in the PK layers, and oil deposits in the AC layers [3]. Nevertheless, the BT layers lying below the PK are also promising, which are the object of the study.

One of the methods of increasing the volume of resources and reserves of deposits is the study of horizons lying below the main ones that being developed. At field No. 1, the main volume of production is carried out in the Cenomanian PK layers, which contain large deposits of gas with an oil rim. Among the layers lying below, the group of BT layers, whose oil and gas potential has been proven in other fields of the Tazovsky district, is considered promising.

According to the results of studying the borehole information of the BT layers, it was found that the BT9 layer, which is the lower cover layer of the Neocomian, according to the models of V. S. Muromtsev [1], is confined to the shallow shelf zone, and the clay zone can be associated with fluctuations in sea level and a change to a deeper one, which can be considered a rhythm of a shallower way, or a decrease in the level with the accumulation of clay material in lagoon conditions. In general, the layer is characterized by poor reservoir properties, and therefore, further prospects for studying the oil and gas content of this reservoir can only be associated with finding non-structural traps.

The first stage of processing the initial data on the object was the study of the seismic cube with the use of various attributes (harmonic mean value, average energy, maximum amplitude), according to the results of which, an anomaly was identified in the form of an underwater canyon in the studied area, the filtration and capacitance properties (FCP) of which can be significantly higher than the FCP of the host rocks. The geological model compiled by Potapotova E. A. [1] confirms the geological occurrence of the anomaly. The next stage is the

identification of tectonic disturbances near the anomaly, as well as the identification of the seismic surfaces of the BT9 layer roof and the incision itself. The structural surfaces of the selected geological body and the layer roof are constructed. Based on the dependences of the morphometric parameters of the incisions [4], the power of the studied body and its volume was determined. Localized resources are estimated by analogy. The layer analog is the BT10 of the Zapolyarny field, from which gas is extracted. The result of the assessment was 5.59 billion m^3.

The result of this work is the discovery of a forecast deposit, the determination of the morphometric parameters of the selected structure, and the construction of a 2D model with the calculation of the volume and the resources assessment.

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META-HEURISTIC APPROACHES FOR PERMEABILITY ESTIMATION OF HUGIN FORMATION, VOLVE OILFIELD, NORTH SEA, NORWAY

Convenient dissemination of permeability is decisive to regulate the reservoir's quality and nature. With singular approaches of determination of permeability in assorted porous medium, it can be altered regarding environment and the considered scope of porosity media. Nowadays, artificial intelligence approaches exploit to investigate and relate between permeability of core samples and well logging data.

Artificial intelligence techniques are familiar in permeability estimation even with more heterogeneity of reservoirs. Reservoir's zones with an individual network for each geological characteristic gives further proper and authentic outputs than designing a particular network for all zones [1]. Middle Jurassic Hugin Formation is a possible mouth bar setting deposited at the time of overall transgression, reflects variations in sediment supply, which indicated by fluctuated values of permeability and porosity due to the change in clay content and grain size.

Support Vector Regression method has a rapid run with a small portion of time and shows more accuracy [2]. According to geological parameters of each zone of the reservoir, the designing of individual networks is more authentic than a single network for all zones [3]. The qualified Support Vector Machine (SVM) will be monitored for recommendation and future endeavors to estimate the permeability for other reservoirs in Volve oilfield. Unquestionably, gaining substantive findings using well log data may further show SVM's intelligence to forecast petrophysical parameters, including permeability and porosity.

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FEATURES OF ACCUMULATION CONDITIONS OF SEDIMENTARY COVER IN THE SOUTH TORGAI BASIN

In the structure of the South Torgai sedimentary basin, according to certain geological features, three structural floors are distinguished [1]: the lower one-which serves as the foundation of the sedimentary basin; the middle one – is represented by quasi – platform deposits; the upper one – the platform complex is studied in the most detail and is represented by Mesozoic and Cenozoic deposits.

The Jurassic structural floor consists of lithocomplexes typical of intracontinental sedimentation: eluvial, proluvial-deluvial, and alluvial. Eluvium deposits are mainly represented by clarified greenish-gray, sometimes almost white kaolin clays, in the lower part containing sharp-angled fragments of strongly weathered underlying basement rocks-mainly gneisses, chlorite-sericite and clay shales of the Pre-Paleozoic, Lower Paleozoic, less often-weathered sandstones, siltstones and mudstones, effusive rocks of the Middle-upper Paleozoic. The thickness of the eluvium varies dramatically in area. It is absent in sections, and the sedimentary complex of the cover lies directly on the weathered rocks of the foundation. The maximum thickness of clay eluvium in the section of the 2-Kumkol well exceeds 100 m. This indicates [2] a significant dissection of the Pre-Jurassic relief and within the protrusions of the foundation. The proluvial-deluvial type of sediments, according to drilling data, have extremely limited areas of distribution in the Jurassic period. This type can be confidently attributed to [2] conglomerates and gravelites composing the Doshchanskaya section (wells 1P-Akshabulak and 3-Aschisay), as well as the lower (basal) layers of gravelites and gravel sandstones of the Sazymbai formation, opened by wells 2,5,6,7-Doshchan and coarse-clastic deposits of the Kumkol formation (well 41-C). Alluvial deposits are most widely developed in the Sazymbai, Doshchanskaya and Kumkol formations, which make up the lower parts of the Jurassic rhythm complexes. They are mainly represented by fine-and fine-grained, rarely medium-grained sandstones, siltstones, often obliquely layered, mainly of quartz and polymictic compositions, with a high content of quartz grains, which indicates the remoteness of the areas of demolition. Beds of channel sandstones have a thickness of 5-10 to 20-30 meters or more, often replaced by layers of fine-grained sandstones, siltstones and clays of lake facies.

In the structure of the section of the Cretaceous-Paleogene structural floor, the deposits of the Lower Cretaceous (mainly Neocomian) are considered, which are oil and gas-bearing and were studied in detail in the sections of wells. The morphogenesis of the Neocomian lithocomplexes, like the Jurassic ones, is typical for formations of the intracontinental sedimentation regime. They combine almost all facies of the outflow cones, riverbeds, floodplains and lakes.

Deluvial deposits take part in the structure of the section of the Aryskum horizon at the base of the Lower Taul sub-formation. They were opened by wells at the Kyzylkiya field (sle. 15,12,20), etc. Alluvial deposits are everywhere involved in the structure of the Aryskum

horizon and the Upper Taul sub-formation. In the Aryskum horizon, they are represented by lithofacies of the cones of the outflow, riverbed and floodplain. In terms of facies, the outflow cones tend to the western and eastern edges of the Aryskum trough (pl. Doschan, Aryskum, Konys). Sand-gravel-pebble alluvial-proluvial and alluvial deposits in these parts of the trough fill the entire stratigraphic volume of the Aryskum horizon, while in its inner part (Kyzylkiya Square, West Nuraly, Aksay), basically, they compose the lower section of the section. At the same time, there is a transition of deep-clastic rocks mainly into sand layers. Their thicknesses vary from 5 to 50 m. The thickness distribution shows that the demolition of the clastic material occurred from the Lower Syrdarya arch, which is probably a raised denudation area, which predetermined the high speed of watercourses and the transportation of large-scale clastic material.

In general, a single drainless sedimentation basin was formed on the territory of the Aryskum trough in the Lower Neocomian period, the central part of which was filled with lithocomplexes of the floodplain facies and a shallow lake. The upper sections of the Neocomian section are composed of clay siltstones and silty clays with lenticular interlayers of fine-grained sands [3].

The sediments forming the Jurassic and Cretaceous-Paleogene structural floors of the sedimentary cover of the South Torgai sedimentary basin differ significantly from each other. A feature of the Jurassic lithocomplexes is their formation in exclusively intracontinental conditions characterized by an active taphrogenic tectonic regime. The formation of the Cretaceous-Paleogene structural floor of the South Torgai sedimentary basin is associated with a period of long intermittent pulsational deflections of the Turan plate, accompanied by marine transgressions.

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PETROPHYSICAL MODELS OF ACHIMOV DEPOSITS TAKING INTO ACCOUNT THE FACIAL ENVIRONMENT

In connection with the depletion of reserves of the main oil and gas complexes, the greatest interest is attributed to hard-to-recover reserves, complex-built objects of the sedimentary cover. One example is the oil-bearing complex of the Achimov deposits of the Malobalykskoye field in Western Siberia. With the increasing importance of these deposits, there are problems that complicate the search and assessment of deposits. Such problems include a high degree of reservoir compartmentalization, sharp facies variability, high clay content, low permeability values, etc. The purpose of this work is to increase the reliability of the interpretation and assessment of the petrophysical properties of reservoirs using well logging based on facies typification.

The main productive reserves of the studied field are contained in the deposits of the Achimov formation (layers Ach1, Ach2, Ach3). Until recently, the interpretation of well logging results was carried out for all layers according to a single petrophysical model, which led to the omission of oil-saturated intervals and the loss of reserves. Since the Achimov deposits are mainly represented by sandy bodies, the reservoir and lithological properties of which are closely related to the peculiarities of their formation under various conditions of sedimentation, i.e. facies, then petrophysical models are needed for each of the layers separately. In this regard, the facies typification of rocks is a topical research today.

A facies is a rock body with specific features [1]. With the help of logging, conditional facies are distinguished by electrical, acoustic and radioactive properties – which are called electrofacies [2]. To determine the conditions of sedimentation of the Malobalykskoye field and build a facies model, a set of data was used, such as photographs and description of the core, the results of sampling and well logging. Using these data, as well as the results of studies of neighboring fields, the conditions for the formation of deposits of the Achimov formation were determined. Deposits of the Achimov formation were formed in a deep-water environment (cones of turbidite flows) as a result of the removal of clastic material along the inclined towards the center of the basin [3, 4].

The facies were distinguished according to the feature of the most adequate visual convergence of the logging curves (SP, GR) with the principal models developed on the basis of general concepts of the conditions for the formation of the studied complex. The facies association of the upper fan includes a series of canals cutting into each other and the most sandy and powerful parts of the blade. Large turbidite channels are characterized by a block or bell-shaped curve of electric logging (SP), reflecting the sandy composition of the deposits. The facies of the medial part of the fan are characterized by the funnel-shaped shape of the SP curve, reflecting the gradual sanding of the sediments up the section. The facies association of the distal part of the fan is represented mainly by clayey fine-grained sediments.

To build a refined petrophysical model, it is necessary to take into account the facies belonging of rocks and determine the boundary values for each facies zone. The boundary values of porosity (φ_1 = 13.9%, φ_2 = 13.4%, φ_3 = 8.6%) and permeability (k_1 = 0.79 mD, k_2 = 0.66 mD, k_3 = 0.137 mD) were determined for each facies zone, taking into account the revision of petrophysical correlations.

In the course of studying the structure of the Achimov deposits, a facies analysis was carried out, a comparison of the porosity-permeability properties (reservoir properties) of sandstones attributed to different facies settings was performed, and the influence of facies on the reservoir properties of rocks was investigated. As a result of the studies performed in the wells with the maximum initial information, 3 facies associations were identified: 1) proximal part (upper fan), 2) mid-fan, 3) distal turbidites. the proximal parts of the fan fans are characterized by the best reservoir properties, the facies zone of the lobes is characterized by the average reservoir properties, and the facies of the distal (tail) part of the turbidite fan are bad reservoirs. Based on the obtained petrophysical models and the identified facies zones the well data will be reinterpreted in future.

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SCENARIOS FOR INCREASING OIL AND GAS RECOVERY RATES FROM BROWNFIELDS WITH 3D MODELLING AND SIMULATION

The petroleum industry has developed dynamically, pushing it in a completely different direction in last decades. The volatile trends in crude oil prices and the special geopolitical situation presuppose a timely contraction of investment in exploration for new oil and gas fields at the expense of increasing production rates in already exploited brownfields. With an increasing demand for oil and gas and difficulties in finding new major hydrocarbon fields, research on methods to improve oil recovery rates from existing fields is more necessary now than ever.

In Bulgaria, most oil and gas fields are mature or in the last stage of exploitation. The large set of geological, geophysical and technical data on the hydrocarbon accumulations in the country gives a good characteristic of the natural reservoirs, as well as quantitative dimensions of the resources and reserves in them. Most of these hydrocarbon accumulations were discovered in the 1960s, 1970s and 1980s, suggesting outdated methodologies and concepts for processing this data. The improved computer software packages, which are rapidly developing and are widely used in the O&G industry, are of particular importance for the new technologies. They allow the integration of a large amount of data that can be analyzed and processed simultaneously. Software applications and platforms, together with modern geological scientific concepts, are becoming a powerful tool for achievement of economic growth at minimal investments.

For a number of reasons, most of the reservoir intensification plans change or need to be adjusted during the production cycle of certain hydrocarbon fields. Some of the reasons include the following:

- Lack of detailed characteristics of the natural reservoir and assimilation of the main mechanisms of production in the early stages of development, i.e., reducing risk and uncertainty over time. The situation is similar with almost all oil and gas fields in Bulgaria (Dolni Lukovit, Dolni and Gorni Dabnik, Bardarski Geran and others);
- Poor yield productivity, i.e., production below the expected and early water flooding of the reservoirs;
- Economic criteria, for example low oil prices, as is the current situation in recent years;
- The application of new technologies “Enhanced Oil Recovery (EOR)” - horizontal drilling to undrained oil and gas saturated zones and methods of intensification, i.e., reperforation of the productive intervals and injection of various fluids in the natural reservoir;
- Dynamic and flexible management is needed to optimize the production from the brownfields, and hence the value of the assets acquired during the full exploitation cycle.

The application of the methodologies and techniques of modern computer 3D Reservoir Modelling and Simulation based on physical models can significantly facilitate the development and increase the coefficient of recovery from the existing oil and gas brownfields. 3D reservoir modelling is building a computer static (geo) and dynamic model of a productive natural hydrocarbon reservoir. The computer-generated model has a number of advantages: (1) it allows for the integration of a large volume of different types of data, which can be updated or edited at any stage of the modeling; (2) the implemented mathematical operations expand the range of possibilities for quantitative and spatial calculations; (3) the interaction and migration of the fluid flow in the reservoir can be observed during the operation of the hydrocarbon field.

Simulators are mathematical expressions based on differential equations, modeling in a series of discrete steps the behavior of the flow of fluids (oil, gas and water) in the reservoirs and their change in time and space.

The main results of the simulation of the 3D reservoir model are the localization of the

zones with current oil saturation, gas saturation and water saturation in the range of the defined reservoirs. Quantitative calculations of hydrocarbon reserves and resources are performed during the simulation, especially for reservoir areas.

The natural reservoirs with less thickness, which predominate within the Bulgarian brownfields, could contain significant hydrocarbon resources. One of the main problems with this type of reservoirs is the conical effect around the bottomhole zone, which has a negative impact on the degree of efficient oil extraction. Therefore, applying the methodology of 3D reservoir and simulation is extremely important to select the optimal strategy in the projection of well locations (position, length, distance from the fluid contacts, rates). Practice shows that horizontal wells are the most suitable for the exploitation of reservoirs with less thickness. The ability to achieve high oil and gas production over a longer period of time with controlled rates are just some of their advantages.

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STUDY OF NATURAL SALINIZATION AND TECHNOGENIC DESALINIZATION OF RESERVOIRS DURING EXPLORATION AND DEVELOPMENT OF OIL FIELDS

Oil fields of the Pripyat oil-and-gas bearing region and regions of the south of the Siberian platform occur in saline reservoirs. Salinization of rocks significantly impairs their porosity and permeability, which reduces the efficiency of geological exploration for oil and gas in the areas with the most intense salinization. The ability of halite to dissolve when interacting with the water injected for oil displacement leads to a significant change porosity and permeability properties of the reservoirs during the development of oil deposits, that has a significant impact on well operation and field development in whole. It all goes to show that it is necessary to study the scale of natural salinization and technogenic desalinization of reservoirs from all sides and take into account the features of its manifestation during exploration and development of oil deposits [1].

Salinization of rocks of the East Siberian and Belarusian hydrocarbon deposits was noted when studying the lithological composition of subsalt and inter-salt deposits in the sixties and seventies of the last century. For the first time V.S. Mulyak and F.N. Yakovenko (1965) as well as Yu.I. Maryenko and V.G. Postnikov (1967) pointed out the presence of halite in the productive horizons of the Markov field in the south of the Siberian platform. At the present time the salinization of rocks is recorded here in almost all oil and gas prospecting areas and hydrocarbon reservoirs. The first information about the salinization of the inter-salt and subsalt rocks of the Pripyat trough is given in the published works of A.V. Kudelsky and K.M. Obmoryshev (1971), R.S. Sakhibgareev (1974), V.V. Panov (1975), V.L. Tyumentsev (1977).

The most complete characteristic of data on salinization of rocks from different regions can be found in the works of A.A. Makhnach (1982, 1989). Meanwhile the initially lithological, descriptive study of saline rocks is transferred into a complex lithohydrogeochemical study of the conditions for the formation of halite in the void space of sub-evaporite strata. In the same period works on the hydrogeochemical study of this problem appeared, in which these issues were solved by studying the saturation degree of formation waters of subsalt and inter-salt complexes with sodium chloride (V.G. Zhoglo, 1977, Bukaty et al., 1981.).

Numerous laboratory studies of the salinization degree of oil and gas reservoirs in wells of oil fields in Eastern Siberia and Belarus showed a significant effect of the salinization process on porosity and permeability [1, 2]. In different regions of the considered territories the association of salinization to certain lithofacies has been established. Nevertheless, such studies have characterized only a small part of the section of individual wells, which did not allow to assess correctly the scale of the manifestation of this process as a whole. The assessment can be carried out in more detail when investigating the process of desalinization of such reservoirs during the operation of oil fields, the development of which is carried out with the injection of low-salt waters into productive reservoir to displace oil to the bottom of production wells. For the first time such an approach to assessing the scale of salinization of productive rocks was proposed and tested in 1996 by V.D. Poroshin. Since then, such studies have been carried out regularly for the majority of wells of Belarusian oil fields producing water-cut wells. As a result, for the first time in quantitative terms the scale of dissolution of halite contained in cracks, pores and caverns of productive horizons was established during the development of a number of oil deposits. The results of such an assessment carried out by the authors using new methodological techniques (S.L. Poroshina, 2020) [3] for the Voronezh deposit of the Zolotukhinskoe field indicate that the total volume of halite dissolved and carried out with associated waters for the entire period of its operation is estimated at 7581 m^3. It is shown that these processes are actively continuing in the Belarusian deposits at the present time. The schematic maps constructed on the basis of these data indicate the irregularity removal of dissolved halite by associated waters in different parts of the deposits, which may represent the extent of natural salinization within the study areas.

The presented materials indicate that the assessment of the scale of salinization of productive oil and gas reservoirs and the study of the process of their desalinization during the development of hydrocarbon deposits should be carried out in a complex using the methods of lithological, lithofacies, hydrogeochemical and field hydrochemical (lithohydrogeochemical) studies.

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STUDY OF NANOPARTICLE/POLYMER/CACO3 INTERACTIONS TO OPTIMIZE DRILLING FLUID PERFORMANCE

Colloidal suspension agglomeration and filtration occur in many natural phenomena and engineering applications. The most common colloidal theory problem is stabilizing a colloidal dispersion; agglomeration reduction through interparticle force control. If the particles agglomerate, the agglomerated sizes increase, increasing the sedimentation (or deposition) rate randomly [1]. Drilling fluids are composed of a base fluid, water, and solid particles suspended, calcium carbonate - $CaCO_3$ [2]. In most cases, polymers are used to disperse the solid material. However, factors such as mud contamination, size, the solid concentration solids, changes in pH, etc., can alter the surface charge and affect the colloidal stability and alter the drilling fluid properties.

An alternative to the current improves the drilling fluids properties is the potential employment of nanoparticle technology [3]. However, few fundamental studies are available in the literature or omit the interactions between particles for such colloidal suspensions. Thus, this thesis focuses principally on the colloidal stability in the polymer-$CaCO_3$ system and the solid packing in the filtration process in the presence of nanoparticles (NPs). SiO_2 NPs are a common material widely used in drilling fluid improvement. The colloidal stability of the water-based drilling muds (WBM) in the presence of SiO_2 NPs was evaluated by monitoring rheological and filtration properties varying the particle size, concentration, and charge surface NPs. The NPs with the smallest size, highest total acidity, and the most negative value of zeta potential had the highest capacities of filtration volume and filter cake thickness reduction. These factors favor the dispersion forces, allowing the reduction of aggregates, favoring an ordered particle deposition with superior coverage.

Once they have formed the filter cake, the attractive forces predominate the system, reducing the empty spaces between particles. Also, NPs are retained in the porous surface due to the affinity between the rock silica groups and the SiO_2 NPs active sites. Hence, the SiO_2 NPs could interact in the following order with each item evaluated: Polymer < $CaCO_3$ < rock. In the case of the polymer, interacts the most with the rock, followed by NPs and then $CaCO_3$. NPs do not generate significant changes in the rheological profiles of the WBM. However, the yield point and gel strength, which are strengthened at low shear rates, were improved with the presence of NPs, the attractive forces predominate. The lower the distance between SiO_2 NPs-polymer, the greater the force of attraction between the molecules.

This study provides a broader landscape of the role of SiO_2 NPs in the improvement and design of drilling fluids to a field application. Strategies and methodologies for application and scaling the WBM with NPs in the drilling are proposed according to the field experience.

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EFFICIENCY OF EVALUATION OF FINANCING OF STATE PROGRAMS IN KAZAKHSTAN

In the current crisis conditions, like a pandemic, the state is forced to constantly analyze and develop the country's budget system and update issues related to ensuring the policy of financial stabilization of the territories and the process of financial security.

With the correct organization of program-target budgeting, the quality of budgetary funds management increases, the processes of formation, implementation and monitoring of government programs are significantly simplified, and the effectiveness of public spending increases.

The issues of the effectiveness of financing state programs as an instrument of the policy of financial stabilization of territories are controversial and are discussed in the works of such authors as Bogacheva O.V., Lavrov A.M., Yastrebova O.K., Barulin S.V., Kusmartseva V.S.., Raisberg B.A., Fokina T.L. [1 - 3].

State programs provide an opportunity to comprehensively link the strategy of the territory, budget and programs of departments. In this regard, there is a need for annual adjustments and clarification of the timing, indicators of target indicators, the amount of funding for government programs. Therefore, changes at the end of the year in the state program must be justified and given on the basis of assessing the effectiveness of the state program. Some indicators reflecting program performance also need additional justification.

Evaluation of government programs is one of the ways to solve it. Evaluation of state programs is a tool that allows you to get a picture of the progress of programs and helps to obtain information for making decisions regarding the further implementation of programs. In the process of implementing any project or program, it is advisable to take into account the experience already accumulated. This opens up opportunities to avoid common mistakes and, at the same time, integrate the most successful approaches that have proven their effectiveness in practice into management processes. Despite the fact that our country has already officially adopted a methodology for assessing the effectiveness of the implementation of government programs, the analysis of best practices can increase the efficiency of government programs management.

Evaluation of the effectiveness of the implementation of the state program is an assessment of the actual effectiveness based on the results of the implementation of the state program, taking into account the amount of resources allocated for its implementation, as well as the realized risks and socio-economic effects that affect the change in the relevant area of socio-economic development of the country's regions. Goal achievement indicator is a quantitatively expressed indicator characterizing the target state (change in state) of the level and quality of life of the population, the social sphere, the economy, public security, state institutions, the degree of realization of other socially significant interests and needs in the relevant area. The immediate result is a characteristic (in total terms) of the volume of implementation of the measures of the state program. (Resolution of the Government of the Republic of Kazakhstan dated December 31, 2019 No. 1050 "On Approval of the State Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2020 - 2025" (as amended on March 15, 2021) http://adilet.zan.kz/rus/docs / P1900001050.

In accordance with this document, a kind of state program implies a set of measures and instruments of state policy that ensure, within the framework of the implementation of basic state

functions, the achievement of priorities and goals of state policy in the field of industrial and innovative development and security. At the same time, a system of measures is being developed, which should be interconnected in terms of tasks and timing of implementation and resources.

The Budget Code of the Republic of Kazakhstan annually introduces an assessment of the effectiveness of the implementation of state programs, and also defines the principles of the effectiveness of spending budget funds: economy and effectiveness. Frugality is the use of the least amount of budgetary resources to achieve the planned results, and efficiency is the achievement of the best result in the presence of a certain limited amount of budgetary funds. [4].

For a clear mechanism of budgetary financing, in order for the program to meet the expectations associated with increasing the efficiency of public spending, state programs must comply with the following principles:

1) clarity of purpose - when formulating a goal, it is necessary:

- specific (compliance with the implementation of the state program);
- specific;
- measurable;
- attainable;
- relevant (compliance with the final results);

2) unity of purpose;

3) compliance and unification.

In accordance with the proposed principles in acting e m legislations e included BASIC e criteria proposed effectiveness of the state program:

a) criteria of economic efficiency, taking into account the assessment of the contribution of the state program to the economic development of the country, the assessment of the impact of the indicators of the state program on various spheres of the regional economy. Estimates can include both direct (direct) effects from the implementation of the state program and indirect (external) effects arising in related sectors of the economy of the Republic of Kazakhstan;

b) criteria of social efficiency, taking into account the expected contribution of the implementation of the state program to social development, the indicators of which cannot be expressed in value.

Scientists and experts determine the need to distinguish between the categories of "performance" and "efficiency", understanding the former as the ability to achieve the set goals, and the latter as the optimal ratio of the resources expended and the results obtained.

In this regard, the risk of the implementation of government programs can be interpreted as the implementation of their financing, comparing with the budget or with the revised budget plan. Therefore, we believe that the risk-free execution of the state program is one hundred percent of its financing, and all other methods of financing can presumably be attributed to risky ones. Thus, the current trends in the development of public financing are associated with the transition to a results management system, which is based on the financing of specific government programs related to the achievement of specific results.

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HIGH SEAS – NEW QUESTIONS, OLD PROBLEMS. AWAITING FOR ANSWERS

The sea areas outside the territory of the national jurisdiction comprise around half surface of the Planet and most of its biodiversity. The international community is recently getting more and more aware of the growing and expanding threats to marine biodiversity of the world ocean.

How could unavoidable environmental intrusions of business activities be minimized? How could processes of degradation of biodiversity be slowed down? How could the necessity to use the components of biodiversity and necessity to preserve such biodiversity be balanced? The answers to these questions have been searched by the international community for more than one decade.

The results of these searches formalized in the appearance of a number of international global, regional and sectoral agreements as a result of which the states committed to implement and adopt various mechanisms and instruments, including those aimed at ensuring control over the use of components of biodiversity, reducing possible negative impact of business activities of the state of biodiversity.

In 2004, the General Assembly of the United Nations took a decision on the establishment of the Ad Hoc Open ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction.

Since the start of discussions in 2006, main focus has been mainly made on weak points and gaps in the current international legal and policy framework and whether they require the adoption of a new document. In particular, the states discussed possible adoption of the United Nations Convention on the Law of the Sea (UNCLOS)[2] Implementing Agreement on conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction.

Today the United Nations are approaching the final stage of then negotiation process that has been lasting in various forms for more than 15 years. The United Nations Intergovernmental Conference planned to finalize the development and adopt the text of a new, legally binding instrument on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction in 2020.

However, the parties to the negotiations never managed to come to a consensus with regard to both objectives of the future agreement or its main components.

The historical aspect of the decisions taken by the states and enthusiasm shown by many delegations and observer-states do not necessarily mean that the coming negotiation process will be easy. There is still no clear understanding of which challenges in the field of conservation of marine biological diversity in the open areas and sustainable use of components will be addressed in the end.

However, the work on the agreement is in process... We hardly should wait for completely new answers to old questions related to the conservation of biodiversity from the coming document. But those small additions that could be made to this new document have an immense potential in increasing the efficiency of operation of the current system of management of open areas in the context of reaching the goal of conservation of marine biodiversity.

In this document we are going to focus on the legal aspects related to laying submarine cables and pipelines, one of the types of business activities of the humans in the high seas.

The issues of the balance of the freedom to lay submarine cables and pipelines with other freedoms of the high seas and the rights effective in the ocean floor have not been significantly analyzed in the Russian legal literature at present[1].

The freedom to lay submarine cables and pipelines, one of the freedoms in the high seas, stipulated by the United Nations Convention on the Law of the Sea (UNCLOS) of 1982 is facing uncertain future in accordance with the new international legally binding instrument, which is under discussions in the United Nations.

1. There is no direct mentioning of submarine cables or pipelines in the resolution taken by the United Nations General Assembly on holding the Intergovernmental Conference on an international legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (hereinafter, the Document). But it is indicated that the work and results of the Intergovernmental Conference should be fully consistent with the provisions of the Convention.

2. The issues in the new Document, that will probably have an impact on the freedom to lay submarine cables and pipelines beyond areas of national jurisdiction, include: (1) management tools and (2) environmental impact assessments which are the mechanism used to protect and conserve marine environment and biodiversity.

3. The objective of High Seas Governance (and, as a matter of fact, constant objective of the marine law) is how to balance these two allegedly competing but equally valuable interests: protection of marine environment and biodiversity and freedom of the high seas to lay submarine cable and pipelines in the areas beyond national jurisdiction.

The historical function of the marine law has always been in balancing the competing types of use and interests. In the face of new challenges and potential conflicts the way to reach this balance remains the same: flexibility based on cooperation, consultations and compromise.

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OIL SORBENTS FROM AGRICULTURAL WASTE: A CIRCULAR ECONOMIC APPROACH

Introduction. Today, about two hundred types of various sorbents are produced and used in the world for oil spills remediation, which in turn are subdivided into natural organic, inorganic and synthetic. The quality of sorbents is determined by their absorption capacity in relation to oil and oil products, buoyancy after oil sorption, the possibility of oil desorption, regeneration or utilization of the sorbent [1, 2]. The purpose of this study is to obtain natural sorption materials for the remediation of oil pollution by utilizing agricultural waste [3].

Materials and methods. Agricultural waste was used for the study, namely a mixture of husks of agricultural crops of the Liozno grain base; hulls of sunflower, peanut, buckwheat, barley, radish; cotton bolls; pericarp peas, beans, rapeseed. All samples are with a particle size of 0.25-1 mm. For them, the basic physical and chemical properties have been determined: humidity according to GOST 12597-67, bulk density according to GOST 16190-70, pH of the water extract according to GOST 32327-2013, adsorption activity for iodine according to GOST 6217-74, adsorption activity for methylene blue according to GOST 4453-74, pore volume by

the "molecular probe" method according to GOST 17219-71 and oil capacity according to GOST 33627-2015.

Results. The moisture content in the selected samples is about 5% wt., which indicates a high ability to dry the samples; potentiometric titration established that the aqueous extract has a weakly acidic medium, and the bulk density of the samples averages about 100 g / 100 cm3, which is comparable with industrial sorption materials. The adsorption activity of the samples with respect to iodine is about 20%, and after treatment with a weak NaOH solution it increases by 30% and is similar to the enterosorbent brand "Polyphepan", i.e. has comparable microporosity. The adsorption activity for methylene blue, which indirectly characterizes the sorption capacity in relation to petroleum products, for the studied samples of agricultural crops is about 100 mg / g (after treatment with an alkali solution it increases by more than 10%) and is similar to Polyphepan in this indicator. Using the molecular probe method, it was found out that agricultural waste is characterized by a highly developed total porosity (the total pore volume in water reaches 1.5 cm3 / g) with a wide pore size distribution.

The sorption capacity in relation to West Siberian oil (density at 20 °C: 860 g / cm³) is more than 3 g / g (after treatment of the samples with water and alkali solution it increases), i.e. the oil capacity of agricultural waste is higher than the economically effective value for industrial analogues. Table 1 shows the sorption capacity for sunflower husks, cotton bolls and a mixture of husks of agricultural crops of the Liozno grain base in relation to oil and oil products: lighting kerosene (density at 20 °C: 775 g / cm³), diesel fuel (density at 20 °C: 825 g / cm³) and vacuum distillate (density at 20 °C: 905 g / cm³) of samples depending on the type of processing in g / g.

Table 1 – Sorption capacity of samples in relation to oil and oil products

Type of raw material	Product	Initial sample (without treatment), g / g	Solid residue, g / g		
			after cold water extraction	after hot water extraction	after alkaline treatment
Sunflower husk (lat. Helianthus annuus)	oil	3,3	3,8	3,9	5,5
	lighting kerosene	2,1	2,5	2,6	2,8
	diesel fuel	2,2	3,1	2,9	3,0
	vacuum distillate	3,9	3,8	4,6	4,2
Agricultural husk mixture (lat. Folliculi rusticarum fruges)	oil	10,8	9,6	8,6	6,7
	lighting kerosene	5,2	4,7	4,3	2,3
	diesel fuel	7,2	4,9	5,6	3,0
	vacuum distillate	8,2	8,4	9,1	8,0

Analysis of the sorption capacity in relation to oil products made it possible to establish that heavy oil products are absorbed by all samples of agricultural crops much more efficiently than light ones. The linear increase in the sorption capacity of the samples with an increase in the density of the oil product allows us to make the assumption that there is a process of physical sorption due to the forces of molecular interaction, mainly dispersion. The value of the oil capacity of the mixture of agricultural husks in an unprocessed form surpasses the most widely used sorbent for the elimination of oil pollution Spill-Sorb (up to 9 g / g), while the cost of obtaining oil sorbents by utilizing agricultural waste does not exceed $100 per ton.

Conclusion. Utilization of agricultural waste to produce oil sorbents will expand their range, reduce the burden on the environment and obtain an economic effect.

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SOLVING THE SOCIAL PROBLEMS OF THE REGION USING THE TENDERS MECHANISM

A fundamental requirement for the sustainable development of any region is to ensure an adequate standard of living for its people. It is necessary to develop an appropriate mechanism for dealing with social problems, for its achievement. Nowadays, Donbass has a complex geopolitical situation, which makes it possible to develop a specific branch of industry and mineral and raw material sector. The low investment attractiveness of medium and small businesses in the productive sector to private investment, including in the construction sector, is a the endemic problems characteristic obstacle to the sustainable development of the territories. The lack of development of the investment and construction complex leads to a number of problems not only in the economic sector but also in the social sector, such as: lack of social support programs for the population, waste of natural resources and the high level of pollution affecting the social and working life of the population. Scientific novelty of the research consists in the development of a mechanism for solving social problems of the region by improving the procedure of contract bidding. The argument of the need to develop an appropriate mechanism is based on a study of the legal framework and scientific literature of domestic and foreign authors.

One of the reasons for the lack of social and economic development of the region is the low activity of entrepreneurs in the production sector of the economy, which entails a decrease in tax revenues, reduction of jobs and purchasing power of the population. As one of the methods of stimulating the activity of the investment sector can be used the state social procurement involved in the formation of demand for various socially significant projects, such as new construction, repair, reconstruction and rehabilitation restoration of housing stock, construction of infrastructure facilities in the region (playgrounds; engineering networks; production and installation of various treatment facilities, etc) [1].

Lack of normative acts regulating the process in Donbass legislation regulating the process of formation and placement of the state social order. However, in dealing with social problems of the region through the tender process, it is advisable to apply the experience of the Russian Federation in this area, as an example.

A critical review of the current situation in the construction complex of Donbass shows that the construction organizations competing in the process of contract bidding, have low success rate. This is due to a discrepancy in the quality of construction products to those requirements that are put forward by consumers; shortcomings of the procedure of contract bidding in the construction, which is expressed in an incomplete representation of its competitive

advantages; inefficiency of information support system of contract bidding and as a consequence, reducing the level of provision of construction companies with orders. The mechanism of contract bidding is one of the effective instruments to ensure a balanced solution to the pressing problems of socio-economic development of the region [2].

To reverse negative trends to stabilize the population, to improve the level and quality of life can be implemented through investment and construction projects. Improvement of mechanisms of contract bidding in construction is of particular importance for the Donbass, because the effective system of contract bidding allows construction companies to get real orders, as well as improve the effectiveness of investment and construction projects.

Stimulation of business activity of small and medium businesses can be done by the placement of various, small-scale government orders through contract bidding. Also, depending on the class of complexity of the work presented in the orders, it is advisable to simplify the requirements for bidders. For example: to lower the minimum period of entrepreneurial activity from 3 to 2 years; the possibility of admission to participation in the tender of enterprises, having in their staff specialized part-time workers: the formation of a system of tax incentives for winners and contractors on the results of tenders; permission for participation in contract tenders of associations of small businesses.

Of particular importance for the Donbass is the possibility to implement various nature protection projects, investment and construction projects to restore the ecological situation and recycling of industrial sector waste and solid domestic waste. As measures to attract entrepreneurs in this area of activity can be used: preferential taxation, priority in the case of participation of the enterprise in contract bidding.

The procedure for solving social problems through the mechanism of contract bidding involves:

- formation of a complex program to identify the most significant social problems;
- allocation of private problem areas by cities and districts;
- formation of the need and criteria for contract bidding;
- definition of criteria for selecting and encouraging bidders and winners of contract bidding;
- analysis of the efficiency of order fulfillment.

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RESEARCH OF IMPROVEMENT OF THE ENTERPRISE ECONOMIC ACTIVITIES

The entry of the country into the number of fifty developed countries in modern conditions is influenced by the financial and economic result of the activities of each enterprise, enterprises operate on the basis of the state development strategy and implement their economic direction in the course of achieving a common goal. Currently, the development of each state is carried out on the basis of innovation, informatization, digitalization, therefore, it is relevant to determine the main problems of the enterprise. and for the innovative development of an enterprise and, on its basis, the state, first of all, it is necessary to develop science, which needs support from the state.

As a result, the National Innovation System should be formed, offering new products and services corresponding to their quality, price, volume and conditions for entering the market with effective demand.

Full realization of the economic potential of the market system of the economy ensures the maximum return on the existing production capacities of the enterprise. The material composition of the enterprise's potential ensures that all production resources are simultaneously in the production process, and the normal operation of the enterprise is possible only if they are interconnected, proportionate and relevant. To enhance the use of the production capacity of the enterprise, the economic mechanism for managing this process must function effectively. The first level in the economic mechanism is a comprehensive assessment of the use of production capacity, which determines the reserves and costs of production and economic activity. Such an assessment should be based on industrial relations that assess its resources, cost and performance conditions. At the same time, the production capacity of the enterprise should be considered as an integral system that characterizes the maximum potential for the production of competitive products that meets the total consumption of the enterprise with the full use of all resources.

The economic and financial strength of the company has been adopted to maintain the characteristics of the movement of the currency. Calculations show that the maximum part of the company's foreign exchange flows is required for calculating loans and taxes. The problem of useful shortcomings is significantly associated with a long period of expression of funds, unreasonable management of its individual elements, but in some cases the absence of certain politicians in this area. A separate list of the firm's funding sources - real income and depreciation - is by no means aimed at subsidizing money renewal projects, but is broken down into different proportions of assets used.

An active step in the formation is implementation, intensive assistance of all divisions in obtaining income, reducing costs with an increase in the part of the transaction, developing a list, changing the coordination divisions of entrepreneurship. The table shows the systematization of alternatives to the economic transformation of the company.

Table 1 – Options for financial restructuring of LLP «Uakyt»

Description of the business environment	Restructuring option
factors constraining the development of the enterprise	financial restructuring together with the organizational unit.
there is no profitable but efficient capital structure.	restructuring of claims (extension of the loan term, etc.)
adds value to the business in the current management environment. However, the net worth of the enterprise is lower than the value of unmanaged liabilities.	capital restructuring with the distribution of the full amount of liabilities between candidates.
it can be useful, but the business is poorly managed. Refunds are possible after a change in leadership and development strategy.	capital restructuring. The new structure of the action strategy or changes in management allows the allocation of needs according to absolute priorities.
the enterprise is easily liquidated before sustainable development is achieved (poor management, end of the enterprise life cycle).	distribution of competitive weight by eliminating the priorities of the assets and interests of the enterprise.

It is wrong to separate the financial reorganization of a firm with its anti-crisis strategy. In connection with these data, in this case, the plan for the financial and economic recovery of economic entities is an anti-crisis strategy, which, in its essence, provides for directly interrelated actions:

– the direction of the firm's activity in the commodity market (marketing strategy);

– concepts other than production installations (production strategy);

– implementation of additional financial resources (financial strategy), methods of attracting;

– internal production management and organization (personnel / management strategy).

Thus, to improve the economic activities of the enterprise, use innovative methods of enterprise management.

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FORMATION OF AN APPROACH TO ECONOMIC ASSESSMENT OF OWN LOGISTICS COMPLEX OF A NEW PROJECT OF AN INDUSTRIAL ENTERPRISE – NIVENSKY GOK

The relevance of the work lies in the fact that today in Russia one of the main tasks is the formation and comprehensive development of transport infrastructure. It is worth noting that the infrastructure industry is a sphere of national interests, and in order to integrate the transport complex into the world transport system, it is planned to carry out the following measures: systemic development of port infrastructure in accordance with promising directions of foreign trade; consolidation of the growth trend in the share of Russian ports in the handling of goods of the national cargo base; creation of mechanisms stimulating the modernization of the fleet; development of infrastructure for road and rail transport. It so happened that in Russia the development of transport and logistics infrastructure is often associated with the development of industrial enterprises of the mineral and raw materials complex. In particular, export-oriented companies [1]. The formation of an own logistics complex of industrial enterprises, which is an interconnection into a single system associated with loading and unloading goods, packaging, storage, labeling and changing vehicles, is an extremely important task for the development of the economy as a whole [2].

The study of scientific articles and economic literature has shown that, until now, there is no single definition of the concept of a logistics complex. A scientific and practical approach to the economic assessment of the development of their own logistics complex of companies in the mineral resource complex, taking into account the specifics of their development, has not been formed [3]. The interrelation of micro-, macroeconomic factors, including the development of the local transport and logistics system, and the industrial enterprise itself is not always taken into account. In this connection, the definition of the "logistics complex" has been corrected in the work, presented as an interconnection in a single system associated with the loading and unloading of goods, packaging, storage, labeling and change of vehicles.

Confirmation of the relevance and research of the scientific and methodological base confirmed the need to form an approach to the economic assessment of the effectiveness of the development of its own logistics complex of a mineral fertilizer manufacturer on the example of the Nivensky GOK, which was selected as the object of research. In this connection, the work simulates an approach to the economic assessment of the impact of the logistics complex on the efficiency of the enterprises of the mineral resource complex, which is based on three main stages of assessment: preparatory, methodological and methodological. inside the framework of

the formed approach, an economic assessment of the effectiveness of the development of alternative options for the own logistics complex of the Nivensky GOK was carried out, from which the optimal option was selected from the point of view of economic efficiency.

It is worth noting that an integral part of the approach is the formed algorithm for assessing the effectiveness of the development of the logistics complex of an industrial enterprise, which served as the basis for the formation of a scientific and practical approach. Within the framework of the algorithm, the existing state of the transport infrastructure, as well as potential directions of supply, is investigated. After that, the possibilities and necessity of creating a logistics complex are determined. Subject to the identification of limiting factors for the development of distribution, alternative options for the development of the company's logistics complex are formed: logistics outsourcing, the formation of its own logistics complex, a mixed version. After the economic assessment and analysis of all options for the development of the logistics complex, the final stage should be considered the choice of the most effective option for the development of the enterprise's distribution.

On the basis of the developed algorithm of the scientific and practical approach, an economic assessment of the effectiveness of the development of the own logistics complex of the Nivensky GOK was carried out, namely:

– the expected economic results of the development of the main production of K-Potash Service LLC were obtained based on the project and the development of the internal transport infrastructure on the territory of the industrial site (NVP = 302,211 million rubles);

– possible restrictions have been established in the sales volumes of K-Potash Service LLC products up to 200-300 million tons per year, provided that the internal transport system is operated. The NVP was set to decrease to 24,274 million rubles;

– the option of building its own logistics complex for the Nivensky GOK was formed and evaluated;

– determined and analyzed alternative options for the development of the distribution of Nivensky GOK products, including outsourcing of logistics services to the foreign seaport of Gdansk (Poland), which has the necessary technical characteristics for the sale of the entire volume of products of K-Potash Service LLC and the basic version of the Nivensky GOK's own logistics complex, including various types of transport and logistics facilities: seaport, rail and road transport;

– regarding the use of the services of PM Gdansk, the following risks were identified: an increase in tariffs, limitation of sales volumes, etc. If, when forming your own logistics complex, the net reduced effect from the implementation of this project for 34 years will be 298,284 million rubles, then using the services of the PM Gdansk NVP the house will decrease 180,227 million rubles;

– the effectiveness of the development of the own logistics complex of the Nivensky GOK has been proved, the net reduced effect from the formation of which will amount to 298,284 million rubles. In the work, the economic effect is defined as the difference between the economic results of assessing the implementation of alternative options for the development of the enterprise's logistics complex. In terms of economic indicators, the development of its own logistics complex at Nivensky GOK is more attractive for K-Potash Service LLC, where the difference between NPV indicators for a 34-year calculation period was RUB 118,057 million.

Summing up the results of the study, it should be noted that the use of the formed scientific and practical approach will allow the company's management to more reasonably evaluate the measures for the creation and development of its own logistics complex, taking into account possible micro- and macroeconomic factors of influence from the internal and external environment.

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ON IMPROVING OF THE RECRUITMENT SYSTEM WITH THE USE OF DIGITAL TECHNOLOGIES (CASE STUDY OF RN-BASHNIPINEFT LLC)

Personnel is a special feature of the research and design institutes of the oil industry, which are part of the corporate research and design complex of PJSC Rosneft Oil Company. In order to perform tasks under specific types of activities, highly qualified and highly specialized employees are required. To date, closing unique and complex vacancies takes from one month to several months. The difficulty consists in the fact that employers make high demands and the applicants themselves may have high expectations. In addition to this, there may be very few available specialists in the market who would be suitable for the position needed by the company, and on the contrary, there are a lot of competitors-recruiters. In such cases, it is necessary to increase the coverage funnel and IT.

The work considers the current trends for improvement of the recruitment system in Russia and abroad. The analysis of the market of foreign and Russian recruitment systems, performed in the work, allowed us to draw the following main conclusions:

– it is necessary to develop in the direction of automation, robotization and digitalization of recruiting, cognitive recruitment and HR branding [2];

– many companies automate the selection process and use chatbots for the initial screening of candidates [2];

– pursuant to the results of research, in Russia there is a maximum involvement of HR specialists in most stages of recruiting, while in the world there is a wide automation of its initial stages [1];

– according to experts' assessment, the recruitment function of most Russian companies is in the stage of standardized operative recruitment (2nd level of maturity out of 4) [1].

In 2020, organizations faced the need to be able to adapt the recruitment system to the remote mode. Offices around the world have been transferred to the remote operation mode, and the function of personnel selection has also gone online. In accordance with the current conditions, the advantages of remote work of the recruiter, combined with digital recruiting elements for remote work, were highlighted.

Due to the current economic situation in Russia and in the world, companies are forced to develop and move to more advanced levels of maturity. The ability to use modern digital technologies in the current environment is one of the most valuable competencies of a recruiter today [3].

The proposed “Boolean search” technology for searching to the specified parameters on the internet, gives more relevant results, saving the recruiter from viewing an extra hundred pages. Combined with the search on not so popular sites for employee search, such as social networks, professional communities, messengers, etc., Boolean search will be an advantage in searching for a unique specialist. Boolean search implies that the employer sets the task - in a certain market segment, to find a candidate meeting certain parameters (his qualifications, professionalism, motivation for further development, personal qualities, etc.) and to determine the most suitable one. The technology makes it possible to combine phrases and words using Boolean operators — NOT, OR, AND. Boolean operators allow you thereby to both limit and expand the framework of search queries.

This search technology has its own peculiarities, such as the recruiter’s knowledge of the Boolean query technology, coordination with the security service to gain access to other search channels, or the need to pay for premium access to the job database of new sites. However, free time appears for the recruiter. The specialist finds time for other, equally important tasks, such as conducting interviews, closing other vacancies, or analyzing the labor market. The reach and quality of candidates increases. As a result, the specialist finds not just suitable, but really the best candidates for both managerial positions and specialists’ positions. Production receives labor on time and increases production efficiency, which undoubtedly leads to an increase in the company’s profit [3].

Boolean search is extremely effective in collaboration with an automated personnel accounting system. In September 2020, an automated personnel accounting system was purchased for RN-BashNIPIneft LLC. This software structures and automates business processes in the HR department, is a powerful optimization tool that allows you to significantly increase the efficiency of employees and reduce the costs of the enterprise. An analysis of the recruiter’s work activity over the past 6 months showed that the recruiter began to save up to 40% of the working time for closing a vacancy.

Currently, there is a great interest in the digital sphere and modern digital tools in Russia, as well as in their implementation in the field of recruitment. A large selection of services offered in the market opens up completely new opportunities for the employer to increase business efficiency and reduce time and financial costs. At the same time, among the many tools, it is very important to select the tools that are most suitable for solving the tasks facing the company.

In the course of this research, the developed algorithm was tested on the example of RN-BashNIPIneft LLC. The Company’s local internal regulations governing the recruitment of personnel have been studied. The stages of closing a vacancy have been reviewed and the prerequisites for improving the recruitment system have been identified.

Based on the results of the performed analysis, a preferred strategy for the development of the recruitment system has been formed both for RN-BashNIPIneft LLC and for the other 28 corporate research and design institutes of PJSC Rosneft Oil Company. By implementing the recommended strategy, the CRDIs of the CRDC of PJSC Rosneft Oil Company will be able to significantly reduce the time for closing of vacancies, and, consequently, increase the efficiency of their work by more than 40% (based on the experience of RN-BashNIPIneft LLC), and the 28 CRDIs will save ~ 19.5 million rubles

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INCREASING THE EFFICIENCY OF SCENARIO SIMULATION IN PROJECT MANAGEMENT IN THE CASE OF MINING ENTERPRISES

Scenario modeling one of the most popular way to solve production problems. Its advantage lies in the possibility of optimizing the system before its practical implementation [1]. When preparing investment competencies of specialists, methods of analytical modeling are most often limited (analysis of indicators, building tables, deterministic or regression models, most often Excel methods). With the development of digital technologies, it became possible to use simulation modeling (hereinafter - SM), that is, "dynamic", in cases where an analytical solution does not exist or requires excessive labor costs [14]. The main advantage of the simulation model is that it takes into account the "expanding" behavior, allows an unlimited number of scenario tests (experiments) during the model runs [4]. Dynamic model makes managerial decisions easier, especially when input parameters suddenly change, which increases the quality of the developed plan for the implementation of an investment project by reducing uncertainties and risk [13].

A review of literature sources showed an increasing interest in solving practical problems, while the number of scientific works devoted to the development of methods for using SM to increase economic efficiency in the production management process is little or outdated [1, 2, 8]. This means that scientific research is required to analyze all new knowledge that is being generated by practical solutions. Our research therefore is based on a practical study in Mining University, directed to confirm the planned productivity (calculated analytically) of the anhydrite mine development with a service life of 30 years.

Preliminary analysis show that the final look of the model, its main functions and the degree of elaboration of the details depends on the goal. At the initial stage of building a simulation model, when the most general elements of the production process are specified, it allows for the identification of excess (or missing) equipment of transport equipment. This way, the most efficient numerical volume of the vehicle fleet is achieved, downtime is eliminated and thus productivity is increased. With further elaboration of the existing model, the range of possibilities for its application expands. More additional characteristics will open up an opportunity for the specialist to optimize the management of not only the fixed assets, but also the working capital. The subsequent development of the model and the number of input parameters is the calculation of a sudden breakdown or malfunction of any piece of equipment. At this level of detail, a specialist can not only predict in advance, but also prevent the consequences of industrial accidents already at the planning stage.

Greater detailing and the degree of model elaboration naturally requires more money and labor costs. The degree of model detail is selected from the characteristics of a specific project; it is necessary to clearly understand the purpose and object of simulation. At the same time, the development process of the model can be extended in time in such a way as to distribute the costs of its creation, starting with its effect already at the initial stages of work.

The process of introducing modeling tools into the production environment is currently an exclusively practical task without a sufficient scientific description, which allows us to talk

about the effectiveness of comparing analytical and simulation-scenario tools when managing investment projects of mining enterprises.

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LEGAL PROBLEMS OF ENERGY DEVELOPMENT IN CONNECTION WITH THE IMPLEMENTATION OF THE GREEN POLICY OF THE EUROPEAN UNION

In such a rapidly changing world, it is becoming evident that more and more attention is paid to the problems of climate change, in particular, climate legislation. The leadership of the European Union foresaw the need to legalize a set of measures to create developed environmental legislation that could reduce natural risks, social tension among citizens, and improve external economic conditions for its economy.

The Green Agenda is becoming one of the leading directions for the development of this integration association. Europe has an extensive regulatory framework and practice in terms of regulating climate policy. Since the adoption of the Paris Agreement in 2015 [1], replacing 1997 Kyoto Protocol, the EU has positioned itself as the most responsible leader in climate policy. For example, even within the framework of the Kyoto Protocol, the EU developed its own Emissions Trading System (EU ETS)[2], which was conceived as a key instrument for regulating and reducing greenhouse gas emissions in the context of combating climate change. In 2019, a new "Green Deal for Europe[3]" was adopted, which set the main goal for the EU to become the first continent to achieve climate neutrality by 2050.

To achieve its goals, the European Union intends to develop a variety of legal instruments and carry out reforms. Among the most relevant in the economic field, it is worth noting:

- reform of the Emissions Trading System;
- setting targets for countries in specific sectors (Effort Sharing Regulation);
- revision of the principles of forest and soil management (LULUCF) for CO2 adsorption;
- creation of the Carbon Border Adjustment Mechanism - setting import tax based on the carbon footprint of the imported product;
- reforming the directives on renewable energy and energy efficiency;
- revision of legislation on CO2 emissions in mechanical engineering and in the transport sector.

The Climate Agenda is an extensive list of measures to reduce greenhouse gas emissions as a result of anthropogenic impact. Climate legislation complements the sectoral legislative systems already existing in the EU, for example, legislation in the field of environmental protection, energy and industry, trade and transport, construction, agriculture, etc. Another important factor in the development of EU climate policy is international cooperation with countries and organizations, as the climate agenda has a transboundary character.

Regarding the renewal of existing international free trade agreements, the European Parliament has already voted to revise the provisions of the European Energy Charter [4], which protects investments in the most emitting industries. It can be said that in terms of free market and trade conditions, the EU is redefining customary rules, undermining the legitimacy of resource industries as such and their ability to be used as a comparative advantage for national economies. In this context, energy security and energy trade also remain important issues.

In view of the particularly severe consequences that climate change can cause for the economy, environmental management and participation in the international division of labor, the climate agenda is very important for Russia. After all, the climatic issue affects many components of the economy, especially the raw materials and energy sectors. It is important that the EU climate legislation is adequately represented in Russia, in the most objective and independent way. Indeed, in defining climate policy, Europe, obviously, is guided by its own interests and needs, which are not always correlated with the interests of its partners.

As a result, it should be noted that studying the EU experience in this area is useful for a number of reasons. First, the European Union has progressed further than many other countries

in developing and implementing climate policies. Secondly, it has a significant impact on other countries and regions, significantly determines the international regulation of the environmental agenda in the world. Third, the implementation of the stated goals is taking place against the background of the economic crisis, and how the EU can overcome it will be a useful experience for other countries.

It should be noted that the Russian side must be ready for a global restructuring of the economy. The gradual abandonment of burned fuel and a potential drop in demand for fossil resources can damage the national economy of Russia and change the situation on international markets.

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ALGORITHM FOR MAKING DECISIONS ON APG UTILIZATION (USING THE EXAMPLE OF THE MESSOYAKHA FIELDS)

Introduction. For a long time, oil and gas companies have been flaring associated petroleum gas (APG). So, in Russia for the period 2014-2017 the volume of APG flaring was kept at the level of 10 billion cubic meters. In 2018 and 2019 the volume of APG flaring doubled and reached 20 billion cubic meters. In 2019, the level of APG utilization in Russia was 82.9% [1]. However, APG flaring leads to economic and environmental consequences-it is accompanied by the release into the atmosphere of large amounts of carbon dioxide (CO_2), methane, as well as soot, benzapyrene and other components dangerous to the environment. The economic problem is that APG flaring is a waste of a valuable energy resource that can be used to support economic growth.

The choice between APG utilization and its flaring is not worth it for most oil and gas companies today - it has long been known that associated gas is a valuable resource. This is confirmed by the results in achieving APG utilization level of such companies as Surgutneftegaz (utilization rate - 99.6%), LUKOIL (97.6%), Tatneft (95.6%). Therefore, today companies focus on making a decision on the choice of a specific method for APG utilizing, focusing on the greatest economic effect and reducing the negative impact on the environment. With the development of technologies and the transformation of views on the development of the oil and gas sector, companies increasingly began to use methods for utilizing associated petroleum gas, which are part of the circular economy concept. The above defines the purpose of the scientific research – the creation of methodological tools for making decisions about the method of APG utilization at a particular field.

Main part . Associated petroleum gas (APG) is a mixture of gaseous hydrocarbons dissolved in oil, which are released during the production and preparation of oil. APG is a richer gas in composition than natural gas. This is due to the fact that in addition to methane and ethane, there is propane, butane and other hydrocarbons in the oil gas.

In the world practice today, the main methods of APG utilization are the following [2]: reinjection of APG into the reservoir, injection into the Unified Gas Supply System (UGSS), power generation, simple and deep conversion.

The study identified a number of criteria influencing the decision-making on the method of APG utilization, such as: the volume of APG production at the field; remoteness of the field from the Unified Gas Supply System; the volume of capital investments; period of technology implementation; applicability of technologies to the geological conditions of the field; economic benefits of technology implementation; prospects for the sale of commercial products obtained in the course of APG utilization.

On the basis of certain criteria influencing the choice of the APG utilization method, an algorithm was developed to make a decision on APG utilization at the field.

As an example, the method of APG utilization for the Messoyakha deposits was selected. Messoyakhaneftegaz is a joint venture of Gazprom Neft (the project operator) and Rosneft, which owns licenses for the exploration and development of the Messoyakhskoye field group [4].

In 2021, the company plans to commission several gas cycle infrastructure facilities at once. At the Vostochno-Messoyakhskoye field - a compressor station with a preliminary gas discharge unit with a capacity of 1.5 billion m^3 per year. At the Zapadno-Messoyakhskoye field there is an underground gas storage (UGS), where APG will be pumped until a decision on its further useful use is made. A 47-kilometer gas pipeline will connect these two key facilities.

Since the question of the useful use of APG for the Messoyakha deposits remains relevant, on the basis of the created algorithm for making a decision on APG utilization, the authors selected the most suitable APG utilization technology for the Messoyakha deposits.

Conclusion. Thus, the work identified environmental and economic problems of APG utilization by flaring it, collected data on the APG utilization methods used. An algorithm was drawn up for making a decision on the method of APG utilization at a specific field. In the final part of the study, recommendations are presented on the implementation of APG utilization technology at the Messoyakhskoye fields.

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DIGITALIZATION OF BUSINESS MODELS IN THE MINING INDUSTRY OF THE REPUBLIC OF BELARUS

The mining industry of the Republic of Belarus is one of the fundamental foundations for maintaining sustainable economic development, as it creates the necessary conditions for the development of other sectors of the economy by providing them with mineral, raw material, fuel and energy resources. The key enterprises of mineral resource complex of the Republic of Belarus are OJSC «Belaruskali», RUE «Belorusneft», OJSC «Belarusian Cement Plant» and others.

Undoubtedly, the priority tasks of the above-mentioned productions, as well as any others, are to increase efficiency through modernization of the technical, technological and organizational base. In the context of modern trends in the application of new industrial models, the need for digitalization of industrial enterprises as a method of increasing competitiveness is relevant. The creator of the new industrial model, K. M. Schwab, notes: «We are witnessing dramatic changes in all industries, which are marked by the birth of new business models, a disruptive impact on established traditional companies, as well as a radical transformation of production, consumption, transportation and supply systems» [1, p.5]. Technological changes are a part of the industrial model that changes not only all stages of production and product realization, but also requires the creation of new methods of business modeling.

Business model is a mechanism for organizing production, the purpose of which is to maximize profits, taking into account the initial resources and the specifics of the enterprise. That is, the improvement of business models can entail a change not only in the organizational structure of production, but also in the methodology of profit extraction. Digitalization of business models allows the simplification and acceleration of producer-consumer interactions through the automation of some processes and production functions.

To determine the structure of the business model it is necessary to take into account the specifics of the enterprise. So, the target vector of «Belorusneft» company development is «development of specialized software for automation of logistic processes» [2, p.363], since the specifics of this enterprise is transportation and delivery of oil products on regional and international level. Therefore, it is necessary to provide the process of forming a consumer order with a maximum automation, building transportation routes, accompanied by the automation of management functions, carried out with the help of digital technologies transport control systems and specialized software «Transport logistics». According to the company, the production department proposes to implement an automated system «Oil Supplies», which involves the accounting of goods at retail outlets (retail sale of goods), accounting for its own vehicles, transport logistics of petroleum products. Such innovations change the methods of relations between the participants and counterparties of the production network, which determines the transformation of the traditional business model of the company, transferring it to the digital level.

The development vector of the open joint stock company «Belaruskali» is also aimed at the structural automation of production, the coordination of the activities of the mine and other divisions of the company, as well as the export management system. Thus, «Internet trading without warehouse, based on direct delivery, is being introduced» [3, p.325], which indicates the transformation of traditional business model, as global information channels are formed through Internet trading, which can expand not only the range of counterparties, but also investors, i.e. implementation of such structure can give the opportunity to increase investment attractiveness of mining enterprises.

The possibility of digital transformation of mining enterprises is primarily based on the transformation of the management and command component, that is, the presence on the organizers' and teams' desire to create and improve ideas for quality modernization of production is a key factor. According to PricewaterhouseCoopers, only seven mining companies out of the global Top-40 have a technology director, an IT director and a digital technology director in their senior management. Thus, the vector of innovative development of Belaruskali JSC is directed by the «Department of Automation and Introduction of New Technologies», which employs a whole staff, which indicating a high degree of the interest of the company to have a competent management center that increases the competitive power of the enterprise through its authority. Thus, for the realization of priority goals of the development, mining enterprises «need to maintain a balance between the current goals of the enterprise (growth of capitalization, increase in profitability) and ensuring economic security in a long term» [4, p.21]. This also requires qualified managers with bilateral competence: «The successful solution of the set tasks involves updating the content of engineering training and economic profile with the position of creating more certain and effective competences in the field of economic security of enterprises» [4, c.21].

Based on the above, we can conclude that the digital transformation of the mining industry is a complex social challenge, as it requires agreements between all participants of the production network. The complexity of digitalization of business models is also due to a number of specific aspects, which are inherent to the industry in question. For example, the high degree of capital intensity and the little commensurable material and technical base of production cause inertia in the development of the organizational and managerial basis of business processes. The stages of implementation of digital technologies in the internal business processes of the company lead to the construction of external digital channels of market communication, which will allow domestic mining companies to conduct their activities in the wider information sphere and in this way attract more investors.

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EU CARBON TAX AND ITS IMPLICATIONS FOR RUSSIAN ENERGY SECTOR: LEGAL FRAMEWORK, WTO-RELATED ISSUES AND POSSIBLE SOLUTIONS FOR GOVERNMENT AND BUSINESSES

In 2019 the European Union adopted the EU Green Deal, a document which aims at making the EU economy climate neutral by 2050. In order to achieve this ambitious goal, among other measures, the EU is planning to impose a carbon tax on its imports. Oil and gas industry is one of the most carbon-intensive industries, and changes in the structure of the European market

are expected to be most significant for countries that export a significant part of their carbon-containing products to the EU. Russia could be one of the countries most affected by the adoption of the carbon tax, as the EU is its key export market. It is necessary to understand what type of legal framework may be introduced based on the propositions of the European Commission and the already existing European and international experience in regulating carbon emissions, the issues regarding WTO norms and possible measures that the government and businesses can take in order to prepare for the adoption of the carbon tax. The problem was addressed by various researchers such as M. Balashov, Ye. Motosova, D. Weisbach, Z. Zyarova, C. Damro, M. Mehling, J. Cendra and others.

The legislation related to the tax is still being developed. The European Commission has offered several possible mechanisms of taxation: border tax (a differentiated taxation system depending on the industry of the importer and the intensity of carbon emissions of imported goods), adding importers to the EU Emissions Trading System (EU ETS) and allowing them to buy quotas in the same way European producers do, or adopting a unified carbon VAT for all manufacturers of carbon products, both foreign and domestic.

In recent years, several countries have adopted measures to reduce carbon emissions using emissions trading systems (ETS) and carbon taxes. Finland was the first country in the world to introduce a carbon tax. Since then, 16 European countries have followed suit. However, there is not a unified approach in EU countries towards what carbon tax should look like. Tax rates in different countries vary significantly, ranging from less than 1 euro per tonne of carbon emissions in Poland to more than 100 euros in Sweden. Neither is there a single approach towards what types of greenhouse gases carbon taxes can be levied on. Some countries impose tax on almost all types of greenhouse gases, while others tax just a small number of them. One may come to a conclusion that in such a situation adopting a unifying measure at the EU level may be appropriate. In December 2015, about 200 countries signed the Paris Agreement, aimed at reducing carbon emissions due to global warming. The Paris Agreement does not set standards for reducing emissions, and each country sets its own goals. Countries in the world most often use emissions trading systems or carbon taxes as key measures to encourage carbon reduction. These two instruments are not mutually exclusive and, in some jurisdictions, both are applied simultaneously (for example, in Mexico, some provinces of Canada, Finland, Sweden, Norway, Denmark, Iceland, and a number of other European countries) [1]. However, existing initiatives cover only 22% of the world's greenhouse gas emissions, and the cost of emissions is still too low to meet the goals of the Paris Agreement.

The emissions trading system includes emission limits for certain industries. In these industries, companies must obtain a permit for each unit of emissions. The EU emissions trading system, launched in 2005, is the first and by far the largest in terms of coverage (about 4% of global greenhouse gas). This system can be considered quite effective: in 2018, greenhouse gas emissions in the covered sectors decreased by 29% compared to 2005; the goal is to reduce them by 43% by 2030 compared to 2005. However, the effectiveness of ETS in terms of limiting carbon emissions is still limited. It helps to set clear emission limits, but the price of carbon emissions is not fixed and depends on the demand for quotas: when demand is low (for example, during a crisis), the cost of quotas will be low, and the ETS will not provide enough incentive to reduce emissions. Creating a reserve can reduce the volatility of emissions prices by allowing the state to buy quotas, stabilizing prices when demand is low. On the other hand, a carbon tax assumes a rate set by the government per unit of emissions or per unit of emissions exceeding the limits. Unlike the ETS, the tax sets a fixed price on carbon emissions, but does not guarantee a certain level of emissions. The carbon tax offers stable carbon prices, so energy producers and entrepreneurs can make investment decisions without fear of fluctuating regulatory costs. [2] The EU emissions trading system is the cornerstone of the EU's climate change policy and its key tool for cost-effective reduction of greenhouse gas emissions. It limits emissions from more than 11,000 high-capacity energy-consuming plants (power plants and industrial plants) and airlines operating between these countries. The system covers power generation and heat-intensive

industries, including oil refineries, steel mills, and the production of cast iron, aluminum, cement, glass, ceramics, paper, cardboard, acids, and organic chemicals. Participation in the ETS is mandatory for companies operating in these sectors (with some exceptions). It operates according to the “cap and trade” principle, when the limit is set on the total amount of certain greenhouse gases that can be emitted by the installations that are part of the system. Within the limit, companies receive or buy emission quotas, which they can exchange with each other as needed. It offers flexible approach that may guarantee the reduction of emissions where it is least expensive.

In addition, the new tax must comply with the requirements of the World Trade Organization. The tax may be interpreted as a protectionist tool which is not in accordance with the WTO rules principles (in particular, the most-favored-nation principle, as well as tariff bindings, national treatment principle, a ban on quantitative import restrictions) [3]. However, there are some possible objections to the claim that the carbon tax does not comply with the GATT rules. There are competition-related objections (one can think of the tax as a measure that is "equalizing the game", since EU producers already pay carbon taxes, while importers do not) (there are exceptions in favor of this in Articles 2 and 3 of the GATT), environmental objections (Article 20 of the GATT provides for abatement of emissions or encouraging other countries or foreign producers to reduce emissions, provided that the import adjustment is a measure "necessary to protect the life or health of humans, animals or plants" (Article XX (b) of the GATT) or "relevant to the conservation of dwindling natural resources" (Article XX (g) of the GATT).

To conclude, the author would like to point out that the introduction of this tax is going to affect companies in various sectors of the economy in the EU and beyond. Given the size and significance of the European market, the tax will put even more pressure on companies and governments around the world, forcing more and more countries to take additional measures to limit emissions and develop their own legislation. There are various measures that government and businesses can take in order to prepare for this drastic upcoming change in the legal framework. Russian government may start negotiations with the EU to form a new trade agreement or to amend the existing ones, it may follow the example of other countries and start the process of developing domestic legislation regulating the issue, or it may try to challenge the new tax through the WTO mechanisms based on the considerations mentioned above. Russian energy companies may want to adjust their financial plans and develop an action algorithm in case that the tax is adopted, since they may suffer significant financial losses. It would also be wise to introduce the procedure of carbon footprint audit, modernize production facilities in accordance with modern standards, and to employ a more responsible approach towards carbon footprint neutralization [4].

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SUSTAINABLE DEVELOPMENT ECONOMICS AND GLOBAL INVESTMENT TRENDS

At present, in the current world economic system, traditionally aimed at economic growth, a vector aimed at solving social and environmental problems is more and more clearly traced. In this regard, within the framework of economic theory and practice, there is a constant search for various new approaches and measures to improve the economic situation in the world. The paradigm of sustainability, reflected in the packages of documents of UN conferences, which are key for the common future, was developed and supported by almost all world powers at the end of the last century. At present, the vector of sustainable development is being actively discussed by the international community, indicators of sustainable growth and their comparability are being analyzed.

The paradigm of sustainable development (also called the «model of the future of civilization») was formed at the end of the last century as a symmetrical response to the emerging threats, due to the global deterioration of the economic situation. This concept is aimed at changing the attitude of mankind to the investment environment, as well as improving the quality of life in conditions of economic growth. Of scientific interest is the study of sustainable development trends at various levels of economic systems (micro and macro), as well as the identification of its possible aspects and factors of influence, such as: the triad - environmental, social and economic, to which information, technological, legal and others. These aspects are in close interaction, and have a common goal - to improve the well-being of humanity in the context of long-term development.

The current state of the world economic system is characterized by a high level of turbulence, which has a negative impact on economic processes. All this leads to structural transformations and violations of market mechanisms, to transformations in the socio-economic sphere, and many others. etc. The uneven economic development of countries is observed, the negative consequences of the crisis phenomena occurring in Europe, the USA, etc. are obvious. The contradiction in the processes of globalization and regionalization is growing. These processes lead to an imbalance in the world economic system, namely: on the one hand, they complicate the processes of economic development, and on the other, they contribute to their growth. In this regard, it is necessary to understand which main global trends are currently determining the development of the world economy, which factors have the greatest impact on it in the context of sustainability.

The main trend in the development of modern civilization is the predominance of economic interests over various geopolitical contradictions. Against the background of the development of the above tendency, the formation of a multipolar world is observed. The main decisions in the framework of international legal issues of the economy of sustainable development are taken by the UN General Assembly. At present, according to experts, the authority of the UN is declining in the international arena, key decisions made by the UN by a number of countries have been repeatedly questioned, and sometimes even ignored [1].

The tendency of technologization - the development of neo-industrialization - has a significant impact on sustainable development. At the head of neo-industrialization are human resources and intellectual capital, as well as innovative networking, investment and computer technologies. Those states that are actively involved in the processes of technologization of their economies, creating and expanding all kinds of innovative cooperation in the form of clusters, technological platforms, etc., attracting investors, increase labor productivity, their business activity and, ultimately, competitiveness in the world economy. However, it should be remembered that with the growth of industry, the negative impact on the environmental component of sustainable economic development often grows.

At present, the IT-technologies industry is growing at a tremendous speed, including advanced developments in the development of artificial intelligence, additive technologies, etc., which cannot but affect the resilience indicators of countries [2]. As noted by analysts, in the near future the industry will undergo significant changes, this will affect the socio-ecological and economic indicators of the countries. The global impact of digitalization, which is rapidly penetrating all areas of the economy, creates a new platform of opportunities for both business and the life of the population.

At the head of this economy is the knowledge economy and information economy. The main features of the information economy are personalization and individualization of consumption. Thus, the digital economy on a global scale is becoming the most important driver of global economic growth. Experts predict various positive effects in the context of sustainability from technologization and digitalization of society:1. an increase in the quality of life of the population; 2. the emergence of innovative forms of doing business; 3.opportunities for monitoring activities due to transparency and high speed of data transfer; 4.growth in labor productivity; 5.cost optimization associated with simplifying the information transfer process, etc.

An important aspect of sustainable economic development is the quality of life of the population, despite the controversial nature of its concept in science. Its concept covers such parameters as life expectancy of the population, mortality, fertility, number of diseases, etc., as well as indicators of the education of the population, the possibility of obtaining high-quality affordable education, and finally, the creation of a comfortable living environment, including safety, environmental characteristics, etc.

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NEW REQUIREMENTS FOR THE QUALIFICATIONS OF LABOR RESOURCES AS A FACTOR OF MINING ENTERPRISES ECONOMIC SECURITY

The mining industry is a source of mineral resources and a base for almost all sectors of the economy. Extraction and processing of minerals are traditionally considered as a source of foreign exchange earnings and budget receipts in the form of taxes or royalties in favor of the state. Frequently mining enterprises are city-forming enterprises. Respectively, the socio-economic development of individual regions depends on their effective functioning. As S. Yu. Solodovnikov remarked, «new challenges and threats to the national and economic security of the country can be promptly identified and neutralized only at the enterprise level» [1, p. 189]. Consequently, ensuring the economic security of mining enterprises is an integral part of ensuring the economic security of the country as a whole.

One of the ways to ensure the economic security of mining enterprises is to improve the skills of labor resources employed in this industry. Mining enterprises have special requirements for the professional skills and competencies of workers and engineering staff. It is caused by the specifics of working conditions, high professional risk and the need to manage specialized machinery and equipment. Consequently, mining companies often compete for experienced workers.

The digital transformation of the industry places new demands on the skills of workers. According to McKinsey Global Survey, digital transformations are even more difficult than traditional change efforts to pull off. Only 16 percent of respondents say their organizations' digital transformations have successfully improved performance and also equipped them to sustain changes in the long term. An additional 7 percent say that performance improved but that those improvements were not sustained [2]. Metals and mining companies are investing in digital technologies across the value chain, from operations to procurement, sales and marketing. Unfortunately, many of these investments have fallen far short of their potential. According to BCG's Digital Acceleration Index (DAI), the metals and mining industry is roughly 30% to 40% less digitally mature than comparable industries, such as automotive or chemicals [3]. On one level, it isn't surprising that so many metals and mining companies struggle to implement digital transformations. Their workforces tend to be blue-collar and are often less familiar with digital solutions than in other industries; they frequently operate in remote locations with poor network bandwidth and where the rugged terrain makes deploying digital sensors difficult. There also can be cultural resistance to incorporating digital into processes that have been established for more than a century—automation that could lead to workforce redundancies. However, it is important to understand that digitalization doesn't directly lead to a reduction in the number of workers. It causes a change in the structure of employment, including the emergence of new professions. Key factors of successful digital transformation include: having a digital-savvy leader in the management team, investment in digital talents, setting cross-functional or enterprise-wide hiring goals based on specific skill needs, giving employees a say on where digitization could and should be adopted, continuous learning or open work environments.

Although the mining industry didn't cease operation during the pandemic, companies had to adapt to the new environment and change the way they operate. The main changes include scheduling of remote work and an increase in the level of automation of work processes. Much of what was implemented spontaneously in the current situation will be preserved and will be used on an ongoing basis in the future. At the same time uncertainty about the long-term effect of the consequences of the pandemic remains and makes companies prepare their strategies for unexpected risks. The pandemic has demonstrated that automation and digitalization of operations can reduce costs and improve production efficiency.

Digitalization creates the preconditions for deskilling – a process by which skilled labor within an industry or economy is eliminated by the introduction of technologies operated by semi- or unskilled workers. As a rule, when enterprises carry out automation, workers who previously performed operations by hand have a better understanding of the technological process than operators who have only theoretical knowledge of manual production. Accordingly, this factor negatively affects the economic security of the enterprise.

Cybersecurity should be considered as one of the areas of ensuring the economic security of an enterprise. Despite the economic damage from cyber attacks, only 12% of mining executives expressed concern about cyber threats. At the same time, over the past three years, the number of registered cases of data leakage in mining companies has increased four times [4]. The rapid spread of cyber threats in the mining industry is primarily due to the active informatization of technological processes. However, in the mining sector, there is a problem of division of areas of responsibility for information security and security of technological processes. As a rule, the protection of such processes isn't within the competence of the head of the information security service or the IT department. It leads to the blurring of priorities, the emergence of deficiencies in the information environment. Thus, it seems reasonable to improve the interaction between specialists of various functional departments, as well as expand the area of their professional knowledge in order to minimize threats to the external environment and solve complex cybersecurity problems.

The mining industry can be considered as a driver of the socio-economic development of the state because it provides other sectors of the economy with different mineral raw materials.

Accordingly, ensuring the economic security of enterprises in this industry is an important area of ensuring the economic security of the country as a whole.

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BUSINESS MODEL INNOVATION CANVAS FOR BELARUSIAN CHEMICAL INDUSTRY

Introduction. Chemical Industries are the prime factors to convert the raw materials into desired products that we use in our day-to-day life. This has brought a tremendous change in the way the things operate. It is very important for us to understand the importance of the chemical industry which has touched all our facets of life like Agriculture, Environment, Food, Hygiene, Transportation, etc. [1] The purpose of this report is to give some insight into JSC Mogilevkhimvolokno, focusing on some particular aspects of the development of innovative products. It contains the overview of the investment project which is to be implemented by the Company. In particular, the brief description of the innovative product is given. In conclusion, the economic effectiveness of the project is assessed.

Body. For over 50 years Joint Stock Company Mogilevkhimvolokno has been keeping its stable positions among leading manufacturers of polyester products. Its aim is to meet the demands of our customers while maintaining safe working conditions and reducing environmental impact.

JSC Mogilevkhimvolokno is an investment-attractive enterprise due to the availability of production territory located on the area of the free economic zone “Mogilev” with special tax regulations, developed utilities and transport infrastructure, highly experienced personnel, own power generating facilities, and large production areas. All that create attractive conditions for carrying out new production plants [2].

It is proposed that JSC Mogilevkhimvolokno to implement a project on developing hollow conjugated polyester fibres (HCS), the product which is innovative for European market. As a result of globalisation, working with international clients, customers and partners is more important than ever.

The three dimensional crimp, combined with the hollow, gives superior resilience and insulates the final product. Hollow conjugated polyester fibres are widely used in a number of applications.

It is mainly utilised for the production of nonwovens and for filling textiles (pillows, soft chairs, etc.).

Currently, in the sector of fibers of the 'conjugate' type, the most widespread fibers are 3 den, 7 den, and 15 den [3].

According to the Chemicals, Polymers and Fibres Research by PCI Wood Mackenzie (the UK), the consumption of polyester fibers will reach 300 thousand tons per year in the EU countries by 2025. According to the survey, the manufacturers in the Baltic countries import about 20 thousand tons of this type of fiber annually.

The main consumers of polyester fiber 'conjugate' in the EU countries are manufacturers of bulky nonwovens and quilted products, etc.

The potential competitors of JSC Mogilevkhimvolokno are some Asian manufacturers that produce relatively comparable types of fibers. Furthermore, one of the largest producers of polyester fibres is Sasa Polyester Sanayi AS (Turkey), the production capacity of which amounts up to 160 thousand tons per year.

During the analyses of competitors, it has been concluded that JSC Mogilevkhimvolokno has got more advantages among the competitors. The Company is distinguished by high quality products, its own raw material base, absence of customs barriers, as well as lower costs of logistic components (such as transportation costs). However, the Company needs to increase its production capacity since it is significantly less than the same indicator for the competitors.

To analyse the attractiveness of this project, it is necessary to determine its economic indicators and the effectiveness of investments.

Table 3.5 shows the economic indicators of the investment project.

Table 3.5 – Economic indicators of investment project

No.	Economic indicator	Value
1	NPV	65,570
2	IRR	10 %
3	PB	5.9
4	PI	1.17

Source: Business Plan of JSC Mogilevkhimvolokno

Based on the economic indicators presented in Table 3.5, it has been identified that the payback period for this project amounts to 5.9 years, the return on investment for the project is 117 %, and the internal rate of return is 10 %. The net operating profit (NPV) is positive; the income of the project will cover the required investment costs within 6 years.

The model has been proved to be reliable and cost-effective with the projected production volumes, tariffs and production costs. The applying of this project creates favorable prospects for the development of the enterprise.

Conclusion. The analysis undertaken has proven that this investment project is cost-effective and its implementation is expedient. The implementation of this project will open great possibilities for the development of both the enterprise and the country's economy.

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CARBON CAPTURE, UTILIZATION AND STORAGE: PROSPECTS IN A CIRCULAR ECONOMY

Today, developing and scaling out CC(U)S technologies seems to be one of the most realistic ways to reduce the concentration of carbon dioxide (CO2) in the atmosphere. The scale of emission reduction achieved by these technologies depends on how much CO2 is captured and what happens to it next. After being captured, CO2 can be injected into deep geological formations for permanent storage – CCS (carbon capture and storage). CO2 can be used to produce marketable and valuable products – CCU (carbon capture and utilization). Technologies in which CO2 is both utilized and stored are called CCUS (carbon capture, utilization and storage) technologies.

CC(U)S initiatives are already being developed and scaled out, but their growth rate is low. CCS initiatives and EOR-CO2 projects are the ones that are predominantly implemented. In 2020, there were 26 operating CCS facilities in the world, while CO2 utilization technologies are still in the early stages of development. As circular economy principles are becoming part of industrial processes, the role of CO2 is changing; it is now considered to be a valuable resource rather than industrial waste. CCU technologies correspond to the principles of a circular economy, which makes it vitally important to make them widespread. Thus, the aim of this research is to study and assess the current state of and the prospects for CC(U)S technologies in a circular economy and also to present a case study of a CO2-based methanol production project.

By now, around 50 CO2 utilization technologies have been developed. The key features of the main CO2 utilization applications were analyzed, including development level, emission reduction method, size of potential market and etc. Predictive estimates for their development were provided. Despite the importance of CCU technologies for making a transition towards a circular economy, it is expected that the market for CO2-based products and services will remain small in the short term [2]. The main barriers to market expansion are strict production standards and regulations as well as serious price competition. The price is influenced by the insufficient development of related technologies that could reduce production costs and the lack of incentive to pay extra for environmentally friendly products. Long-term growth prospects for the CO2 market are difficult to quantify as most technologies are still being developed. Analyze of forecasts of emission reduction volumes was carried out and it was revealed that, according to the most positive forecast, CO2 utilization will amount to 7 million tons per year, which is 22% of today's energy-related CO2 emissions [1,2,3].

Commercial projects for converting CO2 into valuable products are just starting to emerge. To understand the economic aspects of full-scale project implementation in the CCU sector, efficiency indicators for the world's first commercial CO2-to-methanol production at the Svartsengi geothermal power plant in Iceland were calculated. The project's key indicators for a period of 20 years at a discount rate of 8% show that scaling CCU technologies out is quite promising. NPV is equal to 5.6 billion USD, and PI is high (1.66). With an IRR of 14% and payback period 123 months, the project is considered to be economically efficient.

A sensitivity analysis of the project was also carried out. It was concluded that the profitability of the project is limited mainly due to the volume of production. The limitation of 4,000 t stems from the experimental nature of the project; the volume can be increased to achieve economy of scale. It was also revealed that the project is highly sensitive to the cost of hydrogen production. The price of hydrogen directly depends on the cost of electricity. Iceland is one of the most attractive countries in terms of renewable energy prices.

Using the example of a real methanol production facility in Iceland, we can conclude that the product with an estimated cost of 680 $/t cannot compete with methanol produced from fossil fuels (290 $/t in 2020 [4]). It is assumed that with the development and expansion of renewable

energy technologies, the price of electricity will decrease, which in the future may reduce the cost of hydrogen production, and, consequently, that of "green" methanol. Despite the fact that there is a market where buyers are willing to pay more for low-carbon materials, competition will prevent these products from gaining a wide market share. Considering also the innovativeness of the technology, and the limited range of territories available for construction, a project with such characteristics may seem unattractive to private investors. Consequently, it is the government that should undertake to develop and scale CC(U)S technologies out by creating a favorable economic climate, regulating carbon taxes, and financially supporting new projects.

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SPECIAL ASPECTS OF WASTE-FREE BUSINESS PROCESSES IN THE CONDITIONS OF GREEN AND CIRCULAR ECONOMY

Among the various points of view of scientists on the essence of the green economy, we follow the vision of it as a science that studies various approaches to economic activity, where economic growth is achieved through the rational use of various types of resources to reduce emissions of greenhouse gases and pollutants, as well as through increasing the importance of human capital (knowledge, innovation, creativity, culture).

The circular economy is one of the areas of the green economy, offering the state and business modern approaches to increasing resource efficiency, achieving social effect in the consumption of goods, in particular, through expanded producer responsibility, as well as reducing the environmental impact of production and manufactured goods. The concept of a circular economy is a practical basis for the implementation of a green economy and provides business processes to ensure a more environmentally friendly resource use by achieving the goals of sustainable development of society. The transition to a circular economy is a tremendous opportunity to transform the economy and make it more stable, contribute to the achievement of climate goals, conserve world resources, create new jobs and competitive advantages for the countries implementing circular economy [1].

We adhere to the basic postulates, strengths and possibilities of ideological, economic and evolutionary approaches in relation to one of the main areas of the green and circular economy – the use of wastes to ensure the environmental safety of enterprises in the Republic of Belarus that harm the environment.

Currently, all the efforts of the state in the field of waste management are aimed at an alternative to waste disposal. Possible options for waste management that have developed by this time are prevention or reduction of waste generation, reuse of waste, recycling waste to obtain materials or energy [2].

Based on the above, the purpose of the study is to substantiate and study the possibilities of business processes to ensure waste-free production.

A condition for introducing the concept of a circular economy is the necessity to reorganize business processes related to material resource management, which raises the question of rethinking the value chain. Researchers Anders Wijkman, Kristian Skanberg noted an important feature: in an economic system of a linear type, waste is taken into account in physical terms (tons, cubic meters, etc.), at the microeconomic level, their consumer value is assumed to be zero, since consumer properties are completely extracted, and in the remaining mass of material resources there is no utility left.

A look at the use of waste in business processes allows us to assert that the cost of waste is determined according to the data of enterprises that accept waste for neutralization and disposal, and is defined as the total cost of their neutralization, disposal and storage at the landfill. However, with the introduction of circular economy practices, the situation changes radically. At the enterprise there is an opportunity to use not only primary, but also secondary material resources, while there is an opportunity to choose which resources to use at each stage of the production cycle, depending on the existing technology [3].

Comparison of the cost of primary and secondary resources forms not only a stable demand for secondary raw materials, but also “the price ratio between primary and secondary resources in the market” [4]. As a result of ineffective organization of business processes, waste exists with zero cost. As a result of the introduction of circular principles, waste begins to be accounted at the micro level according the cost of replacing primary resources, and at the macro level – according the cost of lost opportunities from under-production. However, if we consider waste-free business processes in the long term, then “the increase in the cost of primary resources creates incentives for the enterprise to use cheaper secondary raw materials and to additional investment in the process of recycling material resources” [4].

The study also examines the prerequisites and opportunities for the introduction of green technologies into technological processes in such spheres of production as textile, clothing and footwear industry, agriculture and forestry, building materials industry.

The study of the possibility of waste-free production in the implementation of circular economy approaches allows, in the context of the reorganization of business processes, to obtain the following advantages: investing in the process of recycling material resources, improving the environmental situation.

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TRANSITION TO LOW-CARBON FUELS FOR OIL AND GAS TRANSPORTATION BY SEA AND ITS IMPACT ON REDUCING GREENHOUSE GAS EMISSIONS

The International Maritime Organization has set goals for decarbonizing shipping by 2050. The global COVID-19 pandemic and the associated economic downturn, and the regulatory and incentive measures adopted in various countries, have increased the awareness that the oil and gas industry needs to change towards decarbonization. In the period from 2019 to 2021. oil and gas companies (BP, Shell, Total, Equinor, ENI, Repsol, etc.) have started setting emission reduction targets, including zero targets for direct GHG emissions from companies 'operations and indirect emissions related to companies' energy supply, as well as greenhouse gas emissions related to the use of oil and gas companies ' products and methane emissions. Alternative to other fuels that can be considered as an alternative for shipping in the long term: liquefied natural gas, ammonia, hydrogen, methanol, electricity. Dutch company Shell (Shell Tankers (Singapore) Private Ltd) has signed a number of contracts, chartering 10 dual-fuel oil tankers of the Aframax class, which use LNG, from Sinokor Petrochemical Co Ltd, which, in turn, plans to receive them from Samsung Heavy Industries in South Korea in 2021. The International Maritime Organization considers ammonia as one of the most likely zero-emission fuels in the future. Ammonia is a compound of nitrogen and hydrogen. Although ammonia is widely distributed in nature, it is a caustic and dangerous compound in its concentrated form. Ammonia gorenje does not contain carbon, however, for its combustion requires a special fuel. Ammonia tankers are not yet used, however, an Aframax-class oil tanker with an ammonia engine is already being developed. This vessel is being constructed as part of a multinational project led by Samsung Heavy Industries. It has already received basic certification from Lloyd's Register, the Maritime Classification Society (London).

A similar development is being carried out by Hyundai Mipo Dockyard. Since October 2019, the shipbuilder has been working on a project to create an ammonia-based power plant together with Lloyd's Register and German engine manufacturer MAN Energy Solutions. As part of the project, Hyundai Mipo Dockyard is responsible for the basic design, and MAN Energy Solutions is responsible for the development and technical characteristics of the dual — fuel ammonia engine. Hydrogen. Hydrogen fuel cells for tankers, as well as ammonia, are still in the development stage of the technology. South Korean shipbuilding company Samsung Heavy Industries and American solid oxide fuel cell manufacturer Bloom Energy have signed an agreement to jointly develop fuel cell vessels. Fuel cell tankers are environmentally friendly due to the fact that oil-fueled generators have been replaced with solid oxide fuel cells (SOFC), LNG is used as fuel, energy efficiency has been improved and GHG emissions have been significantly reduced. If you use fuel cells on Aframax class tankers, where 3 MW generator engines are installed, then greenhouse gas emissions will decrease Methanol. The use of methanol on tankers is considered as a commercial technology. Already today, 21 tankers are operating on methanol. The first designed vessels of this type are equipped with dual-fuel engines on methanol produced by MAN and ME - LGI. The use of fully electric vessels is currently restricted. Only ferries and short-distance vessels are equipped with fully electric motors. The mass installation of electric motors on tankers is still hindered by the size of the batteries, as well as their cost. However, according to DNV GL Alternative Fuels Insight, in 2019, hybrid installations were already installed on two tankers, and three more vessels were in the process of being built. The cost of switching to low-carbon bunkering fuels varies greatly depending on the type of fuel. In 2020, fuel oil and LNG were the cheapest, and due to the greater energy intensity,

LNG was cheaper than fuel oil, the difference was 3.5% per 1 ton of fuel oil equivalent. The most expensive alternative was considered to be hydrogen, however, hydrogen tankers are at the design stage, and the estimates given are very approximate.

The plans of international oil and gas companies include a whole process of deep decarbonization, which includes the introduction of technologies for the capture, utilization and storage (burial) of carbon and the use of hydrogen as fuel. The relevant projects in Europe, the United States, and the Middle East are at various stages of development and implementation, but so far they are completely dependent on large government subsidies. To date, the total capacity of the Carbon Capture, Utilization, and Storage (CCUS) projects is only 10 Mt of CO2, although by 2050, in scenarios that meet the goals of the Paris Agreement, by 2050, the storage of CO2 in volume terms should reach 4.6 Gt of CO2-eq. This is comparable to the scale of the entire existing global oil and gas industry and opens up huge opportunities for the development of a new business line that uses the core competencies of oil and gas companies. It would be appropriate for regulators to develop a climate strategy with more ambitious climate goals and a comprehensive strategy to reduce greenhouse gas emissions in the oil and gas sector (including a strategy to reduce methane emissions). It can include a variety of regulatory mechanisms – standards, goals, requirements for monitoring, reporting and pricing of greenhouse gas emissions, rules for certification and verification of projects to reduce emissions, etc. It is also important to approve public funding for R & D and pilot projects to reduce GHG emissions, especially in the area of deep decarbonization. Corporations should include decarbonization in their overall business strategy and investment plans, rather than limiting it to the departments of health, safety and environmental protection and investor relations. To implement an effective decarbonization strategy, any company needs to review its overall strategy and corporate governance.

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CLIMATE RELEVANT FINANCIAL PERFORMANCE INDICATORS FOR CLIMATE-SMART MINING

With the advent of the fourth industrial revolution in 2011, the mining industry radically changed its traditional and conservative mindset and has been gradually implementing new technologies for the benefit of society. Nowadays, the Mine 4.0 is mainly focused on efficiency, productivity and safety while taking care of the environment, typically known as sustainable mining [1]. This approach aims to take profit from mineral resources, sustainability exploited, in order to help develop the world's economy and fight climate change. However, in current times amidst the pandemic, social challenges in vogue such as the Social License to Operate (SLO) and new mobility trends and consumption patterns have raised a more rooted and understood awareness toward climate change [2]. These new trends nudge the mining sector to adapt its

operations across the entire lifecycle to move accordingly and adopt innovative and creative mining approaches in the near future. This is where “Climate-smart Mining” comes into play, a concept that was first coined in 2016 by the Spanish organization REMIO (Renewable Energy and Mining International Observatory) [3] and one year later recognized by the World Bank [4]. Climate-smart mining seeks to accelerate the energy transition to a low carbon society with sustainable, proactive and innovative models that foster responsible and traceable exploitation of mineral resources, thereby encouraging their rational use. Only by following this path will the mining industry be involved in other related sectors such as renewable energy and electromobility and have access to niche markets that promote social development.

Throughout the life of a mine, from mineral exploration to post-closure, high volumes of materials are moved, and vast amounts of energy (electricity and fuels) are required, which comprise up to 50% of the total in comminution stages in metal mining [5]. This electricity demand has been typically satisfied from fossil fuels whereby the carbon footprint of the mine increases. Notwithstanding, socio-economic changes are prompting mining companies to take measures to reduce their greenhouse gases (GHG) emissions, especially the Scope 2 and 3 emissions from upstream activities according to the GHG Protocol [6], which are most of the time overlooked in corporate reports. The objective of this research is to evaluate the potential of climate mining, taking a virtual copper mine as a case study.

The methodology consisted of an extensive desk review on the novel concept of climate mining followed by a review of classic financial indicators as well as development of other KPIs focused on the positive climate impact of climate mining. To start with, the case study was divided into two scenarios with slight modifications based on assumptions taken from the literature review. Whilst the fossil mine relies on non-renewable electricity from the grid to meet its energy demands, the climate mine is self-sufficient with renewable energies from solar panels installed on-site. To continue, both scenarios were evaluated from a classic financial perspective and compared by contrasting NPV, IRR, payback period and WACC values among other indicators. Then, an evaluation of CO2 emissions savings achieved with climate mining was analyzed by means of KPIs focused on CO2 equivalent emissions like carbon productivity, Levelized Savings of Energy and CO2, which were converted to value considering the WACC for each scenario. The results obtained show that the climate mine project has a NPV 3.6 times higher, a IRR 6% bigger, and an earlier payback compared to the fossil fuel mine. In terms of climate impact, the climate mine saves energy in 48.92 $/t Cu and the carbon footprint is reduced by 0.94 t CO2eq /t Cu.

To conclude, an innovative climatic approach of the mining operation of study has definitely added value to the project, resulting in a WACC of 4.8% in contrast to 6.48% of the fossil mine, hence increasing the value of the mine in 1019 $/t Cu and 19.7 t CO2/t Cu. This added value stems from the benefits of a climate product that not only reduces Scope 2 emissions but also generates a positive mining liability after closure, the solar plant. All in all, a climate mining approach will help fulfill a great number of the United Nations Sustainable Goals and targets related to climate change, and what is more, reduce the WACC of a mine project, meaning increased mineral reserves for its rational exploitation, thereby accelerating the energy transition to a low carbon society with low impact mining on climate.

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THE RELATIONSHIP BETWEEN SOCIAL AND ENVIRONMENTAL CAPITAL IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT GOALS

In view of current trends in society, such as globalisation, digitalisation, migration, the development of socially functional technologies, population growth and the unspoken liberal-market rule that economic growth is too fast and the resulting increase in production capacity for whatever reason, production is no longer sented to meet the needs of society to maintain its vitality and ensure reproduction, but to satisfy its consumption needs for the demonstration of the sign. Consumers spin the production machine, thereby increasing the consumption of the producer's resources as well. We find ourselves in a situation where "man himself is a threat to the planet and to humanity" [1, p. 168]. The result is a circle of overconsumption that selfishly destroys the environment. The key to the solution of this problem can be the Concept of sustainable development, because it addresses the three most important aspects of the development of society: human, economy, ecology. It is important to note that there is no single programme which can be accepted by all of society. In any case, because of the differences in economic systems or personalities of the subjects themselves, differences of opinion will be found among individuals. National interests and the level of accumulated social capital have to be taken into account. The success of the Sustainable Development Goals (SDGs) is not possible without a link between social and ecological capital, which have a direct impact on economic development, since the human factor currently has a significant influence on the deterioration or improvement of the ecological situation, which at this stage of society cannot be ignored.

The SDGs prioritizes the most important investments in social capital: improvement of the quality of education and availability of quality medicine. As S. Solodovnikov rightly points out, "however, education is the most important factor in accumulating social capital" [2, p. 35]. It contributes to the establishment of social ties, increases the degree of social activity. "One year increase in the term of education leads to the growth of social activity from 9% (dinner parties) to 14% (number of social projects)" [3, p. 117]. It can be argued that learning is one of the best ways to accumulate social capital, as there is the formation of common mental ties, as well as interests that increase the level of trust in society, form social organizations. But we should point out that individuals might not get a return on their investment in social capital, so the motivation to develop it will decrease. We should also note that education has the opposite effect. People with higher education (with few exceptions) are less likely to be religious and trade union members (Helliwell, Putnam (2007)), as trade union members are mostly from the working professions.

Education can qualitatively change community attitudes towards the environmental approach. Membership in various social movements will establish trust within them, increasing social capital. By informing society through lectures, specialised subjects and the training of a qualified and environmentally aware workforce. Skilled workers are able to reduce the burdens of human activity in terms of their own specialisation and to coordinate action to make the rest of the company's employees more environmentally friendly, also by creating social bonds of trust.

The specificity of social capital is that "its aggregate amount in society is not the sum of "social capitals" of all its subjects". [4, c. 52]. That is why it is necessary to increase education and awareness in the approach to the environmental problem of all participants of this or that social group.

Increasing the level of social capital will also reduce the destructive impact of social and functional technologies, a special case of which is fashion. First, it will reduce the pressure on the use of resources. Through fashion, society is subject to greater consumption of goods or services, most commonly in the form of light industrial goods. According to the concept of consumer society (J. Baudrillard, 1970; T. Veblen, 1899), consumption is one of the tools of "entry" into a new social class. Individuals consume more and more in order to create the appearance of well-being. There is an opinion that "people aspire to own fashionable things because they are made to think that fashionable things are always better and more beautiful than unfashionable things" [5, p. 119]. If the effect of fashion were to diminish, the consumption of intensively renewed goods would also diminish. Secondly, fashion for ecology as an element of socio-functional technology. The creation of a visible interest in the ecological situation increases the prestige of the producer, the state in society. But is it worth talking about environmentally friendly production in Zimbabwe, when in January 2013 the state budget was $217? The aspiration of the leading states to green their production facilities introduces a trend worldwide, but does not take into account the fact that many undeveloped states have production facilities from those very world-leading countries. They do not take into account budgetary constraints. In the pursuit of universal tolerance and the pursuit of supposedly well-intentioned goals, society only seeks to demonstrate. In reality, the Green technologies, if they are to be introduced and applied, rather than merely simulated for the sake of showing off their superiority, are costly innovations. In reality, many governments today are not prepared to spend their budgets and impose environmental restrictions, because that would mean limiting production and use of natural resources. Today, ecology is just another form of business, in which ecologization is just a means to promote products.

Thus, the subject factor is becoming increasingly important today. We find ourselves in a situation where the environment is no longer able to bear the strain imposed on it. Humanity is intensifying consumption due to natural processes in society and under the influence of socially functional technologies (fashion), having a significant destructive impact on the environment. Increasing the level of social capital mainly through education is able to reduce the burden on the environment because the awareness of individuals is increased, social movements are created and the influence of social-functional technologies is reduced. The concept of achieving the goals of sustainable development is capable of evenly developing society in the three areas of human, economic and ecological development, while considering national interests. However, not all states are ready for ecologisation, as they do not have the necessary amount of money.

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ECONOMICS OF SUSTAINABILITY AND GLOBAL INVESTMENT TRENDS. PRINCIPLES OF CIRCULAR ECONOMY AND COST-EFFECTIVE USE OF RESOURCES

Interest in a circular economy is on the rise nowadays, and the eco-friendly way of living of today's people forces innovations to be focused in this direction. Moreover, in the era of climate change, ocean pollution and limited resources, humanity must exist in a more energy-efficient way. I chose this topic because the circular economy is today's trend, and it helps to tackle previously mentioned problems partly. Moreover, I think this topic is relevant due to its potential and low study level. However, in order to study the circular economy more, we have to understand what it is all about and how everything is working when we speak about the cost-effective use of resources. Therefore, many governments introduce a lot of documentation regarding the circular economy.

To start with, according to Ellen MacArthur Foundation, the circular economy may be defined as "a systemic approach to economic development designed to benefit businesses, society, and the environment. It is regenerative by design and aims to gradually decouple growth from the consumption of finite resources" [1].

The idea of circular economy is simple, wastes of one production are materials for another. Therefore, there are no materials that can be called wastes in a 100% efficient circular economy. This type of economy also implies goods to be durable and manufacturers to disassemble them for further recycling or reuse. Another principle is that the energy for production, recycle, disassembly, etc., would be obtained from renewable sources like sun, wind and waves [4]. University of Oxford, together with Saïd Business School, points out three principles of circular economy [3]:

1. Design pollution and waste out of the system
2. Keep material and products in use at optimal level
3. Build and restore natural capital and regenerate natural systems

There is no definite statement on the principles of the circular economy, but another set of them, according to sustainability for all, can be listed as follows [2]:

1. Waste becomes a resource: that's the core of the idea behind the circular economy. Materials that can be degraded quickly are returned in nature, and others are recycled or reused.
2. Second use: Goods may be used in another way if they do not meet consumer needs.
3. Reuse: working parts may be used in other goods in the future.
4. Reparation: if a part of a good is damaged, it should be possible to repair it.
5. Recycle: If a part of a good cannot be repaired, it must be recycled.
6. Valorization: If a part of a good cannot be reused, repaired or recycled, it should be used as a source of energy.
7. Functionality economy: goods should be rented rather than sold, and once it has completed its functions manufacturers gets it back to disassemble and repair, reuse or recycle.
8. Energy from renewable sources: this principle has been described before, and it implies moving away from hydrocarbons as sources of energy.
9. Eco-design: the product should be designed. In a way in which it would have the most negligible impact on the environment.
10. Industrial and territorial ecology: production process must be well organized to avoid having an excess of anything, from materials to time.

To sum up, it is essential to mention the importance and future impact of cost-effective use of resources. It is one of many steps that have to be made to neglect human greenhouse activity and increase our planet's life. More innovations and radical changes should be implemented in our lives if we want to give future generations a better place to live. "In the end,

the term ‘circularity’ may just be one way to make us aware that we need a more encompassing, integrated and restorative sustainability path that includes people as much as technology and nature.” ― Michiel Schwarz, A Sustainist Lexicon.

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THE ROLE OF BIG DATA AND DIGITAL ACCELERATION TO OVERCOME CIRCULAR ECONOMY CHALLENGES AND COST-EFFECTIVE USE OF RESOURCES IN OIL AND GAS INDUSTRY

Introduction. This presentation will explore the ways in which big data, data analytics and digital acceleration can address climate change - the Circular Carbon Economy and its 4Rs - reduce, reuse, recycle and remove - as an inclusive and balanced solution to address greenhouse gas emissions. Throughout this presentation it will be explained how the forces that pressure the oil industry are forcing the industry as a whole to define its new business imperatives where governments and oil and gas (O&G) companies are reimagining business models, business processes, and job descriptions enabled by the transformation drivers to achieve:

- Innovation beyond the barrel – energy outcome providers
- Products and service digitalization
- Ability to compete as an ecosystem
- Digital platform

Main Part. Despite the world's intention to move towards a carbon-neutral future, global fossil fuel demand continues to grow. The oil and gas industry is being challenged to meet the increased need for energy while simultaneously reducing overall emissions. Such scenarios call for practicable and convincing solutions to support the transition towards a low-carbon world. As digital technologies gradually permeate all activities in our societies, they have an ever-stronger impact on patterns of economic growth, social inclusion and environmental sustainability. In this changing landscape, energy efficiency is also changing, with new digital technologies enabling greater control, optimization and analytics. New policies and new business models will greatly enhance end-use and systems efficiency to guarantee a reliable and affordable supply of energy.

The oil and gas industry is committed to investing in new technologies to meet energy demand and the challenges of sustainability. The industry is investing heavily in the research and development of new technologies to improve efficiencies in operations. The industry is also at the forefront of creating the next-generation of advanced biofuels and large-scale offshore wind; developing and advancing renewable technologies from pilot project.

First part analyzes how O&G companies can decarbonize and how current technologies can address most of the O&G industry´s emissions. Second part introduce the participants to the

world of big data, data analytics and digital acceleration, while explaining why big data is considered the fourth paradigm of science. It will define with facts and data the characteristics of big data and the business models created from data analysis and technologies. The third part of this fact-based research will analyze the applications of circular carbon economy and its 4R in the O&G industry, with applications based on big data and digital acceleration.

Conclusion. This fact-based research is the result of the author's systemic approach to how O&G companies can decarbonize while using big data and taking advantage of digital acceleration in a way that can benefit businesses, society and the environment. In order to overcome the hard facts and data. The author will define along this presentation the priority actions to be implemented by the industry to guarantee the fulfillment of environmental commitments, take advantage of the digital acceleration and guarantee a sustainable continuity of the business development.

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JUSTIFICATION OF THE EFFECTIVENESS OF INVESTMENT ACTIVITIES IN THE FIELD OF ALTERNATIVE ENERGY SOURCES

The analysis of the global energy production and consumption market and the forecasts of many analytical companies indicate that the volume of oil production as a source of energy will steadily decline every year and, as a result, revenues and, consequently, the profits of oil companies will decrease.

The challenge of maintaining the profitability of oil companies requires the development of new investment solutions that would reduce the cost of oil production. A structural analysis of production costs for oil recovery shows that, with existing production technologies, electricity costs account for about 30 percent of all production costs.

At the same time, the promising fields of most oil companies are located in the northern zone of Russia, in particular, in the Nenets Autonomous Okrug, where there is no developed infrastructure and large power generating capacities, which excludes the possibility of reducing the cost of electricity from traditional sources.

An analysis of the map of potential regions for the use of renewable energy shows that a large territory of Russia is most suitable for the use of wind energy, and in particular, its northern part is those regions where it is planned to increase the volume of oil produced. The applying of modern wind turbines will make it possible to harness wind energy and use it for the production needs of the mining complex.

The wind power industry is starting to develop actively in Russia. The government, implementing orders for the construction of wind farms on a competitive basis, acts as an accelerator for the development of a new direction for the country's production of industrial-scale electricity. In addition, according to the Ministry of Energy of Russia, a significant increase in

energy production among renewable energy sources over the past 5 years has been accounted for by wind energy [4]. All this indicates a high probability of the emergence of new projects in the field of wind energy in the near future.

Thus, the implementation of an investment project in the field of wind energy in an oil company will not only allow to provide remote fields with the required amount of electricity, but will also lead to a decrease in the production cost of oil production. In addition, the implementation of a pilot project can serve as the beginning of the creation of a new business model with innovative technologies and related industries in the activities of oil companies, which will be reflected in an increase in their market value.

The environmental component of this project also plays an important role. The introduction of alternative energy sources will reduce the amount of natural resources burned and CO2 emissions into the atmosphere [5], which will have a positive impact on the oil company's reputation.

The purpose of the research work is to evaluate the effectiveness of investment activities to create a new business model in an oil company using the example of Joint Stock Oil Company Bashneft.

A subsidiary of Joint Stock Oil Company Bashneft, the oil production company «Bashneft'-Polius», was selected as the object of the study. In the course of this work, a feasibility study of Joint Stock Oil Company Bashneft was carried out, reserves for reducing the production cost of oil production were identified, electricity costs were estimated, and a map of the potential use of renewable energy sources, the state and prospects of wind power generation in Russia was reviewed. Based on the results of the analysis of the geographic location of promising deposits and their distance from the main production facilities of the country, as well as the cost of equipment, an assessment of the required level of investment in the project is given.

After calculating the required level of investment, an assessment of the effectiveness of investment activities was carried out using several methods: the method of discounting cash flows and the method of assessing economic value added (EVA) [1]. Based on the results of the assessment, the potential role of the introduction of alternative energy sources in increasing the market value of an oil company was determined and possible scenarios for the further development of such projects in the oil industry of the country as a whole.

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RARE EARTH INDUSTRIAL COMPLEXES IN RUSSIA: MECHANISMS FOR DEVELOPMENT

Currently, issues related to the development of rare earth industrial complexes are becoming particularly relevant for Russia. A success in the scientific and technological advance depends largely on the availability of these metals. Rare earths are successfully used in the production of catalysts, glass, metallurgical alloys, permanent magnets, etc. [1]. Recent trends related to the global energy transition have proved an overriding importance of these group of metals in a view of manufacturing of electric cars, li-ion batteries, wind turbines and other progressive «green» technologies [1-2]. The forecast estimates are indicative of an expected increase in the REM consumption at the side of Russian industries (electronics, aircraft industry, etc.). However, the country's position remains uncertain – on the one hand, Russia possesses huge amount of REM reserves, on the other hand, they are not exploited. The level of the REM import dependence exceeds 80% [4]. Rare earth projects are still considered to be ineffective from an economic standpoint. Therefore, providing the national economics with the required REM is a strategic priority, and, at the same time, a great challenge for Russia [3].

The study found that the development of REM industry in Russia might be characterized as fragmented as there no complete technological cycle to produce high value-added products (oxides, magnets, alloys). The need for the development of unique mining and refining technologies leads to significant costs [2-3]. Thus, the complexity, high level of knowledge- and capital-intensity of rare earth production facilities influence the investment attractiveness of REM projects and prospects for their implementation.

In general, the problems and barriers formed in Russia in case of rare earth industry have systematic characteristics [3]. This leads to the necessity to apply particular tools and mechanisms to stimulate and to support the national REM industry taking into consideration its specifics (geological conditions, technological aspects, economic and financial risks, environmental pillar). The mechanisms discussed in this research include the financial and non-financial development institutions, special tax and legal regimes. The possible means and conditions to attract both domestic and foreign investment in the national REM sector are examined. The factors influencing the prospects of rare earth industrial raw material complexes' creation and development are determined.

The methodology of this study includes case studies, system-oriented and strategic analysis, the decomposition method and comparative analysis. The content-analysis for the academic literature and analytical reports on the topic has been used to investigate the approaches applied in foreign countries, including China, the USA and Australia. The experimental part of the research consists of the application of the mechanisms chosen to evaluate the efficiency of the industrial complex's creation for the extraction and processing of perovskite-titanomagnetite ores of the Afrikanda deposit. The methods of the investment projects' economic assessment have been applied to determine how different economic mechanisms might influence the REM projects' financial indicators.

The mechanisms offered might allow to increase the efficiency of REM projects' implementation from an economic point of view and stimulate the creation of rare earth industrial complexes in a full technological cycle in Russia. The study makes a number of practical recommendations related to the support of REM projects at different stages: mining, processing, product development and sales. To activate the process of creating and developing REM industrial complexes, it is necessary to ensure the consistency of the applied state support measures, as well as to revise the provisions of the current subsoil management system to expand

the possibilities of involving technogenic objects and already developed deposits in the production process.

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TRANSFORMATION OF MINERAL-RAW LEGISLATIVE BASE OF RUSSIAN FEDERATION ON THE BACKGROUND OF FALLING DEMAND AND OIL PRICES

The report will propose the resolution of the following problems in the sphere of reproduction of the mineral resource base of the Russian Federation:

– Currently, at the legislative level, there is no legal definition of the concepts of "reproduction of the mineral resource base" and "Mineral-raw materials base";

– The absence of legal definition of the concepts of "reproduction of the mineral and raw material base" and the "mineral resource base" complicates the interpretation and the uniform application of applicable law on subsoil;

– The law on subsoils requires the development of a conceptual apparatus, it settles the problem of regulatory consolidation of terminology that has established in this field of legal relations.

In the current reality, the problems which exists in actual license system remains without practical solution. Apparently, it interrupts the exploitation of natural resources:

For example: the current management system. In the sphere of reproduction of the mineral resource base of the Russian Federation, leads to the fact that a large number of stages of geological study of the subsoil are carried out by government organizations for budgetary funds, and the intensity and efficiency of search and evaluation work decreases.

Private investments (small mining companies) on the search and evaluation stage are absent. At the same time, subsoil users in the Russian Federation are usually limited to the diffracting existing exploited deposits and obtaining licenses in the fields that were discovered during the USSR.

There is also an unresolved question to control the licensing of subsoil users.

The main disadvantage of the existing management system for the development of the mineral resource base is the substantial duration of the process of involving deposits in industrial development. Subreptions need to go through a large amount of expertise before starting work on the site, and the process of involving the field in industrial development takes 5 to 7 years

"Solving problems in the field of reproduction of the mineral resource base is achieved only if there are a number of conditions:

– relevant legislative and regulatory framework;

– clearly certain priorities and goals of the country - the owner of natural resources (due to the fact that a number of opportunities laid down in the licensed system, mutually exclusive nature is carried);

– an effective system of organizations of state regulation and control (from the point of view of public welfare) of the subsoil use process".

Most geological organizations operate in the form of federal state unitary enterprises and joint-stock companies, which are carried out with the minimum participation of the Federal Agency.

On subsoil use. Given the special importance of the mineral resource base for the economy, it is advisable to determine the procedure for the participation of specialized federal state institutions in the geological study of the subsoil, since due to stable budget financing and state support, such institutions are able to ensure continuous work on reproduction of the mineral resource base. In addition, conducting a comprehensive study of the regulatory regulation of reproduction of the mineral resource base, we can determine a number of recommendations for improving legal regulation which will be represented in actual report.

We hope that the results of this report will be useful for improving the legal provision of reproduction of the mineral resource base of the Russian Federation, as well as for further research in the field of subsoil use.

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CREATING A COMMON SERVICE CENTER AND APPLYING THE RECRUITMENT STRATEGY MAP AS A WAY TO IMPROVE THE EFFICIENCY AND QUALITY OF THE WORKFORCE IN AN OIL COMPANY

In the conditions of the developing market economy in Russia, the efficiency of enterprises depends on the quality of labor resources, so the technology of competent recruitment of personnel has a serious impact on the achievement of the final goals and mission of the organization. Hence, there is a need to create and implement innovative and effective HR management technologies in organizations [1]. The paper sets the task of determining and optimizing the economic costs of personnel recruitment and improving the efficiency and quality of labor resources by creating a common service center (CSC) and further bringing the operational functions of personnel management into it, as well as by implementing the personnel selection strategy map at the enterprise. The theoretical and methodological basis of the work was the works of Russian and foreign authors and experts such as: V. I. Gerchikov, V. V. Zharikov, I. V. Razdolskaya, E. Vulpen, G. Roberts, etc. The subject of the study is the effectiveness of the personnel recruitment system in PJSC "Surgutneftegaz".

The analysis of the quantitative and qualitative composition of the company's employees allowed us to assess their compliance with the needs, and also revealed trends in the qualitative change of personnel. The paper analyzes the number of workers in general and for each category, calculates the structure of employees with the allocation of the share of workers, analyzes its dynamics, as well as the qualification composition and distribution of employees by length of service. A study of the recruitment and selection system showed that the Company has a developed recruitment system. The company has a transparent staff selection system aimed at attracting the best candidates. To attract employees, both internal and external sources of candidate search are used. However, recruiters face a number of problems, including difficulties with mass selection of personnel," aging " of personnel, a narrow labor market, etc.

The company is highly competitive. At the same time, it is not possible to avoid high turnover of young employees and completely close the need for personnel, which reduces the

effectiveness of personnel management. The fact of non-compliance with the deadlines for closing vacancies is due to the lack of qualified personnel in the oil industry. In addition, exceeding deadlines indicates the need to improve the recruitment system, and also entails an increase in the Company's transaction and financial costs. The presence of these problems makes it necessary to centralize the recruitment functions in the PJSC "Surgutneftegaz".

One of the most effective measures, based on the real experience of a number of Russian oil companies, is to carry out personnel restructuring with the further transfer of operational functions to a common service center. The creation of a CSO with a further division of functionality and the concentration of professional recruiters in a single center will reduce the selection time, quickly identify the causes of turnover and thereby increase the effectiveness of recruiting and the Company's workforce as a whole. The implementation of the proposed measures can presumably reduce the time of closing the vacancy to the planned values.

The second important point that affects the efficiency of the recruitment, selection and recruitment process is the introduction and systematization of KPIs for the HR service. Some of the KPIs discussed in this paper are practically not used by Russian companies in practice. This fact entails an underestimation of a number of costs. Accounting and grouping of indicators will allow you to identify advantages, eliminate disadvantages, as well as evaluate and improve the effectiveness of the current recruitment system in the Company. In addition, the optimization of these items of expenditure by the KPI efficiency assessment method will improve the efficiency of the main economic indicators of the enterprise [2].

Based on the strategy of the organization, a map of the recruitment strategy is built with the allocation of a number of key performance indicators that will allow achieving strategic goals in the field of personnel management [3].

As a result of the implementation of recommendations for improving the personnel management system at the enterprise, namely, improving the recruitment system, it is possible to achieve a reduction in the closing time of vacancies and increase the efficiency of labor resources, which will entail possible economic benefits.

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A METHOD FOR MAPPING THE STAKEHOLDERS OF A MINING COMPANY IN CONNECTION WITH THE IMPLEMENTATION OF A DEVELOPMENT PROJECT

For almost two decades, the approach focused on intangible assets has been gaining popularity in terms of building enterprise value. At present, intangible resources are a key factor of competitive advantage of enterprises, especially significant are the issues related to know-how and knowledge resources. The importance of intangible issues was recognized as early as 1987, when the concept of Sustainable Development, that is, intergenerational solidarity that will simultaneously meet the needs of current societies without compromising the chances of meeting the needs of future generations, was coined. Another concept closely related to and, in a way, resulting from the idea of Sustainable Development is Corporate Social Responsibility, which is

a concept of functioning of enterprises according to which they should implement their strategies including social and environmental issues, placing particular emphasis on these issues both in their commercial activities and in their contacts with stakeholders.

The term *stakeholder* was introduced in 1963, initially defining "groups without whose support an organization would cease to exist". There is also a broader formulation of this concept defining stakeholders as all organizations or individuals who participate in the development of a project. The company's market value is built for these various stakeholder groups, among which we can distinguish internal stakeholders (e. g. employees or shareholders) and external ones (e. g. customers, suppliers).

In the case of mining companies and the implementation of their development projects, it is necessary to obtain what is known as a *licence to operate*, which is the granting of permission to carry out a project or business subject to regulation or supervision by the licensing authority. In view of the above, it is necessary to build an appropriate strategy for the operation of the enterprise, taking into account the CSR strategy. In turn, the basis for building an effective CSR strategy is to map stakeholders and then conduct effective dialogue with them.

The aim of this paper is to present the author's method of stakeholder mapping for the mining industry in order to build an effective strategy for sustainable development in the future. The paper presents an algorithm for conducting research work, starting with the identification (mapping) of stakeholder groups, through the determination of their level of influence and interest, ending with the construction of a matrix indicating the necessity of undertaking specific communication activities.

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SUSTAINABILITY AND CIRCULAR ECONOMY: SO SIMILAR BUT SO DIFFERENT

Introduction. Nowadays, more and more people are getting concerned about the future of the planet. As a result, lots of document, plans and perspectives have already been built on the topic of sustainability.

Modern countries policies are to be based on several binding international agreements. One of them is The Paris agreement that acknowledges climate change as a common concern of humankind [3]. The central principle of this outstanding achievement of diplomacy is that countries have a Common But Differentiated Responsibility. It offers governments flexibility in implementation; however, it increases the uncertainty of the result [1]. Nevertheless, even though the effect of this agreement is so complex and holistic that it can be hardly foreseen, it is a significant step towards the low-carbon future.

Another critical accomplishment of global diplomacy is SDG goals. The Sustainable Development Goals are the blueprint for reaching a better and more sustainable future for all [5]. Especially after the pandemic, there appears a possibility for these goals to guide the recovery, greener production, sustainable economy and resilient society [4]. SDG shape the future and establish tendencies in governance and social life.

Paris Agreement and SDG are two main pillars of human progress and survival, but this list is far from exhaustive. They are to influence the whole globe.

Main Body. Some believe that the circular economy concept was developed as one of the ways to achieve sustainability. However, it deals with various goals.

Both concepts of sustainability and circular economy are widely discussed. However, there is no established definition for either of them.

Most scientists agree that "sustainability is the balanced and systemic integration of intra and intergenerational economic, social, and environmental performance". As for the Circular Economy, it is described as "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. That can be achieved through durable design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling". [2]

Despite often being used in similar contexts, the similarities and differences between these concepts have not been made explicit in the literature, therefore blurring their conceptual contours and constraining the efficacy of their use.[2]

Many experts argue about the profit of two different conceptions being put into practice. Sometimes, it is s stated that sustainability aims to benefit the environment, the economy, and society at large. At the same time, the primary beneficiaries of the Circular Economic appear to be the economic actors that implement the system. However, as the Circular Economy prioritises the economic systems with primary benefits for the environment [2] and society, finally, from my point of view, the whole planet, including humanity, wildlife and still nature, seems to gain most no matter basic principles of which approach are implemented.

As for the differences, the main ones are listed in table 1.

Table 1 – Critical differences between Sustainability and Circular economy[2].

	Sustainability	Circular Economy
Origins of the term	Environmental movements, NGOs, non-profit and intergovernmental agencies, principles in silviculture and cooperative systems	Different schools of thought like cradle-to-cradle, regulatory implementation by governments, lobbying by NGOs like the EMF, inclusion in political agendas, e.g. European Horizon 2020
Goals	Open-ended, multitude of goals depending on the considered agent and her interests	Closed loop, ideally eliminating all resource input into and leakage out of the system
Main motivation	Diffused and diverse reflexivity and adaptive→ past trajectories	Better use of resources, waste, leakage (from linear to circular)
What system is prioritised?	Triple bottom line (horizontal)	The economic system (hierarchical)
To whose benefit?	The environment, the economy, and society at large.	Economic actors are at the core, benefitting the economy and the environment. Society benefits from environmental improvements and certain add-ons and assumptions, like more manual labour or fairer taxation
How did they institutionalise (wide diffusion)?	Providing vague framing that can be adapted to different contexts and aspirations.	Emphasising economic and environmental benefits
Agency (Who influences? Who should influence?)	Diffused (priorities should be defined by all stakeholders)	Governments, companies, NGOs
Timeframe of changes	Open-ended, sustain current status "indefinitely"	Theoretical limits to optimisation and practical ones to implementation could set input and leakage thresholds for the successful conclusion of the implementation of a Circular Economy
Perceptions of responsibilities	Responsibilities are shared, but not clearly defined	Private business and regulators/policymakers
Commitments, goals, and interests behind the use of the term	Interest alignment between stakeholders, e.g. less waste is good for the environment, organisational profits, and consumer prices	Economic/financial advantages for companies, and less resource consumption and pollution for the environment

Conclusion. Both social media and scientists believe the terms of sustainability and circular economy to be interconnected. The connection between these two concepts is so strong that some even mess them up. However, a considerable difference between them exists.

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NATURAL GAS AS THE BEST FUEL IN THE MODERN WORLD

Introduction. This topic is highly relevant due to the outstanding environmental friendliness of gas among traditional energy sources. Therefore, its application will help humanity to achieve the goals of sustainable development.

With the world around us bent on self-destruction and with environmentalists warning of imminent catastrophe, the issue of sustainability is becoming more and more acute. Contrary to popular belief, one of the cleanest sources of energy today is natural gas. Among all fossil fuels, natural gas has the best indicators in terms of the energy released per volume and pollution from combustion products, including greenhouse gases [1]. Even biofuel is inferior to gas in terms of the cost of the energy itself and the capital cost of building power plants and in terms of emissions.[2] Moreover, attempts to dispute this assertion by those who advocate widespread use of solar energy cannot be considered even remotely meaningful as long as refined petroleum products are used to manufacture solar panels. No safe method for recycling dead batteries has been discovered.

It is natural gas that can provide the highest levels of efficiency and safety so necessary for the fuel and energy complex of many countries at the current stage of world economic development, and that can give an impetus to the further development of their energy sector.

Main body. Natural gas can be used in almost every sphere of human life.[4]

Every year, the demand for gas remains relatively stable, despite the economic crisis.[5] It still cannot be replaced; for example, in terms of price/heat output, it often has no equal, and sometimes it cannot be replaced due to the specific infrastructure development in a particular region.

It should also be noted that this mineral resource is exceptionally environmentally friendly.[6] Its combustion products only include water and carbon dioxide, which are harmless to the environment. Although in 2020 environmental issues are receding into the background, giving way to the economic crisis caused by the pandemic and the fall in fuel prices resulting from the OPEC+ disruption, the development of the fuel and energy complex is a resource-intensive and long-term process that requires long-term goals and plans essential for the whole of humanity to focus on. [7]

As for comparing gas with renewable energy sources, again, everything is clearly in its favour. The fact is that the methods for storing gas are relatively cheap (approximately 40 times cheaper than storing energy in batteries) and make it possible not only to store the energy needed to meet the needs of households, industry and governments sustainably but also to use it in portions, i.e. when required[8]. Unfortunately, no technical solution has yet been found for any of the green energy sources. Even hydropower plants, which often use water-level control technology, do not produce electricity in such a precisely regulated manner.

According to Fatih Birol, executive director of the IEA, natural gas can contribute to a cleaner global energy system.[9]

Moreover, business insists that natural gas is the transition point, if not the ideal solution.[10]

After all, it is natural gas that, on the one hand, provides a high return on investment and, on the other hand, comes close to achieving the goals set by the Paris Convention, making it an attractive market for businesses that care about their business reputation, but are not prepared to overpay for the transition to renewable energy, which is highly costly and time-consuming. [11]

The main disadvantage is that it is limited and unevenly distributed around the globe if it can be named as such.

The Russian Federation, the undisputed market leader, continues to do all it can to maintain its leading position, actively exploring its territory and other less developed countries by investing in promising areas through major state-owned companies. The development of new fields and the discovery of new projects is one of the tools to maintain a country's competitiveness and ensure energy security, which is becoming increasingly important in the current environment.

Conclusion. Thus, gas is a traditional hydrocarbon resource that is environmentally friendly and energy-intensive while relatively cheap but difficult to transport. Natural gas is an energy carrier, both suitable for the end-user and widely used in industry.

The Russian Federation has all the prerequisites for leadership in natural gas markets, with its significant gas reserves.

Natural gas is currently and, in the near future, the most affordable green energy source[12]. Even though there is some decline in demand in the short term due to the coronavirus pandemic and climate change, it is natural gas that will facilitate the transition to renewable and alternative energy sources for many countries, which is still a long way off.

Drawing a conclusion, gas, a source of energy, is the best way to achieve a net-zero economy, as its comprehensive implementation can improve the performance, not of the industry but the world in general.

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ECONOMIC POTENTIAL OF DONBASS MINING ENTERPRISES: DEVELOPMENT STRATEGIES AND EFFICIENCY

Currently, the instability of the institutional environment of the Donetsk region does not allow us to consider the development of the economic potential of mining enterprises only based on their production modernization and improvement of technology. Especially since now, the problems associated with the sale of their products are coming to the fore. At the same time, the strategy of developing the mining industry, as one of the basic branches of Donbass fuel and energy complex, is one of the elements of the development strategy of the region. Therefore, other areas of development are also necessary for mining enterprises, the reasonable choice of which is an urgent scientific task.

The strategies of enterprise management are considered, the most used of which are strategies of passive existence, strategies of active existence and development strategies [1]. For mining companies, the most attractive are development strategies. They differ from others in that the company itself directly affects the environment by diversifying production and introducing innovations in its activities. Diversification involves the production of other types of products or services, as well as the parallel implementation of the main and additional activities of the enterprise, which should help to increase its efficiency. Despite the narrow specialization of mining enterprises, they are no exception to the use of production diversification and the world experience confirms this.

Diversification of activities should start with the active work of mining enterprises, and not wait for their closure and the formation of a depressed territory. In the Donetsk region, since 2015, more than 20 mines and several quarries have been closed, the territories of which can be converted into technoparks. At the same time, the state should adopt appropriate legislative acts and provide assistance and support for the creation of such parks. These are benefits and assistance from the state: targeted financing on a non-refundable basis; interest-free loans; exemption from customs duties on the import of equipment; tax benefits; the right to lease a land

plot and other benefits. Ultimately, this will allow planning further development and economically stable existence, both for the enterprises themselves and for the region as a whole.

The directions of diversification of production and innovation activities for mining enterprises of Donbass based on the creation of industrial parks, taking into account factors of the external and internal environment, as well as international experience, are justified [2]. For working mines, diversification can be the extraction of associated products – methane gas and water reuse, activities related to agriculture and mushroom farming, the creation of small enterprises for deep processing of coal, as well as the creation of innovative products from coal production waste. For the closed mines of the region, promising and innovative areas of development are underground coal gasification (for mines that still have sufficient mineral reserves), mining of mine gas outside the fields of existing mines and using it as motor fuel for cars, reuse of mine water, underground agricultural farming, the creation of enterprises for the dismantling of landfills, of which there are more than one and a half thousand in the territory of Donbass, and the creation of museums of industrial heritage. For closed quarries, it is possible to create fish farms and even diving centers, recreation areas and sports grounds, geoparks and thematic museums. In addition to attracting tourists, they can be used to train students [3, 4].

Thus, the analysis of various models of strategic choice is carried out, the most acceptable strategies for mining enterprises are selected. These are development strategies related to diversification and innovation. Various types of diversification of activities for both operating and closed mining enterprises are analyzed based on domestic and international experience. Measures for the development of economic potential for mining enterprises in the region are proposed. The issues of obtaining a number of benefits from their implementation are considered, as well as their economic efficiency is calculated.

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OBJECT TRACKING IN AN ENVIRONMENT WITH OBSTACLES

In today's world, as technologies evolve with exponential speed, almost every aspect of our lives becomes more and more dependent on AI. One of the most growing AI fields is computer vision. Using computer vision tasks like image processing, object detection, object tracking, and text recognition makes tremendous achievements. One of these achievements is the autonomous security systems, which are heavily used in our daily lives. These use-cases vary from simple home door lock systems and/or smartphone AR camera toys to highly secure government applications and national bank security systems. Object detecting and tracking in an environment with a presence of multiple obstacles is a very common task, but existing solutions sometimes can be very expensive in computational resources and expensive in general. This paper addresses several concepts of image processing, object detection, and object tracking and suggests optimal use cases for each of the spoken concepts and suggests the best general solution for this task.

Computer vision is an interdisciplinary scientific field that deals with how computers can gain high-level understanding from digital images, videos, or live footage for example from security cameras. From the perspective of engineering, it seeks to understand and automate tasks that the human visual system can do [1]. Computer vision is concerned with the automatic extraction, analysis, and understanding of useful information from a single footage frame or a sequence of frames. It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding. As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multidimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models for the construction of computer vision systems. Computer vision suggests solutions for a variety of problems, the main two branches are: recognition and motion analysis [2, 3].

Recognition is a general term that describes the process of analyzing, classifying digital images and identifying different objects in them. These three main problems of object recognition in the digital frame often create confusion about the meaning and difference between these terms. Motion analysis is the method that studies a sequence of graphical frames (that can be retrieved from a video and/or some footage from a high-speed camera) and gives us information about apparent motions in the given frames. This algorithm may vary based on the application/scenario. In some scenarios, the camera can be steadily fixed and the objects of interest can be in random motion. In the other scenario, the shooting camera can be mounted on a moving object that moves around a point of interest. There can even be cases when both the shooting camera and the object of interest are moving.

If the motion analysis concepts are used to detect motion in the frame sequence than the video tracking or just tracking is an algorithm that helps to locate moving objects over time using video frames or directly reading frames from the camera hardware. Video tracking can be a very time-consuming process depending on the amount of data that needs to be processed. In some cases to perform video tracking first, the application needs to use an object recognition technology to find the object of interest in the frames and then perform the video tracking algorithm to locate and track that object.

The main principle of video tracking is to find the selected object in the sequence of frames. That problem can be hard to solve in case that the speed of moving objects is greater

than the frame rate. Another difficulty while trying to find a solution for this problem is that the tracked object changes the moving direction or the moving angle. One possible solution for the aforementioned problem is to generate a motion model. The motion model is a set of instructions that describes the possible movements of the object that might be captured in the video frames. There are three main approaches to this problem [4].

- Separation of the object of interests from the entire frame
- Generating rough 3D map using single frame and descriptions for each detected object
- Switch the view if it is applicable for the problem

This is a very simple solution for this problem, but it is very handy in many scenarios. The separation of the object of interest can be done in many ways. One of these ways is using object detection based on object color and shape. For separation the object detection algorithm needs to be initialized with the object of interest, then the tracking algorithm needs to extract that object from the mainframe and consider the frame as an empty rectangle and the "shadow" of the tracking object.

The main goal of generating rough 3D map using single frame is to generate information about the 3D objects in 2D video footage. For example, the video frame shows the big empty room with a square floor. The camera that captures all is mounted in the nearest top right-hand corner of the room. In the middle of the room, there is a solid box. Also, there is a moving ball in the room. When the ball gets behind the cube, the object tracking algorithm will lose the target and it can't be recovered automatically. The algorithm in this case will determine that the obstacle is a cube with certain dimensions and the ball is behind it.

Now let's discuss the case when the ball goes behind the cube but the object tracking algorithm can't determine the 3D sizes of the cube and can't perform an egomotion algorithm. The simplest and obvious solution to continue object tracking is to find another viewpoint so the cube doesn't overlap the ball in the selected frame. The main problem of this solution is to calculate which viewpoint to choose. For this purpose, the object tracking algorithm must use a very well-trained neural network because the object can have a non-symmetric shape.

Computer vision has many use cases and many algorithms for each possible problem. They are based on human vision and decision techniques. For object detecting and tracking in an obstacle-full environment, the algorithm must be dynamically adjustable and must combine several solutions. It must handle as many corner cases as it can, but it doesn't need to be very complex in order to save some computing time and resources. In this article, we have spoken about 3 simple solutions for this problem, but there can be more solutions depending on the selected environment and object of interest.

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SECURE ORGANIZATION OF REMOTE USER ACCESS

Many enterprises are faced with the problem of remote work of their employees. The majority was not ready for such an operations mode, since the dogma "an employee in the workplace means he works" remained the most obvious work and productivity recognition principle.

However, within the framework of the Strategy "Kazakhstan-2050", the President of Kazakhstan, Kassym-Zhomart Tokayev, clearly highlighted the development of infrastructure, including the digitalization of society and an increase in the efficiency of management mechanisms. Thus, Kazakhstan enterprises should not only introduce and expand new technologies, but also widely use available digital technologies.

By the way, the readiness for new challenges and the transition to remote work of employees caused a surge of interest in information security products and an increased demand for such services.

The implementation of the remote work mode, as to office workers, does not cause problems and questions if properly planned and is accompanied with competent tasks definition.

There are three main directions in organizing the mode of remote work of personnel:

- sharing documents, videoconferencing.
- access to the internal enterprise systems.
- Internet access for employees.

Let us look on access to collaboration with documents and video conferencing. To organize this opportunity, you can use commercial services from Google, Microsoft O365. These services will allow you to have a common space for working with documents, databases, provide video and audio communication services, and collective discussions. You can choose a suitable plan and switch to the cloud service quickly and painlessly for the company.

Working with cloud services removes security and data safety concerns. There is no need for backups and the danger of data infection / leakage.

Video and audio-conferencing capabilities allow companies to fully monitor staff performance and additional business opportunities.

Access to the internal systems of an enterprise is a very promising approach. VPN technologies have become part of our everyday life. However, their diversity requires additional skills from IT specialists of companies. The easiest way to set up a VPN is OpenVPN based remote access. As a service, you can choose products OPNsense, Zentyal, PFsence. These are free products and easy to implement. The commercial ones include IDECO, Cisco, FortiGate, CheckPoint.

What is important is to ensure transparency and ease of customization, readiness to work "out of the box". Complex systems will cause rejection and inefficiency for remote users.

Access to the Internet for employees of an enterprise is one of the most difficult moments in organizing remote access. The user becomes a potential threat to the company's information system. It is necessary to control its connections to prevent malware from entering to the enterprise network. Alternatively, you can use cloud proxy services, such as Zscaler, which will help you filter services and site categories, as well scan traffic for viruses.

I would also like to note that when introducing remote access technologies, it is necessary to consider that the state and quasi-public sector is obliged to work through the Unified Internet Access Gateway (ESHDI). There are some restrictions on the ports and services used, which may limit or even prevent the implementation of remote access. Insecure protocols are blocked, so when planning the organization of remote access, you need to keep these restrictions in mind.

It is good practice to allow connections only from computers that are managed by the company's system administrators to reduce the risk of data leakage or unwanted and malicious software entering to the enterprise network. In the absence of such an opportunity, the organization of a secured container with business data, which allows keep them to be saved in unchanged mode. Microsoft Intune is an example of such a solution.

Kazakhstan companies are also entering on the information security market, so far only in the mode of providing external services and products, however, the development of domestic software provides confidence that Kazakhstan products will be created to ensure information security.

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METHOD FOR CALCULATING THE COORDINATES OF INDOOR WIRELESS NETWORK COVERAGE, STRUCTURES FOR ARBITRARY BEAM SCANNING FROM A RADIATION SOURCE TO A RECEIVER

This paper proposes and describes an algorithm for calculating the coordinates of a given indoor wireless network coverage area based on ray tracing method. This method, despite its high accuracy, incurs high hardware costs. The task of the algorithm is to reduce hardware costs when calculating the coverage area, so that the accuracy of the data was still high. The results of the algorithm have been compared with experimental data and are a good fit to them.

The use of wireless technology in the manufacturing and mining sectors is steadily increasing. Remote control systems, environmental and equipment monitoring and robotic systems all require a strong radio reception area for their operation. The main technology for building wireless local area networks is the IEEE 802.11 family of wireless LAN standards, popularly known as Wi-Fi.

Wireless local area networks (WLAN) solutions are implemented everywhere to increase mobility in manufacturing. WLANs are easy to deploy in small spaces and typically use a single access point. Examples include home WLANs as well as small business wireless networks.

However, when creating large wireless networks in industrial environments, the architect faces a number of challenges. The IEEE 802.11 family of standards operates in the 2.4 GHz and 5.1 GHz frequency bands, on which there is strong radio signal absorption by the medium and together with the low power of the access points (AP) their range does not exceed 70 m even in open terrain. In manufacturing areas with complex partition configurations and materials with different values of complex dielectric constant, determining the coverage area without modelling is a very complicated and time consuming process. Without using software simulation, the only way to determine the coverage area is to measure the radio signal strength using special equipment in all rooms where the WLAN is to operate. Building production wireless networks means creating a large coverage area and therefore measuring the signal strength experimentally for a single AP will not give the desired result. Performing manual measurements for dozens and hundreds of wireless routers is very expensive and time-consuming. Consequently, specialized software algorithms implemented in CAD which make it possible to assess the nature of electromagnetic wave propagation and select the optimal location of TD on the basis of drawings

plans production and technological facilities, are very relevant. The existing programs are characterized either by a large error in the calculations or by the consumption of a huge amount of resources for their calculations [1].

The aim of this research is to create an algorithm for calculating the coverage of wireless networks of IEEE 802.11 standards family inside the premises with a complex configuration of partitions with the accuracy of the data obtained is close to the experimental measurements.

In order to develop a model for the propagation of scanned rays, we use ray tracing method [2-6] as its basis. The main advantage of this method is that models based on this method are quite accurate, but have rather high hardware computational costs. The task of this algorithm is to optimize ray-tracing model to reduce the computational cost. As a starting point, a single scanning ray of arbitrary length and a scanning angle of 15 degrees is selected, the distance to an obstacle, its thickness, complex dielectric permittivity of the material and angle of incidence on the reflecting surface of the obstacle for each of 24 scanned rays are set, and the coverage zones, for which the calculation is carried out, are also defined. The algorithm is based on the principle of radiowave propagation loss calculation with 0.01m increment step up to the moment the calculated losses coincide with the value of given zone and then the coordinates of given zone are put into calculation result table. All subsequent scanning beams are calculated according to this principle.

As a result of developing the algorithm we will be able to develop software for determining the coverage of wireless networks inside premises with a complex configuration of partitions made of different material. This will enable a comparative analysis of access point placement when planning coverage in production and reduce the cost of purchasing wireless equipment during the digitalization of technological facilities compared to the deployment of a wireless network without planning a coverage map.

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SELECTION AND CONSTRUCTION OF SHEWART CONTROL CHART FOR A SELECTED PROCESS

One of the foundations of the modern functioning of production processes in a manufacturing company is the use of statistical process control (SPC) systems, implemented through the methodology used in process quality assurance systems. Its foundation is the

constant running of the control chart tool, which enables an objective assessment of whether a given process is characterized by normal variability or non-standard variability.

The aim of this study was to develop a Shewhart control chart for the cycloid production process and to analyze the collected results in terms of the occurrence of instability symptoms of this process. This made it possible to check whether the discussed process is qualitatively capable and whether it is not affected by special (non-standard) variability, as well as to identify the reasons for this state of affairs. Among the methods used to design the control charts, there are design and stabilization methods.

The project begins with the presentation of Shewhart's control charts as the primary tool of the SPC methodology. It includes a short description of it, as well as the types of control cards and their structure. In addition, the principles that should be followed in their creation and the design methods used in the project were presented [1]. The next part of the work presents a short description of the cycloid machine and cycloid, which is the result of its work and which was used as research material. In addition, the features of the product taken into account in the construction of the control card were discussed, as well as the type of selection.

The activities carried out during this study initiated the determination of the volume of cycloid production needed for further activities and its implementation. 19 samples with a number of 5 were established, which gives a total of 95 pieces. Then, the controlled features were selected for which measurements had to be made. Once it was known what quantities will be tested, the type of control chart could be selected. It was decided to have a couple of Xbar-R control cards. It was necessary to check the compliance of the tested distribution with the normal distribution. For this purpose, a histogram was built and a chi-square test was performed. It was also important to check the qualitative ability of the process and the advisability of using a control chart, determining the values of the coefficients C_p, C_{pk}, P_p and P_{pk}. In the next step, the values of the control limits were calculated and a control chart was built. When it was necessary, the boundaries were corrected. After the cards were built, their analysis was conducted for the occurrence of symptoms of process instability. Then, conclusions were drawn from the analysis and potential reasons for this were given.

As part of the analysis, symptoms indicating the instability of the process were specified [2]. Out of 8 examples identified in the literature, as many as 5 were found in the control cards tested. The following symptoms were distinguished: "point beyond the control line", "two out of three consecutive points in a row are more than 2 standard deviations from the mean in the same direction", "five (or six) consecutive points in a row are more than 1 standard deviation from the mean in the same direction", "seven or more consecutive points in a row move towards increasing then decreasing" and "seven or more consecutive points on one side of the center line”. Thanks to the conducted analysis, it is known that this process needs to be improved in terms of stability.

Particularly many symptoms were distinguished for the diameter of the cycloid, therefore the focus should be on improving the achieved results in this respect. Three factors were distinguished that may be potential causes of process instability. The first was the use of various writing materials in the production. The second was a thorough modernization of the cycloid machine, which could disrupt the machine. The third factor described was the inexperience of the operator in the production of cycloids. Taking them into account could significantly improve the process stability and the quality of the produced cycloids.

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AUTOMATION OF DATA ACQUISITION FROM A ONE-WAY TRIAXIAL PERMEAMETER APPARATUS USING ARDUINO SENSORS

Introduction. The flexible wall triaxial permeameter apparatus can be used to investigate the hydraulic and chemical conductivity of compacted fine-grained soils, soil cement, and soil cement bentonite [1], [2]. The coefficient of permeability is of key importance to the estimation of seepage loss, pore water pressures, quicksand conditions, contaminant control, design of dewatering, dams and drainage system. Manual data logging from a triaxial permeameter apparatus is accompanied by varied widely human and environmental errors that may lead to erroneous hydraulic conductivity determination. Monitoring the factors affecting hydraulic conductivity determination requires several sensors to be attached to the permeameter system. The sensors that can be attached to the permeameter system are those related to the liquid level, pressure, humidity and temperature, etc. Various ways of measuring the fluid level have been investigated by previous researchers [3]. Load cells are among the sensors that are used to measure the fluid level [3]– [6]. However, the load cell sensor is known to have creeping characteristics [7], [8]. In 2001, Kopczynski and Ness investigated the five factors that affect the accuracy of weighing systems [9]. In this study, the automation of a flexible wall one-way triaxial permeameter apparatus for testing the hydraulic conductivity of soils, soil cement and soil cement bentonite was investigated. The objectives of this experimental study are: (1) to automate data acquisition from the permeameter apparatus, (2) to investigate the effect of environmental factors on the load cell for the seepage measurement, (3) to investigate the stability of the load cell for continuous measurement of fluid level within 24 hours, and (4) to predict the coefficient of hydraulic conductivity using artificial neural network in R.

Main Part. The load cell creeping response and its recovery has been investigated by other researchers [7], [8], [10]– [12]. In this research, a 50g constant load was used to investigate the creeping characteristics of the 5kg Arduino load cell at real-time room temperature and humidity. It was found that the load cell creeping is highly influenced by temperature. This coincides with the documented results by Mohamed et al., which stated that load cell creeping is highly influenced by the thermos-elastic effect [8]. Moreover, this study discovered that real-time humidity also has an effect on the load cell creeping. The HK12-P138B 0.5MPa pressure sensor was found to have no effects on the load cell creeping characteristics as

it was an independent sensor and connected to a separate electrical supply from the Arduino Uno. The standard of deviation of the mass from the regression analysis for days one, two, three, four and five were found to be 1.08, 1.99, 1.68, 0.99 and 0.75 respectively. Upon completion of the regression analysis for each day, the logged data were combined in order to determine the creeping characteristic for the five days of investigation had a variance of 4.4, the standard deviation of 2.1 and an average mass value of 49.93g.

The results obtained from the automated apparatus were analyzed using the artificial neural network (ANN) to predict the permeability of the tested samples through the implementation of the logged dataset for sample I, II and III. The sample I, II and III had 1449, 1452, 1441 records respectively. Each dataset was divided into 80% for training and 20% for testing. Each sample was tested separately through the application of the same confining and seepage pressure. The RMSE of the sample I 6.24e-11, predicted mean was 1.55e-9 and actual mean 1.59e-9, the RMSE, predicted mean and actual mean of sample II were 7.15e-11, 1.721e-9 and 1.75e-9 respectively, while the RMSE, predicted mean and actual mean for sample III were 2.0e-10, 2.26e-9 and 2.42e-9 respectively. Exponential Asymptotic Regression Models were fitted to the ANN results through iteration in OriginPro software. In the case of a non-continuous monitoring permeameter system, it can be deduced that sample I between 20000-45000 seconds had attained its steady state. However, because of the temperature change between 45000-75700 seconds, there was an increment in the coefficient of permeability, because of the change in the water viscosity which led to an increment in the amount of water flowing through the sample.

Conclusion. This research presents the investigations of the possible implementations of Arduino sensors and microcontroller in the fabrication of the one-way triaxial permeameter apparatus. The automation of the one-way flexible wall triaxial permeameter apparatus was investigated and implemented at a cost of $2970 USD. Data acquisition from the one-way triaxial permeameter apparatus was automated using Arduino sensors and a microcontroller. The Arduino microcontroller was programmed using Arduino Language and the data logging application was programmed using Visual Basic Language in Visual Studio an integrated development environment. The Arduino sensors and microcontroller were found suitable to be used in real-time permeameter apparatus fabrication. The environmental factors that affect the load cell creeping were investigated. The real-time temperature fluctuation was found to be one of the major contributors to the load cell creeping. The creeping of the load cell within 24 hours was found to be within the acceptable limit for permeability determination. The environmental factor for the hydraulic conductivity testing does not only affect the viscosity of water, however, it also affects pressure regulators. The stability of using the Arduino load cell to measure the effluent water was investigated using the artificial neural network. Therefore, The Arduino load cell is capable of recording a dynamic load like seepage water from the petameter apparatus with an error between 0-2.4g within 24 hours. The prediction of the hydraulic conductivity using the ANN was found to be the ideal method that can be implemented for the precise prediction of the hydraulic conductivity of porous materials. Therefore, this methodology can help to determine the hydraulic conductivity from the logged data at a high coefficient of determination R2> 0.90.

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CREATING FACE PANORAMA FROM MULTIPLE IMAGES FOR AUTHORIZATION

With the help of modern progress, things that were previously considered unattainable are becoming daily routine nowadays. As sad as it may sound, it is a good thing, because in return all of us get the opportunity to benefit from these great achievements. Facial recognition is one of the fields that has greatly evolved thanks to this progress. From early days human’s face was how people recognized each other. Person’s face is used to identify him; besides it can give a lot of information to the perceiver, including their mood, attentiveness, and intention. Clothing, voice, and other characteristics can also be used to recognize the person, but the face is the most distinctive part of the human. Nowadays people are recognized not only be other people, but even using computers. Face recognition is still a new and less studied field. Despite it face recognition is already a significant part of our life. It has a great demand and is used in security, marketing, and even for unlocking your phone [1]. The aim of this work is to create a face panorama from given images of a person. The result can be used to authenticate him, to restrict from access to the mining site the unauthorized personnel and make authorized persons entry easier.

To recognize and extract a person’s face in a picture image analysis must be used. Image analysis is done by a computer to extract the needed information about an image by different techniques: 2D and 3D object recognition, image segmentation, etc. Image analysis is the extraction of meaningful information from images; mainly from digital images by means of digital image processing techniques. Image processing is a rapidly growing area and is being used in more and more spheres, such as engineering and computer science. Image processing is composed of these three main steps: input the image for analyzing, process and modify the image, and output the modified image or the necessary information obtained while processing the image.

One of the most useful tools for image analysis is homography. Homography maps the points in one image to the corresponding points in the other image by using a 3x3 matrix and

shows the same corresponding points. Now since homography is 3x3 matrix, we can show it like this:

$$H = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix}$$

Equation 1. Homography

Using the Equation 1 we can get the equation for homographic transformation from (x1, y1) to (x2, y2), which will look like this:

$$\begin{pmatrix} x_1 \\ y_1 \\ 1 \end{pmatrix} = H \times \begin{pmatrix} x_2 \\ y_2 \\ 1 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix} \times \begin{pmatrix} x_2 \\ y_2 \\ 1 \end{pmatrix}$$

Equation 2. Homographic transformation for two points

Using homography, one image can be transformed into another, but there is a catch: images must have a common plain, and only that plain can be used for transformation. If a picture of some scene is taken, then the camera is rotated, and a picture is taken again homography is still possible and panorama can be created. The pictures will have some common objects, using which, the pictures can be aligned and stitched together [2].

The difference between making an object panorama and a scene panorama, is that in case of scene panorama only the camera angle changes. While making an object panorama, also the camera itself moves. As the cameras that are taking the images are fixed in position, we know the distance from the object, and the angle, at which is object is photographed. To be able to authenticate the face from multiple images, the shape of the face must be known. 3D reconstruction is used for this purpose. 3D reconstruction is done using point clouds. Point clouds are a set of data points located in space. Each point has several measurements, such as the coordinates in 3D plain, the luminosity of the given point and sometimes the color of the given point, stored in RGB format. Cloud points together represent the 3D shape of object. Point clouds can be rendered, but by converting them to polygon meshes it is easier to inspect the result. This process is called surface reconstruction.

Multiview stereo (MVS) is a type of 3D reconstruction, which is used to reconstruct 3D shape of the object using multiple photographs. It uses images from different angles to generate cloud points and construct the object. All MVS algorithms expect a set of images and their corresponding camera parameters. The MVS algorithm's result will be as good as is the quality of the input images and camera parameters. The generic pipeline of an MVS algorithm looks like this: image collection, computation of camera parameters for each image, reconstruction of the 3D object of the scene from the set of images and corresponding camera parameters, and reconstruction of the materials in the scene, if possible. Throughout time many different algorithms have been suggested. Two algorithms have proved to be most effective: depthmap reconstruction and point cloud reconstruction [3].

Depthmap algorithm takes a set of images and their camera parameters, analyzes the images and converting the images into a finite set of depth values, then reconstructs a 3D object. Depthmaps are effective for scene analysis and visualization, but it is difficult to create a 3D object from depthmaps. Depthmap loses quality if some parts of the object are visible only from one image or if there are depth discontinuities. Point cloud algorithm resolves these problems since it uses all the input images to construct single point cloud 3D object. Corresponding points from all the input images are collected into a point cloud. When the 3D object is being constructed, the point cloud is used to place the points in the right places. Although some points might be wrongly corresponded creating minor mistakes in the result.

The mentioned algorithms both have strong and weak points, but they work best together by supplementing each other. Multi-stereo view algorithms solve many problems regarding 3D reconstruction, including 3D face reconstruction. Mistakes and inaccuracies will always take place while 3D face reconstruction, but it can always be improved on to become more reliable and faster. This system can be used for 3D face reconstruction. And the result of 3D face

reconstruction can be used for authorization by comparing the result with faces in the database. If the face doesn't exist in the database, then the person is not allowed to enter the location.

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USE OF GEOGRAPHIC INFORMATION SYSTEMS ON THE EXAMPLE OF THE SAYAK MINE

Currently, the importance of using geographic information systems (GIS) for forecasting and field development cannot be overestimated. Starting from the moment of mapping data compilation, digitization and further data maintenance, GIS is used. But at the heart of any GIS is an information model. When creating the information model, topographic plans of the earth's surface, plans of mining horizons, geological maps, sections, and other mining and graphic documentation of various scales in the accepted coordinate system, located on paper, were used as a cartographic basis.

Maintaining such documentation is an integral part of the work performed by the geological survey service. The preparation of the initial materials consists in selecting from all the cartographic data accumulated as a result of various observations, those that carry the necessary information for building an information model. Further, based on the source data imported from Autocad, the Datamine Studio program digitizes and builds workings (Figure 1, 2).

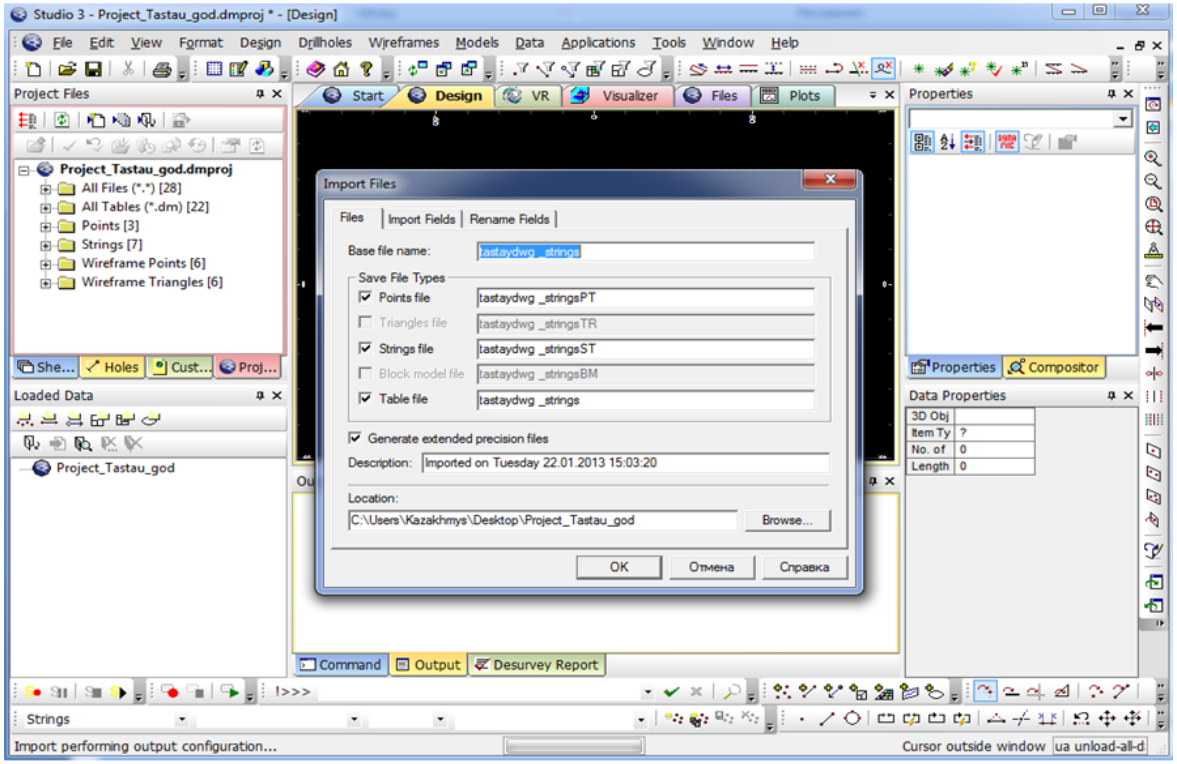

Figure 1 - Importing data from Autocad to Datamine Studio

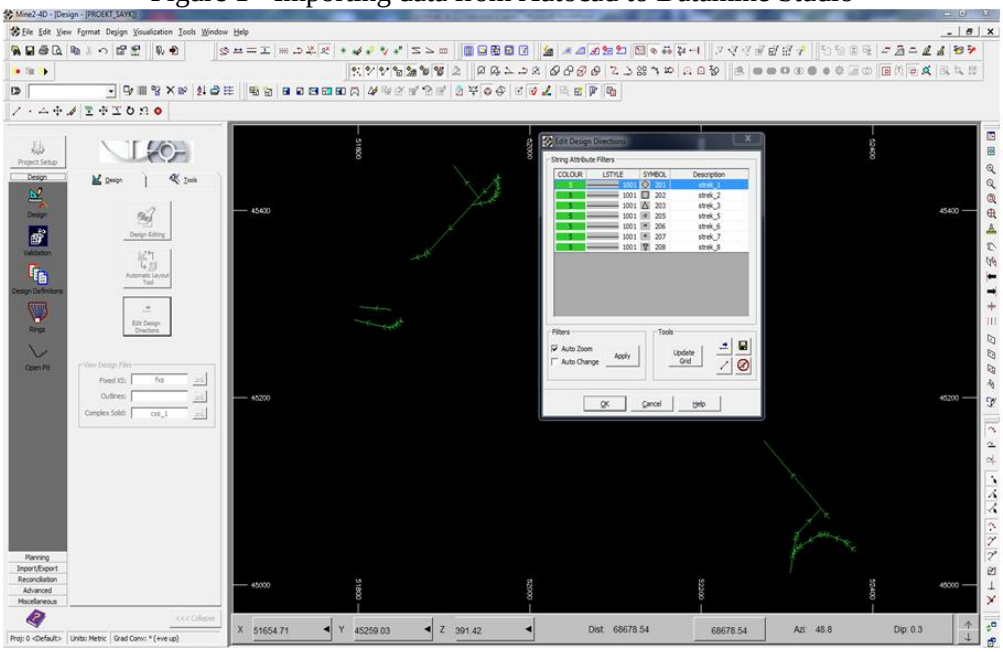

Figure 2 – Digitization and construction of workings in the Datamine Studio program

At the final stage of digitization, the data was checked and edited: the compliance of the received digital image with its solid original, the coincidence of the actual and analytical coordinates on individual fragments of the digital plan, the compliance of the electronic map with the requirements for mining and graphic documentation and the accepted symbols were checked. Next, the data is imported into the M2-4D program (Figure 3).

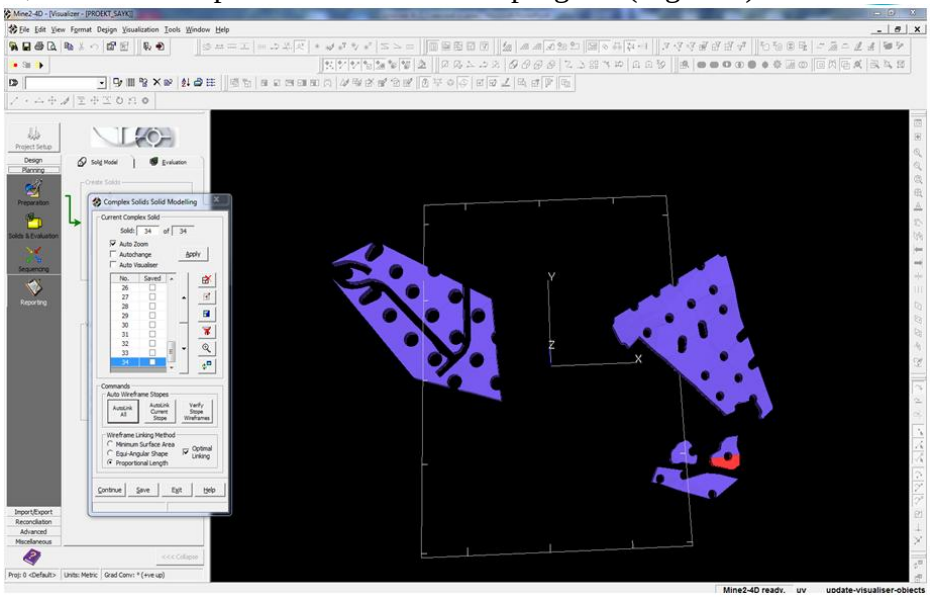

Figure 3 – Creating wireframes in the M2-4D program

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DEVELOPING A WEB APPLICATION USING ASP.NET MVC TECHNOLOGY

Now, the field of information technology is one of the fastest growing and most promising areas. Due to the ubiquity of the Internet and its undoubted relevance, Web development encompasses more and more technologies and expands the possibilities that can be implemented. One of the popular MVC web technologies is used to create the application.

A web application is an application that uses a client-server type of data exchange that occurs through a browser. Control, form, and type of information is distributed both on the server and on the client side. For example, server resources are used to store the bulk of data, the interaction process is carried out in the network. Web applications are multi-platform services, because one of their huge advantages is the ability to maintain the independence of the client part from the type of operating system.

One of the great advantages of web applications is access to them using any platform, operating system. Anyone can use web applications with internet access. Web applications do not need to be downloaded as they are accessed over the network. Users can access the web application through a web browser such as Microsoft Edge, Google Chrome, Mozilla Firefox, or Safari.

The MVC design pattern allows you to isolate parts of an application from each other without disrupting their collaboration.

This technology was first described in 1979 for a different environment. The concept of a web application did not exist then.

The request is sent to the controller. The controller receives data from the model and passes that data to the view. The view displays data for the end user.

The template is based on:

– Model is data and rules for working with them. In any application, work occurs with data and with them, there are certain restrictions and ways of processing them. Models are responsible for setting requirements and defining actions on them.

– View is a form in which the data will be available to the user. With the help of views, it is determined how the application will look, what the end user will see or not.

– Controller - a tool that allows you to process client requests (HTTP GET or POST), depending on how the user interacts with the interface elements and what actions are taken. The main purpose of the controller is to process and coordinate information coming from requests, which is necessary for the execution of an event or action specified by the client. In general, the controller determines the appropriate event, model, and view.

ASP.NET supports three main development models: Web Pages, Web Forms, and MVC (Model View Controller).

ASP.NET MVC Framework is a lightweight, well-testable presentation framework that integrates with existing ASP.NET features like master pages, authentication. In .NET, this structure is defined in the System.Web. Mvc assembly. The latest version of the MVC Framework is 5.0. The Visual Studio IDE is used to create ASP.NET MVC applications that you can add as a template to Visual Studio.

ASP.NET MVC contains the following features:

– With the help of this technology, it becomes possible to create applications with a complex architecture and accompanying tools, while providing convenience and efficiency in development.

– Contains an easily modifiable structure that can be easily changed or set the properties and settings necessary for the development process. If built-in technologies are not

suitable for creating an application, for example, the Razor engine for creating views, there is an option to use any other mechanism, customizing it as needed by the developer.

– Uses the component design of the application, logically dividing it into Model, View and Controller components. This feature allows the management of complex and large applications, while leaving the ability to develop the required parts of the project in isolation.

– The MVC design pattern increases the efficiency and convenience of testing the developed project, because any elements of the application in this case are created based on certain interfaces and tested using dummy instances of classes.

– Provides support for all available broad functionality of ASP.NET, such as: authorization and authentication, processing master pages, data binding, injecting custom controls, ASP.NET routing.

– Does not implement the View State principle (which is available in ASP.NET). This allows you to create simple applications with full developer control.

ASP.NET MVC is the main framework that is based on ASP.NET, while providing advanced functionality aimed at building and validating an application.

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DIGITALIZATION OF MINING ENTERPRISES IN KAZAKHSTAN

Information technologies in modern companies are considered as a tool that allows to increase business efficiency and contributes to the achievement of strategic business objectives. The goal of implementing innovative IT-solutions is to effectively organize the company's activities.

The efficiency and completeness of the use of all available information at the enterprise — for example, geological, economic, environmental, financial and other data-is determined by the use of information technologies, which can be called one of the most powerful tools for business development, which allows to provide a qualitatively new level of optimal and flexible management, design and planning decisions [1].

A serious aspect in industrial safety issues is also the timely and high-quality provision of all levels of information management about accidents, incidents, accidents, occupational diseases, microtraumas, and inspections performed.

Effective use of information technologies is impossible without a strategic vision of business development directions and without taking into account its specific needs, both current and those that will arise in the future. The main purpose of the digitalization process is to provide an integrated approach to the development of IT-technologies, automation and data transmission systems, to present a plan for the development of information systems and technologies, defining the sequence of actions, projects, as well as priorities, deadlines, and the amount of necessary organizational, financial, human and other resources.

The largest mining companies of the Republic of Kazakhstan aim to cover all production processes, starting from geological exploration, production, processing, transportation and

ending with the production of finished products, where all data on operational processes, process efficiency, product quality will be available in real time. Advanced technologies for the collection, processing and transmission of objective data, followed by comprehensive planning and automatic control of the execution of planned tasks.

The main directions used in the introduction of new technologies [2]:

1. Development of telecommunications;
2. Development and modernization of DATA centers and IT infrastructure;
3. Implementation of the Supervisory Control and Data Acquisition System (Scada);
4. Implementation of the Manufacturing Execution Systems (MES);
5. Implementation of Enterprise Resource Planning (ERP) system;
6. Implementation of the electronic document management system.

Development of the telecommunications platform. One of the most important tasks is to build a basic infrastructure component for the rapid exchange of information, namely, the organization of a high-speed and reliable data transmission channel.

Development and modernization of DATA centers and IT infrastructure:

- Information infrastructure, which includes server equipment and provides processing and storage of information;
- Virtualization - allows optimal use of computing resources;
- A well-developed IT infrastructure that provides users with all the resources (Active Directory, Email, VPN access, etc.) and tools of the Company's employees for both office and remote work.
- Telecommunications infrastructure that provides interconnection of data center elements, as well as data transfer between the data center and users;
- Engineering infrastructure that ensures the stable operation of the main data center systems.

The SCADA system is a tool program designed to automate the monitoring and control of the technological process in real time. The main purpose of the program created with the help of SCADA is to give the operator who controls the technological process complete information about this process and the necessary means to influence it.

The main tasks of SCADA:

- Process Visualization, Human-machine interface (HMI);
- Operational process control;
- Manage emergency messages and events;
- Analysis of historical data (trends);
- Generation of reports on the technological process.

MES system, a level of production process management that operates on the basis of received information from lower-level automation systems that provide real-time technological data to obtain a reliable, transparent and effective process management tool based on production dispatching systems.

The ERP system is a comprehensive solution designed for planning and managing company resources, including such basic modules as financial management, sales, supply, assets (Maintenance and repairs), production, warehouses, personnel and budgeting [3].

An important step in the successful integration of ERP into the company's business processes and the commissioning of modules is the continuous training of business users, so the IT service team has developed a training program, and if necessary, specialists go to business customers and explain in detail the capabilities of the system.

Electronic document management, allows the company to ensure the transition from paper to electronic format of working with documents, significantly reduce the cost of paper, as well as refueling and maintenance of printing equipment.

The main effects of the introduction of information technologies in the framework of digitalization of the enterprise are:

- increased productivity;

- development of new wireless technologies for monitoring and analyzing activities;
- improving the quality of IT services;
- distributed information access;
- improving the quality of management information and processing speed;
- development of industrial information security systems.

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CALCULATION OF MAXIMUM ALLOWABLE ANNULUS SURFACE PRESSURE

The goal of the project is to create a MAASP calculator app that improves the performance of supervisors by speeding up the speed of calculations and minimize human error.

Standardize the MAASP calculation to identify repeatability and ensure the quality of calculations, as well as to determine the operating parameters of wells during operation. MAASP occurs when drilling wells - this is the maximum closed (non-circulating) pressure that can be applied to the annular space on the surface before the formation directly under the casing Shoe begins to collapse (leakage). Today on field staff uses "Wait and Weight", "Driller's" methods are used in the kill sheet which are time-consuming to calculate manually, while app can solve this problem and minimize risk of human error. The list of formulas was taken from the official source ""IWCF Well Control Practice"". By the way all data provided based on IWCF as they have international accreditation and standardization.

In order to calculate MAASP value were used «Wait and Weight», «Driller's» methods. These methods used in order to prevent leakage and maintain stability in the well. Wait and weight method is killing well in one circulation. Once the well is shut in and the pressure has stabilized, the pressure in the closed drill pipe is used to calculate the weight of the kill fluid. Sludge of the required mass is prepared in the mud pits. When ready, the kill fluid pumped into the drill pipe. Initially, it is necessary to maintain a pressure in the drill pipe sufficient to circulate the drilling fluid, plus a reserve equivalent to the initial pressure in the drill pipe when closing. This total decreases steadily as the mud descends towards the bit, until, with the blind mud on the bit, the pressure required is simply equal to the pressure required to pump the blind mud around the wellbore.

Driller’s method is borehole impact using existing drilling weight. Then the drilling fluid rises to the required level and circulates through the well. The choke adjusted to reduce the pressure in the drill pipe when the kill fluid pumped into the string. When the muffler is on the bit, the static head of the mud in the drill pipe balances the formation pressure. During the remainder of the circulation, when the inflow pumped to the surface, followed by the contents of the drill pipe and the mud, the pressure in the drill pipe maintained at the final circulation pressure by adjusting the choke. First circulation: Pump the shock out of the well using the existing drill weight. Second circulation: Pump the kill fluid around the well.

My main suggestion for solving this problem is creating an application.

• Java" was chosen as a programming language due to its features such as cross-platform, as well as the ability to work with an unlimited number of variables. In addition, the language "Java" is easy to write and easy to understand.

• The values calculated in the Killsheet app are accurate to the hundredth, which minimizes the risk of errors and inaccuracies.

• Given that supervisors spend about 15 minutes on conventional fields, the application will reduce the time for extraction to 2 minutes.

• • Also, for the purpose of detecting errors in production, there is an additional function for writing data in excel sheet..

• Deposits in different countries of the world sometimes use different units of measurement, which proves the need to add a new function, such as unit conversion.

	Function	**Description**
1.	The accuracy of the computed values	Rounding values to thousands minimizes the risk of error due to inaccurate data output
2.	Time	Allows you to save time spent on calculations up to 2 minutes
3.	Chronology	The application allows you to record all the calculated values in a file format "Excel", which will allow you to react in a timely manner to any inaccuracies in data entry and simulate the previous outcome
4.	Conversion	Convert units to create a common system of input units

Implementation of program simplifies one of the problems in well control by reducing human factor and reducing time to make operations. According to financial calculations, it will also bring economic value to oil companies.

App has some development opportunities such as

– Adding a function for monitoring wells online, which will allow the supervisor to respond to them in a timely manner in case of problems..

– The function of tracking the progress of drilling, namely uploading all the necessary indicators to the cloud and the ability to observe the trends in the development of the field from anywhere in the world

– Ability to predict well capture by entering additional data

– Given the simplicity of programming in the "Java" language, all data received from sensors, such as the SIDPP indicator, which is recorded using the sensor. Data from the sensor will be loaded into the program and, if necessary, the code will be rewritten on the microcontroller for simplicity and convenience.

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CONSTRUCTION OF LITHOLOGICAL MODEL OF MINERAL DEPOSITS USING ARTIFICIAL NEURAL NETWORKS

Development of digital technologies and geological data processing techniques creates opportunities for the development of detailed models of rock massifs. With the help of pattern recognition technology, based on the method of classification and identification of engineering-geological elements, building a three-dimensional engineering-geological model, where the basis for the interpretation of the result is not the subjective nature of the model, but the mathematical apparatus, becomes possible.

To create a three-dimensional geological model, we have to prepare data that collected as a result of field prospecting works

Primary information includes geodetic coordinates of observation and sampling points; borehole core and rock samples; field observation, documentation, and sampling logs; results of analyzes of samples and tests of mineral raw materials; records of geophysical observations and others [1].

Secondary information includes types of information obtained as a result of processing, interpretation, analysis or generalization of primary data as: geological reports and graphical applications to them; published maps and explanatory notes to them; digital maps of geological content and permanent models; banks and databases on mineral resources, monitoring of the geological environment, geophysics and subsoil use, and others [1].

Based on the received geological information, a geological model is built using mining and geological information technologies (systems, MGIS), which are complexes of algorithms and corresponding programs designed for processing mining and geological data, organized and accumulated in digital format in databases [2, 3, 4]. Information technologies provide processing of initial numerical and text data, creation on this basis of new information on the objects under study, further processing of the information, processing of graphic information and the formation of new graphic documents based on the results of processing information of various types [2, 3, 4].

Traditional methods of geological models are based on the construction of sections (cross-sections, polygonal), statistical analysis and block modeling [5]. An artificial neural network is trained based on information about a mineral deposit obtained as a result of geological exploration, based on a sampling log. When training an artificial neural network, information about blocks with a known lithological difference is supplied to the input, the output is the rock belonging to this block. After the end of the training process, the parameters of the neural network are saved and based on these parameters, a volumetric block model of the mineral deposit is predicted (Figure 1).

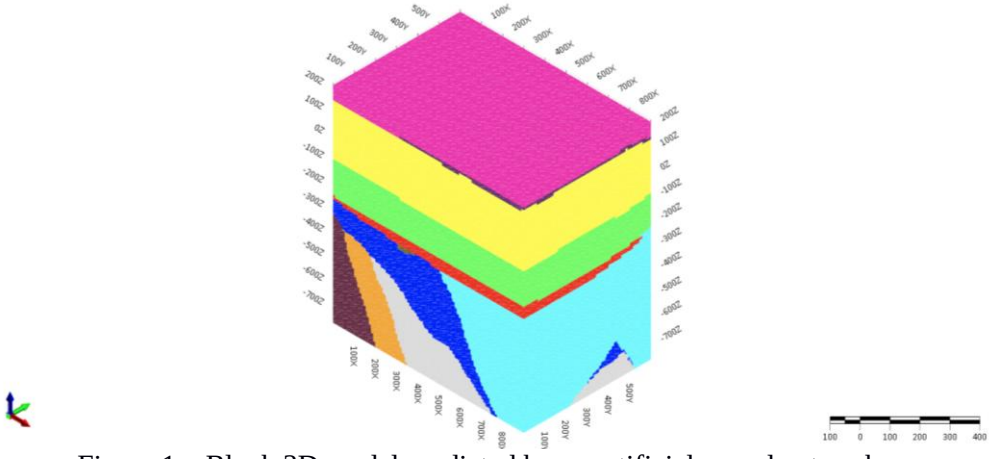

Figure 1 – Block 3D model predicted by an artificial neural network

The method of constructing three-dimensional models of mineral deposits using artificial neural networks will not only improve the quality of modeling and interpretation of geological data, but also significantly speed up the processing of geological information obtained as a result of exploration work at all stages of field development and the formation of technogenic massifs with required accuracy and the reliability of the results. Creation of a block geological model of a mineral deposit using an artificial neural network enables the model evaluation by mathematical methods not only in two-dimensional space, but also makes possible a spatial zoning of the mineral deposit for more detailed analysis.

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PROJECT PEPPERMINT – A DIGITAL AND EDUCATIONAL APPROACH TO IMPROVE STEM CAPABILITIES IN THE MINING INDUSTRY

Mining means the extraction of raw materials and is therefore at the beginning of a technical and educational value chain. In order to cope with the wide-ranging mine-life-cycle activities, it is essential to invest in the education of the next generation's engineers. In Germany, many secondary level graduates decide to pursue a STEM (Science, Technology, Engineering, Mathematics – in German "MINT") degree in tertiary education. Unfortunately, the dropout rates in STEM education are high and students struggle with basic subjects like science and mathematics where they are lacking knowledge they should have acquired at school [1]. With the project "PepperMINT" (https://peppermint.thga.de), funded by RAG-Stiftung (No. 20-0004), we present a new approach to close gaps in school STEM education and prepare first semester students for a successful beginning of their studies. PepperMINT will be developed as a MOOC (Massive Open Online Course) hosted by the TH Georg Agricola (THGA), offering digital courses in mathematics, physics, chemistry and engineering. Students will be introduced to the lectures and exercises of the THGA by the integration of interactive and applied examples. For example, the mathematics module of trigonometry can be taught by applying mine-surveying technology (e.g. mine-shaft measurements or borehole logging) or geomonitoring methods (e.g. earth-observation). The concept allows students to get to know the area of mining and post-mining before they decide in which area they want to pursue their academic career. With the conception of a MOOC, the e-learning platform can be used independently from the location and available time. The project PepperMINT has the potential to gain attention from pupils and students all over Germany, to attract the engineers of the next generation and will therefore improve the value chain of mining and the circular economy.

The reorganization of school curricula in Germany has led to changes in high school education. Disadvantaged students and especially those in structurally weak areas around former mining sites, have been severely affected by these changes and require profound support and professional training. The project PepperMINT creates a sustainable opportunity for STEM education in the form of open online courses that are integrated into an open learning management system (LMS). PepperMINT is designed for school education and also for the orientation phase of studies. The project and can serve prospective students to align different levels of knowledge and to close potential knowledge gaps. At the same time, PepperMINT fulfills the possibility to get insights into engineering studies and the broad field of mining.

For the content creation of the online classes, the curriculum of the STEM senior classes and the curricula for first semester students at the THGA are extracted and combined. The focus is on the STEM subjects mathematics, physics, electrical engineering and chemistry and the connection of these subjects with applied and practice-oriented examples from the faculties and research areas of the TH Georg Agricola. In order to increase and maintain the activation and motivation of participants, the modules consist of different media learning materials and activities, such as videos, simulations, quizzes and other interactive tasks. Entering the PepperMINT MOOC, the user needs to select a course (e.g. physics) and a specific module (e.g. kinematics). Afterwards the user needs to pass the first test (diagnostic assessment). Based on the result of the diagnostic assessment, the users receives the recommendation to work on different learning activities, which vary in their levels of difficulty. Having processed all learning activities, the user needs to do a summative assessment in order to complete the module. After completing the summative assessment, the user receives adaptive feedback on the level of knowledge and a badge that is used as a motivating and gamifying element. Collecting all final

badges across the different modules, the user will get a certificate of completion for the whole course.

The PepperMINT project and the structuring of the learning environment are currently in the development phase. At the moment, there are four different courses on the internal Moodle instance, which correspond to the subjects mathematics, electrical engineering, chemistry and physics and contain first modules (prototypes). The courses are developed in a human-centered design approach and will be continuously adapted to the needs to the target groups. With the aim of finding out more about pupils' interests in STEM topics in general and identifying pupils' requirements for STEM online courses, an online survey for pupils was designed. The first results (n = 192) show that the focus on application-oriented examples and activation of the participants corresponds to the wishes and interests of the pupils surveyed so far. The project is currently undergoing its first test phase, in which pupils from a cooperating school are testing the first modules. Based on the feedback of the tests, the existing content is revised and the courses will be constantly enhanced.

The project PepperMINT pursues the long-term goal of identifying potential knowledge gaps in STEM subjects and closing them throughout the courses. Furthermore, the project provides an orientation and information opportunity for students to learn about engineering courses and obtain specific study-relevant knowledge and enable a realistic picture. Young people can be motivated to study engineering and the number of freshmen in the STEM subjects can be increased, as well dropout out can be prevented. Prospective students can review their required qualifications and competencies in STEM subjects and compare their expectations for engineering studies with the content of the PepperMINT courses. By designing a MOOC, the courses are available as online courses to anyone interested, regardless of time, geographic, or financial constraints. The PepperMINT courses can be an important step as a support service during and after the COVID-19 pandemic. Ultimately, the PepperMINT project contributes to a sustainable education for the mining industry and the training of the next generation of engineers.

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AUTOMATED CONTROL AND MONITORING SYSTEM ELECTROREFINING OF COPPER

Introduction. Copper is a strategically important metal used in the electronic and electrical industries. In Vietnam, there are ore reserves of oxidized copper ores, but they are still under development. In addition, the steel industry in Vietnam is focused on the development of the secondary industry as part of the raw materials in the form of scrap and waste of copper production is exported abroad. It is of scientific, technical interest and is relevant to the use of secondary resources for the organization of small production of cathode copper for the electrical industry of Vietnam.

Content. In Vietnam, copper ranks third in aggregate and consumption among metals, after steel and aluminum. Due to its good electrical conductivity, thermal conductivity, high strength, copper and copper alloys are widely used as electrical conductors in industrial and civil electrical equipment of Vietnamese manufacturers[1].

The energy potential does not yet allow the organization of large-scale projects in the metallurgical industry. The source of electricity for organizing the production of a copper smelter is the National Energy System, which operates at high voltages of 500 kV, 220 kV, and 110 kV and an average voltage of 6 kV to 35 kV [3]. To solve the problem of the short-term shortage of electricity, the task is to increase production efficiency, automate process control, and especially minimize the loss of electrical energy at copper smelters [4].

Electrolytic cathode copper is an energy-intensive production and carries high costs due to imperfect control and management of the main parameters affecting the specific power consumption. First of all, it is the temperature of the electrolyte, the composition of the electrolyte, the inter-pole distance, the content, and the level of sludge deposits in the electrolyte cell. Some of the parameters are not controlled, which leads to a decrease in the energy efficiency of production. The main causes of energy losses during the electrolytic refining of copper are dendritic short circuits (fusion of electrodes), which are associated with the distance between the cathode and anode (inter-pole distance). Also, losses are associated with the formation of sludge, and in this case, losses are associated with an imbalance in precious metals, which are always present in copper production.

The aim of the study is to increase the level of automated control and management of electrolytic cells by reducing the number of manual measurements. It is necessary to create a digital control system, which must ensure the operation of the neural network through the stochastic system using the Database at all levels of the electrolysis ACS. The task is to minimize the inter-electrode distance, taking into account changes in the concentration and temperature of the electrolyte. All parameters through a neural network should be interconnected in order to ensure operating control of the process in the event of a short-circuit of electrodes or an increase in the level of sludge. For optimization, it is necessary to install additional control points equipped with sensors and microcontrollers to transfer data to the database of the automation system. Special scanning thermal imagers and cameras, technically, can be an element of creating a digital twin of the entire operating system of the automated process control system "Copper Electrolysis".[2]

Conclusion. Increasing the level of control and management through digital automated systems in the electrolytic refining of copper will reduce energy consumption by 15-20%, which makes it possible to organize production in conditions of power shortage.

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SYNTHETIC DATA APPLICATION FOR INDUSTRIAL MACHINE LEARNING

Nowadays, machine learning technologies are increasingly used to solve industrial automation problems. A distinctive feature of such algorithms is the need for large arrays of structured (labelled) data on which they are trained. The quality of the functioning of the automation system based on machine learning, in particular, technical vision, largely depends on the quality of the training sample used. It should reflect the nature of the process under study as accurately as possible, in other words, be representative. [1] Obtaining such a sample is a very

laborious process, it is necessary to capture as many different variants of the states of object under investigation as possible. So, for example, if it is necessary to classify an object, then it is necessary to include in the sample as many unique instances of each class as possible, which can be difficult due to the intraclass variability of the object, that is, objects belonging to the same class can have different representations (color, shape, size, etc.).

In most cases, developers of industrial automation systems do not have at their disposal the required amount of production data sufficient to implement machine learning algorithms. This is due to many factors: the company did not preliminarily maintain the required parameters or did it inappropriately; automatic marking of industrial data is difficult, and manual marking requires a high level of specialist competence; data collection needs to be done over long-time intervals (months and years). As a result, these limitations in the aggregate significantly complicate the implementation of machine learning algorithms in automated control systems for technological processes. [2]

This problem can be solved by programmatically generating the necessary data based on mathematical models of technological processes and devices, as well as special visualization and physics simulation tools. Many technological processes can be simulated in specialized software packages, in which the parameters of the process can be set algorithmically, which makes it possible to reproduce various production situations. In addition to mathematical models, some graphic 3D editors (Blender) and game engines (Unity, Unreal) can be used to generate training samples. The latter is most preferable when working with a technical vision since in addition to the rendering system, they are also equipped with a physics engine, albeit more primitive than in mathematical packages, but sufficient for simulating kinematics, particle systems and solid-state physics.

The proposed method has several advantages. Synthetic data can be obtained in a relatively short time, while the sample size is limited only by the time and capacity allocated for its generation. The developer can independently set the optimal distribution of different classes in the sample for training based on the problem. For synthetic data, it is not required to carry out markup, since it can be carried out directly in the process of calculating the model and generating a sample. [3] The disadvantages include the need to use expensive software packages for modelling and visualization of technological processes, the need for large computing power, increased requirements for the qualifications of specialists, implying a deep understanding of the nature of the simulated processes.

The work is devoted to methods of generating training data for computer vision algorithms using the example of metallurgical production. A review and comparison of existing techniques for preparing and synthesizing training data based on models, as well as data markup tools, is made. Examples of possible generation methods and options for using artificial data in training computer vision algorithms, such as pattern recognition and semantic image segmentation, are considered. An overview of real problems of industrial automation, including machine vision algorithms, is given, and alternative options for their solution using synthesized data based on a model of a technological process are considered. The paper compares the results of the operation of algorithms trained on synthetic data and data obtained from real technological objects.

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GEOSCIENTIFIC OBJECTS DIGITIZATION – VARIABILITY OF PHOTOGRAMMATRIC METHODS IN GEOSCIENCE

A wide range of disciplines are increasingly attuned to new digital technologies to assist in the process of archiving, analyzing, and presenting geoscientific objects, like fossils and minerals. In the past few years, new non-destructive digitizing techniques have provided powerful ways to better visualize those objects. For example, X-ray micro-tomography, laser scanning or photogrammetry [1]. Photogrammetry, or structure from motion, is a method for reconstructing an object in 3D from high-resolution photographs and relies on optics and projective geometry principles (e.g., stereoscopic vision). It can be performed with either terrestrial (digital close-range photogrammetry) or aerial photographs (e.g., in remote sensing), and is one of the easiest and most cost-effective 3D-digitizing techniques, because it only requires a digital camera and specific software [2]. The increasing use of photogrammetric methods benefits from both the wide variety of available programs and the accessibility of sufficiently powerful computers.

As an introduction to branches of geosciences such as palaeontology, stratigraphy and historical geology and digital methods applied therein, we conceptualized a workshop for high-school students focusing on 3D digitization of geoscientific objects. The topics included the basics of 3D imaging in the field of photogrammetry and various scanning methods, but also applications for presentation of digitized objects, such as replicas (e.g., 3D printing). The aim was to explain the complex principals of 3D digitization in a simple and understandable way and to show that photogrammetry is an application that is becoming more and more important not only in science but also in everyday use. The workshop was designed to show the students how to use simple tools (in this case a cell phone) to obtain photogrammetric images of objects in order to create 3D models of them. Furthermore, different options of generating, editing and presenting 3D models with a free and user-friendly software (3DF Zephyr) were explored. The response from both students and their teachers proved the attractiveness of this hands-on approach.

Close-range photogrammetry can be assisted and refined by appropriate tools, especially when objects of interest are in parts or entirely difficult to reach. Such an object is an 8.35 m tall fossil conifer trunk from the Petrified Forest of Chemnitz (Saxony), incorporated into the Freiberg Geological Institute and spanning over three floors. We are testing the applicability of an industrial robotic arm (Universal Robots UR5) for facilitating and partially automating the process of obtaining high-resolution images. A digital camera can be easily attached to the tool center point (TCP) of the robotic arm with the help of a 3-finger grip (Robotiq). The robot not only safely reaches difficult areas and stably holds the camera, it also measures the pose (position and orientation) of its TCP with accuracy of up to 0.1 mm. We plan to include this information into the photogrammetric modelling process, hoping to enhance the final quality of the 3D model.

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LASER ULTRASOUND DIAGNOSTICS OF NEW MATERIALS. DIGITAL PROCESSING

The development of new materials, their study and the improvement of old ones are called upon to play an important role in conditions of a shortage of resources. This is relevant for many areas of science and technology. For example, the modern aerospace industry is constantly looking for lighter, stronger and more heat-resistant materials that can help reduce emissions, reduce fuel consumption and increase speed. That is why composites have become the most popular materials in the aviation industry. It is also important to note that the automotive industry is constantly facing new challenges to develop new materials from steel and alloys that are stronger and lighter than those currently used. It is also important to note the construction industry, in which the requirements for the safety of buildings and structures are constantly increasing and new relatively cheap materials are being created that require diagnostics.

All of the above has led to the need to develop modern effective methods for detecting, diagnosing and predicting dangerous processes of destruction of heterogeneous structural materials using advanced digital technologies and robotic systems, as well as to the creation of application programs for processing and storing large amounts of data.

Existing methods, such as acoustic emission, ultrasonic or acoustic laser vibrometry, thermography, can only determine the presence of defects, without giving important information about their localization, geometric parameters and damage to the internal structure. Traditional non-destructive ultrasonic methods and the use of modern flaw detectors and tomographs, using piezotransducers and antenna arrays based on them to excite and receive elastic waves, turn out to be ineffective in the study of heterogeneous media due to the strong attenuation of acoustic vibrations in them. Non-destructive testing methods such as terahertz spectroscopy, as well as X-ray tomography and neutron radiography, which provide information about the internal structure of the samples, are expensive. In addition, a study with the necessary resolution can be carried out only on small samples for a long time and under laboratory conditions.

It seems promising to develop a new method for diagnosing the structure and properties of various structural materials based on laser-ultrasonic diagnostics. This method is implemented in several operating modes of the corresponding installations. One of the main ones is the pulse echo mode, in which a wave is generated and recorded on the same side of the sample, which requires one-way access to the object of study. The next ones are shadow and immersion shadow modes, in which the sample is placed between the generator and the receiver in a cuvette with water.

The advantage of this method lies in increased sensitivity, informational content, the ability to work with small samples, and an increase in the productivity of the measurement process [1]. Below are the results of studies of various materials.

In one of the works [2], the internal structure was investigated, the local elastic moduli of the fragments of the steel structure of the building were determined. Due to the fact that this structure began to collapse at a load of 60% of the calculated one, it was necessary to identify defects in order to establish the exact cause of the destruction. As a result of the work (Figure 1, a), multiple defects with a width of about 50 microns and more of various lengths were established. This method allows examining metal products with a thickness of up to 20 cm and a cross-sectional area of 3 to 10 m^2.

In work [3], the internal structure of an unmanned aerial vehicle body part was investigated (Figure 1, b). The composition of the part is polymer composite materials of interwoven carbon fiber strands located in a matrix of epoxy resins or "binder". The average

thickness of sample No. 1 was 1.65 mm; average thickness of sample No. 2 - 2.05 mm. The result of the work was a built 3D model of the sample with a map of defects. Defects in composites were successfully localized with an accuracy in the direction of propagation of the ultrasonic beam up to 30-70 μm, in the perpendicular direction - 400 μm.

Also, this method allows you to determine the elastic properties of rock samples [4] (Figure 1, c), to partially determine the structure, creating a 3D model of the sample. A general algorithm for conducting experiments is presented and it is proved that for a preliminary assessment of the dynamic modulus of elasticity, it is sufficient to use plate specimens, which are prepared from full-size specimens (drilled cores).

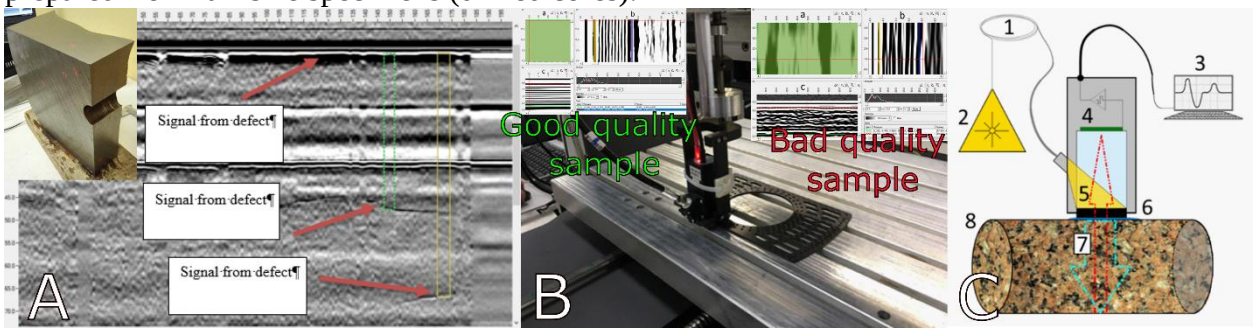

Figure 1 - Study of various materials using laser ultrasound diagnostics: (a) the structure of a metal fragment, (b) the structure of a composite material and (c) a scheme for measuring elastic moduli in rock core samples optical cable (1), laser (2) , computer (3), detector (4), laser radiation (5), optoacoustic generator (6), pulses (7), granite specimen (8)

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SMART - TECHNOLOGY AS A TOOL FOR MONITORING THE LEVEL OF KNOWLEDGE AND INCREASING THE QUALIFICATION OF THE STAFF OF THE ENTERPRISE

Human resources play a significant role in the formation of the competitiveness of any enterprise, since it is the person who ensures the most efficient use of the company's resources. The problem of rapid obsolescence of professional knowledge, in turn, requires organizations to

constantly improve the qualifications of their employees in order to achieve success. Highly qualified and competent personnel allows you to create products that will be competitive in the market, which is one of the interests of the leaders of any organization. This is evidenced by the following fact [1]: Human capital in the national wealth of the world community is 64%, natural capital - 20%, and physical only 16%. The share of human capital in developed countries is up to 80% of their national wealth. Consequently, human resource management is an important component of the company's strategic development. Employees of all industries must systematically and without fail confirm their qualifications and raise their level, studying and mastering modern achievements in their industry. It is also necessary to develop professional competencies based on a systematic multidimensional vision and study of innovative technologies, taking into account their multidimensionality and continuous updating of content, technologization of the process of acquiring knowledge, increasing the interest of employees in obtaining new knowledge, the interest of management in conducting regular monitoring and improving the professional level of the company's personnel, and etc.

However, the issue of monitoring the professional knowledge of a particular employee and, if necessary, increasing its level at a particular enterprise, is not given sufficient attention. In real conditions, the level of training and retraining of professional personnel of an enterprise is affected by a number of factors that restrain their active acquisition of knowledge and practical skills. These include: weak information infrastructure of the enterprise; lack of professional and educational content in areas of activity for the acquisition of modern knowledge and skills, tools for creating digital models of professional and educational content; lack of the ability to conduct regular monitoring, ways to assess the quality of training of employees of the enterprise and conduct trainings for training and retraining of personnel of the enterprise in areas of activity using modern tools.

At the present stage of development of society, such a tool is “smart” digital technologies, such as SMART technologies. Smart is known to be an abbreviation for Self-directed, Motivated, Adaptive, Resource-enriched, Technology embedded [2]. According to Professor V.P. Tikhomirov. “Smart is a new paradigm for the development of society”, which requires the Internet and specially trained people who create new knowledge ”[3]. The leading idea of the study is that the solution of problems associated with the periodic monitoring of the level of knowledge of employees of any enterprise, as well as with the organization of training courses aimed at training and retraining of personnel of the enterprise in the areas of activity should be based on the use of the capabilities of the latest achievements of "smart »Digital technologies, such as SMART-technologies, which will support the company and increase its revenues. For this, it is necessary to develop new monitoring methods, assess the level of knowledge and improve the qualifications of enterprise personnel using SMART technologies, implemented in the format of distributed Web applications. The program we are developing is aimed at solving the problem of developing the infrastructure for advanced training systems, consulting and information services for a particular enterprise. The result of the implementation of such a program will be SMART-technology for monitoring the level of knowledge and conducting training for the training and retraining of personnel of the enterprise in the areas of activity, which is: the integration of computer programs and information technologies, intelligent educational applications based on multimedia, as well as SMART-devices; an integrated intelligent virtual environment that allows, using SMART technology, SMART devices and the Internet, to create endless opportunities for training each of its participants.

The results of technology implementation will ensure the transformation of information and knowledge into capital. The purpose and objectives of the program: increasing the efficiency and validity of production decisions for the development of the enterprise based on the acquisition of professional knowledge by its personnel, necessary and sufficient for the introduction of innovative technologies into the enterprise. To achieve this goal, a step-by-step solution of the following tasks is necessary: At the first stage, the main task is to select and justify methods and means for monitoring the level of knowledge and improving the

qualifications of the company's personnel. At the second stage - the creation of a model and methodology for monitoring the level of knowledge and conducting training, training and retraining of personnel in the areas of the enterprise, adaptable to the state of the modern infrastructure of the enterprise. At the third stage, the structure and composition of the SMART-technology data warehouse, implemented in the format of Web-applications, it will be developed, which will make it possible to switch to the use of design and management methods for the multi-level database system (DB) of the SMART technology. At the fourth, final stage, a CASE-tool for filling professional and educational content and a SMART-technology for monitoring the level of knowledge and advanced training of the company's personnel in the areas of activity will be developed.

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DIGITALIZATION OF OIL PRODUCTION IN THE REPUBLIC OF BELARUS

Over the last two centuries oil is considered to be one of the most important resources. The production, supply and use of oil have always influenced the economic policy of the country and its safety. It determines the world politics and international relations.

As for the standards of oil production on a global scale, the share of Belarus is insignificant compared with such world leaders as Saudi Arabia, the United States, Russia and many other countries. But we must point out the fact that with relatively small reserves of oil and the inaccessibility of its production and extraction from oil fields has not stopped in the Republic of Belarus for 55 years.

The main oil production enterprise in the Republic of Belarus is the Republican Unitary Enterprise "Production Association "Belarusneft". As the general director Lyakhov A. A. noted: "The main task of recent years is the stabilization and maximum possible increase in the level of oil production" [1]. If we pay attention to the statistics, from 2016 to 2020, oil production in Belarus has been growing from 1645 to 1710 thousand tons per year. Undoubtedly, it is due to the increase in seismic exploration and exploration drilling, which helped to increase the chances to discover new oil deposits.

Over the past two years, with the help of an active increase in geological exploration in Rechitsa region, a new Guryanovskoye oil field was discovered in April 2021, with total reserves exceeding 800 thousand tons of oil, according to geologists' calculations. Since the oil in this area is good and easily extracted, work there does not involve any additional technologies, which is profitable from an economic point of view because the costs of means of production are minimized.

But such discoveries are simply incredible rare for the oil industry. Yuri Gribovsky noted: "Today, local deposits are at the final stages of development. The main large assets have

been discovered, their resource is running out. But new ones, as a rule, are small in terms of reserves and difficult to develop" [2]. It should be understood that the depletion of natural reserves, aging infrastructure, as well as the need to develop hard-to-recover hydrocarbon reserves will lead to the use of high-tech equipment and digitalization of oil and gas companies.

As S. B. Suloeva, Doctor of Economics, said: "At present, digitalization of a company in the oil and gas complex is the use of new high technologies with existing business processes without changing their principles and structure" [3], which indicates the optimization of traditional processes rather than transforming the business model of the enterprise. Optimization will reduce the costs, from the production activities of oil and gas companies and to the sale of petroleum products. With the introduction of digital technologies, companies will be able to solve a number of main tasks: firstly to increase the efficiency of oil production (including from hard-to-reach areas); secondly, of course to decrease the number of failures in the operation of various equipment and, as a result additional production costs.

The first organization in Belarus to introduce digital technologies in practice was oil and gas production department "Rechitsaneft". The Integrated Operations Center began work there on June 1, 2020. "The main tasks of the Center are to increase the volume of oil production by the introduction of innovative technologies, to increase the labor productivity of geologists and management technologists, to reduce the production cost at oil fields and gas production at "Rechitsaneft" due to the optimization of production processes" [4]. With the help of this Center, it will be possible to collect, store, process and analyze all data about the fields, technical aspects of work there, resulting in the optimization of personnel work and assistance in decision-making and further planning of the work of oil production enterprises.

Thus, the development of systematic digitalization of oil production enterprises in the Republic of Belarus will positively affect the prospects in this industry in the future. Automation of production will reduce production losses, prevent equipment downtime, increase the speed of decision-making by management, and enlarge oil reserves in the Republic of Belarus in case of unforeseen changes in the global conjuncture.

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APPLICATION OF PORTABLE MINI-SPECTROMETER AS OIL AND PETROLEUM PRODUCTS QUALITY CONTROL SENSOR

The issue of quality control of petroleum products remains an urgent issue in petroleum refining industry. The application of portable spectrometric devices for analyzing petrochemical products is not particularly new concept, but up to now the existing technologies do not respond

fully to the market demand for such devices. Presently, practically all portable optical sensors use thermal emission sources with filters or laser diodes, which limits the field of application. Opto-electronic methods serve as an indirect measure of oil and petroleum properties, such as availability of asphalt-resinous substances, water cut, oil refining depth, different types of impurities and predominance of certain hydrocarbon groups and so on. There are different methods of optical analysis, depending on which parameter of light radiation is put in the basis [1]. The method of infrared spectrometry is widely used for joint determination of qualitative and quantitative composition of hydrocarbon-containing compounds. Advantages of the method include simplicity, reliability, performance, versatility for mathematical processing of results and the possibility of express analysis, which is especially important for evaluation of oil product quality control in conditions in real-time production process. [2-3]. The purpose of the research is to investigate the possibilities for the applying of portable minispectrometer based on near infrared LED matrices as a sensor of express-analysis and hydrocarbon quality control using three oil samples from the Pervomayskoye oil field (Tomsk region): sample No.1 - raw oil, sample No.2 - oil with partial sulfur content after treatment of heavy impurities, sample No.3 - diesel fuel.

A LED portable mini-spectrometer LMS-R from LED Microsensor NT measures the reflection and scattering spectrum of solid and liquid samples in the spectral range from 1.3 to 2.4 micrometers. It has a high measuring speed < 1 s and compact dimensions (60x42x42 mm). The device is made in a single metal casing, including optical and electronic blocks. The main element of the optical unit is a 12-element LED matrix and a broadband photodiode, covering the near infrared range from 1.3 to 2.4 microns. At the time of measurement the LEDs switch on one by one and irradiate the surface of the measured sample, the reflected radiation is recorded by the photodiode, converted into an electrical signal and processed by the built-in electronic unit and specialized software. The measurement result of the device is a dependence of the reflection coefficient of the sample on the wavelength, which is displayed by the program as a spectral curve or as a histogram [4].

Initially, a calibration measurement was made relative to the fluoroplastic reflectance standard in the relative measurement mode. In this mode, in the absence of the fluid under study, the instrument displays 100% of the signal at all wavelengths. In the presence of the substance under study the absolute values of the sample reflection coefficients are displayed. After calibration, a sample of diesel fuel was taken and applied to the substrate of the standard. Next, the instrument was placed on the sample, with the minispectrometer window positioned close to the center of the sample being measured. The instrument measured for 1 second, after which the result was displayed in the program window. A calibration "reference" measurement was performed before each measurement of samples № 1, № 2 and № 3. Residual particles of samples № 1, № 2, № 3 on the substrate caused a slight shift in the spectra of the fluoroplastic etalon.

Results of measurements show that spectra differ not only in degree of transmittance (absorption), but also in form. Transmission spectrum of oil from the field (sample № 1) is characterized by strong absorption in the short-wave region, unlike samples № 2 and № 3, which confirms the presence of heavy impurities in crude oil. The lowest level of absorption is characterized by purified diesel fuel. Each level of refinement reduces the absorbance in certain areas of the spectrum. The time per measurement is very short, which allows you to monitor the oil refining process in a continuous mode.

The experiment confirmed that the peculiarities of the forms of spectra obtained by the LMS-R minispectrometer allow the identification of petroleum products at different stages of crude oil refining. Subsequent analysis of the chemical composition of petroleum products and the given spectrum of the studied samples make it possible to determine the presence of certain substances in the composition of the samples under study, and the amplitude of the spectral bands makes it possible to determine their percentage composition. In the future it is planned to carry out researches of wider range of samples of oil products, tying them to the real

technological process of processing and to the control of parameters which are of practical interest [5].

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DATAFICATION OF MINING COMPANIES AS A MEASURE OF ADAPTING TO THE DIGITAL ECONOMY

Introduction. The success of companies in the digital economy is ensured using digital technologies. Big data streams are the circulatory system of digital technologies. The use of big data provides companies with sources of decision-making, tools for long-term forecasting and effective planning of their activities. Big data, as a resource for the digital economy, is the key to enterprise agility, sectoral and regional cooperation, and the inclusion of enterprises in value chains. The use of big data allows to extract previously unknown knowledge from accumulated datasets through the process of cleaning, transforming, and interpreting the datasets. The problems of digitalization and robotization are actively explored in researches of Belarusian scientists Yu. V. Meleshko, T. V. Serhiyevich. Detailed understanding of the specifics of the mining industry is provided in the articles of Yu. V. Meleshko. The joint article of E. Brzychczy, P. Gackowiec and M. Liebetrau is devoted to the discussion of the need to use big data in the mining industry. To reveal the peculiarities of modern society, let us turn to the researches of the famous economist, Professor S. Yu. Solodovnikov, whose researches are aimed, among other things, at developing approaches to modernizing the Belarusian economy.

Main part. To describe the current situation in the economic field, we will use the results of the scientific research of S. Yu. Solodovnikov, who writes that “the post-market economy is characterized by the presence of highly efficient industrial production, a significant increase in the share of the service sector in GDP, a further increase in the importance of knowledge for economic development, the development of the Internet-technologies and new (post-market) forms of competition " [1, p. 39]. The increasing importance of knowledge is manifested in the digital economy in the role that is assigned to the use of big data. Metallurgy, oil and gas, transport, telecommunications, electric power, mechanical engineering, and the financial sector are named as areas where the use of big data is in demand. Researchers refer to the implementation of predictive analytics based on big data by Gazprom Neft as successful examples of implementing the use of big data, the program of innovative development of which is planned that the total expected effect of its implementation will be more than 100 billion rubles by 2025 cost savings and will allow more than 100 million tons of additional reserves to be involved in development [2, p. 398]. McKinsey experts among “technologies enable a fundamental shift in the way mining works” lists technologies based on **data, computational power, and connectivity; analytics and intelligence; human–machine interaction; digital-to-physical conversion [3]. These** technologies able to commit “a shift marked both by harnessing the flow of information to reduce variability in decision making and by deploying more centralized, mechanized operations to reduce variability in execution” **[3].**

Digitalization, carried out on the basis of big data, is considered as a tool for increasing the productivity of the mining industry, which is, as the Belarusian scientist Yu. V. Meleshko writes, “a complex of industries for the extraction and enrichment and processing of minerals” [4, p. 106], noting that the peculiarity of this type of economic activity is manifested in the cost structure: “the most important factors influencing the cost of mining enterprises include a number of natural factors (also called fundamental), such as: mining and geological conditions of occurrence, physical and chemical properties of minerals and economic and geographical location of the deposit” [4, p. 106].

At the present time “Miners already produce huge amounts of sensor data, potentially enabling them to obtain a more accurate and consistent picture of reality at the rock face than ever” [3]. The importance of using big data for the mining industry is due to the fact that “the acquisition of large amounts of machine data allows obtaining a more complete picture and in-depth knowledge of the efficiency in which processes are carried out. Hence, decision-making can be supported, and indications for processes efficiency improvement identified” [5]. Using Big Data, Mining Companies “can identify process deviations, and bottlenecks, which are based on event logs from system databases” [5]. A key feature of big data mining applications is that organizations have the ability to reflect “real process behavior recorded in IT systems”, and thus, “the obtained process models can be treated as more reliable than process observations and complementary to other manual process documentation sources. <…> informing relevant stakeholders on irregularities, failures, and delays, enabling them to react on identified problems, giving the inputs to increase efficiency of production processes” [5].

Further competitiveness of enterprises, including the mining industry, will be ensured through robotization, which will be the next stage in the creation of an enterprise that is quickly adaptable to new conditions. At the same time, as T. V. Serhiyevich notes, “the processes of digitalization, automation and robotization of industry cover all stages of production – from obtaining and analyzing data on emerging market trends, computer-aided design and design, robotization of logistics and the production process itself to digital positioning tools and sales” [6, p. 56].

Conclusion. Thus, the development of information and communication technologies serves as a source for the large-scale application of big data. This data, which serves as a resource for the digital economy, stimulates the development of more efficient and reliable approaches to decision making. One of the areas of implementation of the application of big data, as demonstrated in the examples, is the mining industry. The use of big data leads to the formation of new approaches in the organization of production due to its robotization. Timely measures to modernize the enterprise, based on information and communication technologies, ensure the competitiveness of enterprises in the digital economy.

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APPLICATION OF DIGITAL TECHNOLOGIES FOR INCREASING ENTERPRISE ENERGY EFFICIENCY

The electric power industry is one of the basic industries; the energy security of the country, the operability of industries and the sustainable development of the economy as a whole depend on its efficient and reliable functioning. Over the last thirty years, energy consumption has been growing steadily and the load on the existing energy systems has increased as a result of the need to expand generation. It is important to note that the biggest pressure on the energy system occurs only during certain periods of time, which requires an additional generation capacity. One approach to solving this problem is Demand Response concept. This approach has become widely applicable due to the emergence of digital interval meters and smart grids. However, despite the existence of a number of studies [1-3], the issue of using retrospective and planned energy consumption data for optimal planning of load allocation on the electricity grid remains not fully resolved. The aim of this work is to develop and implement algorithms for optimal allocation of electricity consumption to improve the enterprise energy efficiency.

The main source of data used were the energy consumption values of the devices obtained from the Schneider Electric Smart Panel system during an experiment in the laboratory of the Educational Research Centre for Digital Technologies. The low-voltage panels enable real-time measurement, monitoring and control at the site. Data from the generation and consumption plan of the System Operator of the Unified Energy System was also used.

Based on the demand response concept, two algorithms have been proposed: load sharing in intermittent time intervals and load sharing in continuous time intervals. The first algorithm allows finding such an allocation of equipment operation over the hourly operating intervals that the total consumption in the network will be minimal. As a development of this solution, an algorithm has been designed and implemented to determine the moment of device switching on, which makes it possible to find such a moment of starting interval at which the network load over the whole operating range will not be more than the output limit and the device operation will be completed by the specified moment of time.

The proposed algorithms can be implemented individually or together. Combining the operation of the two algorithms allows the best effect to be achieved. At the initial stage, the most perspective operating intervals are determined, and the subsequent stages are detailed to select the optimum operating time.

This approach has a number of effects. The economic benefit to the electricity suppliers by reducing the need to build new generation capacity and the cost savings to the users by allowing them to choose a period to operate at a lower tariff rate and by not having to use additional energy sources and therefore reducing fuel costs, which is especially important for remote and isolated power systems, including areas in the Arctic region [4]. In addition, the environmental effect obtained by reducing the fuel consumption of diesel generators is also important, which also has a positive impact on the environment and enables the company to reduce its carbon footprint and comply with its socio-environmental development strategy.

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FORECAST ANALYSIS OF THE COVID-19 INCIDENCE IN LEBANON: PREDICTION OF FUTURE EPIDEMIOLOGICAL TRENDS TO PLAN MORE EFFECTIVE CONTROL PROGRAMS

Ever since the COVID-19 pandemic started, all governments have been trying to limit its effects on their citizens and countries. This pandemic was harsh on different levels for almost all populations worldwide. For this purpose, researchers and scientists got involved and worked on several kinds of studies and modeling techniques to get a better insight into the spread of the virus to stop it at the earliest time possible. Some of those studies rely on signal processing and time series analysis. The problem with these techniques is that their predictions are based only on historical data. So, they do not consider the real cause of the virus spread, which is human interaction. Other studies rely on solving differential equations that characterize a particular population. Some of the famous examples that fall under this category are the SIR (Susceptible – Infected – Recovered) and the SEIR (Susceptible – Exposed – Infected – Recovered) models. Although these models characterize a population, they consider this population to be homogeneous, which is why we cannot use them to model complex human behavior. This is where the final modeling technique comes to the rescue: It is Agent-Based Modeling. This technique is used to build artificial intelligence systems that mimic human behavior, where individuals are modeled as agents having specific needs and characteristics. These agents interact with each other and with their environment. This interaction contributes in a way or another to the results we want to obtain. So, we get our results without explicitly programming them. We only have to program the behavior of our agents. In this study, we built an Agent-Based Model to simulate the spread of COVID-19 in Lebanon with the different control measures that the Government applied. Then, we used this model to study the effect of opening schools and universities on the pandemic situation in the country since the Lebanese Ministry of Education was planning to do so progressively, starting from 21 April 2021 [1].

For this purpose, we built a small country that represents Lebanon in different aspects. Our virtual country has several locations where an agent can be (houses, hospitals, markets, malls, nightclubs, companies, churches, mosques, universities, schools, and an airport). Among

these locations, Houses are the origins of the population. This is where an agent is born. Each house is characterized by a specific number of agents living inside of it. Each of these agents has a particular age, religion, profession (School Student, University Student, or a Worker), and some locations where he can go depending on his age. All of this information is sampled from real Lebanese statistical distributions using Monte Carlo Algorithm. In addition to that, for the simulation to take a realistic Lebanese aspect, we give some agents the ability to make visits to other houses. An agent can even travel outside the country for a few days.

The simulation starts with one agent being infected, and the others are susceptible (can be infected). The infected agent will go into the world, interact with other agents, and possibly infect them. This is how the number of infected agents grows. Agents travelling to the country can also be infected, and of course, can infect agents they meet. The simulation process runs for several days. At the beginning of each day, an agent is assigned a list of locations where he will be during each hour of the day (schedule). This is how agents meet at different locations. When an agent is present inside a location, he is considered to be in a room of this location. This is why different locations are modeled as different rooms, each having specific characteristics, and based on that, each location has a defined infection rate. This rate indicates the chance of an infected agent infecting another agent within the same location (or room). In our study, we used a COVID-19 risk calculator developed by the Harvard School of Public Health that is based on their peer-reviewed paper [2]. This calculator helped us approximate the infection rate for different kinds of rooms where an agent might be. This rate considers many factors that include the room's space, the activity done inside it, the precautions taken by the agents, the amount of social distancing, and many more. An agent can infect others only during the infectious period that lies between the latent period and ten days after the incubation period [3]. Once an agent becomes infected, he will develop symptoms. These symptoms can be categorized between Mild/Moderate, Severe, or Critical. An agent can also be asymptomatic (does not develop symptoms). After developing a symptom, an agent can recover or die. Death and recovery rates vary depending on the severity of the symptom.

During the simulation, we can introduce specific control measures. These measures can force agents to wear masks, close specific locations for some days, close the airport, or even introduce a complete lockdown. The effects of these actions can be monitored from real-time charts through the simulator and can give an insight into the effectiveness of a control measure applied at a specific time.

To make sure the simulator is functioning correctly, we tested two theoretical concepts that we hear a lot when it comes to COVID-19, which are: Flattening the curve and the Second Wave Scenario. Then, we simulated all the actions that have been taken in Lebanon since the start of the pandemic until 21 April 2021 to see their effect on our virtual country, and then compared our "Active cases" pandemic curve with the real one of Lebanon. We ended up with a very similar-looking curve. Now that we have a curve representing the Lebanese pandemic situation, we can predict what will happen in the future based on the Government's actions. In fact, the Lebanese Ministry of Education expressed their willingness to open schools again progressively starting from 21 April 2021 until 17 May 2021 [1]. This is why we wanted to see the effect of such action via our simulator, especially that the vaccination process is still slow in the country. Based on the results we obtained, we conclude that opening schools and universities now, especially with the delays in the vaccination campaign, would be harmful for the pandemic situation inside the country. Our simulation also showed that the number of deaths would rise more sharply after applying such actions. This is why we recommend postponing them until the vaccination campaign progresses more effectively, especially that, until 26 April 2021, we only had 4% of the whole population who have taken the first dose of the vaccine and only 2.2% who were fully vaccinated [4]. The last thing to note is that our simulator can be used to study the virus spread in any country and not just Lebanon. We only have to feed it the corresponding data instead.

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LOW-CODE TECHNOLOGY AS A NEW DIRECTION IN THE DEVELOPMENT OF DIGITAL TRANSFORMATION OF THE MINING INDUSTRY

Digital transformation is becoming an inevitable stage that most enterprises in the world want to reach in order not to lose their competitive edge [1]. With the advent of Industry 4.0, smart manufacturing has become a technological pinnacle to be conquered in the process of enterprise digitization [2]. Short- and long-term operational planning also plays an important role in building developed manufacturing. More and more advanced technologies supporting production planning, analytics or sales predictions are appearing on the market. For planning solutions to bring full added value, they must be fed with proper data. However, it often happens that the current infrastructure of enterprises does not allow for using advanced planning solutions. Data is not collected in an appropriate way or its transfer is difficult.

The author's research and market observations of Poland and Eastern Europe show that the mining industry is open to the application of new technological solutions [3]. Unfortunately, before implementation, the facilities of the current technological infrastructure are not always ready. Companies often use outdated technologies and systems that are not compatible with modern solutions. It has been hypothesized that the system infrastructure of mines is most often not connected to new solutions. Moreover, creating such integration requires costly investments. For advanced tools to work efficiently, the right input data must be collected properly. Gathering the right data, both quantitative and qualitative, is the key to effectively using advanced planning tools and thus improving mines productivity.

The solution may be the use of low-code Enterprise app technology. Traditional programming methods and tools can hardly meet the high demand of industrial software due to its long development cycles, while low-code programming can significantly improve industrial software productivity, lower barriers, and reduce development costs [2]. By 2024, low-code application development will be responsible for more than 65% of application development activity [4]. Therefore, low-code is becoming a new direction among technology solutions in the world. The Scopus database reported only 6 articles by 2018, and by 2021, there have already been 38 scholarly articles on the topic of low-code [5]. The rapid growth of low-code and interest in the technology is due to its characteristics. Low-code is an flexible agile technology that makes it possible to create solutions using a minimal amount of programming code making the whole process faster. Low-code makes it possible to develop applications and tools to collect and manage data from equipment, including mining equipment such as loaders, scales and more.

You can automatically collect the data you need to make better decisions inside and outside your organization. It allows connecting the old infrastructure of companies with new facilities of Industry 4.0, which can be fully used.

The aim of this paper is to present the possibilities of low-code technology and to indicate this technology as a solution accelerating the enterprise preparation for implementation of advanced planning solutions. The paper presents an analysis of 3 selected low-code platforms on the market. The research considered 4 main criteria: (a) integrations with popular enterprise support systems (ERP, WMS, iOT, AR, Planning/Analytics platforms) (b) scope of available integrations and possibility of their creation, (c) functionality and possibility of flexible solution creation, (d) time of solution creation and integration.

It was pointed out that low-code technology used in various industries is an ideal tool for creating integrations with systems and legacy infrastructure of enterprises. Low-code technology allows systems to be leveraged and integrated so that data can be quickly transferred from one place to another. Using low-code technology allows you to transform all your data into a holistic view and control of the entire process. It helps you make better decisions and allows you to see the important parts of your processes without having to use systems. The use of low-code can improve how historical data is collected and feeds advanced planning tools. The application of low-code in the mining industry can produce great impacts and optimization results without system revolutions or organizational disruptions. This topic is the subject of further research for the application of low-code in the mining industry broadly.

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MATHEMATICAL METHODS AND ALGORITHMS IN 3D MODELING OF PROCESSES OF A COILED TUBING UNIT

In the article the prospects for the development of coiled tubing technologies in the Russian Federation for servicing oil and gas wells described. The author identifies the following criteria for the effectiveness of the use of coiled tubing units: preserving the life and health of service personnel, preserving the ecological health of the environment, achieving the highest economic results from the operation of oil and gas wells.

The author substantiates the need to create a software and hardware complex for training personnel for the maintenance of the coiled tubing installation.

It is necessary to bring the training process closer to the real conditions of work with the equipment of the coiled tubing installation. There are many factors to consider that affect the life cycle of a coiled tubing. For this, it is necessary to develop mathematical methods and algorithms that simulate processes in a coiled tubing installation.

The author proposes to use a mathematical model of the accumulation of fatigue damage in a flexible pipe under low-cycle loads, taking into account the temperature gradient and the effect of aggressive media. This scientific approach will take into account the main factors affecting the condition of the coiled tubing.

The development of a software and hardware complex will allow: to significantly speed up the process of personnel training, to improve the quality of training, to avoid the breakdown of real equipment in the training process. The developed mathematical methods and algorithms are planned to be used in the program for predicting the current state of the equipment to improve the efficiency of the coiled tubing unit control system. At the moment, the work is at the stage of software testing and debugging.

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COMPUTER ENGINEERING AS A MEANS OF INCREASING THE QUALITY OF TRAINING OF ENGINEERS

The recently emerged concept of "computer engineering" includes a set of tools, methodologies and approaches associated with the use of computer and computing technologies in engineering activities. At the present stage, one of such tools, which makes it possible to carry out mathematical modeling of objects and technical systems as close as possible to reality, is Micromine. It is a multifunctional mining and geological system designed for visualization and interpretation of various geological exploration data in a 3D environment, building three-

dimensional block models, classifying and quantifying resources and reserves, as well as for mining design.

In Kazakhstan, users of Micromine software products are more than 20 large companies, such as KazZink JSC, JV Vasilkovskoye Gold JSC, Syrymbet LLP, Iskander GRK LLP, Kustanai Minerals OJSC, Geointsentr LLP, JSC "Altynalmas", LLP "JV Kazakh-Russian Ore Company", Kazakh National Technical University named after K.I. Satpayev, Gold Land LLP, Nova Zinc JV, Mining and Economic Consulting LLP, Kazgipro-Tsvetmet LLP, East Kazakhstan State Technical University named after D. Serikbayeva, Saga Creek Gold Company LLP and other companies. These companies offer a variety of software solutions for geologists, miners, surveyors and other specialists, significantly optimizing labor costs and the time required for specialists to solve certain problems. In this regard, high-quality training of future engineers is required to work in the Micromine program. This direction of engineering activity, which includes a set of methods and means of practical problem solving with the help of computer technology and applied information technologies, is usually called computer engineering (CI). The need to train students in computer engineering is dictated by modern requirements for young specialists. In accordance with modern educational concepts, the level of professional qualifications of a graduate of a technical university, first, implies its ability to creatively solve problems of creating new technology, developing high technologies, and optimally organizing production in the context of global informatization. In this regard, the applied discipline "Computer Engineering" was introduced into the process of training students in the specialty 5B070300 "Information Systems" in order to teach them computer design, as well as the practical aspects of new information technologies, and their application in future professional activities.

MICROMINE includes the study of the following modules: The CORE module is the "heart" of the Micromine system and is supplied with any of the system modifications. This powerful module will allow you to import, check, process, display, interpret and analyze a variety of data on surfaces, wells and underground workings. EXPLORATION has extensive tools for visualization, interpretation and processing of exploration data. The FRAME MODELING module provides tools for constructing, managing and analyzing 3D solids and surfaces used for exploration, reserves estimation, geological and mining modeling. The RESERVE EVALUATION module includes a number of functions for modeling, mining planning and reserve estimation. The MINING module contains powerful intuitive tools for designing surface and underground workings. The SURVEY module is designed specifically for the import and processing of mine survey data. The OPTIMIZATION module is used to determine the most profitable quarry shells for given mineral reserves, economic parameters and processing parameters, as well as to analyze the amount of stripping and costs by periods. The PIT OPTIMIZATION module creates the optimal shells for the pit contour. Visex (Visual Explorer) is a full-fledged 3D visualization environment that allows you to simultaneously display and edit multiple layers of data. The PRINT module expands the capabilities of the Print function, which is part of the CORE module. DOME system is designed for real-time production management, as well as for the analysis of data obtained from various sources of the enterprise. DOME provides tools for planning, budgeting and reporting on production statistics. The new STRATIGRAPHY MODELING module is ideal for reservoir simulation. It includes an intuitive visualization of stratigraphic layers, which makes it easier to understand the interactions between them. Moreover, the interpolation functions easily handle changes in reservoir thickness, more accurately describing the characteristics of the field. The new CONDITIONAL MODELING module uses radial basis functions (RBFs) to model grade shells, lithological boundaries, faults and surfaces. These wireframes are easily displayed in the Viewer in Visex and are a valuable tool for completing geological and grade interpretation.

In order to study these modules, a set of laboratory works has been developed: 1. Preparation of exploration data and their import into Micromine. 2. Verification of geological prospecting databases. 3. General characteristics, tables and graphics. 4. Interpretation of

mineralization. 5. Wireframe modeling. 6. Digital models of surfaces. 7. Sampling of sampling intervals and calculation of composites. 8. Geostatistical analysis. 9. Block modeling. 10. Interpolation of grades within the block model. 11. Classification of reserves by categories and obtaining a report. 12. Additional sections of the report on the calculation of reserves. As a result of mastering the discipline «Computer Engineering», students must: have an idea of: computer engineering; about the Micromine software product; know: basic concepts of computer engineering; characteristics of the computer engineering market; analysis of the software market for computer engineering in the world; state policy in the field of computer engineering; functionality of the Micromine software product for the mining and exploration industry; Micromine modules; be able to: process the results of exploration and mining works; to acquire practical skills in solving time-consuming tasks of using a computer engineering system for: data interpretation; building three-dimensional models; calculation of reserves; design of a mining enterprise.

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QUALITY CONTROL OF WEAR-RESISTANT COATINGS OF PIPELINE VALVE ELEMENTS

Introduction. The parameter "coating thickness" differs from other geometric parameters (length, height, roughness, etc.) in that the object being characterized has one-way access (the outer surface of the coating has free access, and the inner surface connected to the base does not have visual and mechanical access), and therefore there is an element of uncertainty as for normalizing dimensions and as for determining them by measurement [1].

A ball valve is a type of pipeline valve that has a spherical locking or regulating element [2]. In order for the products to meet the operational parameters, it is necessary to ensure quality control of the coating of ball elements of cranes. The most important parameter of protective coatings is the thickness of coating. The aim of the work was to find out the instruments and methods of measuring this parameter of coatings of locking elements of ball valves for their further use in product quality control.

Measurement instruments and methods. The control was carried out by the following measurement instruments and methods shown in Table 1.

Table 1 – Measurement instruments and methods

№	Measured parameter	Measurement method	Equipment
1	Coating thickness	Crater-grinding method	Measuring installation of crater-grinding method Constanta SH2, optical microscope.
2	Coating thickness	Magnetoinduction and eddy current phase methods	Geometrical parameter measurement instrument Constanta K6C with gauges ID1-0,3 and FD1.

Experimental data. Five samples of ball valves with the following types of coatings were examined:

– Electroless Nickel-Phosphorus coating (nickel-phosphorus alloy) (ENP) (samples No. 1, 2, 5);
– hard alloy based on tungsten carbide (KVT 176) (sample №3);
– nickel grade 60 (Ni60) (sample № 4).

The results of measuring the thickness of coatings by various methods are presented in Table 2.

Table 2 – The results of measuring

	AD-136 2’’	AD-136 4"	Sealing system DN 50	TAPM39027A-025.01	Samara
Coating thickness, μm					
Declared value	76	76	-	500	-
Constanta SH2	153	70	140	497	86
Constanta K6C, FD1 (calibration ENP)	147	45	-	-	-
Constanta K6C, ID1	36	70	-	-	-

Discussion of the results. The results of coating thickness measurements by the magnetoinduction and eddy current phase methods depend on the magnetic properties of the sample. To use these methods, it is necessary to adjust the measurement instrument, which

consists in the need to measure the uncoated sample area and the adjustment measure of the coating thickness, which is equivalent in its electromagnetic properties to the coating of the controlled sample, which is not always possible in production conditions.

Measurement of the coating thickness by the crater-grinding method is a type of destructive testing, which allows determining the coating thickness with a procedure error of 6% [4]. This measurement method is the most universal, as the measurement results are not affected by the electromagnetic properties of the coating and substrate materials.

Conclusion. The conducted research have confirmed the availability of technical and methodological capabilities for organizing laboratory monitoring of parameters of wear-resistant coatings of pipeline valve elements. At the same time, it is determined that there is no universal set of measuring instruments for monitoring all types of coatings. The complete set of laboratory equipment depends on the chemical composition, electromagnetic and mechanical properties of the controlled coatings. Significant difficulties at the moment are presented by the organization of operational input and operational control. It is revealed that the use of portable thickness measuring instruments, even if they are approved and have passed verification, do not guarantee reliable results of coating thickness measurements. This fact is explained by the physical principles of operation of this device and the complex effect of various physical, mechanical and electromagnetic parameters of coatings and substrates on their readings. To solve this problem, it is necessary to carry out their adjustment (calibration) on the corresponding control samples or measures made from samples of controlled products or similar to them in their properties. For solving problem of metrological certification of coating thickness measures (control samples) was proposed crater-grinding method [5]. The main advantage of the procedure is the use of direct measurements of linear dimensions of the recess (sphere), which eliminates the occurrence of errors associated with the physical nature of the measurement transformation of other measurement methods. In addition, the procedure allows you to perform measurements without destroying parts, on samples of complex shape and large size. The disadvantage of this technique is the violation of the integrity of the coating, in this sense it is destructive.

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NUMERICAL INVESTIGATION OF HAREDNESS DISTRIBUTION IN SICO TEST SPECIMENS ON GLEEBLE 3500^{TM} PHYSICAL SIMULATOR

Hot cracks occur when thermal shrinkage along with restraint-induced deformation cannot be accommodated by plastic deformation. That usually happens during welding to some alloys, which segregate on heating and cooling at near-solidus temperatures. When low-melting and mechanically weak phases form and occur over a wide range of temperatures, this is significant. Hot tensile testing can be used in conjunction with a thermal cycle resembling that of real welding to inspect for susceptibility to liquation cracking caused by the low-melting, weak phases. This procedure can be performed on a thermal-mechanical simulator using GLEEBLE 3500; It involves the tensile testing and determination of the hot strength and ductility of many cylindrical samples at temperatures below solidus. The Strain- Induced Crack Opening (SICO) test is an alternative to the hot tensile test during the simulated welding period [1].

The GLEEBLE 3500 is a modern physical simulator; more precisely, it is a multifunction thermo-mechanical system experimental series. GLEEBLE is able to simulate a wide range of processes in real-time. The developed routines of the Gleeble testing allow accurate determination of temperatures at which the cracks occur as well as the measurement of critical strains to fracture and strain rates which are associated with the hot cracking [2]. At an appropriate geometry of samples and optimum setting of the experiments, the hot cracks generated in the samples have sizes comparable to those that occur in heat-affected zones of real welds or in weld metals; that's why GLEEBLE 3500 was used for the physical simulation [3].

The material used is ZF50 unalloyed structural steel; chemically tested cylindrical specimens were used to perform the strain-induced crack opening test. The GLEEBLE 3500 heats the specimen and then compresses it with elevated temperature. The cross-section of the volume fraction is subjected to deformation, which increases considerably as a consequence of the sealing. Using DEFORM (FEM) finite element software [4], the test is modelled and analyzed. And the result of the physical simulation and the mathematical modelization were compared.

Then the embedding is visualized by sanding and polishing, and milling. Finally, hardness measurements were performed in accordance with the matrix given on the metallographically prepared surfaces of the sample.

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DEVELOPMENT OF A COMPOSITE MATERIAL BASED ON DECARBONIZED RED MUD

Today, environmental problems are gaining more and more momentum. One of these problems is the greenhouse effect, which is caused by an increase in its concentration in the air. A large amount of the greenhouse effect comes from the combustion of fuels and manufacturing plants, of which there are a huge number in the modern world [1]. In Russia, aluminum smelters have a leading position. But in the process of producing the metal itself, along with it emits a huge amount of solid and liquid waste, among which the most dangerous is the red mud. At the moment there is no mass recycling or disposal of it and the solution for waste removal from the enterprise is storage in a sludge pond. If we talk about the scale of production of aluminum itself, as well as red sludge emissions and carbon dioxide emissions within the enterprises located on the territory of the Russian Federation, the figures will be as follows according to the report for 2018: aluminum production - 3.75 million tons, red mud emissions - 7.5 million tons, carbon dioxide emissions - 15 million tons. According to these indicators, we can argue that the work on the topic of aluminum production waste recycling is relevant, and the result, in the form of the production of construction materials based on deactivated red mud, a good solution for the environmental problems of aluminum enterprises with the possible commercial implementation.

Low dispersibility and high alkalinity are the main factors determining the harmfulness of sludge to the environment. Based on this, it is proposed to develop a composite material, which will include waste aluminum plants, namely "red" mud, which will be treated with carbon dioxide before adding it to the concrete mixture. Thus, it will be possible to solve two problems simultaneously: to neutralize and minimize the amount of greenhouse gases emitted into the atmosphere from the production of primary aluminum and reduce the content of sludge in the settling tank.

In order to realize the task, namely the development of a composite material based on decarbonized red mud, the works concerning the reduction of carbon dioxide in the atmosphere were analyzed. It was noted that carbon dioxide can be used in industry as a neutralizer of alkali, which provides an opportunity to use it as a deactivator of high alkaline "red" sludge.

Traditionally composite material consists of two parts - matrix and filler. Red sludge will be used as a filler, which was previously deactivated in two steps, where firstly the waste was treated with carbon dioxide, and the second step was to mix the resulting material with solid silicic acid. The first step was to obtain the acid salts, the second step was to obtain the dry product. The matrix in this composite will be magnesia binder, as it has high hardness, strength, low alkalinity and porosity in the finished product, which is a good solution in choosing such a constituent for red mud work.

In order to determine the feasibility of such a composite material, strength and moisture resistance tests must be performed. The results showed that the concrete composition including red mud and magnesia binder has strength values exceeding those of conventional Portland cement without inclusions (39.2 MPa - Portland cement without inclusions, 40.5 MPa - magnesia binder + red mud). Tests on water absorption also gave positive result and by their value were close to the values of tests on water absorption of Portland cement (0,3 %).

As a perspective direction of application of composite material which includes red mud is the construction of roads for mining machines. The possibility of application of red mud as a component for road construction has already been described by foreign colleagues in the article devoted to application of red mud in construction industry, as well as in the patents there are possible recipes of preparation of such concrete mixture [2,3].

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SURVIVABILITY OF METAL STRUCTURES OF EXCAVATORS IN THE DEVELOPMENT OF NON-BLASTED ROCKS

One of the main reasons for the decommissioning of mining excavators is cracking in their metal structures, reducing their survivability. The survivability is also known as the operating time of the excavator without accidents during the overhaul period. An increase in the number of cracks and their welding might lead to an increase the accumulation of damage in welded seams of metal structures, which increases the likelihood of crack formation and their growth rate.

Excavators operating on blasted rocks have widespread cracking, which is associated with many loading cycles when excavating such rocks. Each piece of rock in the collapse of the blasted rocks, when it meets the excavator bucket, gives a surge of stresses in all-metal structures. Depending on the size of a piece of rock, the stress surge can vary in magnitude. Nevertheless, even a small value of stress surge can lead to crack growth, depending on the size of the crack.

Excavators that worked on loading peat during the entire standard period of operation (15-20 years) did not have cracks, but immediately after the transfer, their development of blasted rocks acquired significant cracks within six months, although the number of excavation cycles per shift remained the same. This is due to the absence of stress surges during the development of a homogeneous peat mass and the uniformity of efforts when scooping it up.

Thus, working on blasted rocks, the most durable, constantly causing the formation of cracks, can be considered an inevitable disadvantage. The formation of cracks in the metal structures of excavators during the development of unexploded rocks, relatively soft and less durable, turned out to be unexpected given that there was no reason for cyclic stresses, i.e., individual pieces of blasted rocks. However, further research showed that the occurrence of cyclic loads and stress surges are subject to the different blockade of rocks.

It can be perceived that rocks have a heterogeneous structure. Due to fracturing, the mountain range consists of more or less solid blocks of various sizes, which depends on the strength of the rocks. According to this study, rocks are divided by blockiness into three categories: large-block, medium-block, and small-block [1].

Large-block ones have an average block size of 0.2 ÷ 0.4 meters, medium-block ones – 0.4 ÷ 1.2 meters, small-block ones – 1.2 ÷ 1.6 meters. Their percentage in the array obeys the normal distribution law (Fig.).

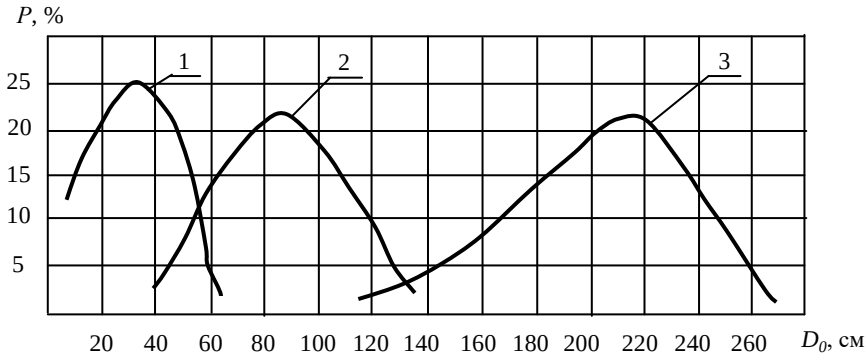

Figure 1 – Polymodality in the distribution of natural units overburden of coal mines:
1 - small-block; 2 – medium-block; 3 - large-block

Large-block rocks must be prepared for explosive excavation, and medium-block and small-block rocks with rare exceptions during development. In this regard, during the excavation of the latter, significant stress surges appear in metal structures. The blocks are destroyed by the teeth of the excavator, while significant stresses arise in the metal structures. When passing one block after another, the teeth of the excavator fall into the fracture zones. As a result, the stresses in the metal structures drop significantly, and therefore, a cyclic load is formed.

The magnitudes of stress in metal structures depend on the size of the destroyed blocks, and the number of stress surges depends on the number of blocks in the rock mass. Therefore, the stress amplitudes are higher in medium-block rocks, and the number of stress surges is higher in small-block rocks [2,3].

Also, the destruction of rock blocks itself affects the development of cracks in metal structures since the blocks are heterogeneous in their strength within their volume. The fracturing of blocks leads to their uneven destruction. More substantial blocks are belonging to medium-block rocks are destroyed with great force on the tooth of the excavator, and in the process of the destruction itself, the loading cystogram changes, which gives a significant growth of cracks.

Despite the abovementioned processes, excavation of large-block blasted rocks gives the largest fracturing and the most significant fracture growth.

The proposed studies made it possible to create a methodology for assessing the survivability of metal structures of excavators in the development of rocks without using blasting preparation.

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ROBOTIC PULSED GAS METAL ARC WELDING (PGMAW) TECHNOLOGY APPLICATION FOR GAS TURBINE PLANT TURBINE SUPPORT HOUSING BUILDING

Gas turbine engines are used both in aviation technology and ground power plants. Moreover, aircraft engines (aircraft derivatives) can be used in ground-based gas turbine installations [1]. In this connection the introduction of the PD engine family is perspective both in the aviation industry and in the energy sector. The important stage in this way is development of serial production of the PD-14 engine, the one of specific needs of which is new welding technology of the low-pressure turbine housing support designing. The main requirement for the manufacture of this heat-resistant nickel alloy unit is to ensure high fracture toughness and a low level of residual stresses after welding.

The aim of this work is the residual stress reduction and crack formation preventing during low-pressure turbine housing support welding and heat treatment. The support housing of the PD-14 engine is a welded structure of two bodies of revolution (internal and external), interconnected by struts. The struts are welded into the outer body along a closed contour, while with the inner one they are butt welded along the mating elements. There is the method of pulsed gas metal arc welding (PGMAW) was chosen after analysis of possible welding methods to solve the posed problem. Consumable electrode welding processes have a higher thermal efficiency compared to non-consumable tungsten arc welding (GTAW), which one is conventional in aircraft engine construction. However, gas metal arc welding is a new method in terms of its application to aircraft engine building. Therefore, the development of the welding technology included several stages such as welding of flat specimens with a thickness of 4 and 5 mm and welding of divided sectors of housing as structurally similar elements.

The experiment was carried out on the welding robotization laboratory of the Welding, Foundry and Additive Technologies Department. The robotic complex included an ABB IRB 1600 robotic arm, ABB IRC 5 controller and welding equipment in two options. The first one was based on EvoMIG350 welding power source and was being used to obtain welding data of five millimeters thick welding. The second one was equipped with AristoMIG 5000i power source and was being used to four millimeters thick welding case and final housing sectors welding.

The purpose of the first stage is to obtain 4 and 5 mm EP718 nickel alloy welding parameters with an extremely low heat input. There are pulsed modes with short circuit (root) and without circuits (pulsed spray) and transverse oscillations of electrode were used. As a result, the sound welds was made by welding parameters with 40% less heat input rate relative manual TIG welding [2]. A complex of non-destructive and destructive tests showed the absence of defects in the obtained joints. Moreover, the important phenomena were discovered by microstructural analysis. The cross-sections showed not only the presence of a fine-grained disordered structure of the weld, characteristic of pulsed welding, but also an almost none grain growth in the heat-affected zone (HAZ), which was refined during the groove machining.

The next step is about welding process simulation to assess the residual stress. There are registered by WeldCloud system welding date were used as the input date for model development. Verification was carried out according to the data of thermometry during experimental welding. Verified for case of plate welding simulation model was applied to structurally similar elements [3]. Residual stress measurement was made to pre-select the most preferred weld pass progression variant. As a result, a two-pass welding scheme was proposed, where each pass was divided into 4 sections. With this sequence, the maximum residual stresses

were obtained up to 50% lower than in the similar manual TIG welding sequence and almost two times lower compared to splitting the weld into two sections

At the final stage, the typical welding and repair technology for the sector was tested. Several welded assemblies were obtained and all meet the requirements of non-destructive testing. Moreover, the selected parameters of welding ensured the absence of cracks even on the unit, on which a large number of passes were applied during the repair process.

The obtained EP718 alloy PGAW technology from this research provides a solution to the main problems arising during welding of nickel based alloys housing engine units. A decrease in heat input and the use of a pulsed mode make it possible not only to modify the structure of the weld metal, but also to control grain growth in the heat-affected zone. This approach avoids cracking.

This result indicates a high potential of pulsed gas metal arc welding for joining heat-resistant structures. However, for a more complete study of the effect of this process on the structure and properties of welded joints, an additional set of studies is required. It is also of interest to assess the resistance to cracking in the above-considered structure in single-pass robotic welding.

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ULTRASOUND ASSISTED ROTARY DRILLING TECHNIQUE WITH SMALL DIAMETER SINGLE-CONE DRILL BIT

This paper is devoted to study an issue of improving the technique of rotary drilling with developed earlier small-diameter drill bits. Along with proposed in [1] new type of single-cone drill bits improving of their characteristics needed to be considered to increase speed and reduce energy consumption of drilling process. During impact drilling rock breaking occurs as a result of drilling tool kinetic energy conversion into the deformation work on borehole bottom. Rock breaking efficiency depends on the mechanical properties and design of the drilling tool

Earlier in work [2] was proposed new type of single-cone drill bit with vertical pin. It is proved that when the body of such instrument rotates, the force is transmitted directly to the cutter and transformed at the bottom of borehole into destructive cutting moment. Due to the vertically mounted roller pin design it used as support surface for the roller-cone cutter, that helps to convert the moment of drill bit body rotation around the borehole axis to the destructive moment of roller-cone cutter teeth impact into another borehole plane. At the same time, the efficiency of proposed drilling method with new type drill bits are 1.5-1.7 times higher than when we use conventional tool with inclined pin or a tricone drill bit.

But in order to achieve higher penetration rates into the rock, the feed force to the bottom of single-cone bit (axial load) must be sufficiently high, from 10 to 60 kN, depending on the diameter of the instrument. This imposes serious restrictions on the materials used for manufacturing of such tool and it's mechanical design. Like measured in [3] the moment of cone hard alloy teeth impact on to the rock during cutter rolling provides the required destruction of rock throughout the borehole length. But the discreteness of the destruction has sporadic nature. This is due to the unevenness of tensile and tangential stresses generated by the roller cutter in the borehole bottom. This forces expectedly must broke the bonds between the grains of the substance.

To enhance the complex crushing-shear action of single-cone drill bit and simultaneously reduce the feed force, proposed to integrate a piezoceramic or magnetostrictive transducer in the bit body. The superposition of high-frequency longitudinal vibrations along with the rotary movement of the bit body increases the drilling speed in hard rocks by 1.5-2 times. In this case, the resonant mode of forced resonator oscillations is considered the most optimal. The concept design of such bit is proposed and studied. But due to the technical complexity of manufacturing and cooling such tool, only prototypes of bits were made, where an ultrasonic transmitter was built into the drill rod directly above the bit. In this case, the ultrasonic energy of high-frequency longitudinal vibrations is transmitted to the borehole bottom through the waveguide, formed from bit body and roller-cutter. To power the piezoelectric ceramics, several versions of power generators with capacity of 2 and 4 kW were made. Also was developed an auto-tuning generator system for matching the output stage on IGBT transistors with a complex load, which piezoceramic emitter represents. In laboratory conditions, test drilling of samples from medium-hard rock was carried out to the depths of 200 to 400 mm. Comparative analysis were made of drilling data for single-cone drill bit with vertical pin and the same bit, but with ultrasonic vibrations assistance in frequency range from 31 to 36 kHz and amplitude from 15 to 30 microns in micro displacements. Gathered data confirms predicted increase in the drilling rate.

The study shows that the effect of ultrasound on the borehole bottom during drilling with small-diameter drill bits makes it possible to destroy the rock with greater efficiency, thereby increasing the drilling speed and reducing energy consumption. This means that the direction of research is chosen correctly. At the same time, there is a lot of manufacturing complexity of studied rock cutting tool. Also needs for reliable electronic equipment must be considered, as well as the necessity to implement stable automatic control system, that poses number of related problems of high complexity.

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THE USE OF DIGITAL SIGNAL PROCESSING TO IDENTIFY THE BOUNDARY BETWEEN COAL AND ROCK LAYERS

The digitization of the economy and society is one of the most dynamic changes of our time. The digitization is the main driver of change in most sectors of the economy. The key drivers of the development of digitization today are: Internet of Things (IoT), hyperconnectivity, cloud computing, big data analytics, automation and robotization, multi-channel distribution models of products and services. IoT - the concept of using the combination of various items that are not only directly associated with the Internet, such as computers, laptops, tablets, smartphones, but also production lines, machines, robots. Such a connection allows the use of the Internet not only in everyday life but also in industrial automation, and leads to increase in production efficiency. Computing clouds are virtual spaces that allow for collection of text files, notes or data in almost any form. Big data is collecting data from various sources and then analyzing it. Properly processed data allows you to create a consumer profile, recognize his needs and requirements in order to increase sales [1].

One of the areas of the economy that can change diametrically thanks to digitization are coal mines. Mining plants want to be competitive int he world market, they must lower production costs in order to offer their product of the highest quality at the lowest possible price. Many years of coal mining forces the mining plants to exploit deeper parts of deposits. The increase in the depth of extraction is accompanied by an increase in the amount and intensity of natural hazards, affecting the cost of extracted coal and work safety. The most common natural hazards in the longwall are the accumulation and explosion of methane and coal dust, rock bursts, outbursts of gases and rocks. Despite the use of systems that can prevent a mining disaster, such as: automatic methane measurement systems, systems measuring the composition of the atmosphere, geophysical systems measuring the strength of rock mass tremors, it is impossible to anticipate all possible threats before their occurrence. One of the most prone to accidents is the longwall area. Limiting the number of people employed in this area would reduce the number of accidents. The development of a coal-rock boundary recognition system will allow to automate the production process, where the presence of an employee controlling a longwall shearer is not required [2].

Digital signal processing (DSP) has found application in many fields of science, such as medicine, telephony, military, and space research. In the industry, DSP has found application in the diagnostics of electric and internal combustion engines, where a potential failure can be detected early using vibroacoustic. The most significant methods of identifying the coal-rock boundary are: γ-ray detection, infrared detection, image detection, mechanical vibration, radar detection. The above methods have both advantages and disadvantages [3, 4].

The article presents the research of sound samples recorded in the longwall. The recorded sounds of mining coal, rock and a longwall conveyor were used for the analysis. A simple

dictaphone recording the sound with a frequency range of 50Hz÷20 kHz was used to record the sound of the shearer's cutting. The analysis of acquired signals were carried out twofold: by the use of typical frequency analysis, and using the STFT. All the analyses were performed in MatLab environment using standard toolboxes. Using the built-in FFT algorithm in Matlab, the frequency spectra for the collected samples were plotted. The next step of the signal analysis was to plot three-dimensional spectrograms using the built-in STFT function algorithm. Hamming windowing was used in the STFT analysis. The result of the STFT calculation is a three-dimensional graph.

The analysis of the acquired sound samples will allow to examine whether the simple digital sound recording system is sufficient for the purposes of the analysis, as a much cheaper alternative to the equipment required in other methods. Researches of recorded sound samples using the fast Fourier transform (FFT) and the short-term Fourier transform (STFT) showed that the differences in the recorded sounds of operation of coal, stone and scraper conveyors differ significantly in amplitudes.

In our further work we are going to develop a model of the cutting process in which sound signal acquired in the neighborhood of the operating cutting head will carry information of a drag of the cutting rock, while the output would be a signal carrying information about the response of the combine motor. A model of cutting coal will be trained using a machine learning approach. Then, signals acquired from the working system will be compared with the output of the model yielding residuals that will subsequently be classified. In the case of significant differences between the measured and calculated output, the conclusion will be formulated that the combine is just cutting shale. Preliminary work has shown that there are significant differences between the recorded signals.

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QUALITY ASSURANCE OF SURFACES OF COMPLEX PROFILE OF PRODUCTS FROM ALLUMINUM ALLOY

Currently, the required quality of the surface or part of the product is provided. Therefore, the final processing of the product is the most important part of the manufacturing process of parts. Final processing of materials on technical, production-technological and operational indicators of product quality, since there is a direct relationship between processing, surface roughness and product service life.

It is urgent to create new and improve known methods and technological processes of finishing in order to ensure the shaping, accuracy and the required quality indicators of the

working surfaces of parts. The solution to these problems lies in the use of innovative technologies based on the controlled nature of the interaction of the tool with the processed surface of the workpiece [1-6].

With the current technological progress, a wide range of enterprises have an urgent need for such a method of finishing the surface of the workpiece, which will provide a low surface roughness Ra (up to 0.01 microns). There are a number of methods for finishing the surface of a workpiece associated with the use of abrasives: abrasive processing, processing using a magnetic rheological fluid as an abrasive, and magnetic abrasive processing using a magnetic abrasive powder.

Magnetic abrasive machining (MAO) is one of the promising methods for finishing with elastic tools. A feature of the method is oriented abrasive cutting (Fig. 1).

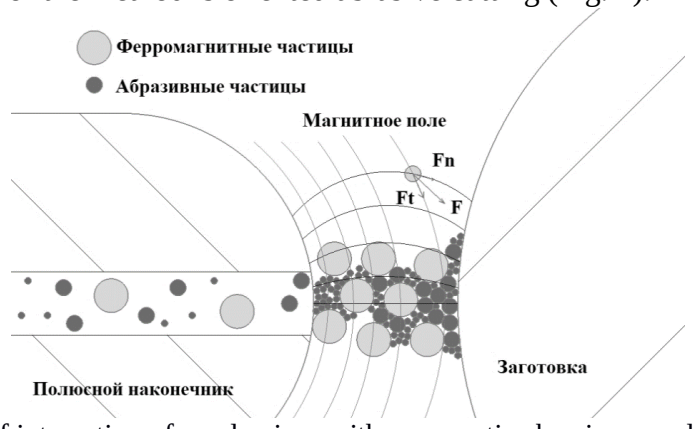

Figure 1 – Scheme of interaction of a pole piece with a magnetic abrasive powder and a workpiece

One of the advantages of using magnetic abrasive processing is that there is no need to manufacture a polishing abrasive tool. This makes it possible to reduce tool and tooling costs by 2.5… 3.5 times.

Other advantages of magnetic abrasive machining over traditional methods of abrasive cutting include: ensuring a roughness Ra up to 0.01 μm, a reduced cutting temperature. All of the above advantages make it possible to obtain the required surface of proper quality and microstructure of the surface layer [3,6].

The creation of a method and technology for magnetic-abrasive processing of parts with a complex geometric shape is an urgent task that requires a comprehensive, integrated approach. To solve it, it is necessary to apply modern methods of computer modeling of the magnetic field in the working space of the installation, which will help to determine not only the dynamics of cutting forces during processing, but also to choose the optimal combination of cutting modes, the efficiency of using ferromagnetic powder of various sizes, the possibility of using coolant. [1,2].

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AUTOMATED, OPTICAL MEASUREMENTS OF FLOW PROPERTIES OF CEMENTITIOUS MATERIALS

Workability of the concrete is the property of the freshly mixed concrete which determines the ease and homogeneity with which the concrete can be mixed, placed, consolidated, and finished [1]. The workability however is not a measurable property. To determine the workability of concrete, other properties are measured instead, such as the flow time and the final spread of the concrete, which constitute the flow properties of the concrete. In construction sites, to determine how workable the material is, flow properties measurements are conducted using a mold of a given conical shape. The mold is filled with the material to be tested and then lifted so the flow can occur. A typical tool used in practice to measure the flow properties is the famous Abram's cone [2]. This cone however is designed to be used for concrete only and is not suitable for mortars and pastes. For mortars and pastes that this study is also focused on, a smaller version of the cone is used, named the Hägermann's cone [3]. The testing principle is very simple: once the cone has been filled with the cementitious material, is lifted by hand for the flow to occur, and when the material stops flowing, two perpendicular diameters are measured. Their mean value constitutes the final spread of the material and the time needed to reach this spread is considered the flow time. Although the procedure is practical and quick, it does have some drawbacks that need to be brought to attention. The first one is the human error either when measuring the final spread and time or/and either when lifting the cone at a possible inclined angle. In either case, the measurements would not represent the true properties of the material. The second one is related to the lack of access to the measurements once they are complete. Normally once the flow has been characterized, the material is disposed and there is no way to get back to it. For any uncertainty, the measurement must be repeated.

In order to reduce to a minimum or possibly even eliminate the human-induced error, but also to have access to the measurement after execution, we have developed at our lab an automated set-up that effectively solved these issues. The flow time and final spread of the selected mortars for this study are thus measured and recorded using the new and automated set-up instead of the common manual set-up.

The first step to achieve our objectives in eliminating human-induced errors was the automatization of the cone lifting. In our set-up, the Hägermann's cone is connected to a pneumatic arm holed by a stable structure. The cone is filled with the material while is in its lower position sitting on the flow table and once the operator is ready to record the flow, pressurized air is released to the arm holding the cone, and lifting it smoothly and without any inclination which would affect the final spread.

The second step was having a way to access the measurement even after its completion. This was achieved by recording the flow through a high-speed camera (250 fps) placed above the center of the cone filled with the material to be tested. Once the operator has conducted the measurements and the flow has been recorded using the fast camera, the raw videos are then processed using a program developed for this purpose only. The program is developed in a way that can give us the raw data to plot the flow curve which is the final spread as a function of time. This is very helpful for the characterization of the material especially in the very beginning of the

flow, which was impossible to measure manually as the material has just started flowing, and measuring the spread with a compass just right after the flow has started was out the question.

The set-up could be subject to further optimization, but as of now, we are able to characterize the flow properties of mortars and pastes without any induced human error and save the raw data or raw videos not just to go back to a specific sample and see if something went unnoticed, but also to create a sort of database with basic mixtures and get the flow curves from the raw data using the developed program, something that was not possible so far. The most prominent feature of the set-up is, however, the extraction of the flow curves from the video recordings using the developed program. In this way, we can know how wide and how fast the material flows at each point in time before it reaches its final spread. The method does not come only with benefits but has also its drawbacks of course. The program is very sensitive to lightning changes, so care must be taken so as not to create any shadows above the sample (people cannot move around the set-up while the camera is recording), as this would be interpreted as data entry by the program. Also, the method is sensitive to contrast. If the mixture to be tested does not have good contrast with the flow table where the material will flow, then the data are a bit distorted. Both of these issues are currently being addressed and the progress looks very optimistic.

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TECHNOLOGICAL ASSURANCE OF THE SURFACE QUALITY AND SHAPE ACCURACY OF A FIBREGLASS FAIRING FOR TVS-2MS AIRCRAFT

Fiberglass is a type of composite material which is currently quite widespread, especially in the automotive and aerospace industries. The value of composite materials lies in the fact that they are much easier to shape than metals, which is why they are used in so many different applications. In the aircraft industry like nowhere else, high precision of shape and surface quality of the component parts is required to ensure the required aerodynamic characteristics of the aircraft and keep them in operation. In the case of composite materials (GRP), shape accuracy and surface quality are ensured primarily through tooling (mould), as well as the method of manufacturing the part, which is the focus of the study. [1,2]

In the course of the study, first of all, tooling for the fairing is designed and manufactured. In the design process, the question arises as to how to make the tooling so that it meets all the quality requirements. Due to the complexity of the fairing shape, it becomes evident that a mere drawing with subsequent production on a machine tool is not enough. Modern CAD systems and CNC machines help to solve this problem. Thus, tooling fabrication process will consist of the following stages:

1. Creation of 3D model of the tooling in a CAD system and generation of drawings (AutoCAD, Compass, SolidWorks, NX, etc.);

2. Creation of the control program for tooling manufacture on the milling machine with CNC model EMCO Concept Mill 250 using CAM system (NX, ESPRIT, CATIA, etc.);

3. manufacture of tooling on the machine in automatic mode;

4. Manual revision of tooling (removal of corners).

Application of CAD systems during design and production of tooling significantly reduces time and cost of production.

Surface quality is essential not only to meet product requirements, but also to make it easier to remove the product from the mould. The lower the roughness or porosity of the mould surface, the less resin will penetrate the pores or fill in the irregularities. A lower roughness means there is less damage to the tool and workpiece during removal. This means that the tooling can be used several times, thereby reducing the cost of manufacturing a composite product, especially in series production.

According to the received model the product is made by two different methods: the method of manual moulding and the method of vacuum infusion. In the general case the essence of the methods is that the reinforcing substance (fiberglass plastic) is laid out in a tooling and filled with a mixture of resin and hardener, the matrix absorbs the mixture and hardens, getting the specified shape, after which it is removed from the tooling. However, there are differences. Manual moulding is the simplest way of making composite products, all operations: laying the reinforcing layer, pouring the resin and distributing it over the mould by a roller, are performed manually by a worker. Vacuum infusion is a method of moulding with vacuum. It differs from the hand moulding method in that after placing the materials in the mould, the mould is placed in a vacuum bag and sealed, after which the air is evacuated. The resin is pumped into the bag under pressure and distributed by the vacuum. This method is cleaner than the hand moulding method. [3,4]

The next step was to compare the two finished products in terms of roughness and shape accuracy, thereby identifying the most suitable method for the specified parameters for manufacturing a GRP fairing. The economic evaluation of each of the methods and the overall cost-effectiveness was then carried out. The following conclusions were drawn from the results of the study. Firstly, the most suitable method for fairing fabrication is the vacuum infusion method. Despite the fact that the method is very expensive compared to the manual moulding method, as it requires a large amount of consumables and higher qualification of the worker, in general the desired economic effect will be achieved. Secondly, fibreglass will reduce the overall mass of the aircraft, resulting in lower fuel consumption. Or it will be possible to increase the total payload mass, which will also result in improved economics. Thirdly, when analyzing fiberglass fairing production, it is evident that tooling is the key factor. Both shape accuracy and surface quality will depend to a large extent (about 90%) on the quality of the tooling. The remaining 10% will come from the precise execution of the manufacturing process and the method of making the part itself.

Parts made of composite materials can be used not only in the area of general and civil aviation, where they are used the most, but also in military aviation, for example, when creating unmanned aerial vehicles. The aviation industry is just beginning to revive in Russia. The percentage of application of composite materials in the design of aircraft is not yet as high as abroad (about 50%), which makes the topic relevant and promising.

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DETERMINATION OF THE CUTTING PROPERTIES OF A TOOL WITH A SPECIAL COATING BY THE METHOD OF COMPUTER SIMULATION

Nowadays, while most of the production processes are robotized, the problem of increasing and controlling the wear resistance of the tool acquires the key importance, since the wear resistance ultimately determines the efficiency of machining operations.

Currently, there are no wide range of methods for the effective use of cutting tools in a production environment, although for the biggest part of modern enterprise these methods are essential. The way out of this situation so far is the development of complex methods using computer systems, based on a scientific approach. It allows us to generalize the already known theoretical ideas and make it possible to achieve good results through the use of forecasting mechanisms and computer analysis with a minimum amount of time.

Applying of the optimum grade of tool material has always been one of the most important tasks of metal cutting. It is known that processing of the heat-resistant alloys by replacing one model of tool material with another promotes increasing its life up to 10 times along with gaining the optimal cutting speed. Therefore, usage of optimal models of tool materials can significantly increase efficiency and reduce the prime cost of processing.

Despite a significant number of published works, developed standards for the machining of heat-resistant materials (NIAT – National Institute of Aviation Technologies, CRIMB – Central Research Institute for Machine Building, etc.), production workers find themselves in a difficult situation after new tool and machined materials appear. The absence of scientifically substantiated recommendations on the choice of tool material and cutting modes for new heat-resistant materials instantly delays the time of their mastering. It’s necessary to discover more advanced methods and solutions for decreasing these terms.

Currently, the most common way of choosing a rational brand of tool material is to follow the recommendations published in domestic and foreign literature. However, the available recommendations do not always meet the constantly growing production requirements. That is why it is often necessary to carry out additional experimental research with the aim of solving specific technological objectives.

Improving the performance of the cutting tool can be achieved with enhancement the properties of the surface layer of the tool material, until the working surface of the tool resists most effectively the specific types of wear. This material must possess a significant margin of safety at bending, compressing and withstand shock loads. One of the most important problems of tool durability is removing of the coverage layer after the tool is deformed and prepared for sharpening. This leads to reducing tool life. The solution to this problem is secondary coverage.

Improvement of the coverage technology for cutting tools and development of new modifications of protective coatings support increase the efficiency of the tool and expand the area of its effective use at once. According to a number of requirements, the protective coverage must ultimately conform to a high degree of wear resistance. Therefore, it must be thermally resistant and grip firmly to the tool body. The coverage selection depends on the type of processing material and the technology of using a particular tool.

These methods can not only estimate the cutting properties of the tool, stressed state of parts and cutting tools, but also predict possible deformation of the part and choose the best tool for processing a particular part. Moreover, they offer recommendations on the appointment of cutting mode before the part is manufactured or sent to production. Computer models are much easier and more convenient to analyze due to their ability to carry out the calculated experiments, which in comparison with a real experiment require less financial costs and time.

The consistency and formalization of computer models make it possible to reveal the main factors that determine the properties of the studied original object, in particular, to study the response of the modeled system to changes in its parameters and initial conditions.

The recommended cutting modes were used for developing the modeling process. They were determined in the process of review of turning a heat-resistant nickel-based alloy XH73MBTJu with a cutter made of WC8 material. Covered cutting tool leads in this work. Titanium nitride TiN with a thickness of 2 microns was chosen as a wear-resistant coverage. This simulation was carried out in Deform software.

In the course of the study we got the results of simulating the processes of cutting workpieces made of the XH73MBTJu alloy with WC6 plates at speeds of 20-25-30 meters per minute. In addition, the similar processes using WC6 plates with a wear-resistant TiN coverage were obtained.

Computer simulation gave us a picture of the distribution of tool wear over the flank surface, which allows us to trace the growth in the amount of wear with gaining the cutting speed. Based on the results and the graphs above, we can make sure that the wear of the tool with the coverage is lower than the wear of the tool without it. Natural experiments are at the planning stage, so at the moment it is impossible to check the convergence of the results yet.

Today, forecasting the cutting properties of tool materials and coverage seem to be an urgent task. The computer modeling is one of the methods that allows predicting the cutting process at the stage of technological preparation of production without conducting expensive experiments. Moreover, this method makes it possible to assign cutting modes for a certain combination of processed and tool materials, by that reducing the time of technological preparation.

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THREAD FINISHING TREATMENT FOR INCREASE THE OPERATION ACTIVITY OF DRILLING RODS THREADED CONNECTIONS

At the present stage of market economy, underground mining is the basis for the efficient functioning and development of mining industry of the country. The rotary-percussive drilling, which is a combination of two main mechanical methods – impact and rotational method, is used during borehole drilling for the rotary drilling intensification. Peculiarity of rotary-percussion drilling method is the method in which the drilling tool under a heavy axial load, rotational moment, as well as impacts which applied with the help of special mechanisms with certain frequency.

Threaded connections are the most loaded elements during the operation of the equipment for the rotary-percussive drilling method. Operational analysis of the modern structures of drilling rods threaded connections shows that the total loads acting in the connection are composed of loads caused by the action of rotational moment, initial force (static loads) and loads arising during the passage of the longitudinal wave. All this together leads to the destruction of threaded connections, which is accompanied by equipment downtime and financial costs for unscheduled repairs.

Performance characteristics increasing of threaded connections can be implemented by means of constructive or technological methods. Constructive solutions in threaded connections often lead to complexity of construction, increase of cost, dimensions and mass of connection. As a result, special attention should be paid to technological ways of solving problem that allow improving the quality of threaded surfaces and, as a consequence, increasing the fatigue failure and wear resistance of threaded connections.

It is known from the theory and practice of mechanical engineering that the performance characteristics of items, such as fatigue failure, wear resistance, etc., depend on the surface quality (roughness, microhardness, etc.) formed at the manufacturing step of items. The final surface quality of item is formed with finishing operations, among which abrasive methods are widely used. However, during the surfaces finishing, most of the methods have a number of significant disadvantages that limit their applicability. That is why it is necessary to resort to the search for new more efficient methods of finishing. One of them is magnetic-abrasive finishing (MAF), by means of which the magnetic-abrasive powder under the magnetic field influence acquires the form of an "elastic brush" and due to a different combination of movements of pole tip and a workpiece the final formation of the product surfaces qualitative characteristics.

Scientific teams on magnetic-abrasive finishing [1, 2, 3] established that in a fairly short time (60- 210 sec) magnetic-abrasive finishing decreases roughness from $Ra = 0.4... 0.44$ to $Ra = 0.03... 0.035\ \mu m$ and waviness in 8...10 times (from 2...3 to 0.2...0.3 μm), increases (compared to circle, bar, tape) local strength and wear resistance of item in 2...3 times, as well as improves curve of the profile bearing length up to 75... 85% [3].

As a consequence of the above, at the Department of Mechanical Engineering of St. Petersburg Mining University it was decided to carry out the research of external and internal threaded surfaces magnetic-abrasive finishing at the final step of drilling rods threaded connections manufacturing. The research has to be fulfilled in order to reduce roughness and increase the contact area fillet of the threaded connection, remove the preceding defective layer formed in the preceding operation and form a new - strengthened layer, increase fatigue failure and wear resistance of the threaded connections.

Before testing the threaded surfaces of drilling rods magnetic-abrasive finishing with CNC, it was carried out to simulation of the magnetic field distribution in the working space of a specially developed device.

The simulation was carried out in 2 stages: initially it was investigated the distribution of the magnetic field with an empty workspace (Fig. 1, a, c). The second stage was carried out first without rotation of the workpiece in the working space (Fig.1, b), then - with rotation of the workpiece in the working space (Fig.1, d). This preparation made it possible to select the most effective combination of workpiece movements and pole tip for the final formation of the qualitative characteristics of the threaded surface during magnetic-abrasive finishing with CNC.

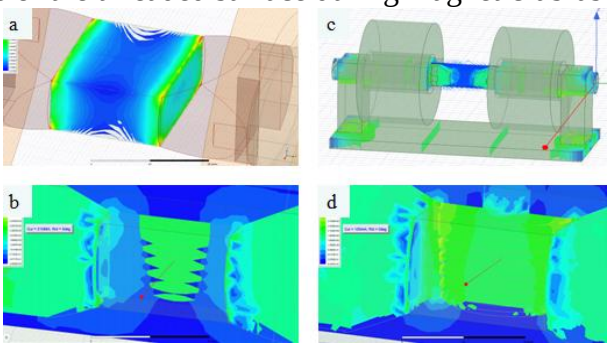

Figure 1 – Simulation of magnetic field distribution in the working space of the device for MAF with CNC

Magnetic-abrasive finishing was carried out according to two schemes on specially prepared workpieces from structural alloyed steel 40X on an magnetic-abrasive device, which is located in the laboratory of CNC machines of Department of Mechanic Engineering, St. Petersburg Mining University (Fig.2). External threaded surfaces were processed with simultaneous rotational, oscillatory and to-and-fro motions of workpiece in magnetic-abrasive mass in interpolar space of magnetic-abrasive device. Internal threaded surfaces were processed with simultaneous rotational and oscillatory motions of workpiece in the magnetic-abrasive mass in the interpolar space of the magnetic-abrasive device. To-and-fro motion in the second scheme was excluded due to the inability to get magnetic abrasive material into the inner zone of the workpiece.

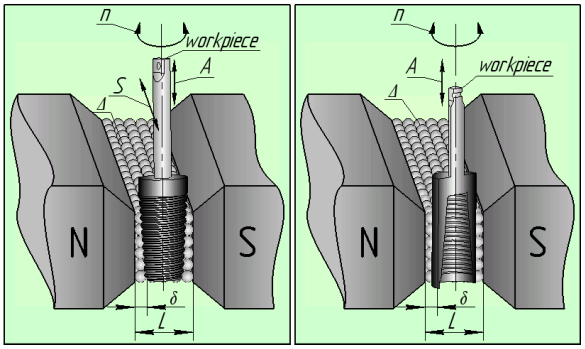

Figure 2 – MAF of external and internal threaded surfaces

A magnetic-abrasive material based on titanium and iron carbide (*TiC+Fe*) were used to form the magnetic-abrasive brush in the electromagnetic system operating space. Varying parameters of magnetic-abrasive finishing were changed in following ranges: powder grain $\Delta = 160... 315\ \mu m$; magnetic density $B = 0.6... 1.0\ T$; finishing time length $t = 60... 210\ sec$.

At this stage, the drilling rod external threaded surface was examined, namely its roughness Ra. It was established that in the analyzed range of the magnetic-abrasive finishing process factors, the roughness of the external threaded surface varies within $Ra = 3.2... 0.2\ \mu m$. Based on the study, it can be concluded that the method of magnetic-abrasive finishing of drilling rods external threaded surfaces is effective.

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DEVELOPMENT OF TECHNICAL PROPOSALS FOR IMPROVING THE STABILITY OF WALKING EXCAVATORS AND SPREADERS

Walking excavators and spreaders are characterized by an operating weight of hundreds of tons, as well as large dimensions with a relatively small supporting area of the propeller.

One of the most important operational properties of these machines is a sufficient degree of stability both in the static working position and during movement on the technological site. First of all, this indicator is influenced by the physical and mechanical properties of the bearing base formed by the waste rock in salt dumps or by overburden in open pits. Secondly, it is the degree and uniformity of compaction of the upper layer of the technological site, as well as the minimum surface slopes formed by bulldozers. Thirdly, the influence on the condition of the rock forming the supporting base of the machines, intense meteorological precipitation in the form of rain and snow, as well as in the off-season periods, especially in the winter-spring period. Another factor that can negatively affect the stability of the excavator is the vibrations of the earth's surface at the moments of periodic massive explosions on the pit benches for preliminary loosening of hard Rock.

For spreaders with a belt conveyor as an executive element, a significant negative factor is the wind load on the elements of the superstructure: the outgoing console, pylon and pulley blocks. The stability margin of excavators depends on the dynamic loads arising from the filling of the bucket with rock, as well as during maneuvering of the upper slewing platform with the boom.

In connection with the mentioned above, it is required to strictly follow the operating modes and prescriptions for the safe conduction of mining operations using walking excavators and spreaders.

A special mode of operation of these machines, requiring analysis for their stability, is the walking process. It can be conditionally divided into the following phases: lowering the skis, lifting the car, moving it relatively stationary skis, followed by lowering to the support base, lifting the skis. After that, the cycle is repeated and the machine moves one step, the length of which is several meters. The loads on the supporting base during walking are redistributed between the support base and the skis, both in size and in places of their application. The support area changes its shape and size during this cycle and depends on the scheme and design of the walking mechanism.

The authors has developed algorithms for analyzing the stability of excavators and overburden spreaders on walking propellers, as well as technical proposals for the modernization of their supporting bases.

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DEVELOPMENT AND RESEARCH OF INNOVATIVE EQUIPMENT FOR MECHANOACTIVATION OF IRON PIGMENTS

Due to the United States' and European Union's sanctions policy, unstable currency exchange rate there is tendency for higher prices for foreign high-tech powder-like material, which has to meet high dispersity requirements. For example, high-quality filling compound at production of ink, plastic and cable industry must consist to 90% of particles with diameter less than 10 micrometers, and the rest 10% of particles must not be bigger than 40 micrometers in diameter. In production of composites for radiation protection, particles in the mixture of lead organosilica and polymers must not exceed 5 micrometers in diameter. High demand for colourant affects negatively its production quality, which main features are color, iron oxide mass fraction, dispersity, resistance to aggressive environment and oil absorption. Market saturation with colorants in Russia deters strict requirements to consumer features, especially to chemical and granulometric composition, amount of iron oxide, compound of chlorin and sulfur. That's why development of modern day technologies and facilities for mechanoactivation of iron color is relevant.

Main colorant consumers are producers of paintwork and construction material, plastic and rubber goods. High-quality natural colorants are especially important for painting ships' underwater part, to protect it from corrosion and shell sticking.

Background for production of iron oxide colorants in Belgorod region is a vast amount of iron ore at Yakovlevksy ore deposit, where colorant ore is available in large amount.

BSTU has conducted research to explore chemical compound and physical-mechanical features of colorant ore and developed conversion technology based on mechanoactivation that allows to compensate foreign supplies and secure its complex and beneficial usage [1].

Mechanoactivation means conversion of powder like material in energy loaded equipment, that changes crystal lattice of processed material, linked to emersion of different structure defects, like displacement or vacancy or new surfaces.

The university conducts the development of mechanoactivation facility based on combined exposure of jet energy at ground material (jet mill with a plain torus shaped grind chamber) to receive ultrathin powder with particle diameter less then 5 micrometers [2]. Pigment's dispersity greatly affects paint features and its covering. The less a particle is, the less it delaminates, on other equal terms, oil consumption increases, as well as filming agent solvent, that is necessary to wet (dampen) pigment. Paint's dispersity affects how smooth the surface of paint coat will be.

During the research operation we have analyzed grind equipment for production of ultra thin powder. Basing on this research we developed a technological solution of a grind chamber section to receive powder with an average particle size of 5 -10 micrometers. We have carried out theoretic analysis of how experimental energy carrier functions and how particles interact in a jet mill grind chamber. This research enabled to define tangential velocity profile of air flow in a grind zone and particle's boundary size as well as radius of its equilibrium path, at a given grind chamber height. We have derived analytically the ratio to calculate air flow tangential velocity speed considering amount of air, discharged out of a jet pipe. Alongside we have analyzed how construction parameters affect the whole production process, namely, how the size of a grind chamber defines the abrasing effect of particles with different diameters.

On the basis of the conducted research, we have designed a digital model of a jet grind facility in a CAD system and explored the air flow of such a model in CAE software, where we

set up the air flow speed at the end of a jet pipe, air speed at the end of a vertical acceleration tube.

We produced a test facility, which included a jet mill with torus shaped grind chamber, air separation system dust extraction and dust collection device. Tests for grinding colorant ore of Yakovlevksy ore deposit have been conducted. As a result, we received iron oxide pigment that met all dispersity requirements. The jet mill design (construction) is protected by utility model patent №190985 [3].

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THE FREIGHT PNEUMATIC ELEVATORS

This article addresses the problem of ensuring high reliability and safety performance of freight elevators. Rope elevator hoists exist more than one hundred years and have become very common, but it is very difficult to achieve their operational efficiency. The authors propose a solution to the problem - the introduction of a fundamentally new type of transport - pneumatic lifting, which capable provides high technical and economic performance. At the specialized enterprise «Pnevmopodyem» a small-lot manufacture of new import-substituting equipment for hoisting in buildings established. The authors present the advantages and the principle of operation of the developed pneumatic elevator. Essential advantage of this machine is the safe work which is incorporated in its design. Considerable attention is paid to the results of tests of cargo pneumatic elevator. The authors come to the conclusion that the design of a freight pneumatic elevator makes it possible to use it successfully for transporting cargo in buildings and structures for various purposes, to reduce capital investments in construction, installation and operating costs. The absence of foreign analogs will allow selling pneumatic lifts not only in Kazakhstan, but also in the countries of the former USSR.

Current issue of ensuring high reliability indexes and safety operational of freight elevators is not solved in full, since the popular rope hoists have a number of design defects and their further improvement only leads to complicacy and increase in the cost of their design. Rope elevator hoists exist more than one hundred years and have become very common, but it is very difficult to achieve their operational efficiency and reduce energy consumption, because it is necessary to hoist an excessive weight of ropes. It naturally affects the economic performance of the elevators. It is also necessary to maintain and periodically change the ropes, which is

accompanied by significant material expenses while operating the elevators. Delivery costs, customs clearance and traveling expenses, composing sometimes a cost of acquiring freight elevator, are the serious burden on the cost of construction and reconstruction of objects [1]. The customer of such equipment bears the significant costs for the construction of machine rooms, shafts and also finishing, erecting and commissioning works. In addition, maintenance of rope, hydraulic and other elevators demand highly-skilled and highly-paid professionals. The lack of freight elevators manufacturing in the Republic of Kazakhstan leads to the need to acquire these machines (rope, hydraulic, etc.) abroad and pay their value in foreign currency. One of the problem solutions is implementation of a fundamentally new type of transport - pneumatic elevating, which capable provides high technical and economic performance. Fundamental principles of theory and calculation methods of pneumatic elevating formulated by the professor of the Karaganda Technical University Yu. A. Nikolayev and discussed in detail in the above sources [1].

At the specialized enterprise «Pnevmopodyem» (Karaganda city) a small-lot manufacture of new import-substituting equipment for hoisting in buildings was established [1]. Manufacture of pneumatic elevators with a carrying capacity of 110, 250 and 500 kg disbursed. Factory and production tests of pneumatic elevators demonstrated working ability, reliability and service life of these machines, their ecological safety. At the present time, freight pneumatic elevators are successfully used in the shopping malls, schools, kindergartens and other facilities in the cities of Nur-Sultan, Karaganda, Petropavlovsk, Aktau. Production of pneumatic elevators can be established in other cities of Kazakhstan, which have machine-building plants. This development is completely ready for industrial production: design and technical documentation prepared, "Know-how". The absence of foreign analogs will allow selling pneumatic lifts not only in Kazakhstan, but also in the countries of the former USSR.

The essential advantages of pneumatic elevators (as compared with the existing freight elevators) are:

- simplicity of embodiment;
- reliability and safety in operation;
- ease of installation and maintenance;
- reduction of costs for the purchase, installation and operation of the pneumatic lift (in 2-5 times);
- a small pressure of compressed air (0.003–0.007 MPa) in the cavity of the shaft creates favorable and safe dynamic conditions for the operation of the pneumatic elevator [1].

Pneumatic elevator works as follows. After loading the loading platform, the hatch closes, and the closures are blocked, excluding their opening. The "Start" button is pressed, the fan turns on, and compressed air begins to flow into the cavity under the loading platform. When a certain pressure is reached, the loading platform on the hovercraft rises to the upper mark, where it braked and stops by stop blocks. A green light comes on at the control point, indicating the possibility of opening the hatch and unloading the platform. All the time of unloading at the upper level, the platform is supported by the pressure of the operating fan. After unloading the loading platform, the hatch closes, the hatch locks are locked, the "Stop" button is pressed and the fan is turned off. In this case, the compressed air in the shaft begins to escape (throttling) through the calibrated nozzle into the atmosphere, as a result of which the loading platform at a given speed on the hovercraft sinks to the lower stop blocks. The green light comes on, the hatch opens, the platform is restarted and the work cycle repeats. During the movement of the loading platform in the shaft, a red light is on, indicating that the opening of the hatches is prohibited.

Essential advantage of this machine is the safe work which is incorporated in its design. In the event of an emergency (power outage, breakdown of the electric motor, etc.), the loading platform does not fall to the bottom of the shaft, but first stops and then begins to descend due to air throttling, squeezing the hovercraft.

Thus, there are all the necessary prerequisites (low cost of the machine and the cost of its maintenance, safety and reliability of work, transportation and customs costs are excluded, no

highly qualified service personnel are required) for the use of freight pneumatic elevators at the enterprises of Kazakhstan and other countries. This makes it possible to eliminate the dependence of Kazakhstan on foreign suppliers of such equipment, to organize reliable technical servicing and repair of machines to solve the problem of load lifting to the future.

Freight pneumatic elevator is simple structurally, has no restrictions on the lift height, has a low tare ratio, low electrical energy costs for one cycle of lifting the loading platform, which allows it to be successfully used to transport goods in buildings and structures for various purposes, to reduce capital investment in construction, installation and reduce operating costs.

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INVESTIGATION OF WEAR AND SCRATCH RESISTANCE ON DUPLEX TREATED AUTOMOTIVE TOOL STEEL

New challenges and demands for the design of complex structures lead to the need of defining new requirements of improved mechanical properties of components. These involve often significantly different properties needed to be achieved in the core and surface of the components. Among the desired attributes wear and/or corrosion resistance, increased toughness, fatigue performance, increased load bearing capacity can also appear parallel relating to the same component. To fulfil such requirements various surface treatments, i.e. surface modification and coating processes can be applied as effective solutions. However it should be considered that all of these technologies have their advantages and disadvantages [1].

Duplex treatment is a combination of two or more different surface technologies producing a two- or multi-layer composite structured surface on the substrate material with the purpose of improving the loadability and durability of the component achievable by neither individual process, alone. Duplex treatments can be considered as effective technologies in the field of surface engineering that can improve the wear, corrosion and fatigue resistance, hardness and durability of the components, as well as provide cost–effective solutions for increasing the lifetime. Application of these techniques together helps to obtain a unique combination of mechanical and physical characteristics, which has favourable impact on the design of substrate and surface jointly, resulting in considerable cost reduction and increase in the productivity of the manufacturing [2]. Thermochemical treatments, such as nitriding and carburising create inherently gradient material structures in the surface layer from substrate to free surface – e.g. with respect to the hardness, resulting in gradually changing interfacial properties, as well as can provide a tough and strong support for the hard coatings[3-4].

The present work demonstrates a study on duplex layers produced on automotive tool steel by plasma nitriding and surface coating. Two different types of coatings i.e. CrN (chromium nitride) and DLC (diamond-like carbon) are utilised to investigate the wear resistance and adhesion. DLC coating is prepared by plasma enhanced chemical vapor deposition process (PECVD) and CrN by physical vapor deposition (PVD). The coating thickness is measured using the Calotest-crater method. The adhesion and the damage mechanism are evaluated by 3D scratch tester. Scratch testing is a standardised method to measure the adhesion of a coating or film to a surface and to measure the resistance of a surface to damage from a hard sharp indenter. This test is performed by applying either a progressive (~linearly increasing) or constant load.

Testing parameters, such as the critical load/subcritical load for coating failure and the scratching coefficient (i.e., the normal force divided by the tangential force that resists scratching) have been introduced to measure the surface properties.

The ductility, cohesion and bonding strength of the coatings are investigated by the machine whose platform may be inclined at a small angle with the horizontal direction, to simulate a gradually increasing normal load. The coated specimens are fixed on the platform, which are slightly inclined at an angle, α and an indenter was adjusted to contact with the specimens, then the platform horizontally moved 3 mm at a speed of about 0.1 mm/sec towards the indenter. During the movement of the platform, the depth of the indenter penetrating into the coated specimen is gradually increased, and scratch tracks were formed on the coating surfaces. According to the features of the tracks and the correlative normal loads, the ductility, cohesion and bonding strength of the coatings is analysed. A thorough understanding of the damage mechanism is presented.

The hardness is measured by micro-Vickers Indentation test. The results are in good agreement with the literature reports i.e. duplex sample possess high hardness as compared to the simply coated specimens. The wear resistance is studied by reciprocating multi-functional tribometer. The analysis shows that duplex treatment is beneficial to obtain better adhesion between the substrate and coating. Furthermore, the wear resistance of duplex layers is higher as compared to untreated samples.

Wear and adhesion are two peculiar problems in the manufacturing industry. Duplex treatments resulted in systematically better scratch resistance properties that manifested itself in a higher critical force and less damage as compared to simply coated specimen. The damage mechanism is strongly dependent on the type of coating, loading condition, type of failure (cohesive/adhesive). The hard CrN coating showed adhesive failure, while multilayer DLC layer showed cohesive failure. This explains the significantly better scratch resistance of the DLC coating. The results presented are useful in the field of tribology and surface coatings in order to contribute useful understanding of complex damage mechanism.

ACKNOWLEDGMENTS

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CONTROL OF THE MECHANICAL PROPERTIES OF STEEL ACCORDING TO THE PARAMETERS OF THE LIMITING MAGNETIZATION CURVE ANNA V. IVANOVA

As you know, the properties of objects in the solid condensed state are largely determined by their crystal structure, chemical composition and the presence of defects of all kinds. The influence of inhomogeneities (in size, distribution, etc.) of these parameters leads to a deviation of the required properties from the object in the local area, which significantly affects its reliability and service life [1, 2]. One of the main properties to which strict requirements must be imposed is the mechanical properties of the material, which determine its service life. These properties must be monitored to ensure the safe and uninterrupted operation of equipment operating at hazardous production facilities. The operation of equipment made of structural steels at hazardous production facilities in most cases occurs under constant external loads of a multi-component nature, which lead to an intensification of the processes of material destruction [3].

The paper considers the possibility of using the harmonic components of the time signal obtained by processing the maximum magnetization reversal curve on heat-treated samples made of steel 09G2S to control the ultimate strength and hardness. This relationship can be used to develop a non-destructive method for controlling the mechanical properties of steel.

The samples on which the research was carried out were made of sheet metal. The dimensions of the samples involved in laboratory studies: 4.0 x 70.0 x 25.0 mm.

The samples were heat-treated to obtain a different structure and phase composition. The samples were kept at a temperature of 930±20 °C for 15 minutes, and then quenched with cooling in water. The quenched samples were released within 1 hour with air cooling at temperatures of 200, 350, 500, 650 °C.

The structure of the steel under study was studied using a JEOL 6008A scanning electron microscope and an Olympus GX53 optical microscope at a thousand-fold magnification. To identify the microstructure, the samples were treated with a 3% nitric acid solution.

The chemical composition of the samples under study was determined using an X-ray fluorescence chemical analyzer manufactured by OXFORD INSTRUMENS X-MET 5100.

It is established that for the amplitude of the thirteenth harmonic of structural steel 09G2S, both the hardness and the ultimate strength, satisfactory dependences are observed, obeying a polynomial of the second degree, which is reflected in Figures 1 and 2. These dependences have a similar character of change and can be used to predict the hardness and ultimate strength. It is noted that the close location of some values in the general regression curve for temperatures of 200 and 350 C may be associated with the processes of reducing distortions in the crystal lattices of steel, which may be associated with the processes of decomposition of martensitic grains and the beginning of cahulation and spheroidization of cementite particles, which significantly affect the mechanical properties of steel [4].

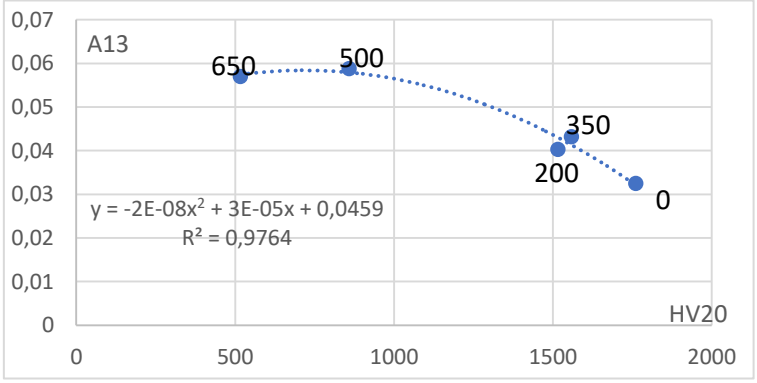

Figure 1 – Dependence of the amplitude value of the thirteenth harmonic on the hardness determined by Vickers

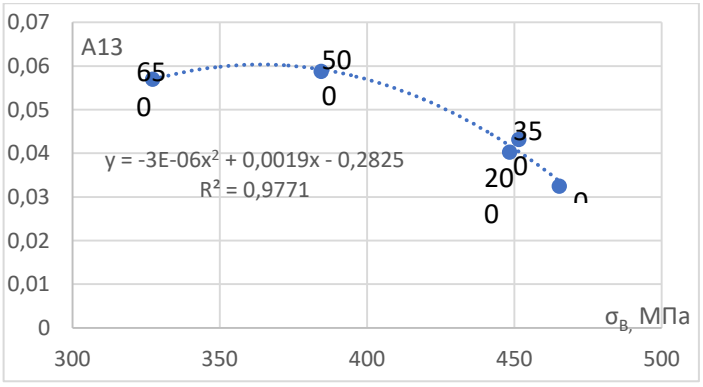

Figure 2 – Dependence of the amplitude value of the thirteenth harmonic on the tensile strength

The obtained data show that a satisfactory correlation is observed for the hardness and ultimate strength of structural steel 09G2S and the amplitude of the thirteenth harmonic.

The study of the structure of the samples under study showed that the coincidence of points in the general dependence occurs at different temperatures of 200 C and 350 C, which is most likely due to the processes of rotation occurring at these temperatures and to the processes of reducing distortions in the crystal lattices of steel during heat treatment.

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INCREASING THE RELIABILITY OF WHEELED RUNNING GEARS OF MINING DUMP TRUCK WITH ELECTROMECHANICAL TRANSMISSION

In the course of development of deposits of various minerals by the open method for transportation of rock mass all over the world in open pits, heavy-duty dump trucks are widely used, the leading manufacturers of which are Caterpillar, Komatsu, Volvo, as well as the Belarusian Automobile Plant (BelAZ).

The results of the analysis of various diagnostic options for vehicle gearboxes show that the following can be used as the main parameters in diagnostics: temperature (oil, housing), noise, vibration, quality of the working fluid in the crankcase, monitoring the condition of the working surfaces of the main gearbox elements during disassembling. At the same time, the

following diagnostic methods can be effective: thermal imager, bench tests of units, control of operating oil parameters, diagnostics of parameters of total angular backlash and spline joints, spectral-acoustic method for monitoring hub housings, monitoring of bearing wear during maintenance.

The severe operating conditions of mining dump trucks impose increased demands on the fuels and lubricants used in operation. Oil is the most effective, flexible, changeable and controlled element and accumulator of informational signs of the state of technology and its systems. The condition of the oil, the level of its parameters change much faster than the equipment failure occurs. This is justified by the fact that under the conditions of the development of a pre-failure state, the content of wear products sharply increases and, as a consequence, the temperature rises. In this regard, we consider it appropriate to use temperature as an indicator of the state of the system. The heating temperature of the oil is of great importance during the operation of the gearbox, because at increased temperatures, transmission oil loses its lubricating properties. As a consequence, there is an increased wear of gears and gearbox bearings.

To maintain the operating temperature of the oil in the operating range in the gearbox, we propose to equip the mechanism with an active casing cooling system, which is a fixed support hub. For this, a spiral channel (tube) is made along the cylindrical surface of the body. As a result of the circulation of the coolant from the active supply system of the machine, a controlled heat exchange will take place through the stationary housing (hub) with an active effect on the oil in the gearbox.

Based on the information mentioned above, to improve the operational efficiency of the RMK, we propose the following measures:

1. To equip RMK with an autonomous climate control system with simultaneous diagnostics by changing the intensity of oil heating;
2. To equip the gearboxes of wheel motors with a hydraulic system for periodic cleaning of oil from RMK crankcases in a static position of the machine, ie, by sucking it out of the crankcase, cleaning parts from wear products in a centrifuge, and returning the purified oil to the crankcase.
3. To conduct a comprehensive analysis of the loading of the drive elements of the RMK, taking into account the influence of two power circuits, ie. from the torque of the traction motor, as well as the load on the wheel from the weight of the machine.
4. To modernize the support hub in the gearbox of the motor-wheel using a system of two spherical self-aligning and one thrust bearings instead of two angular contact bearings.
5. To develop a schematic diagram of a motor-wheel drive with the replacement of the applied reduction gear in the form of a closed differential with a two-stage planetary gear.

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INCREASING THE EFFICIENCY OF BOTTOM SCRAPER CONVEYORS AS A PART OF TREATMENT COMPLEXES

When developing stratal deposits of potash salts, technological schemes with the use of treatment complexes are widely used. The main components of the treatment complexes are: one or three shearers, a face scraper conveyor, a complex of hydro-mechanized supports, as well as a power station.

The efficiency of the face scraper conveyors is achieved by a number of actions for the modernization of equipment structures, as well as optimization of its operating modes, i.e. by improving reliability, increasing productivity, reducing energy consumption, reducing metal consumption and ensuring safe mining.

The following tasks were solved in the current work:

1. Improving the reliability and increasing the resource of the conveyor traction chains;
2. Reducing energy consumption and increasing the productivity of transporting ore with the help of a scraper conveyor.

The analysis of the structure of the face scraper conveyors and the modes of their operation for the transportation of ore shows that there is a possibility of increasing their performance by modernizing their structure.

The efficiency of the scraper conveyor, as well as the resource of the traction chain and drive sprockets, can be significantly increased by optimizing the parameters of the mating elements. For this purpose, the author have developed a computational model of the interaction of the chain elements with the gear rim of the drive sprocket. It has been established that the number of teeth has a significant effect on the magnitude of the friction forces when the chain bends around the sprocket. The comparative analysis has been carried out to determine the power of friction forces depending on the number of teeth in the range from 5 to 11 pieces. The results showed that the sprockets with seven teeth used in the drives of the face conveyors have increased energy costs. They can be reduced to 20% by using sprockets with a number of teeth 9. The diameter increases slightly – up to 27%.

A promising option for the modernization of the process of transporting the chipped rock mass from the longwall to the drift conveyors is to replace the process of moving by dragging the mineral in the conveyor chute with transfer transport, which will reduce friction losses. The transfer is proposed to be carried out as follows: on the scrapers on the back side along the conveyor movement, horizontal plates are fixed, with a pre-calculated area, onto which the rock will be loaded. The plates take up 2/5 of the space between adjacent scrapers.

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ENGINEERING OF A HYDRAULIC TWO-CYLINDER MULTI-STAGE PUMP DRIVE

In our days, a hydraulic drive has a spread usage in industry. A hydraulic pump drive has two variants: a hydraulic accumulation pump drive and a non-accumulation pump drive. The advantages of the pump drive are high efficiency, simple construction, and ease of operation. The disadvantage is the incomplete usage of pump power. The main vector to improve pump drive is reducing pump power. Known methods are subjected to approximate pump load to the characteristic of the so-called perfect pump (P*Q=const). One of these methods based on the usage of hydraulic multiplier, that is activated on high load areas (multiplication mode). It allows using low-pressure pumps [1].

It is proposed to expand the zone of pressure regulation to low load areas with reduction mode, opposite to multiplication mode. Reduction mode is provided by the hydraulic reducer,

that is structurally similar to the hydraulic multiplier [2,3,4]. Two modes of pressure regulation make the simple hydraulic drive became reductive-multiplicative drive, which provides speed and pumps power reduction on high-pressure areas (multiplication mode) and speed and pumps power increase on low-pressure areas (reduction mode). Alignment of pressure on a level that is lower than maximum pressure in force cylinder ($P_{\text{н}} < P_{\text{ц}}^{max}$) with the constant flow ($Q_{\text{н}} = const$) provide reduction of pump power. The increase of speed in the reduction mode compensates the reduction of speed in multiplication mode that keeps the working cycle duration.

The two-cylinder five-stage reductive-multiplicative press drive design is offered. It contains force block 1 consisting of two force 2 and return 3 cylinders; pump station 4; simple double reducer 5 consisting of input cylinder 6 and two output cylinders 7. Cylinder plunger diameters ratio: $D_r^2 < 2d_r^2$. Double multiplier 9 consists of input cylinder 10 and two pairs of output cylinders 11 and 12 that equal in pair but unequal between the pairs. Cylinder plunger diameters ratio: [($D > d_1 > d_2$)] and [$D^2 > 2 (d_1^2 + d_2^2)$]. The Control system includes reversible spool 14, seven three-way and eight shut-off spools; two flow dividers (15,18).

The working cycle includes periods of forward (idle and working) and reverse stroke. All pressure stages are realized with forward stroke. Return of movable elements of force block reducer and multiplier into starting position occurs during the reverse stroke. The reduction stage takes place during the idle stroke. Liquid through reversible spool (14) and three-way spools (17, 29) enter input cylinder 6 of reducer and displaced with two equal flows from output cylinders 7 to force cylinders 2. Reducer provides synchronous movement of force cylinders plungers and at the same time increase of speed (V_i) and working pressure of pumps (P_{pi}) in relation to force cylinder pressure: $V_i = Q_p / (2S_p K_r)$; $P_{pi} = R_i / (2S_p K_r)$, where Q_i – pump flow; S_p - force cylinder plunger area; $K_r = D_r^2 / (2d_r^2) <1$ – reduction ratio; R_i – force of idle stroke.

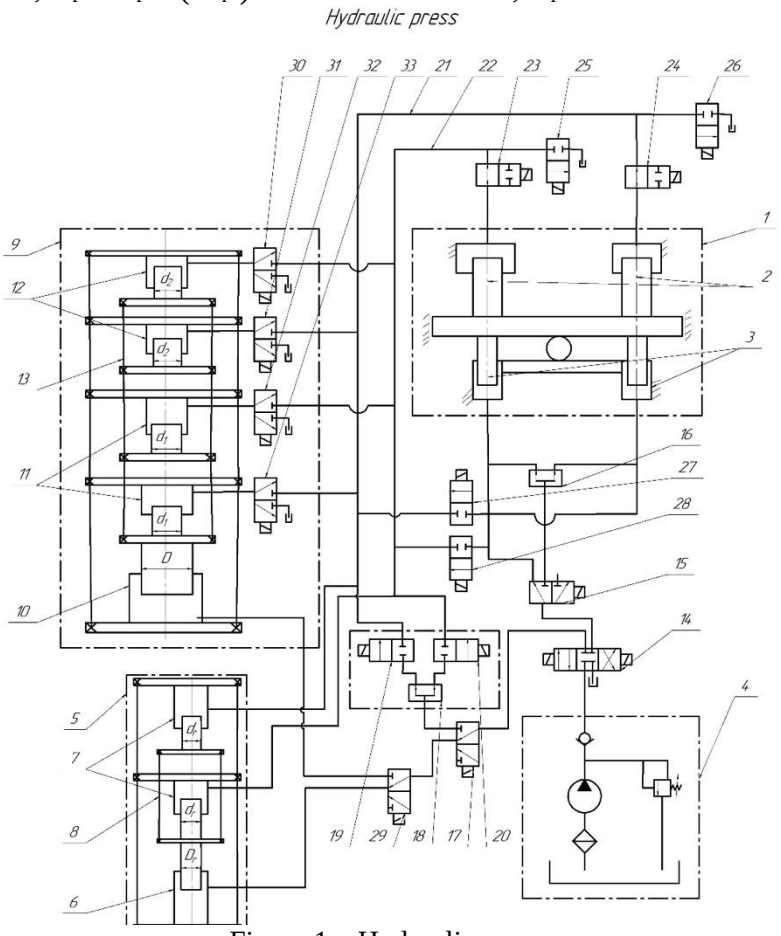

Figure 1 – Hydraulic press

During the working stroke take place consistently pump and three multiplication stages. During the pump stage liquid through reversible spool (14) and three-way spool (17) enter flow

divider (18) and displaced with two equal flows through shut-off spools (19, 20) to force cylinders 2. Shut-off spools provide synchronous movement of force cylinders plungers. Plungers speed (V_p) and working pressure (P_p) provided by pumps flow: $V_p = Q_p / (2S_p)$; $P_p = R_p / (2S_p)$.

During the multiplication stage liquid from pumps through reversible spool (14) and three-way spools (17, 29) enter the input cylinder (10) of the multiplier and displaced with two equal flows from output cylinders 11 and 12 to force cylinders. There is a reduction of force block speed (V_m) and pumps working pressure (P_m) in relation to force cylinder pressure: $V_m = Q_p / (2S_p K_m)$; $P_{pm} = R_w / (2S_p K_m)$, где $K_{мм}$ – multiplication ratio. Multiplication stages occur with an increase of multiplication ratio according to an increase of load It allows to have a pump with significantly lower power than maximum power in force cylinder.

It is possible to change the multiplication ratio by turning off some of the pairs of output cylinders of multiplier from force cylinders. It occurs due to switching three-way spools that are connected with that pairs on a drain (spools 30 - 33).

On the first multiplication stage liquid enter each force cylinder from two output cylinders (d_1 и d_2). Multiplication ratio: $D^2 / [2 (d_1^2 + d_2^2)]$. On the second stage - only from cylinders 11 (d_1). Multiplication ratio: $K_{м2} = D^2 / (2d_1^2)$. On the third stage - only from cylinders 12 (d_2). Multiplication ratio: $K_{м3} = D^2 / (2 d_2^2)$. Based on the accepted ratios of multiplier plungers' sizes $K_{м3} > K_{м2} > K_{м1} > 1$. For example, if D = 220 мм; d_1 = 110 мм; d_2 = 90 мм, then $K_{м1} = 1,2$; $K_{м2} = 2$; $K_{м3} = 3$.

During the reverse stroke simultaneously with force block plungers return in the start position, return of movable blocks of plungers of reducer and multiplier is provided. Meanwhile displaced from force cylinder liquid that fills output cylinder of reducer and multiplier have usage for this operation.

The proposed design of hydraulic two-cylinder multi-stage pump drive allows to reduce pump power and increase drive efficiency also, the reduce of working pressure allows to design hydraulic drives based on the chip middle-pressure pumps - gear pumps and sliding vane pump.

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FATIGUE LIFE PREDICTION OF COAL MINING MACHINE WALKING SECTION

The walking wheel of coal mining machine is subjected to the effect of alternating load, which seriously affects the life of the coal mining machine walking mechanism and ultimately affects the smooth production of coal mining enterprises. The three-dimensional model of the drum is established, and the simulated coal wall is set up through the discrete element software EDEM, and the simulation of coal rock cutting by the drum is carried out to obtain the three-way

force of the drum, and the walking wheel torque is calculated according to the matching formula of cutting load and traction load, and then the finite element model of the walking wheel and pin row is established in the finite element analysis software abaqus to explore the dynamic meshing characteristics of the walking wheel and pin row under different loads, and the stress load spectrum of the walking wheel and pin row is extracted. The results show that the maximum stress is concentrated on both sides of the meshing line, which is consistent with the Hertzian contact theory, and the stress on the compressive side of the tooth root is greater than that on the tensile side of the tooth root, which is consistent with the cantilever beam theory. It is of great significance to improve the dynamic transmission performance of coal mining machine walking mechanism and improve the production efficiency of coal mining enterprises.

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PROSPECTS FOR THE USE OF ROLLS WITH A REULEAUX TRIANGLE PROFILE IN A ROLL CRUSHER AND HIGH-PRESSURE GRINDING ROLLS

At present, there are numerous methods of destruction of rock mass and various variations of crushing equipment used in the processes of ore preparation at crushing and processing and ore processing plants. The processes of crushing and crushing of the rock mass consume the largest amount of electricity, that is, the processes are the most energy-intensive. Therefore, the main task of designers, researchers and engineers is to reduce the cost of electricity and increase the efficiency of crushing units at the ore processing stage.

It is known from the mechanics of a deformable body that a minimum of energy requires the destruction of materials under a tensile means, and a maximum, in turn, requires crushing. It is crushing as a mechanism of destruction of rock mass that is used in all traditional installations for reducing the size of rocks.

Optimization of the mechanism of destruction of rock mass, in which the maximum opening of mineral aggregates with a minimum formed surface occurs, is the main and fundamental task of ore preparation.

In the context of a constant increase in the cost of electricity, ore preparation technologies based on high-pressure grinding rolls are the most promising and economically profitable, which determines their intensive introduction into the mining industry.

Rationalization of crushing unit assemblies - the shape of rolls of a roll crusher and high-pressure press rolls - is a promising direction in the ore preparation industry.

The classic working body of a roll crusher can be replaced by rolls, the profile of which is made in the form of a Reuleaux triangle (Figure 1). This geometric figure is a figure of constant width, therefore, the nip angle for rolls with a given profile is determined similarly to rolls of cylindrical section.

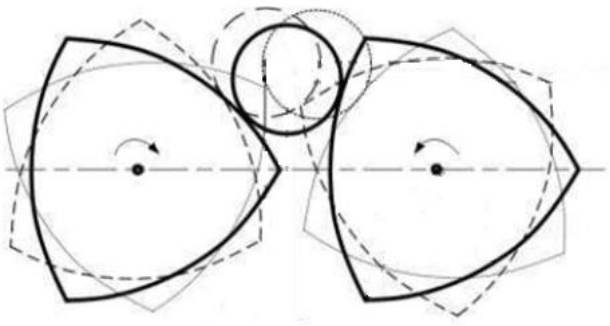

Figure 1 – Schematic of a crushing unit with Reuleaux triangle rolls

The main advantages of using rolls with a Reuleaux triangle profile:

- The cross-sectional area of the Reuleaux triangle roll is 10% less than the cross-sectional area of the circular roll.
- Due to the rationalization of the shape of the rolls, the drive torque of the crushing unit is reduced and, as a result, the specific loads increase.
- In a crushing unit of this type, a vertical reciprocating movement of the ore mass is realized, due to which this movement occurs in the plane. In addition, disintegration efficiency is increased: along with compression deformation, abrasion, stretching and impact deformation occur. These types of deformations are observed due to the system of cyclic (alternating) forces implemented in the working area of the crusher.
- The use of rolls with a Reuleaux triangle profile prevents oversized pieces of ore mass from jamming in the slots between the rolls. The latter fact is due to the rejection of oversized by multidirectional forces arising in the working area of the crusher.

Thus, in the proposed crushing unit with the shape of the rolls in the form of a Reuleaux triangle, compression, abrasion, stretching and impact deformations are realized, which in turn increases the efficiency of the ore preparatory processing, as well as a decrease in electricity consumption due to the symbate reduction of the required energy for the disintegration of the ore mass.

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STUDY ON THE WEAR CHARACTERISTICS OF COAL MINING MACHINE RUNNING WHEELS UNDER CONSTANT TORQUE

Since the prevention effect of overhaul on the wear efficiency of key components of coal mining machine is very poor, it is very important to study the form of its wear efficiency for the intelligent development of coal mining machine. Firstly, we analyze the meshing process of the walking wheel and pin teeth, establish the tooth-pin meshing equation, analyze the wear mechanism of the walking wheel, and establish the numerical wear model of the walking wheel to provide a reliable theoretical basis for the simulation solution. Using the simulation software ABAQUS, combined with ALE adaptive mesh technology and UMESHMOTION subroutine, the wear finite element model of the walking wheel and the pin teeth is established to simulate the wear process of the mesh between the walking wheel and the pin row of the coal mining machine, and the wear depth and contact pressure of the tooth surface are derived, and the relationship between the stress on the walking wheel tooth surface, the contact pressure and the wear depth is analyzed to find out the wear of the walking wheel tooth surface. Reasons to find out the reasons for the wear of the walking wheel tooth surface, to find out its tooth surface wear distribution law, found that the walking wheel tooth root and tooth top wear depth is larger, the wear depth at the node is smaller, mainly due to the root out of the sliding coefficient is larger. The wear depth with the rotation time trend, found that the wear depth with the increase in rotation time and increase, wear rate gradually tends to slow after rising, indicating that in a certain period of time, the walking wheel wear rate with the change in contact area and gradually improve, and finally occur intense wear. By analyzing the wear law of the walking wheel of the coal mining machine, it provides the theoretical basis for improving the structure of the walking wheel and preventing the failure of the walking wheel.

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DEVELOPMENT OF AN AUTONOMOUS MOBILE POWER STATION

The transmission of electricity from district substations of the main power grid to enterprises with a continuous technological cycle for Oil and Gas production in rural areas, via power lines, is by no exclusion associated with short-term power failures at the consumers' level. To restore their normal operation, a time gap may last from few seconds to several tens of minutes. This may lead to significant economic losses. Different studies have been carried out on the influence of perturbations of the input voltage on the stable operation of the IM ECPs, and it has been found that a decrease in the voltage at its terminals to a value of 0.6 U_N with a duration of 0.15 s leads to loss of stability and subsequent stopping. Therefore, an autonomous option for the electric power supply of the field is certainly economically justified. For 1st category users, it is necessary to maintain a backup power supply in a hot standby. However, this solution is quite expensive and leads to generator fast degradation. Considering cold (idle) reserve, an interruption in the power supply may last up to 30 s. Therefore, investigating other technical means to solve this issue is needed. The main idea of the works starts with implementing a power module able to supply a load of 110 kV (including induction motors feeding submersible pumps) in rural areas working within electrical enterprises with a continuous technological cycle for Oil and Gas production.

The proposed solution consists of installing a secondary/standby diesel generator in parallel with a block set of batteries and supercapacitors. When a fault, or an instability occur in the main electrical network, the batteries and the supercapacitor system will intervene. If the fault is beyond the intervention of the stored energy, or if the state of the batteries and supercapacitor is low, the generator will take control of the operation. For faults in the mains network, the storage energy modules will start feeding the motor (load) until the generator starts and gets ready to sustain the load meanwhile the supercapacitor module will take care of the inrush current drawn during the startup of the load. In the case of horizontal boring or horizontal drilling operations, the Mains availability is not always guaranteed, furthermore the operation may be planned for a short period of time, providing power from the grid network may be very expensive as the grid will be of no use after dismantling the site. The proposed solution considers combining the generator, the energy storage modules the corresponding power converters on a truck, thus forming a mobile power station capable to feed a mobile or a short time load.

The proposed solution scheme is composed of the following components:

- A generator feeding a rectifier that supplies a DC-Bus.
- A battery set and a supercapacitor set, each feeding a bidirectional SEPIC converter installed in parallel to the rectifier.
- A Capacitor in the role of a DC-link is feeding a converter that supplies load.

For this purpose, the SEPIC converter parameters are developed using the averaged steady stated and averaged AC models. The transfer function of the Control-to-Output transfer function is derived and used to perform the stability analysis of the model and to implement a voltage control at the output of the converter. The converter will be tested with inputs (500 Volts DC) from battery and supercapacitor modules. Therefore, the role of the SEPIC converter is to

boost the supplied voltage to 800 Volts and maintain the DC-Link bus supplying a load of 110 KW at a constant voltage level. Being of 4^{th} order type, this transfer functions is hard to control, therefore, using Padé-Approximation techniques, it is reduced to 2^{nd} order and 1^{st} order and the control concept (IMC-based PI controller) will consider these reduced order transfer functions.

The second part of the work will focus on developing the AC-DC rectifier system, supplying a DC-Link of 800 Volts, and its relative controller. The input of the rectifier can be supplied by 2 sources, the main network electricity (In case the Mains is available), and in case of any failure, a standby generator in cold reserve is ready to take the load. By the time the generator starts up the energy storage module will be supplying the motor. To achieve this scenario, the rectifier has to be able to ensure a unity power factor (UPF), and thus cancels all disturbances injected into the main network or the generator side. In this regard, the rectifier will be controlled to achieve a bidirectional power transfer and unity power factor using the vector control strategy, specifically voltage-oriented control (VOC) method. Battery and supercapacitor sources are constructed from a set of battery and supercapacitors cells connected in parallel and in series, respectively. Due to imperfection in manufacturing, active cell balancing has been proposed. Finally, the results of the works will be presented, discussed and consideration for future work applications will be recommended.

When it is fed from the batteries or the supercapacitor modules, the SEPIC converter successfully boosts the input voltage to the desired output level (V_{DC}) with a rising time of 1.6 ms and a steady state oscillation around 1%. V_{DC} is kept within the design requirements (0.6 U_N for less than 0.15 s). The voltage controller of the rectifier binds V_{DC} to its referenced value with a response of around 300 ms with a minor oscillation setting a ripple in the DC-link voltage around $\Delta V_{DC} = 0.125\%$. The quadrature current "i_q" is almost oscillates around "0" amperes. The controller's reference direct current "$i_{d\text{-reference}}$" holds "i_d" within its range oscillating with a ripple around $\Delta i_d = 8.9\%$. As a conclusion, the results of the simulation are satisfactory and the control reaches its objectives to achieve the UPF and maintain the DC-link voltage at 800V with a THD 0.14%.

In this work, a model system of energy storage elements (batteries, supercapacitors) has been established, the main role of this storage system is to replace the power needed from a diesel generator during its starting time and to reduce its size. If the system is connected to the main grid, they will help supplying the load in the occurrence of any failure. The storage system is connected to the load via a capacitor DC-link. The concept of the solution is to combine the generator and the energy storage system together with the power electronics converter elements on a single truck, which will provide a mobile power station that can be used to feed a mobile induction motor load or any other similar load. For this a virtual model has been constructed in MATLAB/Simulink, and the available results were shown and discussed. Further considerations will consider the implementation of a unified control scheme taking into account the power share control and some of the mains stability indicators.

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BUYO PROJECT - CREATING SOCIAL ROOM POWERED BY RENEWABLE ENERGY

The idea behind BuYo is to establish a Start-up project. Our solution is based on using hydropower to create electrical energy, which would be utilized for social purposes. The generated energy will power self-sustainable open offices, located on the shores and riverbanks, to meet the needs of modern society and COVID-19 pandemic measurements, so people could work/study via electric devices in the nature by employing completely clean energy plus being used as points to raise the social awareness for the importance energy conservation and renewable energy.

This research includes studying and preparing a new and advanced model for the energy conversion of the transverse waves to electric energy by using an air turbine whose circulation is derived from the air pressure generated by the waves in the special energy conversion column room.

The proposed system also includes the preparation of a computer program written and operated with the help of the MATLAB program, which calculates mathematical equations as the model according to a working algorithm that determines the course of your operation under climatic conditions where they are presented in clear curves and the value is discussed, then useful facts and proposals were reached to build and develop the model in the future.

The aim of taking our idea to The XVII International Forum-Contest of Students and Young Researchers was to let it be challenged and evaluated by professionals and experts, and at the same time, to gather supporters who would also believe in BuYo's success. In order to make our idea happen, we had to distribute it through as many channels as possible; therefore, we were extremely excited and honoured to be invited to participate in that remarkable event.

On a general level, the Buyo project main goal is to raise the awareness and the importance of water and energy rationalization at once and to take a step towards making it a public issue.

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OUTCOMES OF THE GREENY PROJECT. CONTRIBUTION TO THE UTILISATION OF MN SLAGS THROUGH MECHANICAL PROCESSING.

Recently, the reuse of metallurgical slag has gained great importance. The possibilities of Mn-containing slag in the raw material production process are among others to employ as the production of aggregates for the construction (e.g., cement industry). If the Mn content is sufficiently high, use the Mn-Slag in the production of raw materials is favourable.

Raw slag, which contains less than the cost-covering percentage of extractable metals, should be used after crushing as a separate product for building materials. In addition, Manganese is an element of high commercial interest and requires adequate liberation of other slag components by efficient grinding technology. To overcome this challenge, a depth characterisation, mineralogical and mechanical, is required to select the best grinding mechanism. This study discusses the release of Mn-bearing inclusions, focussing on the characteristics of the grains, knowing their intrinsic properties and their response to different grinding technology.

Investigated samples were collected from a molten slag pile in Kvinesdal, Norway and pre-crushed at Metso:Outotec in Tampere.The material is heterogeneous, due to segregation processes during uncontrolled cooling.

As a use case, the GREENY project (Grinding energy efficiency) takes on the efficient reuse of the steel industry's slag that is a side product in steel making. The design and optimisation methodologies, processes and equipment that are developed also apply to other slags and secondary raw materials [1].

In the GREENY use case, the slag contains valuable metals that can be extracted by a combination of selective comminution and metal liberation from the slag. For this purpose, the work was divided into the characterisation of the feed material, the crushing process with compressive and impact loading, and a final evaluation of the products. Testing performed by impact comminution showed more favourable results, including higher selectivity and better liberation compared to compression mechanism. The observed fracture patterns provide indications of preferential breakage supported by high selectivity.

To have a mineralogical characterisation, the following analytical techniques were conducted: Mineral liberation Analysis (MLA), X-ray fluorescence (XRF), QMA (Quantitative Microstructure Analysis); Computerised particle analysis (CPA), among others.

GREENY is a project financed by EIT raw materials, and the partners are METSO:Outotec (Finland),TU Bergakademie Freiberg (Germany), Luleå University of Technology (Sweden), VTT (Finland) and ERAMET (France).

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INCREASING THE SERVICE LIFE OF GAS TURBINE POWER PLANTS USED AT MINERAL DEPOSITS

It is known, that for the supply of power at mineral deposits, a gas turbine power plant is commonly used. Due to the remote conditions of the location of most fields, there can be issues with the reliability of gas turbine engines, whereby an engine failure could deprive the field of electricity and could require the need to replace damaged parts. This can be a serious problem.

The reliability of an engine is dependent on the service life of a number of its parts. One of the main parts that can be considered as a determining factor of the service life of these engines is the first stage turbine blades [1]. These blades work in difficult conditions. High temperatures and high dynamic loads increase the likelihood of defects, which can dramatically reduce the life of both the turbine and the engine as a whole.

A common reason for the failure of these blades is the burnout of the exterior blade walls. The most problematic being the nozzle (stator) blades' leading edge. This is the zone where high temperature gases pass through (in relation to other sections along the length of the profile).

Currently, in high-temperature turbines nozzle blades are used, in which the leading edge has a separate cooling channel, i.e. an independent cavity is created in the leading edge zone, where a coolant is fed [2]. Also, the results of tests of full-scale turbines show that the radial plot of the gas temperature in front of the blade has a maximum that is located approximately in the middle part of the upper half of the blade profile (i.e., approximately 2/3 of the height of the blade from the lower section). Taking into account the requirements for the level of cooling efficiency needed for promising turbines and the results of determining the radial gas temperature in front of the turbine of an actual engine, we can propose the following nozzle blade design. Such a blade contains a profile, the inner part of which is divided into three cavities: two in the area of the leading edge (located above each other in regards to the height) and another one for cooling the middle and the tail part of the blade. The advantage of such a blade is that its design allows for the reach of a stream of cooling air (that is separate and does not cool other sections of the blade profile) to the most problematic section of the blade profile (in terms of temperature tension), thereby achieving a higher level of cooling efficiency, intensively reducing the temperature of the blade, therefore reducing the likelihood of cracks and burnout. As a result, the reliability of the blade is increased, thereby increasing its service life.

The practice of designing cooling turbine blades in GTEs allows for the use of turbulators of various shapes in the internal channels [3]. As of today, usually these are used: pins, matrices, ribs and etc. It is advisable to consider new forms of turbulators which will provide the necessary increase of intense heat exchange needed without critically reducing the air pressure of the cooler. This is done to let go of air that was used for heat removal. Authors propose the new form to be a spiral.

The experimental study of the spiral flow pattern conducted by the authors showed that this type of turbulator allows it to have a higher level of turbulization, which will lead to a more efficient heat removal. The spiral shaped turbulator is installed exactly where cool air is supplied, in the inner channel where the end-wall of the blade is located.

An experimental study of the flow around the cone-shaped spiral allowed us to draw conclusions about the high degree of turbulization of the flow generated by the flow around the spiral. The installation of a cone-shaped spiral directly close to the leading edge allows for the creation of a well-swirled flow that spreads upwards along the leading edge and this contributes to its intensive cooling. It is recommended to release this air radially upwards.

The authors were able to produce a CFD simulation of turbulent hot air passing through the spiral. The simulation showed a 15% decrease in the temperature of air through one spiral.

The spiral was able to provide minimal pressure loss, which in turn is good to let the cool air out from the turbine blade.

The problem with constructing spirals lies with the capability to make turbulators from graphene. The study of the cooling characteristics of graphene conducted by the authors showed that graphene performs heat removal at a higher rate. Graphene can be made with a two dimensional structure, and since it is also elastic it can allow for the construction of nanotubes, whereby many layers of graphene are joined together radially and eventually bent into a tube. This tube is stretched into a spiral and held in place. Another way to produce spirals would be by using wire electrical discharge machining to produce any small graphene models, as it can conduct electricity very well. EDM is already being used on cutting diamond, which has a similar atomic structure to graphene and graphite. The properties of a spiral turbulator made from graphene will be very high both in terms of strength and heat transfer.

The center of the spiral is connected to a rod, which is fixed in a spring mechanism installed in the opening where air is let through.

The future development of graphene production technology will make it possible to obtain a lightweight and durable turbulator that can generate a sufficient powerful turbulent flow to effectively cool turbine blades. It is good to conclude that graphene has a higher level of strength and a higher degree of heat removal from the turbine blades, which in any case will benefit the mining deposits industry.

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METHOD FOR EVALUATION OF THE ELECTRIC POWER CONSUMERS’ CONTRIBUTIONS TO THE VOLTAGE AND CURRENT DISTORTION AT THE POINT OF COMMON COUPLING

The energy efficiency of modern industrial enterprises depends on a large extent of high-tech electrical equipment, which makes it possible to change the shape of the supplying voltages and currents. Electric motors, powered with such a voltage, can operate under different conditions in order to reach wide range of their rotation speed. The advantages of using variable speed drives are obvious, but such a widespread non-linear loads lead to a significant decrease in the electric power quality. In this regard, two research field have started to develop. The first one is the development of devices that compensate for the high harmonics of the consumed current. The second direction is the development of a method that allows to determine the source of distortions relative to the point of common coupling (PCC). If the first issue has been thoroughly studied in the last 30 years and the harmonic filters of various configurations have been

developed that improve the quality of power at the PCC effectively, while the second problem has not been fully solved. Existing methods for determining the sources of high harmonic and their contributions to the total distortions of the network either allow to determine only the dominant source without a clear result in percentage terms, for instance, the active power method [3], the reactive power method [4], the non-active power method [1], the distortion power method [2], or are technically unrealizable a well as do not have fundamental physical and mathematical foundations. At the same time, the availability of a reliable and accurate method could become the basis for a reasonable regulation of the consumers' and the power supply system's responsibility for the quality of electrical energy in terms of high harmonics.

As part of the research the index K_D was proposed. K_D is the consumer's contribution to the distortion of current and voltage at the PCC. The method for calculating this coefficient assumes measuring the consumers' currents and the power supply system's total current for each harmonic separately, after that the projections of the consumers' currents on the total current and its ratio to the total current is calculated. A feature of this approach is the analysis and calculation of consumer contributions in vector form, as a result negative K_D values may appear, indicating that the considered consumer compensates for external currents of higher harmonics.

The carried out theoretical studies substantiate the possibility of using the proposed method. Using numerical methods during computer modeling in Matlab Simulink made it possible to consider typical cases of linear and nonlinear loads ratios and to confirm the dependencies assumed at the theoretical studies. As an approbation of the method, a number of laboratory experiments were carried out on a laboratory branch which allows creating voltage distortions at the PCC that exceed the values regulated by GOST 32144-2013, IEEE 519-2014, IEC 61000-3-6. During the experiments, the high harmonic currents of linear and nonlinear consumers were measured at various loads modes. Negative values of the K_D index were obtained for a linear consumer as an asynchronous motor for a wide range of consumed power, as well as for a wide range of the nonlinear consumers operating modes, represented by either a thyristor rectifier or a thyristor power controller. When conducting an experiment with three consumers connected to the PCC, it is possible to clearly determine whether only one of the nonlinear loads is the source of the higher harmonic current, or two consumers and their ratio.

There is no doubt that additional research is required to expand the scope of the proposed criterion and method. For example, conduct a study with two consumers that include both linear and non-linear loads. It is also reasonable to study systems that include reactive power compensators and higher harmonic filters.

However, it can be concluded that the proposed coefficient K_D can become a tool for a reasonable distribution of responsibility for the generation of higher harmonic currents between consumers connected to the same PCC.

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A METHODOLOGY FOR FORECASTING LITHIUM DEMAND FOR E-MOBILITY IN GERMANY: A SCENARIO APPROACH

Our study tries to portray the rising demand of lithium induced by the surgence of electric vehicles in one country's context and that is Germany. We used a mathematical model built in Excel software and scenario approach to forecast the demand of lithium arising from the electric vehicles in Germany till 2060. A number of studies have demonstrated the future of lithium demand, supply and its availability [1], [2], [3], [4]. [5], [6], [7]. Some studies showed that the future is secure with enough lithium supply [3], [4]. On the other hand, Tahil and Wanger are skeptical about the lithium supply as demand could surpass the existing amount of available lithium [1], [8]. Another study suggest that lithium demand could account for 74 to 248% of the available lithium resources [5]. The importance of recycling has been addressed in many of the studies in order to meet the potential future surge in demand of lithium [2], [3], [8], [9], [4], [5], [6], [7]. Most of the studies focused on the global lithium demand when considering the EV growth. There was a lack of studies related to country specific demand for lithium as EV is surging.

The technologies that are used in building the batteries of the electric vehicles incorporate important natural resources like lithium. We forecasted lithium demand arising from Germany's Electric vehicles growth till 2060, where we used a simple mathematical model built in Excel software with scenario approach. The amount of recycled lithium can be used in meeting the future demand of lithium arising from Germany's EVs is also being calculated. The study also shows the future demand of lithium with or without considering a second life of the battery used in the EV. Furthermore, it shows how much of the worldwide lithium production will be needed to meet the future lithium demand arising from Germany's EV.

Lithium is being used extensively in lithium-ion batteries and the use of lithium is likely to increase in the future as the electric mobility sector is expanding at a rapid pace. In this study we showed that up to 63.4% of the future lithium demand of Germany's EV can be met by recycled lithium when there is second life usage of the battery is not considered. 43.9% of the future lithium demand of Germany's EV can be met by recycled lithium when considering a second life usage of the battery of 6 years. Furthermore, we also showed in one of the scenarios that 28.39% of the worldwide lithium production would be needed to meet the demand arising from the electric vehicles of Germany where recycled lithium was not considered. These results clearly indicate that lithium recycling can play a major role in meeting future lithium demand.

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ROBOTIC COMPLEX FOR MONITIRING THE STATE OF ELECTRICAL EQUIMENT OF ELECTRICAL SUBSTATIONS 110-220 KV

This article presents the new robotic complex, designed for monitoring and diagnosing the state of equipment at electrical substations without permanent maintenance personnel.

One of the main tasks in the power industry is to ensure uninterrupted power supply to consumers. This is achieved through the modernization of outdated equipment and the introduction of digital technologies. Undoubtedly, this brings tangible results, as evidenced by the decrease in accidents in recent years. But despite this, the main requirement for preventing accidents at electrical substations is regular inspection and diagnostics of electrical equipment. The most effective in this regard are remote diagnostic methods, in particular infrared and ultraviolet control methods.

Today, thermal imaging examination is included in the list of preventive methods and is carried out at least three times a year. Visual inspections of equipment at substations without permanent personnel on duty should be carried out at least once a month, in total for a year - 12 [1]. One of the reasons for this is the lack of qualified personnel - the quality of the obtained thermograms and their analysis depends on the competence of the specialist. One of the reasons for this is the lack of qualified personnel - the quality of the data obtained and their analysis depends on the competence of the specialist. Another problem, partly related to the previous one, is large am ounts of data. So, for a thermal imaging examination of a transformer, in addition to high-quality thermograms, it is necessary to take into account a number of conditions: loads, ambient temperature and weather conditions, emissivity of transformer nodes, illumination [2]. With large volumes of work, a sufficiently large amount of data is accumulated, as a result of which the time for analyzing equipment slows down and the likelihood of errors and incorrect decisions increases. Thus, despite the fact that regular inspection in combination with thermal imaging and ultraviolet examination allows detecting equipment defects at an early stage, the frequency of these activities is low. The introduction of a robotic complex for monitoring electrical equipment will solve these problems, increasing the quality of monitoring by automating the diagnostic processes and assessing the state of electrical equipment.

The developed complex consists of a bundle of an inspector robot, a server and an automated workstation. This complex will allow combining thermal imaging and ultraviolet monitoring, thanks to the installation of infrared and ultraviolet cameras on the robot. For navigation at the substation, the robot will be equipped with a laser orientation system. Due to the uniformity of substations of types 4H and 5H, robot route templates will be developed [3]. A charging station is installed at the substation, where the robot recharges the batteries and is in standby mode. The inspection will be carried out both at the request of the operator and according to a pre-planned schedule drawn up according to the failure statistics.

The inspector robot structurally consists of a chassis, a pantograph and equipment diagnostics devices. Control and data transmission units are installed on the chassis also, a laser orientation system and a camera are being installed. The housing is protected from magnetic fields and interference to protect the electronics. The pantograph is equipped with ultraviolet cameras with a wavelength of 7.5 - 13.5 μm and an infrared spectrum, 7.5-14 μm [4,5]. The charging station is installed on the territory of the substation and, in addition to recharging the batteries, acts as a link between the server and the robot, transmitting data from diagnostic devices and the state of the robot. Two software packages will be installed on the automatic workstation: "operator", "analyzer". Through the "operator" program, the personnel perform remote control of the robot and adjust the survey route schedules. The "analyzer" program is designed to analyze the survey data package and compile a report on the technical condition of electrical equipment. The program saves all reports in a database stored on the server, which allows you to quickly receive dependencies and develop a database of damages.

The robotic complex will increase the scope of work on monitoring the condition of electrical equipment, while maintaining the current costs of maintaining the substation. This complex is suitable for substations without permanent duty personnel, where regular inspections of electrical equipment are difficult. This will lead to the acceleration of the adjustment of the repair work schedule and the transition to repairs based on the technical condition.

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REDUCTION OF CARBON FOOTPRINT IN OPEN PIT MINES WHEN SWITCHING FROM DIESEL TO ELECTRICITY

Industry is responsible for about 38% of the global carbon dioxide emissions, of which over 80% is a consequence of energy use. This study evaluates the energy efficiency and CO2 emissions across different scales of operations in iron-ore mining in Western Australia to determine what influence the scale of operation has on the amount of energy consumed and carbon dioxide emissions produced per unit of ore produced. The study was undertaken across three scales of operations based on production capacity and calculated the energy efficiency and related carbon emissions of mining operations from eight mines. This study calculated energy efficiency and carbon dioxide emissions from iron ore mining operations in Western Australia. It

was undertaken in two stages: Analysis of different scales of iron ore mining operations (Broad Scale) and a detail analysis of iron ore mining operation process stages (Fine Scale). The first stage involved a broad scale analysis, which identified the differences in energy efficiencies in various scales of operations. This stage of the study was carried out across three different-sized mines, which were classified based on the production capacity data from thirty-four currently operating iron ore mines in Western Australia. The second stage involved a fine scale analysis, which was undertaken to calculate the energy efficiency and carbon emissions from each step in the mining process from drilling and blasting to the delivery of ore to the ports for shipping. This second stage of the study was conducted on data sourced from six iron ore mines operating in the Pilbara and Midwest regions of Western Australia. The mines ranged in size, based on production capacity from 3 to 60 million tons per annum.

Based on findings, it is recommended that mining companies should indulge to large-scale iron ore mining operations since it was found to be the operational scale with the highest energy efficiency, due to the lowest amount of energy consumed to process a unit of iron ore, while the small-scale iron ore operations recorded the lowest energy efficiency based on the specific energy consumption and energy efficiency index values. Implementation of energy efficiency programs can be identified as an important approach which will allow companies to achieve improvements in energy savings at no or low additional costs. There should be implementation of energy efficiency programs which is an important approach that will allow companies to achieve improvements in energy savings at no or low additional costs. Mining companies should take into consideration the characteristics of the equipment fleet which were identified as the prominent factors that influence the loading and hauling energy consumption at different scales of operations where the larger load capacities, energy efficient technologies and advanced mechanisms in equipment result in lower energy consumption in loading and hauling in higher operational scales. A new standard reporting system, that would contain the necessary parameters, should be introduced to the mining and mineral processing industry.

A multiple linear regression analysis was performed to determine whether the grade of ore, average haulage distance, waste-ore ratio and the production capacity had any influence on energy consumed by the iron ore mining and mineral processing operations, and to determine the relative importance of these parameters on energy consumption. The R2 value of this analysis showed that, 93.9% of total variability of energy consumption is explained by the predictor variables. The analysis of variance results indicates that the synergetic influence of the grade of ore, average haulage distance, waste-ore ratio and the production capacity were statistically significant in predicting energy consumption, The results of the detailed analysis of iron ore mining process stages of small and medium- scale operations identify that loading and hauling is the highest energy demanding process stage in Western Australian iron ore mining operations regardless of the scale at which it is operating. Results from this study were compared with the results of similar studies carried out worldwide to identify the similarities and the differences in energy intensive and highest carbon dioxide-emitting process stages. One carried out in Western Australian iron ore mines, one undertaken in the United States and another in the Canadian iron ore mines which has data only for milling and stockpiling. All three studies in this comparison identified that the loading and hauling operations are the most energy intensive process stage in mining operations, while milling and stockpiling, and drilling and blasting consume lesser amounts of energy respectively.

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POSSIBILITIES OF OPTIMIZING THE PROCESSES OF LOCAL FUEL PROCESSING

Energy saving during the processing of fuel and energy resources is a priority in the industry of the Republic of Belarus. In the technology of producing fuel briquettes dewatering plays a great role and is an urgent issue to reduce specific energy consumption at peat briquette plants. This can include the consumption of heat, electricity and raw materials for the production of one ton of finished product.

Research experience in this area shows that the average value of moisture content of extracted peat increases, and its density decreases. This affects the energy consumption during its processing. A great influence on energy consumption has an increase in moisture content of raw materials and a decrease in the bulk density of peat. Their change is the most significant disturbance of the process of drying and pressing of peat. They also disrupt the relationship between the drying agent (steam, air, water) and the moisture content of the dried material, which leads to a decrease in the productivity of the TBZ and deteriorates the quality of briquettes. Local fuels are currently widely used in the Republic of Belarus. They include peat, firewood, processing waste - sawdust, straw, firewood, scrap briquettes, etc.

In the fuel industry local fuels are dehydrated by thermal drying and mechanical action. A priori data show that energy costs for production of one ton of briquettes at the peat briquette plants (Concern "Beltopgaz") are more than 3.3 GJ per ton for pneumatic-gas dryers, and for raw materials - 1.8-1.9 t/t, for electricity 42 kW/t. For pneumatic-steam-water dryers are respectively 2.1 GJ/t, 1.83 t/t and 70-75 kW/t. [1]

When reducing the specific energy consumption, it should be taken into account that at plants with pneumatic-steam dryers and Peco the value of briquette production most closely correlates with energy intensity, which means the most sensitive downtime due to raw materials, equipment failures. In plants with Zemag dryers, the energy intensity of briquetting is most closely related to the moisture content of the finished product. With an increase in final moisture content, the actual energy costs increase. This fact is explained by the fact that the increase in specific electricity consumption associated with an increase in the moisture content of raw materials is determined by a decrease in the productivity of the plant. Consequently, it is possible to reduce the specific electricity consumption if the dryer capacity is used optimally (the arrival of wetter peat exceeds the capabilities of the dryer for artificial evaporation of the calculated amount of moisture, and low productivity underutilizes the installed capacity of electric motors in the briquette plant). Therefore, the guarantee of minimum power consumption in a briquette plant is the operation of dryers at optimal productivity in terms of the amount of dried peat and the lowest possible initial moisture content of raw materials. Calculations show that the decrease in electricity consumption for the operation of briquette plant equipment when decreasing the humidity of dried peat is approximately seven times less than the increase in thermal energy to remove an additional amount of water.

Among the most common processes for the processing of minerals, first of all, dehydration should be called. There are two types of dehydration of minerals: thermal (drying)

and mechanical (centrifugation, filtration, squeezing, etc.). Dewatering is performed for various purposes: enrichment (for example, improving the combustible properties peat), strengthening of products, changing properties (decrease in thermal conductivity, hydrophilicity), etc.

Energy saving with the simultaneous requirement to intensify the processes of dehydration and extraction requires the introduction of high-tech high-performance technologies with the simultaneous modernization of existing equipment.

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TECHNICAL FEASIBILITY STUDY OF A HYBRID SOLAR/WIND SYSTEM WITHOUT BATTERIES FOR A REVERSE OSMOSIS DESALINATION PLANT - A CASE STUDY OF BETHANIE

Due to the population density of Namibia, the extension of facilities such as water's and the electric grid to remote areas may not always be economic. A reverse osmosis can be used to desalinate the readily available groundwater and provide good quality water to specific areas. A hybrid plant made of solar and wind energy can supply this plant for it to operate autonomously.

This research presents a technical evaluation the sizing and operation of a stand-alone hybrid supply without batteries, and the reverse osmosis for water desalination system for a remote village in Namibia. The objectives of this work were to determine the individual and combined capacity of the solar and wind system, and how the plant would be supplied based on the supply constraint.

The power required was evaluated using the maximum pressure needed for the reverse osmosis operation and the pumping specifications. The system was modelled and simulated in MATLAB using environmental data acquired for the site-Bethanie. Indices were developed to evaluate the performance of the supply system by comparing the produced power to the capacity of the plant.

The results showed that it is best to use solar energy alone to power the reverse osmosis system because the site does not present characteristics that are appropriate for wind energy harvesting. A supply schedule with the load partitioned and a bigger reverse osmosis and supply source was suggested to operate the plant for 10hours with a primarily Deficit index of 20.18% as opposed to 64.55% for the original schedule of 24 hours. The performance of the reverse osmosis system was further improved with more thorough supply schedule developed. The addition of an extra unit of filtrating membranes improved the water production from 65% to 75% for the worst-case scenario, while leading to more than 100% on normal days. To sum up, the study showed that it is possible to reliably supply the system and produce the quantity of water needed by this village.

Having the R.O system powered by solar energy requires the plant to have more flexibility to be able to operate when the power produced is less than the demand. Therefore, a study of a variable R.O operation can be done whereby the performance of the individual components (e.g. HPPs with VFD) of the system can be adjusted to optimally consume the power produced. This option might lead to a lower permeate output. The study might determine accurately the feasibility of a such an operating mode.

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DEVELOPMENT OF A COMPLETE AUTOMATED ELECTRIC DRIVE FOR A BALL MILL WITH INCREASED TECHNOLOGICAL AND ENERGY EFFICIENCY

Russia occupies a leading position in the extraction and processing of ores containing noble, ferrous, non-ferrous and rare metals. The gradual depletion of ore reserves and the presence of refractory ores make it necessary to discover new deposits of strategically important metals and to increase the efficiency of processing ores mined at existing deposits. Areas of the Arctic zone and the Pacific ore belt are one of the most promising and are of great interest in the development of their deposits [1]. Increasing production capacity through new and efficient enrichment technologies is a modern approach to improving existing factories and building new ones. Leading Russian companies for the production of precious metals are interested in the modernization of priority projects. An example of the modernization of such a project is the reconstruction of the Talakhan plant in Norilsk, which is the replacement of several small-capacity mills with three mills with a total capacity of 36 MW.

Ore grinding is a high-tech and energy-intensive process, which is characterized by the complexity of mathematical description, control and optimization, in order to increase technological efficiency and reduce energy consumption [2]. The physics of the process is due to the probabilistic nature of the interaction of the crushed particles and grinding bodies in the mill drum, and observation of the particles in the mill is impossible. The physical and mechanical properties of the crushed ore are variable in the process of mined deposits, and the size of the original ore entering the mill is difficult to maintain at the same level, since a thorough classification under production conditions is impossible.

The existing control systems used to automate the mills of Russian mining and processing factories do not take into account changes in the physical and mechanical properties of the ore, as a result of which, regardless of their values, the mills operate in the same speed mode. The main problem of the operation of mills with such control systems is to reduce the energy for grinding and productivity, with a change in the physical and mechanical properties of the ore, and, as a consequence, an increase in the specific energy intensity of the mining and processing plant [3]. Therefore, a method is needed that will allow to limit the influence of changes in ore properties and will allow maintaining the productivity of the grinding process at a nominal level. The work proposes to consider the possibility of reconstruction of a mining and processing plant using the example of the Vorontsovskiy plant and the possibility of adjusting the mill's operating

mode by changing the rotational speed using an automated electric drive to increase the technological and energy efficiency of the grinding process.

Having studied the technological schemes of the grinding process of foreign mining and processing factories, it is proposed to modernize the technological scheme of grinding on the example of the Vorontsovskiy plant as part of a gradual increase in gold production capacity in connection with the development of new deposits. The modernization consists of the installation of one large Metso 6.4 / 10.2 ball mill instead of the proposed six ball mills to obtain the required grade of ore in the finished product.

It is proposed to consider an algorithm for calculating the optimal speed of rotation, which takes into account the physical and mechanical properties of the ore on the basis of data on the consumption of the original ore and the finished product, as a setpoint for the speed of the electric drive. For the criterion of optimality, the minimum grinding time is taken - 25 minutes, required to obtain a finished product yield of 0.074 mm at the level of 70%. On the basis of the Bond theory, an estimate was made of the energy consumption for grinding ore when its strength properties change [4]. This algorithm was modeled and debugged using Matlab Simulink. Thus, when the physical and mechanical properties of the ore change, the speed of the mill drum changes accordingly. The work presents an assessment of the technological effect according to the developed method.

To implement the developed algorithm, it is proposed to use an automated gearless twin-motor electric drive. The choice of the mechanical structure is primarily due to the power of the controlled object and the provision of high control accuracy. Rigid-coupled two-motor electric drives have some peculiarities in their use. Such an electric drive assumes coordinated accurate control due to the possible uneven distribution of the load between the motors. The uneven distribution is associated with the difference in the winding parameters of the driving machines, which leads to a change in the rigidity of the mechanical characteristics. To balance the loads, a developed algorithm for the correction of the moments as part of the motor control system is proposed. The correction is carried out by adding torque values. The equalization of the moments is achieved by changing the reference to the torque generating current. Therefore, the amplitude values of the currents will not be the same, one of the motors will be re-magnetized. The consumed energy will be spent irrationally, the resources of the engines will be used unevenly. To align the amplitude values, it is also proposed to add an algorithm for correcting the flux linkage reference. Due to the unbalance of the flows, equalization of the amplitude values of the motor currents is achieved. The currents are equal and correspond to the minimum value. It should be noted that the developed algorithms as part of the motor control system do not affect the quality of the controlled speed signal in any way. The economic effect is presented, which (for the selected engine) is 3.2 million rubles in year.

Thus, the results of the work represent a ready-made solution for automating and improving the technological process of grinding ores and can be used in the modernization of existing Russian mining and processing plants and in the construction of new ones in the regions of the Arctic zone and the Pacific ore belt.

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MODELING THE TEMPERATURE OF THE EVACUATION CHAMBER WITH ARTIFICIAL NEURAL NETWORKS

Introduction. In a global context, nowadays, modern control systems play a fundamental role when developing solutions to issues or problems presented in domestic and industrial applications. The main contributions of modern control systems at industrial level contribute to technological innovation, profitability and maintainability of the controlled processes. Within the advanced control strategies under investigation to automate complex processes are: adaptive control, predictive control based on models, robust control, and intelligent control, among others. Intelligent control relies on several techniques such as: fuzzy logic, evolutionary algorithms, and artificial neural networks. Artificial neural networks can be used effectively and accurately for modeling systems with complex dynamics, especially for nonlinear processes that vary over time. The growing interest in neural networks is due to its great versatility and the continuous advance in network training algorithms and hardware [1-2]. The nickel producing companies have continuous processes of great complexity that require automation to achieve a greater efficiency in their productions. In the process of ore preparation, it is important to maintain a temperature control at the outlet of the dryer evacuation chamber, in order to obtain the mineral drying with an established humidity level of 4 to 5.5 %. It must also be ensured that the temperature at the outlet of the electrofilters is above the dew point temperature; to prevent the deterioration of electrofilters, which leads to high economic losses, from accelerating considerably. The inefficiencies in the control of the outlet temperature of the dryer evacuation chamber in the ore preparation process are taken as a research problem and as an objective to obtain an artificial neural model for the outlet temperature on the basis of the main input variables, using Matlab as a calculation tool.

Main part. The drying of the ore is carried out in elongated cylinders formed by a combustion chamber where the hot gases that dry the ore are produced, and by the cylinder where the ore will receive the drying process. These drums have in their interior lifting elements that are responsible for allowing the transfer of heat between the hot gas and the mineral, in addition the dryer drum has a motor system coupled to the body of this which allows it to rotate on its axis. The dryer drum externally rests on two wheels that has two pairs of roller. Internally the dryer is formed near the combustion chamber by guides or baffles welded to the body of the drum that are the ones that direct the mineral towards the outside of the cylindrical part of the drum [3]. The mineral dryer is a complex physical-mathematical modeling object with a large number of input and output parameters which are in a complex interdependence.

The determination of the type of artificial neural network, the number of layers and the number of neurons in each layer that best characterize the process of ore drying process was carried out through a trial and error process that plays with the number of neurons and the maximum permissible error. Through Matlab's Toolbox (nnstart), the performance of artificial neural models was evaluated by using the mean square error and the correlation coefficient between the real values and those obtained by the network [4]. The objective was to provide the network with an adequate number of neurons in the hidden layer to learn about the characteristics of the possible relationships between the sample data. Through the trial and error process, it was identified the feedforward back propagation structure that provided better results. The proposed network consists of two layers: a hidden layer and an output layer. The output layer will only have one unit, which will indicate the value of the oulet gas temperature associated with each input vector presented to the network. The hidden layer will have a variable number of neurons.

Conclusion. The capacity of the feed-forward back propagation network for the simulation of pulp sedimentation processes in the industry was demonstrated. The structure that

best characterizes the behavior of the temperature in the exhaust gases of the evacuation chamber is characterized by two layers with 50 neurons in the hidden layer and one in the output layer, with the Levenberg Marquart learning method (trainlm), and the log-sigmoidal (logsig) and sigmoidal hyperbolic tangent (tansig). Thins one reached the correlation coefficient values of 0.97 during its training and 0.95 in validation, as well as 0.87 in its generalization.

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TIME-INDEPENDENT METHOD FOR CALCULATING THE ENERGY EFFICIENCY AND GREENHOUSE GAS EMISSIONS OF DUMP TRUCKS INCLUDING TROLLEY ASSIST SYSTEMS

The size of a mining operation defines the type of equipment required. The haulage system, as one example, is determined firmly by the mine's annual production. Even the production of a small size open-pit mine could not be attained feasibly by a typical on-highway truck. Mining operations use various types of off-highway trucks to transport materials from loading points to crushers, dumps, and stockpiles. In addition to size, the haulage distance as another equally important factor directly impacts loading and hauling fleet combinations. The comprehensive transporting system determination requires an accurate and precise judgment of different possible choices. This paper presents different configurations of off-highway trucks, including trolley assist systems, and calculates their energy requirements using two approaches based on cycle time and road specifications. Finally, an environmental impact assessment methodology is developed and the results are used for the overall comparison of energy efficiency and greenhouse gas emissions.

Rigid frame trucks are the most common type of trucks that have been using in open-pit operations. They have two main drive train systems, mechanical drive and electrical drive; according to the type of electric current, electric drive trucks are divided into AC and DC types. Electric drives consist of an engine, generator, power converter, wheel motors, planetary gear sets, and retarding grid. The generator converts the diesel engine's mechanical energy to electricity used by wheel motors afterward. The mechanical set has better driving performance in steeper grades with higher speed, while in downhill mode, some electric drive trucks could generate and save electricity. Recuperation system refers to trucks with an electrical power train system that can generate and store electrical energy when driving downhill roads. The capital cost of electrical drives is higher, but the operating costs are lower because some mechanical drive system parts are less worn. Trolley-assist mining truck is an electric-drive rigid-frame rear dump truck that draws electricity from overland power grids when driving uphill.

In an open-pit operation, trucks move uphill with a 7-10 % slope grade when they are loaded; this mode accounts for almost 70 % of total cycle fuel consumption. After unloading, trucks come back unloaded, the best case is when the roads have 3 % of slope grade, which equals the vehicle's rolling resistance on the flat road, then fuel consumption rate is equal to

idling mode. However, they usually come back through the same road with a 7-10% slope grade, which means they need some energy to limit their speed, this mode so-called retarding and some electric trucks can save energy during this mode. Fuel consumption at idle is about 10-15 liters per hour for all classes.

Mining companies keep records of their production based on time, for example, per shift or day. After dividing the fuel consumed by the tonnage of material moved, the result is usually used as an indicator of fleet efficiency. However, this indicator cannot properly represent efficiency even when divided by transportation distance. Although the indicator uses real data, it still does not reflect how trucks operate during cycle time. Even though a change in cycle time has a direct impact on overall fleet performance, it does not significantly affect fuel consumption. When the trucks are idle, fuel consumption is only ten liters per hour; while they are in motion (whether loaded or unloaded), they require 100 liters per hour (based on the Caterpillar 785D model). The time base calculation is very sensitive to the cycle time estimate and fuel consumption rate. In contrast, the energy required to move an object is a function of mass and distance. In this paper, fuel consumption was estimated with a time-independent approach using parameters such as vehicle mass, rolling resistance, and gradient force. Finally, to compare the mentioned systems, an index is assigned to each system configuration based on different energy sources and life cycle assessment methods used for GHG emissions estimation.

The result showed that a trolley assistance system requires a smaller amount of energy due to the better energy efficiency of electric motors compared to internal combustion engines. However, if a lignite-fired power plant supplied the electricity, the trolley assist system had more unfavorable GHG emissions than the conventional truck system. When it came to renewable sources of energy, they significantly reduced the environmental impacts. Further studies are needed to investigate the potential use of renewables in mining operations and to incorporate the financial aspects.

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METHODOLOGY OF CALCULATION THE REDUCTION IN ENERGY CONSUMPTION AT GROUNDWATER INTAKES AS A RESULT OF WELL REGENERATION AND REPLACEMENT OF COILED PIPELINES

A significant reduction in energy consumption at groundwater intakes can be achieved through a number of measures: 1) regeneration of filters that have reduced the flow rate of wells; 2) flushing or replacing sealed pipelines.

Well regeneration. Well regeneration allows to remove impurities from the filter and its near-filter zone, to increase the filter throughput. By reducing the pressure loss in the filter, the dynamic level in the well increases during the pump operation and its geometric pressure $H_{\text{г}}$

decreases. The decrease in the geometric head $\Delta H_г$ as a result of well regeneration can be determined by the formula

$$\Delta H_г = H_{г1} - H_{г2} = (H_{ст} + S_1) - (H_{ст} + S_2), \quad (1)$$

where $H_{г1}$, $H_{г2}$- geometrical head of the pump, respectively, before and after regeneration, m^2/h; H_{ST} - the value of the static water level in the well; S_1 , S_2 - lowering the water level in the well relative to the static one before and after regeneration: $S_1 = Q/q_1$; $S_2 = Q/q_2$ (Q is the well flow rate, m^3/h; q_1 , q_2 are the specific flow rates of the well, respectively, before and after regeneration, m^2/h).

Finally, the decrease in the geometric head of the pump $\Delta H_Г$ as a result of well regeneration can be found by the formula

$$\Delta H_г = Q(\frac{1}{q_1} - \frac{1}{q_2}). \quad (2)$$

Then the decrease in hydraulic energy transmitted by the pump fluid is calculated by the formula [1]

$$\Delta P_W = \frac{Q\Delta H_г \rho}{367000} \quad (3)$$

where ΔP_W is the decrease in hydraulic power [2,3] transmitted by the pump, kW; ρ - density of the pumped-over liquid, kg/m^3.

The decrease in the electrical power of the pump is calculated by the formula

$$\Delta P_e = \frac{\Delta P_W}{\eta_P \eta_M} \quad (4)$$

where η_P — is the efficiency of the pump; η_M- engine efficiency.

The economic effect C when the pump is operating at a reduced head is equal to

$$C = \Delta P_e \cdot T \cdot c_э \quad (5)$$

T is the pump operation time, h; cэ- the cost of kW/h.

Flushing (replacement) of sealed pipelines. Monitoring the condition of the lines connecting wells to the collecting water pipelines and sections of the collecting water pipelines includes measuring their hydraulic resistance using a manometric survey, determining the resistivity value and comparing it with the table value taken for a new pipe.

The measured head loss $\Delta h_{факт}$ at a flow rate Q is determined by the formula

$$\Delta h_{факт} = (M_1 + z_1) - (M_2 + z_2) \quad (6)$$

where z_1 and z_2 - geodetic marks of the points at which the manometers are installed, m; M_1 and M_2 - readings of manometers, m.

Theoretical head losses are $\Delta h_{теор}$ determined by the formula

$$\Delta h_{теор} = (A \cdot L)Q^2 \quad (7)$$

where A is the tabular value of the resistivity of the pipe section, s^2/m^6; L is the length of the section, m; Q - water flow rate in the pipe, m^3/s.

If there is a large discrepancy in the values $\Delta h_{факт}$, a $\Delta h_{теор}$decision is made to regenerate (to replace) the pipe. After completing the measures, the value of the achieved reduction in pressure losses is found

$$\Delta h_{дост} = \Delta h_{факт} - \Delta h_{теор} \quad (8)$$

The decrease in electrical power and the economic effect C are calculated according to SAUS [1] using formulas (4), (5).

Example. The proposed method for calculating the reduction in energy consumption was applied at the Petrovshchina water intake in Minsk. Regeneration was carried out at well № 13b. Well specific flow rates q_1 and q_2 respectively equal to 2,45 m^3/h and 3,13 m^3/h. Reduction of geometric head $\Delta H_г$ (2) was 5,67 m. At the well flow rate Q=64 m^3 /h the difference in hydraulic power P_W(3) before and after regeneration was 0,99 kW. With the values of the efficiency η_P of the ECV 8-65-70 pump equal to 78% and the efficiency of the motor η_M of the same pump equal to 84%, the decrease in the electric power of the pump ΔP_e= 1,5 kW.

On the connection line of the well №10b to the collecting conduit the head loss $\Delta h_{факт}$ (6) at a flow rate Q=63,1 m^3/h was 12,58 m and theoretical head loss $\Delta h_{теор}$ (7) was equal

to 0,33 m. Due to the large divergence $\Delta h_{\text{факт}}$ and $\Delta h_{\text{теор}}$ values was made a decision to replace the pipe. The difference in hydraulic power P_W (3) before and after regeneration was 2,1 kW. With the values of the efficiency of the pump η_P wilo K85-3+NU501-2/22 equals to 74% and the efficiency of the motor of the same pump η_M equal to 83,1%, the decrease in electrical power ΔP_e=3,41 kW.

On the average pumps at the well № 13b and №10b work out 14 hours a day, for six months the number of working hours is equal to 2520 hours. To determine the semi-annual economic effect $Э_{пг}$ use the formula (5). The semi-annual economic effect on two wells amounted to 2163,1 rubles.

This result can only mean that the correct selection of equipment and timely repairs can save money for the company.

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POSSIBILITY ASSESSMENT OF HYDROGEN AND METHANE CO-FIRING IN THE HIGH-EFFICIENCY GAS TURBINE USING THERMODYNAMIC MODELING

Growing energy needs and depletion of finite fossil resources are the principal impulses driving the power industry all over the world. All these factors induce the search for new solutions, and use evaluation of new energy products including mixtures of hydrogen and methane.[1] The application of new fuel is influenced by its high calorific value and the possibility of reducing greenhouse gas emissions.

The thesis is an evaluation of cofiring of hydrogen for thermodynamic and emission parameters based on the genuine gas turbine LM 6000PF. The fuel implemented in the combustion chamber is a mixture of natural gas and hydrogen in varying proportions. The gas turbine system was designed in the Ebsilon Professional Software (Fig.1) [2]. The basic operations are based on the theoretical Joule-Brayton cycle. Compressed air and fuel are supplied to the combustion chamber and as a result of cofiring this medium – chemical energy is transformed into kinetic energy. Next, the products of co-firing are delivered through wires to the gas turbine. The working medium puts pressure on the turbine blades and generates a force. By creating a torque on the shaft the kinetic energy is transformed into mechanical energy. As a result, additional energy is transferred to the generator – mechanical energy -> electricity. Amount of energy is taken to the compressor.

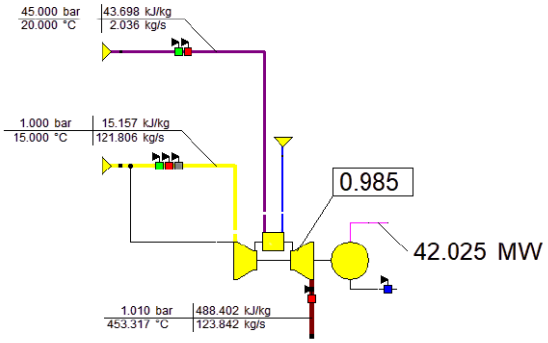

Figure 1 – Gas turbine system designed in the Ebsilon Professional Software

The results of the experiments showed that with a negligible decrease in the process efficiency, an attempt to reduce the carbon dioxide content in the exhaust gas may be equal to 3.8%. (Fig.2) Despite the percentage share change in the fuel - a mixture of methane and hydrogen – the level of generated power and the efficiency of the gas chamber remain constant.

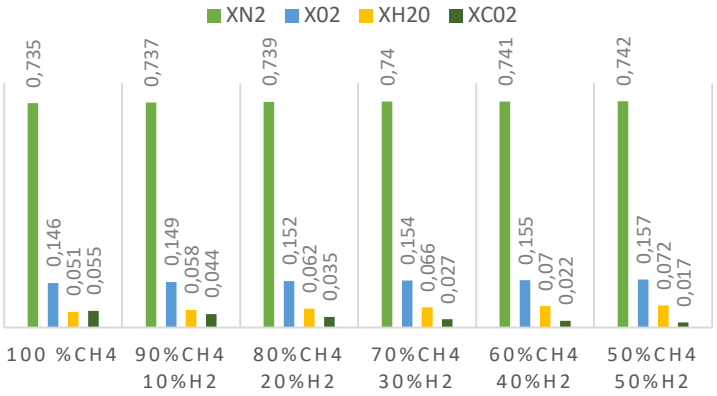

Figure 2 – Exhaust gas emission for energetically balanced fuel

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STUDY INTO THE FEASIBILITY OF CREATING AN EMISSION-FREE COAL POWER PLANT BASED ON CARBON DIOXIDE ENERGY CYCLES AND UNDERGROUND COAL GASIFICATION TECHNOLOGY

The Concept of Sustainable Development provides for a global reduction of anthropogenic carbon dioxide emissions by 2040 twice as much as in 2018. At the same time, it provides for the development of alternative energy and an increase in the rate of carbon-free energy. In order to achieve the target indicators, technical solutions are developed that allow reducing CO_2 emissions into the environment or eliminating it completely. Such solutions are called ‘zero emission technologies’.

One solution is the carbon dioxide energy cycles [1,2,3], in which the cycle fluid used is carbon dioxide. Gas is used as fuel, and oxygen is used as an oxydizing agent, which makes the combustion products only CO_2 and water vapor due to the hydrogen of the fuel. Water is

condensed after the process of expansion of the cycle fluid in the turbine, and pure carbon dioxide remains, suitable for use in another technological process or disposing. Thus we have a power plant where CO_2 is the only waste-product: no nitrogen and sulfur oxides, bottom ash, etc. Obviously, the implementation of underground coal gasification with the use of the resulting synthetic gas in the technology with zero emissions and the subsequent injection of carbon dioxide into the spaces of spent underground gas generators is of interest.

In this work, a study of the efficiency of carbon dioxide energy cycles of different architecture is carried out. The possibility of combining them with the technology of underground coal gasification to create a coal energy complex with zero emissions is considered.

In the course of studies, it has been calculated that the efficiency of energy CO_2 cycles under standard environmental conditions and providing an initial temperature of 1000 °C would be 54-60%, depending on the architecture of the cycle. It has been determined that the efficiency can be increased up to 65% when the initial temperature is raised to 1300 °C and up to more than 70% when the ambient temperature is simultaneously lowered to -6-20 °C (for example, it is possible in the Arctic conditions). The carbon dioxide removal from the cycle would be 2.7-5%, depending on its configuration. The high thermal efficiency of CO_2 cycles provides grounds to assume that the final efficiency of the power plant would also be high. This would allow for high costs for own needs, while the final efficiency would be comparable to traditional coal-fired power plants, but achieving zero emissions.

The experience of practical implementation of the technology of underground coal gasification on the example of 'Podzemgaz' Yuzhno-Abinsk Station [4] is considered. The technology makes it possible not to extract coal from the subsurface, but to transform it directly at the site of occurrence into combustible gas, which by wells can be supplied to the surface. No dumps, excavations, explosions and dust emissions typical for traditional coal mining. Human labor is eliminated underground and in the transportation of fuel, and the technology makes it possible to develop coal seams at significant depth. Study of Yuzhno-Abinsk Station experience shows that after coal seam gasification no threatening cavities arise. Cavities do not exceed two meters in diameter, which is confirmed by investigation of formation burnout zone for presence of voids by means of deep electrical sounding [4,5]. It is estimated [6] that underground coal gasification stations can be capital-intensive, and gas is quite expensive, while maintaining competitiveness. For example, when used in a steam-turbine power unit, underground gasification gas can be 11-17 $/tons of fuel equivalent more expensive than coal at similar coal plants with ash disposal using electrostatic precipitators; 23-30 $/tons of fuel equivalent more expensive than coal at similar coal plants with additional purification from nitrogen oxides and sulfur or than in units with CFBC [6]. In this case power units would work with equal economic efficiency.

The combination of the technology of underground coal gasification with energy cycles on carbon dioxide allows to level out many disadvantages of the former. First, such cycles use oxygen combustion and require oxygen plant, which can also be used for oxygen gasification, which will increase the calorific value of gas (from 1000 to 3000 kcal/m^3), get rid of ballast nitrogen, reduce costs for forced draft and drilling due to reduction of pumped volumes and required well throughput capacity. Secondly, CO_2 inevitably present in the generator gas ceases to be ballast, as it is carbon dioxide that is the cycle fluid of the energy cycle. Thirdly, the carbon dioxide withdrawn from the cycle can be partially used for carbon dioxide gasification, when under the influence of high temperature and excessive carbon CO_2 in the underground gas generator is reduced to CO and can be reused. Finally, the spent gas generators represent a porous gas-permeable structure with a developed system of wells, potentially suitable for disposal of the remaining amount of CO_2.

The implementation of such a complex would create a coal-fired but carbon-neutral technology with zero emissions, and allow the safe use of the vast reserves of coal, which on a global scale are many times greater than the combined reserves of oil and gas. There are no fundamental technological obstacles to the creation of such technology. The main criterion is

economic and environmental feasibility. Therefore, issues related to the provision of the process of underground coal gasification, utilization of CO_2 withdrawn from the cycle and carrying out technical and economic analysis require further study and are of high relevance under present-day conditions.

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THE DEVELOPMENT OF A PUMP UNIT CONTROL SYSTEM AND METHOD OF ITS OPERATION

This work proposes a substantiation and description of the operation method of the pump unit electric drive system with a significant pressure difference at the pump inlet and outlet. The laws of regulation are also described and the optimal method of regulation by liquid flows is given. To substantiate the expediency of using a controlled electric drive, it is necessary to know how the operating mode changes over a whole calculated, annual, period. Daily charts do not

give a complete picture, because they depend on the time of day, day of the week, season of the year and many other factors. These graphs cannot be described with a mathematical equation, which is why it is better to use ordered water supply diagrams, similar to ordered electrical load diagrams. [1]

Serious requirements are imposed on the drive motors of pumping units: from easy control automation and low operating costs to the need to start the engine under load and rotate the rotor in the opposite direction. These parameters are determined by the load characteristic of the pump. Improved operating conditions of power systems where powerful pumping stations are used require the possibility of frequent restarting, which imposes increased requirements on the structures of the stator winding and the starting winding of the electric motor, the heating of which determines the duration of the required pause between starts and the permissible number of starts for the period under consideration.

The peculiarity of the control system of the electric drive of the pump unit is that it contains two electric motors of two pumps connected in series. [2] The first unregulated synchronous electric motor with its stator circuits is connected directly to a three-phase supply network, and the second - an adjustable asynchronous electric motor - to the same network through a controlled converter and has a position sensor on the rotor, as well as stator phase current sensors, two switches for output signals of current sensors, two the adder of these signals and the product block.

According to the proposed method. the output terminals of the regulator of the liquid supply control system are connected to the input terminals of the controlled transducer, a signal source is connected to the first input of the regulator, proportional to the set flow rate of the liquid pumped by the pumping unit, and to the second input - the output of the product unit.

In the method of starting a asynchronous electric motor of a pumping unit equipped with gate valves at the inlet and outlet, as well as an additional bypass pipeline with a third gate valve between the outlet of the first (main) pump and the inlet of the second (booster) pump, first close the first two valves and open the third, then, with the help of a controlled converter, the adjustable synchronous electric motor and the auxiliary pump are accelerated, thereby transferring the main pump to the turbine mode, accelerating the first unregulated synchronous electric motor, when its speed increases to synchronous, the stator windings of the first unregulated electric motor are connected to the supply network, after which the first two are opened valves and close the third. [3]

In the future, it is planned to develop a reference mathematical model of electric motors in the ANSYS Maxwell environment, a control system model in the ANSYS Simplorer environment to obtain reference dependencies of diagnostic parameters and characteristics of motors and the control system as a whole.

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SIMULATION OF AN ELECTRIC POWER SUPPLY SYSTEM WITH DYNAMIC ELECTRIC POWER STORAGE DEVICES

The most significant problem limiting the development of modern cities is the overloaded electrical networks. Power supply problems during peak hours were observed in the United States (Texas, Austin), Norway (South), China (Shanzhun Province) and the United Kingdom (Northeast) [1]. But despite this, in recent years the attractiveness of alternative urban means of transportation, such as electric vehicles, has increased. All because electric vehicles (electric buses, personal electric vehicles, electric scooter, etc.) can make a significant contribution to the process of reducing emissions of exhaust gases and harmful connections in the atmosphere of the modern metropolis and certain areas [2]. The report presents interim results of modeling the power grid complex of a small proud. Electric power storage was introduced into the electricity supply system. In particular, such a drive can serve as a modern electric car transport, provided the use of charging stations with Vehicle to Grid technology [3], which allows the use of the electric car as a battery in exchange for various privileges for owners.

In order to improve the quality of research, the author worked out the issue of modeling the electricity system, which would include: generator stations, district transformer substations, transmission lines with distributed parameters, consumers of electric power and switching equipment. It was decided to use the computer mathematics and simulation systems Of Matlab/Simulink. Using Simulink's built-in features, the characteristics of various elements were set up: power supply systems, electric vehicle battery storage systems, and test scenarios. The simulator provides a tool to study the impact of V2G in a wide range of economic and technical problems related to the operation of physical power.

In particular, the virtual laboratory simulated elements of distribution electrical networks: 1. Three-phase power source; 2. Three-phase lower transformers (110/35 kV, 35/10 kV, 10/0.4 kV); 3. Power lines of different nominal voltages (110 kV, 35 kV), 10 kV and 0.4 kV) with distributed parameters; Consumers of electric energy; 5. Commuting machines.

In addition to developing models, the authors were asked to automate the filling of model blocks to facilitate the modeling of different scenarios. As a result, scripts were written, providing calculation and automatic filling of parameters of various elements of the model: power sources, power transformers, power lines with distributed parameters and switching machines, determining the daily schedules of load consumers. In the future, it is possible to adapt the script to the download of real data, which is the loading of transformer substations or power points in a particular area, as well as real data on the length and parameters of power lines

The main task that the study now faces is the task of setting up the simulation model and the relationship between the data it provides with the real ones in order to verify the correctness of the work. In the future, it is planned to expand the range of tasks solved by simulation, up to the analysis of energy flows within the power grid and analysis of the load of a substation separately.

Integration, based on digital technologies of the information-management complex of urban infrastructure, electricity demand management systems and dynamic power storage systems, will create a synergistic effect that will allow: to remove, in some areas, restrictions on the technological accession of consumers under contracts and applications (including expired implementation); Meet some of the potential demand for projected capacity; Reduce the load on medium voltage networks of 6-35 kV in areas of significant power overload; Reduce the load in areas with a significant amount of electrical equipment in the power supply system of the exhausted resource; increase the number of users of electric vehicles; Develop the network infrastructure of power stations; to create additional investments in the development of the region.

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PREVENTING WAX DEPOSITION IN OIL WELLS USING RENEWABLE ENERGY SOURCES

The project is dedicated to the development of an electrothermal complex powered by renewable energy sources to combat paraffin deposits on the walls of the well. The risks of paraffin formation in oil exist practically in the entire oil production complex of Russia, with some peculiarities in terms of the prevailing paraffin content in each field. About 80% of all oil fields in terms of paraffin content are medium and high paraffinic [1]. To date, the most efficient methods of controlling the formation of paraffin deposits in tubing are thermal methods for providing thermal effect on a wellbore, based on the ability of paraffin deposits not to form a solid phase or melt at temperatures higher than paraffin crystallization temperature of 35-50°C [2].

The most common technological scheme for the operation of complexes for electric heating of oil wells is the consumption of electricity from the power system. However, a feature of many regions in which the main oil fields are located is the lack of centralized power supply. In this regard, the use of electric heating technology is limited.

The cost of building power lines from existing power lines to consumers at the fields (the distance is from 20 km to 60 km) is very high [3]. Moreover, it is necessary to take into account payments for land acquisition and lease of land for power transmission lines, relatively low values of power consumption. In this regard, the use of autonomous power supply systems is more efficient and cost-effective.

Thus, the generation of electricity at the point of its consumption is a more cost-effective alternative to the creation and development of the network infrastructure of centralized power supply.

In such conditions, renewable energy sources are able to meet the requirements of reliable energy supply for the facilities of the mineral resource complex. Thus, the introduction of an electrothermal heating system powered by renewable energy sources will simultaneously:

– to increase the efficiency of oil production;
– to prevent the formation of paraffin deposits through electrical heating of oil wells;
– to increase the energy efficiency and reliability of power supply of the source of electrothermal action on paraffin deposits;
– to ensure energy savings by reducing power losses and electricity consumption.

An important task is to substantiate the structure and parameters of the electro-technical complex with a photovoltaic installation in order to increase the reliability and economic feasibility of the mineral resources sector facilities power supply. Heating of an oil well is

carried out using a heating cable, placed directly in the inner space of the tubing in the oil well, which allows heating the wells to the required depth. Such a scheme for implementation of electric heating does not require underground work, and in some cases it does not need well shutdown.

Energy characteristics of a solar photovoltaic installation depend on two main factors: the parameters of the photovoltaic battery and the characteristics of its photovoltaic cells; solar radiation flux intensity in a particular place and under specific conditions. To calculate the flux of solar radiation, the method by John A. Duffie [5] was used. This technique considers the effect of the external climatic factor on the energy characteristics of the solar battery, thereby increasing the accuracy of forecast calculations in terms of power generation for the region under consideration.

According to the results of mathematical and computer modeling in the environment of Matlab Simulink, energy characteristics, design features and composition of the photovoltaic installation were determined with the aim of uniform distribution of the amount of solar radiation throughout the year. Thermal calculations were performed taking into account the VNIIneft methodology for determining the temperature of oil saturation with paraffin [6]; methods for calculating the heat transfer coefficient in the well [7]; methods Kuptsova S.M. to obtain the distribution of oil temperature in the borehole [8,9]. For the power supply of the heating cable, it is proposed to use photovoltaic solar energy converters with a rated power of 300 W at a solar constant of 1000 W/m2; type and composition of cells is monocrystalline silicon. The efficiency of the solar panel is 22%. The angle of inclination of the solar panels was chosen taking into account the uniform production of solar energy throughout the year and amounted to 60 degrees with an average amount of energy of 5.3 kWh/m2/day.

Thus, the possibility of using autonomous energy complexes based on a solar power station to power electric stations for heating oil wells using a heating cable is shown. It has been established that the concentration of paraffins in the produced oil significantly affects the required installed capacity of energy sources.

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DETERMINATION THE RELATIVE WEIGHT OF PHYSICAL FACTORS IN PIPELINE PARAFFINISATION FOR THE PURPOSE OF IMPROVING THE ENERGY EFFICIENCY OF OIL TRANSPORTATION

Energy costs of pipeline transport are determined primarily by the costs of pumping equipment, proportional to the pressure required to overcome all resistances: local and along the length. As a consequence, in order to reduce them, it is necessary to minimize all kinds of resistances.

Reduction of losses along the length can be achieved together with the system of prediction of paraffin deposits and high-precision system of calculation of parameters to maintain viscosity at a predetermined level. One of the most promising lines in the development of automation is the creation of forecasting systems [1].The elimination of the share of local losses, which are currently caused by flow-controlling measuring equipment, is achieved by replacing it with a sensor bundle that uses a non-contact measuring method.

To achieve this result, the author developed a plan to create a system for predicting pipeline paraffinization, especially relevant in view of the growing trend of the share of heavy oils in oil production and the increase in transport lines located in areas with harsh climatic conditions [2]. The author has determined the composition of the minimum sensor bundle, capable of recording the values of all parameters of the oil stream at the time of paraffinization, developed principles of algorithms for accumulation of useful information, found a cost-effective way of its collection and selected equipment that can record and analyze all parameters of the oil stream and implement the developed control algorithms.

As a part of scientific work the author has modernized the wax detection device [3]. As a result, its reliability (by ensuring the static nature of all elements of the measuring unit) and response speed were increased. The possibility of interferences caused by potential negative interaction of two gamma-rays of the measuring unit was eliminated, false alarms on free solids in the oil flow were excluded and an alarm on emergency deformation of the measuring unit, which leads to changes in the controlled points, was provided.

The author offers an innovative method of viscosity measurement, capable of determining the viscosity of the entire flow, characterized by complete automation and the absence of contact with the transported flow. The measuring principle is based on the dependence of the difference of velocities of the liquid and gas component of the oil flow on the oil viscosity. For the proposed method was deduced a direct formula dependence between the parameters, measurement of which is already effectively carried out in practice by radioisotope method and the value of oil viscosity. The developed method today is by far superior to the analogues which are capable to carry out only contact measurements in small volumes of oil and with low frequency, but is also superior to other non-contact methods being developed, due to the ability to conduct control without breaking the integrity of oil pipeline and with relatively low power inputs for conducting measurements.

The project also presents consolidation of all previous achievements into a single system for automatic control of pipeline waxing and maintaining viscosity of the oil stream at the

optimal level (the level at which total power consumption of pumping units and viscosity control methods is minimal). The construction of such a system would be impossible without all the stages of scientific research and meets the main purpose of the represented scientific project on development of multilevel system of automatic control of oil transportation process to minimize energy costs.

The radioisotope measuring device, taken as the base of the scientific project, has been developed by the scientists of the Saint-Petersburg State Mining University together with the specialists of the "Complex-Resurs" Ltd. The device has passed metrological certification and has a certificate confirming the safety of its use; it is included in the register of measuring instruments of the oil industry. The tests carried out by the scientists of St. Petersburg Mining University guarantee the effective work of the modernized method of paraffin deposits alarming and readiness of the results of the scientific stage for the first stage of implementation in order to improve the energy efficiency of oil transport and collection of the necessary information.

In the interest of the Russian Federation, the development will make it possible to attract investments and use the huge potential of industrial enterprises specializing in the creation of measuring equipment and process control systems. In addition, the anticipated products and results of the project are significant for enterprises employing pipeline transport and introducing modern measuring equipment. Furthermore, the absence of paraffin deposits in oil pipelines, will increase their throughput capacity and prevent planned shutdowns carried out for mechanical cleaning of pipelines. In its turn it will increase the quantity of oil exported by Russia and will increase tax payments to its budget.

The data obtained at the stage of information collection will have a significant potential to determine the specific weight of physical factors in waxing of pipelines, solving the problem faced by scientists for decades. These data will increase humanity's understanding of the physical and chemical processes occurring in heterogeneous flows, making a significant step in areas such as hydraulics, mechanical engineering, organic chemistry. The application of the collected information in creating a program, which by given parameters of built and modernized oil pipelines (oil characteristics, climatic and geographical conditions) can deduce the optimal in terms of reliability and efficiency of systems to prevent paraffin formation and calculate its parameters, has a great perspective.

Significantly, the developed system is completely safe for operation, in its execution the requirements to the radioisotope measuring devices are fulfilled and the rules of electrical installations are observed, as well as the explosion-protected equipment is used.

Thus, the work describes the system of automatic control of oil transport, which has no analogues neither in Russia nor abroad. Its introduction at the initial stage will save up to 36 % of electric power. After collecting information and processing the collected data by neural networks, the system will be able to completely exclude waxing of the pipeline and reduce the energy costs of oil transportation to a minimum by integrated prevention of waxing and viscosity control.

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INVESTIGATION OF THE INFLUENCE OF THERMODYNAMIC PARAMETERS ON THE EFFICIENCY OF A COMBINATION OF STEAM-WATER AND ORGANIC RANKINE CYCLES

This study is a stage in the development of a technology for the operation of a TPP based on a combination of two cycles. For such a steam-organic technology, the working bodies are water vapor and vapor of an organic liquid: pentanes, freons (R-agents), fluorocarbons, silicone oils. The physical properties of organic liquids make it possible to reduce the size of power plants due to their high density and to increase the service life of equipment by eliminating the wet-vapor zone during the expansion of the working fluid. The cycle combination architecture is designed in such a way that no condenser is required in the water-steam cycle, which entails a number of positive effects for environment. The low-boiling working fluids in the Organic Rankine Cycle (hereinafter referred to as ORC) are capable of operating at low temperatures, and the two-stage cycle itself has high efficiency, which becomes higher, the lower the ambient temperature, because an air-cooled condenser is used to condense the ORC-body. Thus, the main aspect of the relevance of the study is the possibility of implementing the technology in dry and waterless regions, as well as in regions with low negative temperatures, for example, in the territories of the Russian Arctic, which has a fragile ecosystem and a lack of power. Quite a lot of research has been carried out on the use of ORCs in the implementation of geothermal power plants [1], in the utilization of the heat flux of exhaust gases from the internal combustion engine [2,3], in the utilization of other low-potential heat fluxes of different technological cycles and industries [4]. PJSC Gazprom has adopted a program for the implementation of waste gas heat recovery from compressor stations using pentane technology based on ORC [5]. However, studies ORC in the framework of large-scale generation when used at thermal power plants have not previously been performed.

Within the framework of this work, calculations of the thermal efficiency were carried out on a wide range of refrigerants - R-agents based on the basic architecture of the cycle; 7 technical solutions were calculated when used in the R134a cycle. As the technology becomes more complex, when all heat fluxes are used in the circuit, the efficiency increases. Calculations were initially performed at + 30 °C air temperature to get a starting point of values and compare to the efficiency of traditional units with chilling water. There is a tendency to increase the efficiency of the cycle with decreasing air temperature, which is used for cooling in the ORC loop. The results of calculating the efficiency of the base cycle and of the cycle with internal regeneration for the ozone-safe refrigerant R32 were obtained; it was found that at a temperature of 0 ° C the thermal efficiency of the cycle is 62.5%. At the current stage, it is necessary to determine the influence of thermodynamic parameters at the main points of the cycle. For this task, the dependences of the thermal efficiency on different R-agents on the initial temperature of the live water steam, on the initial temperature of the R-vapor, on the ambient air temperature, that is temperature of condensation of R-steam, were received. For example, efficiency dependence graph on parameter of initial pressure of R-agent is shown in Figure 1. The dependencies on other parameters were constructed in the same way.

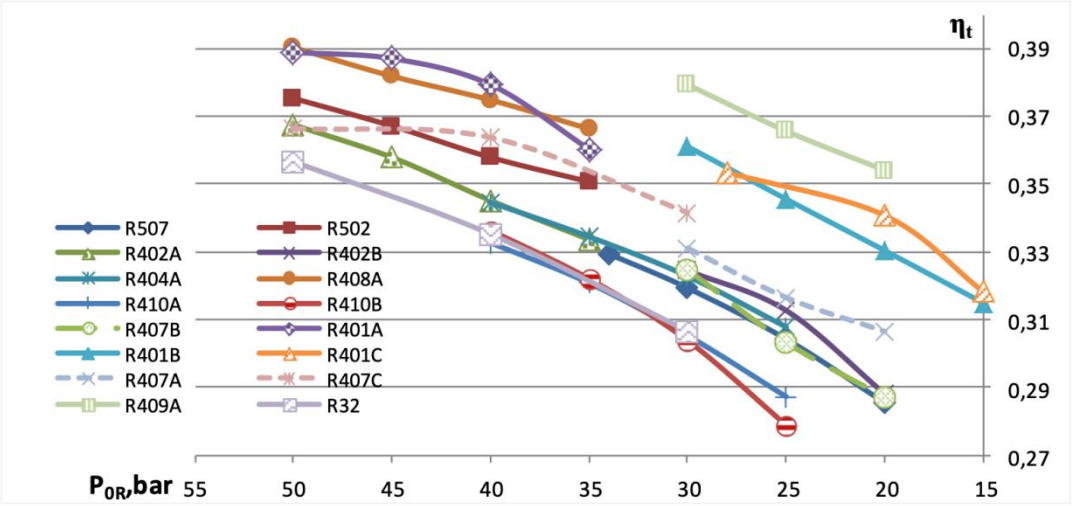

Figure 1 – Dependence of thermodynamic efficiency from the initial pressure of the generated R-steam

By averaging the dependences, it was found that the thermal efficiency decreases by 2% relative values with an increase in the R-vapor temperature by 6 ° C. With an increase in the initial temperature of water vapor by 10 ° C, the thermal efficiency increases by 2% relative values. A drop in ambient temperature of 10 ° C provides an increase in efficiency by 5% relative values. Such conclusions were made upon averaging over all the considered working fluids and in relative values in a circuit of base cycle. At this stage, it is necessary to determine the most thermodynamically favorable working fluid for calculating a real thermal scheme with the required parameters, which is why it is important to calculate the thermodynamic efficiency of technology and the influence on it of various changes in parameters of the cycle. In the future, a calculation of a real thermal scheme will be made, equipment will be selected and a feasibility study of the investigation will be obtained.

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RESEARCH OF SMALL WIND TURBIN WITH A HORIZONTAL AXIS OF ROTATION WITH A POWER FROM 1 TO 100 KW

Currently, in connection with the development of "green" energy, in particular wind power, there are more and more manufacturers from different countries offering their products. The use of small wind power plants (wind turbines) is especially common in the construction of autonomous power supply systems [1]. At the same time, many parameters of the wind turbine affect the final energy generation, which complicates the process of choosing the necessary wind turbine [2]. Therefore, the creation of a database that facilitates the selection of a specific wind turbine is an urgent task.

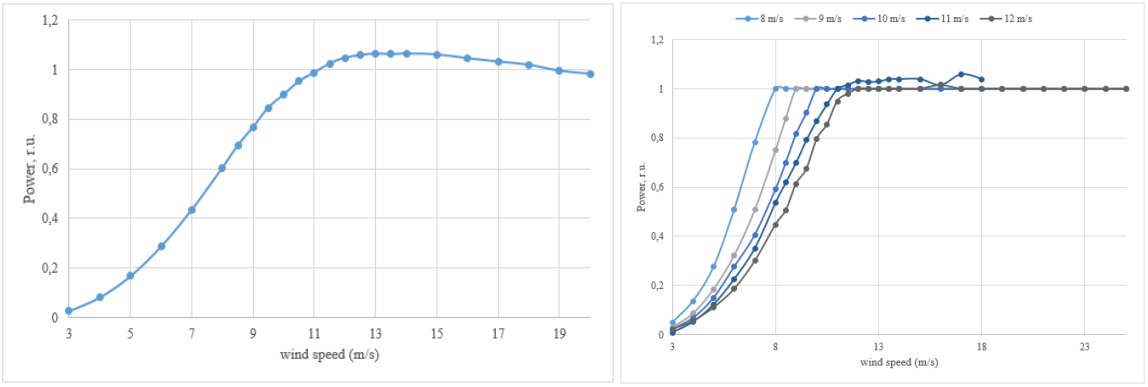
The aim of the work is to create a database of wind power plants with a horizontal axis of rotation with a power from 1 to 100 kW and a unified energy characteristic. Further analysis of wind turbine parameters for more than 20 key characteristics [3], such as:

- distribution of wind turbines by installed power (1-5; 5-20; 20-50; 50-100 kW);
- number of blades;
- generator types;
- distribution of wind turbines by wind orientation technology;
- operating temperature range;
- nominal, minimum, maximum and storm wind speed and other parameters.

The presence of such an array of information allows you to analyze the dependence of the use of certain technologies on certain conditions.

The database includes 247 models, for which the manufacturer specified the energy characteristic (the dependence of the output power of the wind turbine on the wind force acting on the blades). Since the models differ in their rated power, it is not possible to create a unified energy characteristic. To do this, it is necessary to bring each energy characteristic to the form of dependence of the relative power P_r^* on the wind speed. To get such a characteristic, you need to divide the instantaneous power value at a certain wind speed, which the manufacturer specified, by the rated power of the wind turbine.

To create a unified energy characteristic, the coefficient of variation was calculated for all wind speed values (from 1 m/s to 25 m/s), which was less than 33.3% over the entire range. It follows that the set of energy characteristics is homogeneous, and it is possible to construct a unified energy characteristic for all the presented wind turbines (Figure 1).



a) b)

Figure 1 – a) Unified energy characteristic for all models; b) Unified energy characteristics of wind turbines with different nominal wind speeds, using pitch control technology

The created unified energy characteristic for all models, as well as for models using a specific technology with a certain nominal wind speed, allows you to evaluate the possible energy generation and perform a technical and economic calculation to determine the profitability of the project. The use of a unified energy characteristic in the construction of a mathematical model of a wind power plant allows us to obtain research results independent of a specific model.

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ECOLOGICAL RESTORATION OF MINES ALONG THE BELT AND ROAD: POTENTIAL AND CHALLENGES

The Belt and Road Initiative (BRI), proposed in 2013, aims to prompt regional integration between China and other Asian, African, and European countries, which in turn facilitate mining development and infrastructure construction. However, the ecological risks associated with this development are of particular concern[1]. The countries along the BRI are rich in mineral resource[2]. The BRI, as an international development strategy attached widespread attention, is a research hotspot in academic world. Some scholars have already preliminary discussions on the spatial distribution pattern of energy[2], structural characteristics of energy trade, the development potential of mineral resources, energy cooperation and investment strategies. More scholars are concerned about the environmental degradation brought by regional development[3], and their research focus on theory, monitoring, assessment, and regulation[4]. However, mining and its resulting environmental risks and ecological restoration have received less attention. In addition, there is a lack of consideration of mine ecology in the BRI.

To better understand the mining situation and the ecological impacts of mining in the BRI countries, we collected basic data on mineral resources, such as the distribution, types, reserves and output for the next step research. Then, we analyzed the factors affecting the ecological restoration capacity of mines, build an evaluation system of mine ecological restoration capacity conducted from multiple perspectives of economic, environmental, ecological, scientific and technological, political and mining enterprises, next explored the distribution characteristics and the reasons for the variability. Moreover, to ensure data consistency and comparability, a restriction has been placed on indicator selection and data acquisition, and finally the indicators with the same standard and the same measurement method were selected for analysis. Based on above results, the present-day challenges in mine governance were summarized and the future development priorities were discussed.

The results show that the countries along the BRI are the emphasis development zones of mineral resources in the future. There are many kinds of mineral resources in the countries along the BRI, with more than 20 kinds of scarce solid mineral resources such as copper, gold, nickel, bauxite, iron ore, tin and potash. Mining areas in 41 countries have been extracted, with a total of 11,377 polygons that add up to 24,234.757km^2, accounting for 42.31% of the world's. The larger the scale of mineral development, the worse the ecological impacts. There are two main types of mining: open-pit and underground mining, which cause disturbances such as excavation damage, occupation, collapse and pollution. Among them, open-pit mining is more destructive to the landscape. In addition, this paper argues that the ability of mine ecological restoration affected by the major factors such as economic development, environmental governance, scientific and technological innovation, political environment, investment by mining enterprises, and ecological conditions. The spatial distribution of the ecological restoration capacity of mines

varies greatly, with scores of 67.14, 66.80, 65.12, 64.73, 60.20, 58.89 for each region in West Asia North Africa, Northeast Asia, Southeast Asia, Central and Eastern Europe, Central Asia, and South Asia, respectively. In general, it presents the characteristics of "high in east and west, low in the middle", with regional differences and large internal differences among regions.

The development of sustainable mining has become a global consensus, and there are certain challenges to overcome to achieve this goal. The main challenges are low participation of stakeholders, huge financial needs, difficult remediation technologies and weak national management base and lack of targeted regulatory measures. To strengthen green mine governance, the future direction can be to build policy standards applicable to the BRI, develop a life cycle mine governance system, strengthen theoretical innovation, improve the research and development of joint restoration technology and low carbon technology, establish multi-funding guarantees, and introduce sustainable development. Working together to address the serious challenges. In the future, it is recommended to consider incorporating the planning of mine ecological restoration into the BRI and ensure its effective implementation, so as to reduce the impact of mine development on ecological risks.

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EVALUATION OF THE QUALITY THE WATERS OF THE YAMANIGÜEY RIVER USING THE MONTOYA METHODOLOGY

The deterioration of the quality of surface waters due to the increase in anthropogenic activities has been a subject of much attention in recent years. These are subject to various changes resulting from man's actions, which alter the quality of their waters, which causes different levels of contamination in them [1]. For several decades, different Water Quality Index (WQI) have been used to quickly and precisely know the behavior of the quality of different bodies of water, and thus take immediate measures. These aim to simplify the positive or negative characteristics of any water source into a numerical expression. Many have been the WQI that have been applied internationally for the study of surface waters; among them, the methodology proposed by Montoya [2] stands out. In Cuba, due to the importance of the water resource for both social and economic development, it is necessary to search for new sources of water with the quality required for drinking water. This work aims to evaluate the water quality of the Yamanigüey River using the methodology proposed by Montoya.

To analyze the physicochemical and bacteriological properties of the waters of the Yamanigüey River, 12 samples of surface waters were taken in it. The collection, preservation and analysis of the samples were carried out respecting the international criteria recommended by the standardized methods in APHA [3]. Surface water samples were taken in duplicate in 500 mL plastic containers. For the determination of total and fecal coliforms, the samples were taken in Whirl-pak plastic bags. The pH and electrical conductivity contents were determined by the electrometric method, the chlorides by the volumetric method, the dissolved solids by the gravimetric method, the turbidity by the turbidimetric method, the total and fecal coliforms by the technique of multiple fermentation tubes, the apparent color through the visual comparison method and the BOD5 through the BOD determination method (5 days at 20 oC). The physicochemical analyzes were carried out in duplicate to corroborate the results obtained in the Laboratory Projects Unit of the Nickel Research Center, Moa, Holguín, Cuba; which has 14 tests accredited and validated by the Cuban standard NC: ISO/IEC-17025 of 2006 (General requirements for the technical competence of testing and calibration laboratories), for the analysis of water and wastewater.

The water quality index by the Montoya methodology is the only one that has legal connotations for drinking water in Central America and the most used to analyze different bodies of water. This is made up of 18 variables (percentage of dissolved oxygen saturation, biochemical oxygen demand, total coliforms, fecal coliforms, color, turbidity, alkalinity, hardness, chlorides, electrical conductivity, concentration of hydrogen ions, fats and oils, suspended solids, dissolved solids, nitrates, ammonia nitrogen, phosphates and detergents). Because certain tests are more representative of water quality than others, certain specific weights are assigned to the 18 different designated variables, represented by the letter W. These specific weights are in accordance with the nature of the body of water under study. For the calculation of water quality by the Montoya methodology, 10 parameters were used (electrical conductivity, pH, chloride, total hardness, dissolved solids, color, turbidity, total coliforms, fecal coliforms and BOD5) of the 18 proposed by the methodology, since it does not require that all the parameters must be taken to perform a water quality analysis [4].

The WQI calculation by the methodology under study showed that 6 of the 12 samples analyzed (Y-1, Y-2, Y-3, Y-4, Y-5, Y-6) are classified as uncontaminated, with WQI results ranging from 94 – 92 %, while the remaining 6 samples (Y-7, Y-8, Y-9, Y-10, Y-11, Y-12) are classified as water acceptable, with WQI values between 84 – 70 %. The man, in his daily actions, performs actions on the river channels that would take him a long time to recover to obtain an excellent quality. In the field work, it was found that in the first 6 collected water samples, no index of their action in the area was witnessed and therefore the WQI results range between 94 – 92 %, which are classified as uncontaminated. While from sampling points Y-7 to Y-12 (the remaining 6 water samples) it was appreciable in the river and in its surroundings garbage dumps, pig pens with drains towards the river, use of its waters for recreation and car washes, which made it possible that the quality index as we get closer to the coast (the area where the highest concentration of inhabitants is located in the study area) begins to decrease the quality of the water and consequently the WQI decreases with values ranging between 84 – 70 % (water with acceptable quality).

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UNDERGROUND COAL FIRE POLLUTION AND WASTE HEAT UTILIZATION

Coalfield fire is a global geological disaster, causing colossal wastage of coal resource, serious destruction of the ecological environment, and threatening to health and safety of human [1]. The enormous amount of pollutant and noxious matter emitted by coal fires has been significantly detrimental to the global atmosphere, geosphere, hydrosphere, biosphere and ecosphere for years [1]. But there is inadequate exploration on pollution sources and migration in combination with the combustion dynamics. And the current researches of environmental influence emphasize on coal fire geologic hazard and polluting potential, which is limited to intuitive qualitative descriptions. Hence an assessment criterial should be established to analyze the environmental impact for coalfield fire. To tackle the coal fires issues, on the other hand, the traditional work only considered how to remove the thermal energy, rather than to utilize the heat resource, resulting in a huge waste of energy [2]. If the heat can be effectively recycled and utilized other than wasted, it would be influential in accelerating fire extinguishing, alleviating the energy crisis and pollution emissions.

To study the impact of combustion by-products on atmosphere in the Sandaoba fire field, Xinjiang, a region-scale field survey was firstly conducted to investigate the gaseous-solid emissions and thermophysical parameters of combustion products distributed for the entire zone [3]. Combining statistical analysis and thermodynamic theory, the corresponding evaluation method and model are proposed. After comparing the pollution situations at different stages and sections, the coal fire combustion status evaluation and pollution classification were proposed, which herein is favorable to evaluate the coal fire risk and take measures on pollution prevention.

To carry out the feasibility analysis and overall evaluation for the harvesting and utilization of thermal resource underground, both thermal equivalent model and numerical assessment method have been proposed [4]. With the invented system of WHRUS combining thermosyphon and thermoelectric technology, a long-term and certain-scale field experiment was initially conducted in Xinjiang's fire zone. The research presents the results of feasibility analysis and overall evaluation for the harvest and utilization of underground thermal resources, assisted with an invented system of waste heat recovery and utilization system (WHRUS) that combines thermosyphon and thermoelectric technologies. The application of the research indicates that waste heat from coalfield fire can be effectively recovered and utilized, which is a major breakthrough in the field of coal fire prevention and control.

Every year, the total estimates of the gaseous emission are approximately 4030 t of CO_2, 113.6 t of SO_2 and 57.3 t of CO. The emission pollution varies considerably from regions, and is substantially attenuated with the advancement of fire control. Principal component analysis (PCA) refines the thermophysical parameters into three attributions. PCA score distribution shows that thermophysical parameter is dominated by the combustion condition at severely polluted areas. Factor analysis is used to extract four contaminant indicators, which suggests the local air suffers sulfur oxides pollution the most. The air quality index of the eight study sections calculated are all below 60. It indicates that coal fire air pollution is in the medium-to-severe stage. By canonical correlation analysis, thermophysical indicator performs outstanding explanatory for contaminant variates. On the whole, the higher the level of thermophysical

properties in the fire area, the greater the intensity of pollutant emission. Underground coalfield fire is dominated by smoldering, and the overall combustion efficiency is lower than 0.8 which generally declines as the excess air coefficient increasing. Using the local geothermic assessment, the heat recovered from subsurface coal fire can be estimated as the summation of convective and conductive type of geothermal energy. the average heat flow through the fire district is about 495 W/m^2 and the average utilization efficiency is 58%. The WHRUS shows excellent performance on heat transfer with lower resistance of 0.0049 W/℃ and maximum thermal recovery rate greater than 90%. The power generated remains stable and every wellbore produces more than 960 W averagely. The majority of the heat extracted is used to heat water for regional heating in a delivering rate of 38%. Through this process approximately 105 MW/a of otherwise wasted heat could be recovered and reused from the entire investigated fire zone.

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SEARCH FOR THE OPTIMAL OPTION FOR APG USE IN THE EARLY STAGES OF FIELD X DEVELOPMENT

The global trend is a decrease in CO_2 emissions from production to the atmosphere. During the last quarter of a century, important agreements were adopted, such as the Kyoto Protocol and Paris Agreement, which are aimed at stabilizing and regulating the level of emissions, as well as reducing the harmful effects of industry on the environment [1]. Our countries and individual oil and gas companies, following the environmental trend, are deploying global strategies aimed at reducing environmental harm.

CO_2 emissions to the atmosphere in the oil and gas industry are mostly associated with the combustion of by-products of production in flare units (FU) at an early stage of pilot development. Based on this, an analysis of the volumes of gas flared at 6 selected fields was carried out. In the course of the analysis, the volumes of gas production for the period of 2020 and the volumes of gas that are flared at the FU were considered. As a result, it turned out that only 25% of the total production is utilized, which goes against the target utilization level of about 95%.

APG flaring at the FU is due to the minimum investment (about 0.1 rubles/m3) and low time costs (less than a year for the installation of the FU), in comparison with the high capital and time costs for more complex ways of using APG. However, in the long term, the use of FU leads to lost profits, since APG is a valuable product containing the first components of the alkane series, which are well monetized. In the case of field X, the lost revenue amounts to about

700 million rubles for the pilot phase. Thus, the goal of this work is to find an effective solution for APG monetization at the early stage of development of the X.

A review of existing APG utilization methods was carried out [2] and it was revealed that the most promising solutions for the project will be pipeline transport methods and APG processing, since the search for a solution is limited by the following factors: field X is at the pilot development stage; there are two well pads in operation, the APG production profile of which is not very high; there is currently no infrastructure for gas preparation; however, Gazprom's bushes and pipeline are in the immediate vicinity. To solve the problem, three technologies are being considered: a mobile block-modular gas treatment unit (MUKPG), a mobile compressor unit (MCU) and pipeline transport methods.

The technical calculation of MUKPG, MKU and pipeline transport was carried out, technical and commercial proposals were received, on the basis of which the calculation of the economic efficiency of the application of the methods for the X field was made. The first option under consideration was the use of MUKPG, since with the help of this unit it is possible to obtain additional monetization from the sale of APG due to the release of stable condensate.

The calculation of economic efficiency for a mobile block-modular gas treatment plant showed that for current conditions (production profile, volumes of products obtained - stripped dry gas and stable condensate, gas delivery costs, as well as capital costs for the construction of the plant and the cost of its maintenance), the use of such a method at field X is not profitable. According to the calculation, the main performance indicators: net discounted income (NPV), investment profitability index, internal rate of return show the negative efficiency of this technology. Thus, it is inappropriate to use such an expensive technology to separate stable condensate from APG, since its volumes are insufficient for efficient operation.

In this regard, a calculation was carried out for a mobile compressor unit, which makes it possible to prepare APG to the required parameters necessary for its delivery without the release of stable condensate. In comparison with the use of MUKPG, a slight decrease in revenue was obtained due to the lack of stable condensate, however, there was a decrease in capital costs due to a decrease in the cost of units in comparison with MUKPG, a decrease in operating costs due to simplification of the technological process. Key performance indicators, such as net present value and the level of the investment profitability index, although increased, but did not cross the profitability line for this fields X.

Since the options for purchasing installations did not pass the assessment of economic efficiency, the calculation of target targets was performed according to which, in order to achieve a minimum positive value of NPV and while maintaining the level of the gas delivery price and production profile, it is necessary to reduce operating costs by at least 14 times, and indicators of capital expenditures are at least 7 times.

In this regard, the radius of the search path was expanded in the territorial and technological sense, and a new option appeared - the delivery of APG by a direct route to the Gazprom gas pipeline. The fact is that the previously considered solutions to the supposed need to purchase additional equipment for the preparation of APG from field X to the parameters of Gazprom's gas due to the high difference in parameters. In this option, it is possible to connect to Gazprom's wells, where the gas parameters are close to the APG parameters.

After calculating the economics for this solution, it turned out that the NPV significantly increased and crossed the profitability line for this field, the return on investment index became more than 1.15, since capital and operating costs have significantly decreased and advise the targets set earlier. This means that the application of this solution at an early stage of field development is economically viable and promising for the Company.

CAPEX, million rubles	OPEX, million rubles	NPV, million rubles	PI, units	FCF, million rubles	DCF, million rubles
341	173	40	1,17	345	40

In addition, the use of this option provides additional value in the form of APG utilization at the operational stage and the absence of penalties for overfiring. Long-term calculations have

shown that this solution can bring a good economic effect in comparison with the production of a flare unit.

Thus, the economic assessment of efficiency. Based on the options, the most effective was chosen. And also, when working with the selected solution, an additional benefit for the project was identified in the long term.

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THE ASSESSMENT OF TECHNOGENIC TRANSFORMATION OF AN URBANIZED TERRITORY BASED ON THE SNOW COVER RESEARCH (A CASE STUDY OF KEMEROVO)

An urgent problem in the Kemerovo region is environmental pollution, the main sources of that are the enterprises of the coal mining, coal refining and heat power industries [1]. In Kemerovo, the greatest technogenic load is caused by coal thermal power plants and coke-chemical production, that further affects a person, especially the state of the respiratory tract. Snow cover is studied to assess the anthropogenic impact on the components of the environment, as it is able to accumulate and retain pollutants [2-4].

The purpose of the work is to assess the technogenic transformation of the territory of Kemerovo according to the data of the study of snow cover. Snow cover samples were collected in industrial, residential, and recreational areas of Kemerovo in February 2016 and 2020. The work on the selection and preparation of snow samples was carried out in accordance with the experience of many years of work in TPU and regulatory methods [4]. The object of the study is the solid phase of snow.

The study of samples of the solid phase of snow was performed using instrumental neutron activation analysis, X-ray diffractometry and electron scanning microscopy in the laboratories of the MINOC "Uranium Geology" in TPU. The dust load, the concentration coefficient and the total pollution index were calculated in accordance with the recommendations [4].

According to the results of the study, it was found that the dust load in industrial and residential areas under the influence of coal-fired thermal power plants and coking chemical production varies from a low to an average degree of pollution and the average value corresponds to 199 mg / (m2·day.), in recreational and residential areas of the city the dust load values correspond to a low degree of pollution and the average value is 34 mg/(m2·day.).

The material composition is mainly represented by soot, coal, minerals of mullite, quartz (SiO2), orthoclase K(AlSi3O8), albite (NaAlSi3O8), as well as aluminum-silicate and metal microspheres in industrial and residential, recreational and residential areas of the city located in the windward side of the enterprises of heat and power engineering and coke chemistry. According to the results of electron scanning microscopy particles that include Fe, Ba, Pb, Zn,

Al, Na were identified. The studied particles have a dimension from 2 to 20 microns, which can increase the risk of heart disease, respiratory diseases and lung cancer according to the work [7].

According to the results of the ICP-MS and INAA, the following elements have the highest concentration coefficients in the samples in the affected area of enterprises: U, Tb, Yb, Ba, Sm, Sr, Cs, La, Rb, Al, Hf, Th, Na, Fe, Co, that mainly form a high level of contamination. In recreational and residential areas, the geochemical specificity is preserved, high concentrations of U, Tb, Yb, La, Sm, Ba, Sr are displayed. There is a uniform distribution of concentration coefficients with increasing distance in the northern (windward) direction from the boundaries of the coal thermal power plant and the coke plant (from 0.6 to 4 km), in the southern (leeward) direction, the concentration of elements decreases with increasing distance (from 0.8 to 2 km). The receipt of the studied spectrum of elements may be due to emissions from coal combustion at a thermal power plant that uses the coals of the Kuznetsk basin containing trace elements as impurities [8]. The total pollution index changes as the distance increases which characterizes the long-range transport of dust particles in the samples of the solid phase of snow.

The hazard coefficient of chronic non-carcinogenic effects of chemical elements in samples from industrial and residential areas was calculated in accordance with the works [9-11] with the consultation of the associate professor of the OG TPU N. A. Osipova. It was revealed that the value of the hazard factor in Ba corresponds to an unacceptable level for the population. The zone of conditionally acceptable risk includes the following elements: Cr, As, Co, and the minimum level of risk corresponds to Sr, As, Ag, Fe, Zn, Sb. The total hazard index was used to identify the priority organs and systems most affected by the combined effects of several chemical elements. The effect of the elements Cr, Ba, Sr, As, Ag, Fe, Zn, Co, Sb on the respiratory system is noted in double excess of the permissible, and the values of the elements Cr and Ba when ingested can affect the kidneys by 1.2 times more.

To reduce the man-made load on the territory of Kemerovo measures to improve gas treatment plants and timely control over the equipment of chimney-shafts at enterprises, as well as the development of a regional information database on emissions of pollutants into the atmosphere can be recommended.

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THE FUTURE OF OIL SHALE PROCESSING IN ESTONIA

Nowadays, due to the importance of climate change, 2016 Paris Climate Agreement was enacted some policies. Accordingly, in 2019, European Commission legalize the law in a climate and energy package that sets goals for European Union to cut carbon emissions and go carbon-neutrality by 2050. This means that the emission of carbon dioxide into the air should achieve a net-zero rate to the nature.

The European Green Deal is not currently supported by law, but the European Commission wants to achieve an EU climate law in the near future. Some EU countries, including Estonia, have not made a decision on carbon neutrality yet - 2050: then Estonia continues to implement the Riigikogu's 2017 Climate Policy Framework until 2050. It is mentioned that from 1990 to 2050, the carbon emissions should be reduced by 80%. The fulfillment of the objectives set by the European Green Deal will have the greatest impact on the regions with a carbon-intensive economy, especially those regions where oil shale, peat and coal are mined for the purpose of generating electricity. In order to exclude negative effects in these regions, the European Commission proposed to create the "Just Transition Mechanism". A just transition is the application of measures necessary to achieve national and international climate goals in such a way that during the transition to a carbon-neutral economy, the welfare of residents, local governments and the state is preserved at the highest possible level, and entrepreneurs are supported by the public sector to find and implement the following for the transition of new business opportunities [1]. Many countries are encountered with the challenge of how to alternate renewable energy solutions with coal mining the transition from coal mining to renewable solutions. In Europe, coal is mined in 12 countries (for example, Poland, Czech Republic, Slovakia, Germany and others) and in 41 regions in total. The European Union has decided to significantly decrease carbon dioxide emissions for instance in coal-fired power plants. The decreasing use of coal has led to the closure of many mines throughout Europe.

The focus of a “Just Transition” is in regions where fossil fuels are employed as the energy source (the so-called coal regions). In Estonia, Just Transition is mainly mentioned in relation to the Ida-Viru region for the workers involved in the extraction and use of oil shale and associated communities. If in the upcoming years an equivalent enterprise is not created next to the oil shale sector, Ida-Viru County will face an even faster population decline. Major changes in the economic environment require much larger investments than the sources of the Just Transition Fund allowance. Currently, a total of 353 million euros will be allocated through the Just Transition Fund to Ida-Viru County [2]. 153 million euros budget will assign to support investments in Ida-Viru enterprises, which also applies to pertinent industries in Ida-Viru. 50 million - so that Ida-Viru companies could increase the knowledge intensity of their enterprises. 25 million - for supporting services to increase the diversity of entrepreneurship. 15 million - for separate support of specific small businesses. 25 million - to increase the volume of additional education in Ida-Viru. In addition, 20 million should help to "decouple" from the central heating

oil shale. 10 million euros have been earmarked for solving specific environmental problems associated with the extraction and processing of oil shale. For local government investments in the areas to be supported - 15 million euros. 16,74 million euros - support for regional initiatives for a just transition. So, as a result of 273 million euros are provided directly to enterprises.

The aim of the European Green Deal turned out to be the use of electricity. Unfortunately, in Estonia, the use of oil shale in power generation and the production of shale oil from oil shale have been considered on the same level. The production of oils, undoubtedly, has a significant impact on the environment, but we go to gas stations every day to refuel vehicles, is it fair to abandon the production of local liquid fuels. Another question is emerging: Is the liquid fuel extracted and produced in the rest of the world "greener" than shale oil? In the future, electricity generated from renewable resources should replace those where fossil fuels are currently used. Where does Estonia get its own renewable electricity? Whereas nature conservationists, for example, place great restrictions on the creation of mainland wind farms. And even if it is possible to increase the share of renewable energy production in the upcoming years, none of these outlined production capacities will have sufficient capacity to cover the peak load that Estonia needs. The transition will be fair only if it is carried out for a longer time, and it is necessary to maintain the production of oils in the upcoming decades.

By 2030, the Estonian government has set a goal to reduce total greenhouse gas emissions by 70% compared to 1990 (the climate policy framework until 2050 and the state energy and climate program until 2030). An overview of changes in CO_2 emissions in European countries in 1990-2019 shows that over the past 30 years, Estonia has reduced emissions more than any other country. With 62 percent, Estonia was already very close to the 2030 commitment to decrease emissions by 70 percent in 2019. Most other countries are still far from such a result [3].

While the transition to a climate-neutral economy will take a long time, so the next ten years actions are of crucial importance in achieving long-term goals. A change of this magnitude will not only affect oil shale companies and their employees, but also the region as a whole. The effect can be both positive and negative, only time will tell.

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EXPLOITING OF BIOINDICATION METHODS IN ASSESSING THE IMPACT OF OIL AND GAS PRODUCTION ON TUNDRA LANDSCAPES ON THE EXAMPLE OF THE YAMBURG OIL AND GAS CONDENSATE DEPOSIT

Introduction. Natural territorial complexes (NTC) are exposed to various impacts because of intensive oil and gas condensate fields’ development in the north of Western Siberia during the last decade. That lead to significant changes of properties among geo-system components [1,3]. For instance, such ecosystems as tundra are highly vulnerable to exploitation of oil and gas processes. Besides, one should mention that the level of chemical pollution caused by exploitation oil and gas condensate deposits can vary. Gas condensate fields’ development and collateral discharge of sludgy water leads to slight environmental changes, which are difficult to detect by existing methods of local monitoring. However, they influence on local interaction of geo-systems components’ functioning [2]. Bioindication usage gives a possibility

of diagnosing of early disturbances in the most sensitive components of biotic communities and assess their significance for the entire system in the near and distant future.

Volumes and methods. B The study is based on materials collected by the research team of St. Petersburg University IoES (led by M. G. Opekunova) in summer pf 2019 during the field phase of work on industrial environmental monitoring on the territory Oil and Gas Condensate Deposit of Yamalo-Nenets Autonomous Okrug (north of Western Siberia). Sample preparation, consisting of dry ashing of 65 plant samples, took place in St. Petersburg University IoES laboratory. Further analysis was implemented in A. P. Karpinsky Russian Geological Research Institute's accredited laboratory. Chemical elements (Cu, Zn, Ni, Co, Fe, Mn, Cr, Pb, Zr, Ca, Al, Cd, Ba, Sr, Sc, Na, K, V.) were determined by method of mass spectrometry with inductively coupled plasma method using «ELAN-6100 DRC» with complete acid decomposition of samples. The results of studying three geoecological profiles of Yamburg's deposit: Well-224, Well-225 (abnormal), Well -228 (background profile). The study also contains physicochemical analysis of soil horizons, analysis of indicators of lateral and radial differentiation, of concentration ratios are calculated as ratio of chemical elements over test area to the background one. Soil extracts' biotesting was made with using *Daphnia magna* and *Chlorella vulgaris*.

Results and discussion. Located at the monitoring station № 224, a soil cut was made right on the produced water's spill's boundary, that contained hydrocarbon solution. Produced water discharge on the relief lead to soil thawing and appearing of so-called quicksand. Water that used to be frozen in the gley horizon transmitted into the liquid phase. The horizon is similar to viscous liquid because of the presence of clay and colloidal particles interacting with water. Hence, the soil thawing caused by oil and gas industry functioning has a negative impact on tundra's ecosystems. A possible acceleration of the process as a part of global climate change could do irreparable damage to the environment. Several transformation NTC belts appeared in the area affected by sludge solution spill: ccomplete degradation of vegetation (25-50 m), secondary eutrophication (50-120 m) and insignificant transformation of vegetation (120-200 m).

It is also important to mention that plant ash content is rapidly increasing under the anthropogenic influence. Such changes are indicators of mass transfer disturbances. Average ash content of the studied plants varies from 1, 57 to 12, 47%. Mineral parts' maximum content is typical of such species as *Rumex crispus* (ash content 10, 94%) and *Senecio vulgaris* (ash content 12,47%). Along with the enlisted species, mosses *Sphagnum balticum* and *Pleurozium schreberi* also possess high ash content (11, 33% и 7, 45%), However, in this case such a big number results from the samples being predominantly taken from the polluted areas. Increase of ash content and concentration of Na, Ba and Fe in such species as *Betula nana* (it's branches), *Cladonia alpestris* and *Ledum decumbens* serve as bioindicators of soils pollution and thawing of permafrost soils.

Production and technological drilling waste pose the most serious threat for components of the natural environment. Being accumulated and stored at the drilling territory, the waste contains wide range of mineral and organic matters that pollute the environment [2, 3]. Discharge of produced water without thorough cleaning into the open water bodies may cause total extinction of flora and fauna and breaking of functional connections among environmental components. The results of the research show that pollutions by wasted drilling solutions result in soil solutions' alkalization, concentration increase of phenols, chlorides, sulfates and phosphates and Ba, Mn, Ni, Fe, Na in landscape components, phenols, chlorides Na and Ba are indicators determining the presence of produced water in the environment. After studying the enlisted pollutants, we determined reliable positive correlation of toxic effects on test objects with the content of ammonium nitrogen in the aqueous extract ($NH4^+$) with correlation r=0,48 for *D. magna* and r=0,45 for *C. vulgaris*, chlorides (Cl^-) (r=0,37 and 0,43), potassium (K^+) (r=0,46 и 0,35) and (Na^+) (r=0,29 and 0,31). Phenols, chlorides, Na and K serve as indicators of penetration of produced water into environment.

Conclusion. Hence, natural complexes in the studies areas have a weak self-cleaning capacity resulting from law speed of lateral migration. Soil salinization, occurring because of

produced water discharge and wasted drill solutions' accidental spills on relief, is the most dangerous for the north of Western Siberia. As for tundra region it leads to heavy metals, nutrients, chlorides and sulfates pollution. First of all, it contaminates soil and groundwater and causes their alkalization. Ground and especially soil waters are considered to be things of paramount importance when it comes to evaluating drilling manipulations' impact on tundra and forest tundra territories. Generally, hydrocarbon production industry causes slight environmental changes. They need to be regulated by reasonable methods of oil and gas production impact on tundra regions, that are based on principles of migration and chemical elements accumulation in environment and consideration of landscapes' catenary structure.

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LONG-TERM EFFECTS OF MINING SUBSIDENCE ON PLANT COMMUNITIES VIA PLANT SUCCESSION SIMULATION SYSTEM

Mining subsidence is a common terrain induced by underground mining[1], which not only physically damage the roots of vegetation and bury entire plant communities[2], but also influence change the hydrological processes such as infiltration of precipitation, soil evapotranspiration, runoff collection [3]. All these hydrological processes are closely related to the succession of plant communities[4], and thus the plant succession affected by mining subsidence will definitely be different with that without mining. Considering plant succession is a long-term and continuous process, the effect of mining subsidence on plant communities should also be evaluated in the long run. The uncertainties and randomness of plant succession and other related hydrological processes, however, make it difficult to show the long-term effect of mining subsidence on plant communities, by comparing area with or without mining subsidence in real world, especially considering diverse site conditions of two area.

To address these issues, A simulation system for succession of plant communities based on cellular automata was developed to determine the duration and plant pattern of natural revegetation in mining subsidence area; the succession of plant communities in a subsidence area located in Meiyukou mine, Datong City was simulated; spatial and temporal characteristics of plant succession, and key factors resulting in spatial heterogeneity of plant communities were analyzed. Results showed that the errors between simulated and actual plant patterns ranged from 0.04 to 0.59 according to normalized mean squared error (NMSE) in different landscape levels (10*10，20*20, 50*50, 80*80, 100*100 m). Specifically the errors were between 0.06-0.59 in terms of shrub coverage, and were between 0.05-0.14 in terms of shrub coverage, and were

between 0.04-0.12 in terms of vegetation coverage. The results of 50 simulation with bare land as the initial vegetation condition showed it would take 10.46 years on average when the herb coverage reached between 35% and 55% and the shrub coverage reached 7% and 8% in the study area through natural revegetation. In terms of dynamic of natural revegetation, herb communities revegetated rapidly in early stage of succession, while decreased and transformed into shrub communities with the developing shrub coverage; shrub communities appeared firstly after 3-5 years of spontaneous succession, and the revegetating rate of shrub communities increased with accumulation of soil nutrients; only 2 out of 50 simulations of trees appeared after 10 years of natural revegetation. In terms of distribution of vegetation pattern, the low-elevation gully area was rich in nutrients and water due to surface runoff, where shrub communities appeared firstly and spread; the shady area with a small slope was also easy to develop into a shrub community.

To evaluate the long-term effects of underground mining on plant communities, the 30-year spontaneous succession of plant communities in study area under the original scenario and the ground deformation scenario are simulated and compared, with four initial conditions combined with gully and flat terrain conditions, high initial vegetation and low initial vegetation coverage conditions. Results show that the long-term effects of mining subsidence on the plant communities' succession are mainly manifested in restricting the growth and development of trees, and making the deformed area the first to form a settlement area of shrub vegetation, and the originally compact vegetation pattern tends to fragment. Ming subsidence has greater impact on vegetation in flat terrain areas than in gully areas, and has greater impact on vegetation in areas with low initial vegetation coverage than in areas with high initial vegetation coverage; it has the most obvious impact on the pattern of trees, while the NMSE is always greater than 0.5. The long-term effects of mining subsidence on vegetation gradually weaken with the increase of vegetation coverage, and the difference between original scenario and ground deformation scenario will also decrease.

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TRANSPORT AND TRANSFORMATION OF ORGANIC CARBON IN THE EASTERN PART OF THE LAPTEV SEA SHELF

Accelerated global warming especially pronounced in the Arctic region causes a number positive feedback mechanisms including terrestrial and submarine permafrost degradation. The permafrost destabilization causes the release and export of a large amount of terrestrial organic carbon (OC). Through the coastal erosion and increasing river runoff, the remobilized OC is

involved in the modern biogeochemical cycle and, as a result, has a significant impact on the northern climatic system and, as a result, amplifies global warming [1, 7]. In addition to the impact on the biogeochemical and sedimentation regimes of the Arctic seas, terrestrial OC remobilization can lead to serious environmental consequences (shift of carbonate equilibrium, water acidification due to oxidation of incoming "ancient" OC, increasing of greenhouse gases emission) [5]. Identification of the sources and mechanisms for incoming OC transport and transformation is a key link for comprehensive understanding of the modern biogeochemical carbon cycle in the Arctic.

The Laptev Sea is a representative of a terrestrial OC-dominated area being a heterotrophic biogeochemical province with low primary productivity, where the main OC input originates from coastal erosion [4]. Besides, it receives substantial input of the terrestrial OC from the Lena River. During the land-to-shelf transport, exported organic matter (OM) undergoes aerobic biochemical decomposition, oxidation to CO_2, or can be delivered to the deep-water part of the Arctic Ocean [1, 5]. The geological structure of the Laptev shelf is represented by the riftogenic structure of terraced grabens and horsts that have experienced shear deformations [6].

Our research is aimed at characterizing the modern organic matter (OM) stored in the surface sediments of the Laptev Sea in order to estimate its composition variability and attempt to identify the OM sources along the profile "coastline - outer shelf" and along the burial depth.

We analyzed 28 surface pair sediment samples (horizon 0 - 2 cm and horizon 2 – 5 cm) collected across the Laptev Sea shelf during the Arctic expedition onboard the Russian R/V Academician M. Keldysh during fall 2018 [1]. Grain-size (laser diffraction method; SALD-710, «Shimadzu»), pyrolytic (Rock-Eval 6 Turbo, VINCI Technologies), and GC-MS (Agilent 7890B (GC) – Agilent Q-TOF 7200 (MS)) analyses were performed. To provide relevant data for the modern OM an adapted Rock-Eval temperature program has been applied (start of sample heating - 180°C, holding for 10 minutes, then heating to 650 °C at a rate of 25 °C/min).

According to the pyrolysis data, total organic carbon (TOC) for the 0-2 cm varies from 0,4 – 2,71 % while a portion of free hydrocarbons and low molecular weight OM considered as a lipid fraction (S_1) ranges from 0,11 to 0,73 mg HC/g [3, 4]. For a horizon 2-5 cm, a 5-15% decrease in TOC values is observed (variation from 0.51 to 2.45%) with a simultaneous increase in S_1 by 5-20% (0.16-0.84 mg / g sediment) in most samples. The content of relatively termo-labile hydrogen-rich OM or biopolymers (S_2) and CO/CO_2 released by oxygen-containing OM or geopolymers (S_3) correspond to 0,67 – 2,92 mg HC/g and to 1,18 – 5,4 mg HC/g, respectively [3, 4] for the 0 – 2 cm horizon. The 2 – 5 cm horizon is characterized by S_2 values ranging from 0.49 to 3.35 mg / g and S_3 ranging from 1.07 to 4.8 mg/g. There are no fixed alterations connected with depth for these indicators.

The sediment distribution suggests relatively low HI (hydrogen index) and higher OI (oxygen index). Its ratio HI/OI < 1 may be compared to a mix of "Type 2" and "Type 3" kerogens for matured OM determining planktonogenic and terrestrial origin, respectively. For most samples, the OI values decrease with depth, which indicates more intense oxidation processes in the 0 – 2 cm horizon.

According to the T_{peak} values, the samples are grouped into two clusters: with relatively low (from 372 to 401^{o}C) and high values (from 457 to 492^{o}C). Decreased T_{peak} values (coupled with higher HI values) correspond to the outer shelf zone, while high values accord to the coastal zone. These clusters might be potentially attributed to the different sources of OM, both by the type of initial producers and by the degree of its diagenetic transformation.

According to the grain size analyze, sediments are dominated by clay (< 2 μm) and silt (2 - 63 μm) fractions. The sand fraction (> 63 μm) is almost absent.

Qualitative interpretation of a n-alkanes distribution and geochemical indices calculation (CPI, Ki, OEP17,19, TAR, Paq, Pr / Phy) indicate the dominance of terrestrial OM, the cluster hydrobiont contribution (in the outer shelf zone), a low degree of diagenetic OM transformation, suboxidative sedimentation environment for the 0-2 cm horizon.

According to the TAR index for the 0-2 cm horizon, the samples, respectively to the T_{peak} clustering, were divided into a two group with low (TAR <20) and high (TAR> 20) index values. Noteworthy, that for the 2-5 cm horizon, the TAR index lies in the same ranges throughout the study profile and has values of 0.94 to 13.06. This dynamic can be explained that a more intense influx of terrestrial OC has occured recently with river runoff or coastal erosion. This fact is confirmed by high TAR, CPI in the overlying horizon 0-2 cm, and their deficit in the 2-5 cm horizon.

In general, the GC-MS records are directly comparable to Rock-Eval data. Along the studied profile, the contribution of the terrestrial OM in the outer shelf surface sediments is clearly traced despite the great distance from the coastal zone for the 0 – 2 cm horizon. A significant difference in the TAR index between the analyzed horizons can be an indicator of a powerful intensification of the terrestrial OC input into the Laptev Sea recently. However, this hypothesis requires additional analytical proofing. In general, our study complements the available geochemical data on the composition and sources of OM in the Laptev Sea, which is critically important for a comprehensive understanding of the biogeochemical carbon cycle in the Arctic.

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GEO-MONITORING OF CARBON DIOXIDE GAS EMISSION DECLINE DUE TO COVID-19: A CASE STUDY OF NAIROBI METROPOLITAN REGION

Background. The increasing concentration of GHG in the atmosphere following air pollution from industrial and transport systems has been verified as most important cause of

global warming. CO_2 is the most important GHG because it is abundant and it stays longer in the atmosphere compared to the other GHGs. Greenhouse gases are able to absorb heat energy hence when they are in the atmosphere, they cause increased temperatures. This is a major concern as the end effect is adverse weather conditions in a region. Nairobi Metropolitan area experiences high air pollution due to high energy intensive human activities like manufacturing and transport. The **Purpose** is to monitor the CO_2 concentration pattern pre-COVID and during COVID period and predict future pattern through modelling and forecasting.

Material and methods. A statistical modeling method was used. It targeted Nairobi metropolitan area. OCO-3 secondary data was used. The data was obtained by downloading the level 2 (L2) products from OCO-3 data centre. The product files downloaded were in Hierarchical Data Format (HDF). HDFView was used to access the data. Data analysis was done in excel environment, using Microsoft excel version 10.

Results of the study. COVID-19 impacted negatively on the CO_2 concentration due imposed restrictions which reduced human activities. The future concentrations depend on the economic recovery path that the government will take. There are three possible recovery paths, namely: green recovery, fossil fuel recovery and business-as-usual recovery.

Presentation of findings. Findings were then presented in form of graphs and tables.

Conclusions. To be able to keep the concentrations as low as what was experienced during lockdown, the country must consider green economic recovery. This means, use of energy sources that are natural and causes less emissions, for instance, wind, solar, hydro and geothermal sources.

Recommendation. This research recommends the utilization of solar panels for energy due to high solar energy received in the country.

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EXPLORATION OF THE DEVELOPMENT PATH OF NEW ENERGY IN THE BRICS COUNTRIES – INSPIRATIONS FROM DEVELOPED EUROPEAN COUNTRIES

Introduction. Carbon emission reduction has been an important theme in the world for the past 20 years, and carbon neutrality is a goal proposed by many countries in responding to climate change and energy structure transformation [1]. The development of new energy is an important path for countries to achieve carbon neutrality goals. This paper analyzes the factor balance structure and factor preference of the new energy power generation market in the BRICS (Brazil, Russia, India, China, and South Africa) countries and developed European (DE) countries in the context of carbon neutrality in recent years. The research in this paper mainly fills up the following research gaps: (1) The development of new energy in the BRICS countries plays an important role in the transformation of the global energy structure and carbon emission reduction. This paper compares the new energy markets in the BRICS countries with DE countries, and provides reference suggestions for the development of new energy in the BRICS

countries. (2) This paper explores the new energy market structure of various countries, thus revealing the choices of different types of countries for market elasticity in the development of new energy. (3) Under different market elasticity, this paper further studies the contribution of various factors, thereby exposing countries' preference for selection of production factors in the new energy market during the development of new energy. (4) In particular, in the context of carbon neutrality, DE countries have undergone decades of strategic reforms. This paper believes that the BRICS countries should have a more long-term energy strategy and economic development strategy, and based on the results of the research, the BRICS countries should be warned of new energy development.

Main part. This paper mainly studies five questions: (1) In the production process of the new energy power generation in DE countries and BRICS countries, is the production foctors balanced or unbalanced? (2) If the production foctors are unbalanced, what factor preference does each country have? (3) Is there heterogeneity among different types of new energy? (4) Are there differences in new energy production decisions between DE countries and BRICS countries, and if they are different, what are the reasons? (5) If different countries make different decisions, what warnings does this give to the BRICS countries that are relatively backward in new energy development?

To address the above questions, this paper collects relevant data on four types of new energy, including wind energy, solar energy, biomass energy and nuclear energy. Firstly, this paper discussed the factor elasticity of various new energy production in DE countries and BRICS countries [2]. Second, the contribution of each production factor to various new energy power generation is calculated, and the choice preference of each country on the production factor are discussed under different factor elasticities [3]. In particular, this paper compares the heterogeneity of new energy production decisions between DE countries and BRICS countries, and explains the reasons for the differences between the two types of countries from the background of carbon neutrality trends. Finally, according to the different decisions of various countries, this paper puts forward construction suggestions about new energy development for the BRICS countries.

Conclusion. This paper mainly draws the following conclusions: (1) In the field of wind power generation and solar power generation, there is an elastic substitution effect in the production factors of the BRICS countries, indicating that the BRICS countries have chosen the "expansion" strategy with unbalanced factors. Through the contribution analysis, it is found that the development of wind and solar power generation in the BRICS countries is capital-oriented. However, DE countries have chosen a "conservative" strategy that factors balanced. Under this strategy, the development of the wind power market and solar energy market needs to be promoted by both capital investment and technology progress. (2) In the field of biomass power generation, both the BRICS and DE countries have chosen an the "expansion" strategy. Besides, the development of the biomass power generation market is technology-oriented except for India. (3) In the field of nuclear power generation, the BRICS countries have chosen the "conservative" strategy, and the DE countries have chosen the "expansion" strategy. However, due to the safety of nuclear energy, the growth rate of nuclear power generation in all countries is very small. (4) Although capital-oriented can quickly promote the development of the new energy industry, this sacrifices the local welfare of benefits from new energy technology progress to a certain extent. Therefore, for the BRICS countries where the development of new energy is relatively backward, policymakers should further evaluate the balance between capital and technology. In addition, achieving carbon neutrality is more difficult for BRICS countries than DE countries, and BRICS countries should further refine and plan their energy strategies in the long term.

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EFFECT OF MINING WATER ON RIVER SEDIMENTS WITHIN THE EASTERN DONBASS

The Eastern Donbass is one of the main coal-mining regions of Russia. Long-term coal-mining and processing have led to a number of environmental problems that have worsened during the flooding restructuring of coal mines. A number of studies [1-3] indicate that enterprises of the coal industry have the greatest effect on the quality of water and river sediments. The impact of mine waters on the state of surface waters [1] and groundwaters [2,3] has been studied, while the relationship between the chemical composition of mine waters and river sediments has been poorly studied.

With a view to demonstrate the effect of coal-industry facilities on the chemical composition of river sediments, data on the heavy metals content in river sediments were compared with data on those in mine waters.

Iron and manganese have the largest content in the chemical composition of mine waters, and the content of other elements is a substantially lower. The highest concentrations of metals studied are observed in the mine waters of the Komissarovskaya mine. The waters of the Burgusta-Zamkovaya-2 mines are also characterized by relatively high metal contents.

Studies of the river sediments chemical composition within the Eastern Donbass also show that the iron and manganese have the largest content in sediments; concentrations of other metals is significantly lower [4].

In order to show the correlation between mine waters composition and river sediments composition, the couples of technogenic mine waters outlet and sampling site on the rivers of the Eastern Donbass which is situated near to each other are considered. The values of heavy metals concentrations in mine waters (mg/L) and the content of the same metals in river sediments (mg/kg) were compared. At the same time geochemical spectra were plotted based on the data on the chemical composition of river sediments and mine waters. Sufficient similarity between the shapes of the spectra allows us to reach the conclusion about the impact of mine waters on river sediments.

Sampling sites located relatively close to coal-mining facilities were selected for comparison. So, the Vostochnaya and Tatsinskaya mines were compared to sites 22.1 and 23.1, the Komissarovskaya mine was compared to site 19.2 of the Likhaya river, the Burgusta-Zamkovaya-2 mine was compared to sites 24.2 of the Kundryuchya river and 25.3 of the Bolshaya Gnilusha river.

Figure 1-a shows the geochemical spectra of the Vostochnaya and Tatsinskaya mine waters and river sediments in sites 22.1 and 23.1. It can be seen that the shapes of the spectral plots are similar. Spectra also indicate that among metals iron and cobalt has maximum and minimum content both in mine waters and river sediments, respectively.

Figure 1-b shows the geochemical spectra of the Burgusta-Zamkovaya-2 mine waters and river sediments in sites 24.2 and 25.3. Comparison reveals similarity between these spectra. I would like to emphasize that the low content of lead is observed in mine waters while those in river sediments is relatively higher. It points to other possible sources of lead.

Figure 1-c demonstrates comparison of the geochemical spectra of the Komissarovskaya mine waters and river sediments of the Likhaya River in site 19.2. Notable differences between

the spectra are observed here. Zinc has a higher content in the chemical composition of river sediments than copper and lead. In the spectrum of mine water a consecutive decrease in the content of several metals is observed (Ni > Zn > Co > Pb > Cu). However, it should be noted that the Komissarovskaya mine waters are characterized by the highest concentrations of iron and manganese. At the same time the highest amounts of iron and manganese are observed in the river sediments at site 19.2.

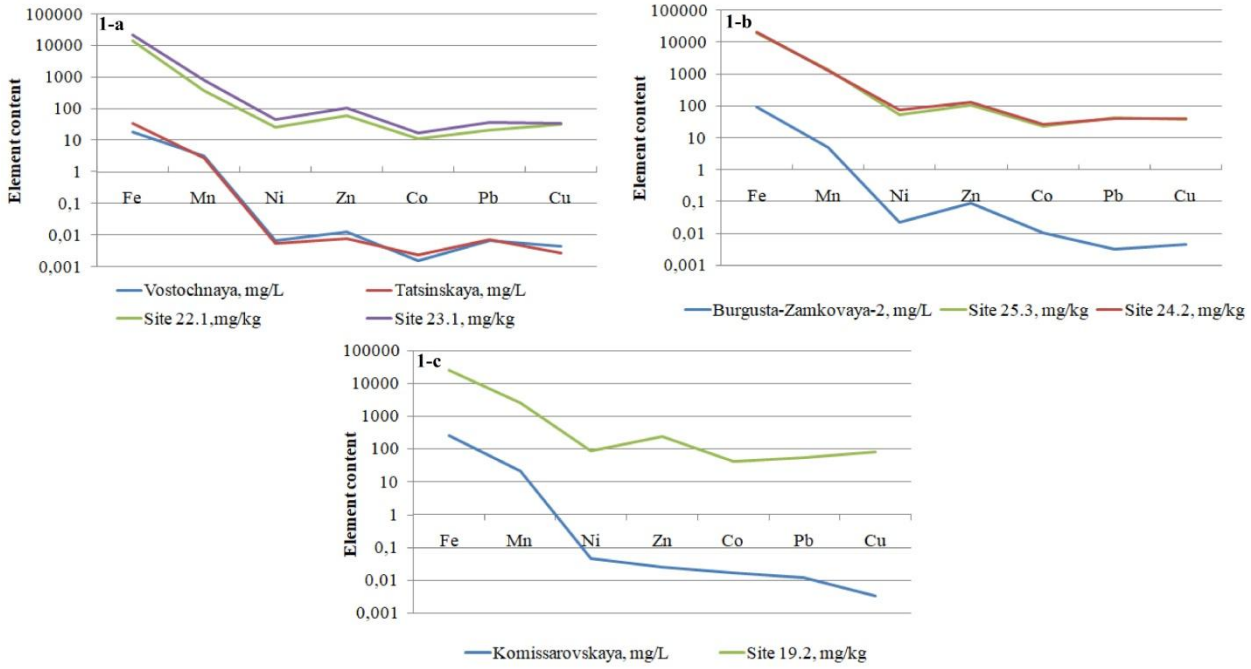

Figure 1 – Geochemical spectra of mine waters (mg / L) and river sediments (mg / kg)

Thus, a strong relationship between the geochemical spectra of mine waters and river sediments has shown. The patterns revealed confirm the impact of technogenic mine waters on the river sediments within the Eastern Donbass. It is necessary to carry out ongoing monitoring of highly polluted mine waters inflow into the rivers.

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EVALUATION OF THE EFFICIENCY IN THE NICKEL MINING PRODUCTION OF CUBA

Introduction. The research pursues to design a procedure that allows evaluating the efficiency in Nickel mining production in Cuba. By integrating technical, economic and environmental variables, it is possible to recognize the elements to be considered in the development of improvement actions in order to obtain products of higher added value. In Cuba, in comparison with the rest of the world, it has been limited not only in the amount of applications, but also in the fields of study, the application of mathematical methods that do not require the specification of a functional form, for this reason it is presented as an effective tool of Benchmarking the data envelopment analysis (DEA) to carry out this research. The proposed procedure provides the efficiency indexes of the selected units, identifies the elements that condition the establishment of goals and contributes to the elaboration of action plans that help companies to be efficient and to increase their productivity in an environmentally responsible way by exploiting economies of scale.

Main part. In Cuba, for more than 10 lustrums, the nickel mining sector has had a determining weight in the reproductive dynamics of economy. The production and exportation of nickel+cobalt occupies a relevant place in the productive values of the country, concentrating such production in the plants "Pedro Soto Alba" with a capacity of 37 thousand annual tons of nickel sulfide plus cobalt and the "Che Guevara" with around 18 thousand tons, both located in the northeast of Holguin, in the municipality of Moa. It is estimated that Cuban nickel reserves represent 37.3% of the world reserves of this mineral. Experts agree that the deposits currently being exploited in Cuba have guaranteed the availability of this mineral for the next 18 to 20 years. Cuba's main markets for its Ni+Co production are China, Europe and Canada despite the US economic-financial embargo that limits technology transfer by developed countries and makes it impossible to use the US dollar in Cuba's international trade.

In the Moa nickel mining industry, the instruments designed to determine productivity and to support production plans have not proven to be effective, considering that the tons produced are far from the capacities installed in the factories. At present, more importance is given to the recording of economic and technical indicators than to efficient ones. According to Martín (2019) [1], no R+D+I strategy is implemented in the mining cluster, integrating the efforts of all the technical and professional production staff, as well as academic and scientific centers, to develop geological-mining software, promote technological change, obtain a product with greater added value and produce less environmental pollution.

It is evident the need to develop alternative procedures that complement the technical-economic analysis of Ni+Co production, from the establishment of comparative analyses that allow setting goals with more objectivity and possibilities of being perfected, based on knowing the real potentialities, regarding the use of raw materials, means and work force in consonance with the hypothesis of Porter [2] and in harmony with the assumptions of sustainable development and its objetives for the 2030 [3].

It is proposed to design a procedure that allows evaluating the efficiency, starting from the determination of the available resources and their relationship with the results achieved in order to increase the efectivity of the processes in nickel mining production of Cuba. The recognition of the elements to be considered in the development of improvement actions (in order to obtain products with greater added value and less polluting for the environment); will guarantee the improvement of the nickel mining business system, by implementing actions that mitigate the negative externalities of the nickel industry and contributing more to the territorial budget in line with the Guideline 9 and 101 of the Economic and Social Policy of the Party and the Revolution of the Republic of Cuba [4].

The experience of the application of the DEA technique has not had the same acceptance in Cuba, compared to the rest of the world, being limited not only in terms of number of applications but also in relation to the study areas, being implemented only in the agricultural sector, public health, tourism, and to determine the profile of Cuban negotiators in companies [5].

Conclusion. It is shown that the national experience in the use of multi-variables efficiency analyzes is still an incipient issue, due to the fact that its application has been very limited, so this practice should be increased, its field of action expanded, and become a tool of the Cuban economy. The design of a procedure to evaluate the efficiency of nickel mining production by identifying the determining elements of it and its link with the results achieved, will allow to recognize the elements to be considered in the development of improvement actions within this industry; which will contribute to the sustainable local development of the Moa Municipality.

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THE STRUCTURAL CHANGE IN CHINA: THE CHINESE HARD COAL INDUSTRY IN FUTURE PERSPECTIVE

With the recently announced climate neutrality for the year 2060, there are plenty of questions in China about the future and the existence of the hard coal mining industry. With an annual production of 4 billion tons of hard coal, China remains the biggest producer of this resource. The consequences for the environment are tremendous and are not just a national issue; it is a global one affecting every one of us. Climate neutrality poses new challenges for this country with its abundance of resources: hard coal is still the easiest and safest way to guarantee the supply of energy to its citizens, whereby energy security is a high priority [5].

The switch to and the integration of renewable energies has already started and, according to the latest 14th five-year plan, should become the main driver of growth in the coming years. The transition to green development with a low carbon economy as one of the most important objectives is imminent (KPMG 2021). These developments will have a decisive impact on the next few years and will drive structural change forward. Since China also has large reserves of rare earths, which are required in particular for the construction of regenerative energy options (electric cars, solar panels and windmills), this presents the market for trade with new challenges. China can have a market share of up to 97% and is therefore clearly the dominant player in this trade area, which will become increasingly important worldwide in the future. But here, too, only one environmental problem is shifted to the next, since the recycling of rare earths has not yet been developed and the sustainability factor is a big question mark [2]. In order to enable the construction of new, supposedly sustainably generating energy in one country or place, in another large areas of pollution are accepted over entire stretches of land. An example of this is the place Baotou (in the western part of the Jiuyan area) in Inner Mongolia [3]. In the meantime, an artificial lake has been created here by discharging the polluted and toxic waste water. The place is primarily known for refining and processing ores, which, among other things, creates the so-called bastnäsite concentrate. The wastewater left over from this process

destroys the vegetation of the soil and possible living beings [2;3]. In addition, the wastewater seeps into the groundwater, where it also pollutes the drinking water and causes possible diseases for the people living there [3]. The occupational safety measures in China are known to be very low, especially in the mining sector, and often end in accidents or even the death of employees and have an impact on the surrounding environment [1]. This is just one of many examples. The global share of renewable energies is currently estimated at 13,5% (2018) of the global primary energy consumption and is expected to double by the year 2050 [4].

What impact will this then have? With regard to sustainability, it can be said that even renewable energies cannot offer a miracle solution. Here, too, CO2 is used for the production of regenerative uses or, according to the current state of knowledge, non-recyclable resources such as rare earths are used as an aid. This energy transition is the first step towards change and also towards the willingness to make big changes. However, this is not the solution that is often promised or presented to the outside world. Nevertheless, it will take a few more decades before only this energy generation is used. In the case of China in particular, other factors such as economic growth and energy security are primarily in the foreground, whereby hard coal and the associated high CO2 emissions, for example, will still play a major role in our environment and climatic effects in the coming years.

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BIOJET FUEL PRODUCTION FROM LIGNOCELLULOSIC BIOMASS: TECHNO-ECONOMIC, LIFE CYCLE AND FLIGHT PERFORMANCE ANALYSIS

Based on a report by the Intergovernmental Panel on Climate Change (IPCC), the entire transportation industry emits 6.7 Gt CO2 per year. The share of the aviation industry is 2%,

growing by more than 6% over the past decade. Climate change mitigation and energy security are core elements in the current European policy. The 2030 climate and energy framework includes EU-wide targets and policy objectives from 2021 to 2030. The principal goals for 2030 are 1) at least 40% cuts in greenhouse gases (GHG) emissions below 1990 levels, 2) at least 32% share for renewable energy, and 3) 32.5% improvement in energy efficiency [1].

The raw materials, cellulose-derived ethanol and palm kernel oil (including palm fatty acid distillates), were sequentially upgraded using thermochemical processes [2]. The ATJ path included dehydration, oligomerization, and hydroprocessing stages. The

HEFA process involved thermal hydrolysis, decarboxylation, and hydroprocessing at the same time. In both cases, a biojet fuel mixture primarily composed of C9 and C15 isoalkanes was produced. The models were simulated in AspenPlus® v.11 chemical engineering process simulation software to design the biojet fuel refining, including sizing equipment and economic analysis. The achieved specific biojet fuel production was 50 wt% for the ATJ and 90 wt% for the HEFA.

On the other hand, the reached minimum selling price ranged between 0.72 €/kg to 1.18 €/kg for the ATJ and HEFA, respectively. The studied routes were evaluated through an exhaustive life cycle assessment in SimaPro® v.9.0 modelling software. The estimated net GHG emissions were 75 gCO2eq/MJ for the ATJ and 18 gCO2eq/MJ for the HEFA; nevertheless, significant improvements were achieved from by-product displacement credits. In both cases, the GHG emissions were under those from petroleum-derived Jet A1 production [3]. Finally, the physico-chemical parameters and thermodynamics were calculated to emulate the combustion behaviour of the produced biojet fuel based on the ASTM D7566 standard requirements, meeting the specifications for synthesized paraffinic kerosene. Finally, the calculated payload vs range estimated a better performance for an intermediate-range flight than conventional jet fuel [4].

In conclusion, the simulated biorefinery for biojet fuel production from oleaginous agri-waste via the ATJ and HEFA thermochemical routes obtained a highly efficient production rate. The lignocellulosic biomass-based biojet fuel is a sustainable Jet A1 surrogate. The combined analyses presented in this work provide quantitative and qualitative information about the lignocellulose-derived biojet fuel production, identifying necessary improvements to make this technically, economically, and environmentally sustainable.

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REDUCING THE GEO-ENVIRONMENTAL CONSEQUENCES OF THE STORAGE OF HALITE WASTE

A particular feature of potash mines is the storage of waste on the surface. Solid halite waste is stored in salt piles, while liquid tailings are stored in slurry pits. A potash slurry pit is considered spent when it is fully filled.

The development of Starobin potash deposit leads to a significant change in the geo-ecological situation in Soligorsk industrial district. The content of useful component in mined ore is in the range of 20 - 35 % that in the process of its enrichment leads to formation of a large quantity of production wastes: for 1 ton of basic production there are from 3 to 6 tons of wastes. At that, potash ore processing waste is divided into solid and liquid fractions [1].

Currently, the area of salt piles and slurry pits is growing. Therefore, important to develop new methods of potash production waste storage that will reduce the growth in the area used for the disposal of this waste and reduce the geo-environmental load in the industrial area. One of actions of reducing the growth in the area is the use of waste slurry pits as the basis for the expansion of salt piles by hydraulic fill [2,3].

The research of the physical and mechanical characteristics of potash wastes is of practical importance for predicting tailings facilities development and, consequently, reducing technogenesis in the halite waste storage area by hydraulic fill.

The physical-mechanical properties of halite waste should be taken as predicted after a theoretical study and justification of the values based on an analytical summary of the results of theoretical and experimental research on the engineering-geological properties of halite waste.

The analysis of researches allows to generalize the results of researches of water-physical and physical-mechanical properties of halite wastes, engineering-geological processes in salt piles from the moment of halite waste storage up to their consolidation. The results also make it possible to determine the peculiarities of obtaining new properties by halite wastes during high-altitude storage and present the predicted physical and mechanical properties of halite wastes deposited in the salt pile, which can be used for designing the salt pile formed by hydraulic fill on the waste slurry pit.

The analysis established the influence of their composition, dehydration, consolidation, denudation and condensation processes on the physical and mechanical properties of halite wastes.

Predictive assessment of changes in physical and mechanical properties of halite waste made it possible to establish patterns of change in their strength properties for the process of hydraulic fill and to present predictive characteristics of physical and mechanical properties of halite waste deposited in the salt pile.

Introduction of new technological schemes of waste storage on "Belaruskali" allows reducing by 30-40 % the withdrawal of fertile land for storage of potash production waste. Almost half the amount of excess salt production in the area of potash ore processing waste disposal, thus significantly reducing the environmental risk of Soligorsk mining district.

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COMPACT UNIT FOR WATER PURIFICATION

In a fast-evolving world, and with a continuous increase in the population, more demands on basic needs such as clean water, and high occupancy of available spaces are needed. Therefore, focusing on people's need to have access to clean drinkable water, a compact unit has been designed to provide purified water in less cost and time and require less space all while being sustainable. This compact unit can be used in several locations, it is easy to transport; it will have a remarkable impact serving small communities, industrial buildings, or even at times of natural disasters when infrastructure may be destroyed. It targets mainly communities with high water consumption rate to benefit from its reuse, communities suffering from water scarcity, and communities paying for clean water even more than fuel.

This compact unit will be including approximately all the traditional processes for water treatment providing almost the same water quality. The compact unit operating at a 2L/s flowrate will consist of an inlet pipe leading to a tank containing all the three processes of coagulation where chemical substances are added to the water to form gelatinous hydracids by attracting particles together, flocculation where the chemicals are slowly blended with the water to attract the small suspended solid and form flocs, and clarification where the solid load is reduced and 85% to 95% of suspended solids and colloidal matter is removed. Traditionally, each tank included a propeller operating at a specific speed for a certain time, this product adjusts the propeller's speed for each required detention time in the single tank while adding the required coagulants. Following this, a reed bed system will be replacing the filtration unit where water passes through a porous medium to remove the remaining suspended solids, color, taste, odor, iron, manganese, and 90% of bacteria, creating a nature integrated system. This reed bed system will be made of three layers of gravel and sand [1] on top of which the reeds will be planted to ensure that the organic matter in the water is consumed by the bacteria in the roots of the plants [2]. An optional disinfection tank could be placed next depending on the end usage of the water to remove the bacteria and microorganisms which may be pathogenic and cause health issues such as water-borne diseases. Finally, water is either stored in a separated tank or directly distributed [3].

It will be executed in an eco-friendly way, using recycled materials thus leaving an economic impact by reducing the cost by up to 50%. As for the environmental and social impacts, it tackles:

- SDG number 6: "Clean water and sanitation", by providing water with good taste, odor, and color.
- SDG number 13: "Climate action", by easy and safe disposal of used materials.
- SDG number 3: "Good health and well-being", by eliminating water borne diseases that cause serious health issues.

This concept minimized the size by combining the first three processes in one tank, and this tank is followed by a nature integrated system where we aimed to reduce the chemical use

and rely on what our nature already has given us by benefitting from the reed plants acting as chemicals removing the bacteria and through sand layers that will allow a natural filtration process. This concept will encourage small communities, especially the target audience which is small villages not able to afford the whole treatment plant construction. Working for a cause was our main motivation to work in this project. Hopefully, this project will be the start of a journey to help Planet Earth not only by shedding light on the severity of the problem but also by solving it and finding innovative solutions to operate in an economic and ecofriendly way.

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ISSUES OF COPPER SLAG UTILIZATION AND THEIR PYROMETALLURGICAL SOLUTION

Over 140 million tonsof copper slag is accumulated in the Russian Federation and these amounts continue to increase. Temporary storage this copper slag is not only needed a large area, but also environmental health hazard. Ecological taxes and standby charges of waste are required cost, which are done it necessary for the most complete disposal of these production wastes. At the same time, these slags contain valuable elements, in particular, iron, copper, zinc, selenium, arsenic and some others, the recovery of which can make disposal profitable [1]. The highest valuableness is represented by iron of these, the content of which is at a level of more than 40%, which is almost at the level of some iron ores used in the ferrous metallurgy. However, the use of this iron-containing material in the classical processes of ferrous metallurgy is complicated by the high (up to 0.6%) content of copper in them [2]. In addition, the extraction of iron by conventional methods cannot solve the problems of recycling the newly formed slag. Other existing methods of processing copper-smelting slags are aimed at extracting certain components from them, but they cannot solve the problem of their disposal in general [3].

The purpose of this work is to develop economically feasible methods for the complete utilization of copper-smelting slags and obtain to obtain popular products.

The object of the study was the mature slags of the copper smelter. The slag contains metal particles containing copper, iron, antimony, and tin. The oxide phase is represented by iron spinel particles and complex silicates containing iron, zinc, and other elements. Spinel contains a relatively high amount of sulfur, and the silicate phase contains impurities of non-ferrous metals. According to X-ray diffraction analysis, the main iron-containing phases of the sludge are fayalite $2FeO * SiO_2$, magnetite Fe_3O_4, and pyroxene $CaFeSi_2O_6$.

In this article we study the processes of processing copper-smelting slags using solid-phase reduction of iron with carbon from thermal coal. At the metallization stage, zinc was extracted into the gas phase, and during the melting of the reduced semi-finished product, copper-containing cast iron with a high sulfur content and an oxide melt were obtained. In the

future, grinding bodies were obtained from this cast iron (Fig. 1), which showed high performance properties, and on the basis of the slag residue – proppants that are in demand in the oil and gas industry (Fig.2)

Figure 1 – Cast-iron grinding media

Figure 2 – Proppants with a diameter of 0.6 – 1.0 mm

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ENVIRONMENTAL PROBLEMS OF THE COAL MINING INDUSTRY (IN THE EXAMPLE OF THE KARAGANDA REGION OF THE REPUBLIC OF KAZAKHSTAN)

This article deals with the enterprise of the coal mining industry. Currently, according to the environmental legislation, special attention is paid to the mining industry [1]. The main type of work of this enterprise is coal mining. Their activity, in addition to coal mining, cover quarries for building stone, coal processing, operation of access roads, railroad transportation, shunting operations, and water extraction and sale. The company has two coal mines - Central and Western.

The deposit is in the shape of an elongated bowl approximately 12 km long and approximately 6 km wide. The deepest point of coal occurrence is only 200 meters. Moreover, the thickness of the layer is up to 30 meters, and the total reserves amount to about 1.5 billion tons. In other words, with a production rate of about 10 million tons per year, the field can be used for 150 years. A total of 11 million tons of coal were produced in the field until 1990. Coal production was reduced to 800 thousand tons per year [2]. According to the long-term development program, by 2022 it is planned to increase the level of mineral production to 20 million tons per year.

This coal is suitable for both power and metallurgy, has the highest calorific value and low ash content, with the lowest sulfur and water content, it can be used in alumina production technology, and it is also attractive for export.

More coal means more energy, but there is an issue with the production of ash from coal combustion (Table 1). Currently, ash and slag waste in a larger amount is stored in dumps. However, placing waste in landfills is not the most environmentally friendly approach.

Table 1 – Total ash and slag quantity for the period 2016-2025 at the enterprise

Quantity of ash and slag	**The total amount of formation, Tons\year**									
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Quantity of ash and slag to be transported to the internal dump of the Central pit.	3021,9	3021,9	3021,9	3021,8	3134,7	3149,7	3149,7	3149,7	3149,7	3149,7
Quantity of ash and slag to be transported to the internal dump of the Western pit	411,590	411,590	411,590	411,590	411,590	411,590	411,590	411,590	411,590	411,590
The total amount	***3433,469***	***3433,469***	***3433,469***	***3433,469***	***3546,006***	***3561,321***	***3561,321***	***3561,321***	***3561,321***	***3561,321***

As with many other wastes, there is the best option - recycling. The first characteristic of ash is that it is inert and non-combustible.

The distinctive properties of ash, which allow it to be used for fire suppression, are:

– absolute no combustibility and preservation of physical and chemical characteristics in the high-temperature hearth of lignin combustion;

– low flow ability, high density and good adhesion of the particles which, with the layer thickness of 30 cm, ensures sufficient insulation of the combustion nidus from the penetration of oxygen into it;

– the presence of boron, which is an flame retardant;

– high alkalinity (pH – 9…10), which makes it possible to reduce the acidity of lignin as one of the causes of its ignition.

It would be nice if it were possible to make fire suits out of ash. That would save a lot of lives. Or put out fires with ashes, or make an anti-fire coating.

Ash and slag waste is used to make sand-lime bricks, with 10-50% less lime and 20-30% less sand. Such bricks have lower density than usual bricks. One of the most promising directions of ash and slag waste utilization is production of porous aggregates for lightweight concrete. Fine aggregate is replaced by ash. As coarse aggregates, crushed stone from fuel slags, ash-based agloporite, roasted and unroasted gravel and alumina claydite are used. Fuel ashes are used to produce fused materials: slag pumice and absorbent cotton.

The technology for producing high-temperature mineral wool by melting in an electric arc furnace has been developed. This material is used for insulation of surfaces with temperature up to 900-1000°C. It is also possible to produce glass, architectural and construction products, and facing tiles. In road construction ash and slag waste is used as the backfill for asphalt-concrete pavement preparation. In addition to the fact that ash does not burn, it has a rich mineral composition. The use of ash and slag in agriculture improves the agrophysical properties of soil, replenishes its micro- and macro-element composition, improves porosity, neutralizes acidity, but it is necessary to consider their danger by radiation, water migration, general sanitary, translocation and toxicological indicators.

Ash is a good local mineral fertilizer. It is a phosphorus-potassium and lime fertilizer [3]. There is no chlorine in ashes. Therefore, its application is especially effective for crops that react

negatively to chlorine (potatoes, berries). Doses of ashes depend on soil conditions, crop nutrient requirements and their content in ashes. The content of nutritional elements in ash varies greatly depending on the composition of organic materials from which it is derived. During the experiment with techogenic soil, a fertilizer was added to improve the organic part of the soil, which contains nutrients. However, the best result was achieved by adding ash to the technogenic soil.

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BIOLOGICAL PHOSPHATE ACCUMULATION IN WASTEWATER TREATMENT TECHNOLOGY

Eutrophication of waters is considered one of the serious problems that pose a threat to human and animal health. The topic under consideration is part of one of the directions of development of science and technology in the Russian Federation - Rational nature management and environmental protection. Eutrophication is a phenomenon caused by excess discharge of nutrients into an aqueous system, particularly by nitrogen and phosphorus. The main sources of phosphates in wastewater are human wastes (30-50% comes from domestic waste). The widespread use of household chemicals (50-70%) leads to the flow of synthetic surface-activated substances into wastewater containing polyphosphates. Phosphorus compounds sources are also industrial waste: meat-processing and packing plant (20-60 mg 1^{-1}) and dairy plant (5–15 mg 1^{-1}). In sewage water supplied for treatment, phosphates are not more than 10 mg 1^{-1}. The efficiency of the biological phosphate removal on average reaches 50% for the wastewaters treatment process. Concentration of phosphate ions after wastewater treatment is 1.5-5.0 mg 1^{-1}, which exceeds the established admissible concentration limit (ACL) [1]. ACL of phosphates (in recomputation of phosphorus) for water bodies for fishery purposes, with varying degrees of trophicity: for oligotrophic - 0.05 mg 1^{-1}; for mesotrophic - 0.15 mg 1^{-1}; for eutrophic - 0.20 mg 1^{-1}. Not all purification plant has developed technologies to reduce the concentration of phosphates to a virtual value in the incoming wastewater. It follows from this that an additional reason for the excessive intake of phosphate ions into water systems is insufficiently treated domestic and industrial wastewater.

This paper investigates the phosphate accumulation process for some microorganisms from biological treatment plants. During research was isolated PAOs consortium from activated sludge in the model experiments with a periodic aeration. The dominant bacteria in the consortium are single Gram-negative cocci and Gram-positive bacilli with straight ends. According to the literature, they can correspond to bacteria of the genera *Acinetobacter*, *Accumulibacter, Mycobacterium*, which have phosphate-accumulating ability. In results was received the PA25 consortium. Biological removal of phosphates from wastewater is based on the use of phosphate-accumulating organisms (PAOs). Most PAOs representatives are part of the activated sludge microbial community. These include bacteria of the genera *Pseudomonas, Acinetobacter, Aerobacter, Mycobacterium, Enterobacter, Moraxella, Klebsiella, Aeromonas,*

Accumulibacter, *Actinobacteria*, *Tetracoccus*, *Tetrasphaera* [1], and nonculturable species which also have the ability to phosphate-ions accumulate [2]. It has now been proven that the efficiency of biological dephosphatation is higher when using a consortium of microorganisms, since the use of isolated species doesn't provide a high degree of wastewater treatment from phosphates. The composition of the studied microbial communities can be influenced by a number of factors, namely, the chemical composition of wastewater, temperature, pH, dissolved oxygen concentration, etc.

In order to assess the growth and accumulation of biomass of the PA25 consortium, periodic cultivation was carried out under aerobic conditions on various nutrient medium. It was found that the composition of the nutrient medium affects the processes growth and biological activity of phosphate-accumulating bacteria. Cultivation on a nutrient medium with a source of carbon, macro- (nitrogen and phosphorus) and microelements, vitamins (group B), and amino acids, promotes the intensive growth and development of bacteria PA25. Cultivation of the PA25 consortium on a nutrient medium with a minimum content of a carbon source, without nitrates and nitrites, leads to an insignificant growth of bacteria. However, the culture medium contains important nutrients: ions Mg^{2+}, K^{+}, Co^{2+}, Ni^{2+} and Cu^{2+} stimulate the growth and accumulation of polyphosphates in PAOs cells.

In the course of further research, the processes of biological phosphate-accumulation were carried out in a model experiment. The enrichment of PAOs is achieved by recirculating activated sludge through anaerobic and aerobic conditions. At the first stage of the process, under conditions of constant aeration, the concentration of phosphate ions in the system decreased by 10% from the initial value. In anaerobic condition PAOs convert volatile fatty acids (VFAs), to energy-rich polymers known as polyhydroxyalkanoates (PHA) with the most common sorts of polyhydroxybutyrate (PHB) and polyhydroxyvalerate (PHV). The energy required for VFA uptake and PHA generation is produced from hydrolyzing the phosphodiester bonds of stored polyphosphates [3]. This issue is of interest, since a significant concentration of PAOs in activated sludge can intensify the process of biological removal of phosphate ions from wastewater. A decrease in the amount of dissolved oxygen in the medium led to the release of intracellular phosphorus compounds by 67%. Enrichment of activated sludge with small portions of PAO storage culture led to an increase in the efficiency of dephosphatation, which increased by 6% and amounted to 40%. In line with to the calculated data, the theoretically possible removal of phosphate ions in the process of phosphate-accumulation is about 80%, which is twice the experimentally obtained value [4]. In this regard, the issue of increasing the concentration of bacteria of the PAOs group in the activated sludge is urgent.

The consortium of active phosphate-accumulating organisms was isolated from activated sludge. The influence nutrient medium of components on the intracellular accumulation of phosphates has been established future will allow increasing the ratio of PAOs in the technological process of biological wastewater treatment. Bioaugmentation of the bacterial consortium into activated sludge led to an increase in the degree of phosphate removal by 6% and amounted to 40%. The intensification of the process of biological dephosphatation of wastewater will lead to a decrease in the supply of nutrients to water bodies, which contributes to the solution of an important environmental problem.

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GROUNDWATER TREATMENT PLANTS' TECHNOGENIC WASTES APPLICATION AS AN ALTERNATIVE ORE-ALIKE SOURCE FOR IRON-CONTAINING NANOPOWDERS AND GOODS PRODUCTION

According to the regulatory documents' recommendations, for the purposes of household and drinking water supply, it is necessary to use water from underground sources, which quite often contains high concentrations of iron. This is especially typical for the West Siberian artesian basin, which is associated with excessive moisture, poor drainage, intense swampiness of the territory, the presence of organic matter and ferruginous minerals.

Iron compounds are trapping on the deferrization filters and then pass into the wash water. After the settling, wash water returns to the initial point of groundwater treatment plant. However, groundwater treatment plants (GWTP's) technogenic wastes are directing forward to the deposition landfills. As a result, a danger to soil and atmosphere emerges.

The GWTP's technogenic wastes has a finely dispersed structure and consists mainly of iron oxides. GWTP's, which supplies water to the water supply system of a settlement with a population of 100 thousand people at a water consumption rate of 200 dm^3 per person a day, an iron content in the source water of 5.3 mg per dm^3 and an iron MPC of 0,3 mg per dm^3, per day forms 100 kg of such wastes.

Considering of this source of iron as a raw material base for pipe-rolling production is irrational. However, such properties of the GWTP's sludge, such as a high content of iron compounds and a high degree of dispersion, make it possible to find application for this technogenic waste in modern high-tech industries. Iron-based nanosized metal powders are used in additive technologies, non-destructive magnetic flaw detection, in the production of LFP batteries and catalysts. The currently used methods for the production of these powders from metal raw materials are energy-intensive, require sophisticated equipment and, as a result, are expensive.

After dehydration, the wastes from the Velizhanskaya station – is a light brown powder, consisting of 58-82% of iron compounds. The granulometric composition of the initial sludge was investigated by the method of laser beam scattering. After wetting and sonication of the precipitate, 88.3% of the particles had a size of less than 21.34 microns. Thermogravimetric and differential scanning calorimetric analyzes of the sludge have shown that the phase transition of hematite to magnetite with magnetic properties occurs at temperatures from 400 °C.

The proposed technological process consists of the following blocks: (1) Separation of sludge from wash water, (2) Reducing its moisture content, (3) Heating and reduction of iron in a carbon monoxide environment. The originally used gaseous carbon monoxide has been replaced by carbon monoxide produced from coal and carbon dioxide in situ to simplify and replicate the process. The developed technological process ensures the complete course of the reaction by mixing the powdery initial sludge with carbon monoxide in a high-temperature vortex gas-dynamic flow created in a cyclone made of heat-resistant steel. Heat recovery makes the process energy efficient. The selection of the magnetic fraction is carried out using an electromagnet, which excludes the ingress of unreacted iron oxide particles and non-target reaction products into the finished product hopper, thereby enriching the raw material and significantly increasing the mass fraction of the target components in the finished metal-containing powder.

For laboratory testing of the proposed technological scheme, similar conditions were recreated on a smaller scale and with a simplified scheme. The investigated GWTP's sludge was

placed in a muffle furnace in a crucible of its own design on top of coal with a grain size of 5-20 mm, which ensures a more complete course of chemical reactions. The selected temperature ranges from 400 to 600 °C is sufficient to activate the reactions. Solid mixtures do not melt.

The study of the chemical composition of the sludge samples using X-ray diffraction analysis showed that in the composition of the samples at an activation temperature of 400 °C, the predominant forms of iron are siderite and maghemite, which have magnetic properties. Maghemite is unstable to heating and transforms into magnetite with an increase in temperature. In the composition of the samples obtained at temperatures of 500 and 600 °C, magnetite is predominant.

To study the particle size distribution of the samples obtained at different temperatures, a scanning electron microscope and a laser particle size meter were used. Electron microscopy of the sludge showed that after thermal activation at a temperature of 400 °C in a carbon monoxide medium, the sludge particles have a quasi-spherical shape with a developed outer surface and are subject to sticking due to the presence of low-melting and water-soluble compounds. With an increase in the processing temperature, the sticking effect disappears due to the transition of low-melting compounds into a gaseous form and a change in the crystal lattice of iron-containing compounds. The particles obtained at a temperature of 450 °C had the most pronounced spherical shape, low open porosity, and a low degree of adhesion with neighboring particles, which are key properties for products based on micro- and nanopowders. As a result of the development of crystallization processes, an increase in the temperature of sludge processing led to the adhesion of particles and their fusion into large aggregates with a brittle structure.

The use of ultrasonic treatment of the samples obtained after thermal activation and placing them in a liquid medium has shown the possibility of achieving the d50 index equal to 70 - 90 nm for samples processed at 400 - 500 °C.

The main result of the research is the identified resource potential for the production of nanosized metal-containing powders of a wide range of applications, including for the needs of high-tech industries. Together with the relative simplicity and low cost of the projected technology, the studied type of technogenic raw materials can be the foundation for the economic growth of regions and countries with an insufficient degree of socio-economic development.

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MICROWAVE ASSISTED METHOD FOR ALKALI TREATMENT OF NANO-POROUS BENTONITE TO ENHANCE METHYLENE BLUE ADSORPTION

Introduction. The industries utilizing dyes are the biggest wastewater producing industries [1]. Industries such as textile, paper, plastic, and food employ dyes to color the final products. Approximately, 100 tons of dyes per year are discharged into water steams by textile industries [2]. The discharge of dying wastewater to rivers and basins pose a potential risk to local resident’s health and ecosystem. Therefore, the effective treatment of dyeing wastewater becomes a task of top priority [1, 2]. Adsorption is a method to be highly efficient for the

removal of color in terms of cost, simplicity of the process, and insensitivity to toxic substances [2, 3]. Natural bentonite is the most widely used adsorbent because of its excellent adsorption efficiency for the removal of organic compounds [4]. It is well known that natural bentonite cannot remove synthetic dyes effectively. In this regard, the low-grade bentonites can be greatly improved by activation process. The efficiency of natural bentonites can be increased by interlayer expansion spaces via physical activation [5].

Main Part. Conventional heat treatment, in which energy is provided from external sources like gas, oil and electricity, is generally used for the fabrication of activated bentonite. However, the conventional heat treatment may take several hours to reach the desired level of activation with heterogeneous distribution of active sites, leading to the incomplete activation. Microwave radiation has been employed to produce adsorbents in which energy is rapidly and uniformly distributed into the material. The microwave-assisted activation seems to be able to remove contaminants quickly and efficiently from wastewater.

In activation process, the microwave power plays an important role. The natural bentonite could be effectively heated by the microwave technique, indicating that the power acts as the main factor in the development of the porous structure. Activation of bentonite in a suspension environment with microwave has been done before, but it should be noted that the activation of paste samples with microwave will be done for the first time. The microwave technique provides fast and uniform heating of a material. Microwave processing has demonstrated significant reduction in costs of manufacturing advanced materials due to energy saving and short processing time.

Conclusion. It is possible to convert natural bentonite to an efficient adsorbent by rapid microwave-assisted technique for removing dyes from wastewater compared with the performance of adsorbents conventionally produced but the following consideration should be noted:

– The efficiency of commercial bentonite compared with the microwave-activated bentonite to remove dyes from wastewater depends on time and radiation power.

– The advantage of microwave activation for improving the porous structure of activated bentonite is that it shortens the residence time to produce the appropriate adsorbent in comparison to the conventional heating procedure.

– The natural bentonite is mainly mesoporous while the number of mesopores were developed in adsorbents produced conventionally with partial destruction of clay minerals. The microwave-activated bentonite influences recovery efficiency by increasing specific surface area simultaneously maintaining the layered structure.

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PROSPECTS FOR SCANDIUM EXTRACTION FROM KIZILKUM PHOSPHORITE COMPLEX SLUDGE

In the crust, the specific minerals of scandium are very rare. Moreover, there are only small economic reserves of Sc bearing minerals including only thortveitite $(Sc,Y)_2Si_2O_7$, scandium phosphite $ScPO_4*2H_2O$, bazzite $Be_3(Sc,Al)_2Si_6O_{18}$, titanium silicate mineral $Sc(Nb,Ti,Si)_2O_5$, and befanamite $(Sc,Zr)_2Si_2O_7$, etc. In nature, scandium mostly occurs in ilmenite, zircon, bauxite, rare earth ore, V-Ti magnetite, tungsten ore, tin ore, uranium ore, coal, and other minerals [1]. *Within* the scandium-bearing ores, scandium is often associated with other rare earth elements, titanium, vanadium and uranium. The global scandium reserves are about 2 million tons, with China accounting for 27.5%, ranking first in the world. There are more than 800 kinds of scandium bearing minerals, which are complex in mineral composition and low in scandium content. They are distributed in other minerals in isomorphic or adsorption states, making the enrichment, separation, and extraction of high-purity scandium quite complex [2].

According to geological prospecting data, the total amount of rare earth elements (REE) in the phosphorite ores of the Jeroy-Sardara deposit of the Central Kyzylkum is in the range of 400-890 g/t [3]. In the process of selective leaching by the highly concentrated sulfuric acid in the process of obtaining superphosphate, up to 40% of rare earth elements are transferred into the solution. During the deposition process of uranium from solution, 50% of the rare earth elements in solution are precipitated together with uranium, and the REE separation rate is 25-30% compared to the initial ore [4].

Different methods are used to separating scandium from impurities and to separate it from other REEs. For example in the process of scandium extraction from bauxite ore residues, phosphoric acid had an advantage in separating scandium from impurities over hydrochloric acid, sulfuric acid and nitric acid. Under the optimal conditions of phosphoric acid concentration of 6–8 mol/l, leaching temperature of 120–140 °C, leaching time of 60–90 min and liquid-solid ratio of 10–12 ml/g, the leaching of scandium exceeded 90%. The majority (98.64%) of scandium could be further extracted via solvent extraction under the conditions of P 204 concentration of 2%, pH value of 1.8 and aqueous-organic ratio of 3:1. [2].

The sludge of the Phosphorite Combine has the following chemical composition. (Tab.1).

Table 1 – Chemical composition of sludge of Central Kyzylkum.

№	Components	Amount (%)	№	Components	Amount (%)
1.	P_2O_5	15,1	8.	U	0,006
2.	Al_2O_3	1,5-3,0	9.	REE total	0,04-0,089
3.	SiO_2	6,0-8,0	10.	Fluorine	1,8-3,2
4.	CaO	42-48,1	11.	SO_3	2,5- 3,5
5.	MgO	2,5-3,5	12.	H_2O	10,0
6.	Fe_2O_3	0,6-0,8	13.	Organic matter	2,8-3,0
7.	CO_2	8-15	14.	Indissoluble part	8,0-8,2

As a result of mass spectral analysis of phosphorite sludge samples obtained for the experiment, the content of Sc in this was determined as 8.7 g / t, respectively.

The research work was carried out at the Navoi State Mining Institute. Samples were taken from 100 g of phosphorite ores and sludges and these samples were dissolved in sulfuric acid solutions of different concentrations (mixing duration 30 minutes).

Studies have shown that reaching 10 g/l of sulfuric acid concentration dramatically increases the solubility range of scandium in the ore by 6.8 mg/l (62%) and the concentration of 30 g/l increases this figure to a maximum value of 9.0 mg/l (82%). Also, the solubility of scandium in sludge reaches 7.30 mg/l (84%) when dissolved in 4 g/l concentrated acid, and when dissolved in 30 g/l concentrated acid, the range of solubility reaches to 8.50 mg/l (98%). Being acid concentration of 40 g/l does not have a positive effect on the solubility range of scandium, which is 9.0 mg/l (82%) and 8.0 mg/l (92%), respectively, for ore and sludge.

The analysis of the obtained results shows that the point of intersection of the optimal values of the degree of transition of the scandium element to the solution and the degree of enrichment of phosphorite sludge as a result of treating with sulfuric acid for phosphorite ore of Central Kyzylkum is the 6 g/l concentration of sulfuric acid, the dissolution rate of scandium and the enrichment rate of the sludge of the phosphorite plant, the sulfuric acid concentration is 7 g/l, the dissolution rate of scandium and the enrichment rate of the sludge are 82% (7.10 mg/l Sc) and 127% (19.1 % P_2O_5), respectively.

It was found that the scandium element in the phosphorite sludge of the Phosphorite Combine can be transferred to the liquid phase using a weakly concentrated sulfuric acid solution, with optimal concentrations of sulfuric acid at 6 g / l and 7 g/l, respectively. In this process, the value of the pH is around 7, which in turn does not cause corrosion, erosion of the equipment in the processes aimed at the separation of scandium from the liquid phase. The absence of loss of P_2O_5, the main component of the sludge, and the increase in the amount of P_2O_5 in the solid phase obtained, are the basis for the involvement in the production of phosphorite sludge, which are currently out of balance, and lead to the selective separation of the element scandium from these raw materials.

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QUANTUM DOTS FROM COFFEE WASTES FOR MINE WASTEWATER DETECTION

Water is critical for all types of mining. In some locations, significant rainfall can lead to acid runoff from mine drainage, tailings piles, and surface mines, polluting streams and rivers. In drier locations, the mining and processing of ores can deliver a one-two punch to local water supplies, both using up groundwater and toxifying aquifers. In general, mining wastewater may

be highly acidic and high in suspended solids. It's common to find contamination with organic compounds, metals, heavy metals, and metalloids like arsenic, iron, and end up in landfills and incineration plants. There is a potential of synthesizing functional carbon-based materials from selected food wastes that can be used to adsorb heavy metals in mine waste manganese [1]. Not only are many productive mines around the world located in areas with stressed water supplies, but also, mining activity has contributed to the degradation of what little fresh water is available. In order to prevent further environmental contamination, mining companies can turn to advanced wastewater treatment solutions that produce water suitable for reuse.

Because mining wastewater can be highly variable, so are treatment strategies, which generally include several different stages and technologies. The waste water treatment is beneficial to the mining industry and has the potential of lowering the production costs. Some of the areas where the treated waste water could be used include and not limited to, temporary or permanent worker encampment; reuse in landscaping or dust control on roads, release to surface water or injection into groundwater; Remediation and mitigation of wastewater when closing a mine [2]. Lately, scientists are employing nanotechnology to generate nanoscale materials with enhanced properties for various applications. In deed some argue that nanotechnology as providing developing countries with ample opportunity to promote sustainable development. One of such applications is in water treatment especially detection of the heavy metals in mine waste water. Another challenge facing most developing countries is the management of wastes. The uncontrolled disposal of solid wastes generates serious heavy metals pollution that occur in the soil, water, serious health risks for the people living close to the dumpsites. Additionally, the high concentration heavy metals reduce crop yields, inhibits the growth of plant, and affecting the immune and digestive system in mammals. More seriously, burning the solid wastes produces dangerous gases that affects the atmosphere.

Food wastes are a potential source of valuable nano elements when they are recycled, because they have a relatively high carbon content. The quantum dots exhibit properties such as magnetic quantum tunneling, special electrical, photochemical and optical properties that enable them to be used to detection of heavy metals in metals in mining waste water. There is a potential of synthesizing quantum dots from waste coffee husks and use for detecting the heavy metals in mine waste water. Nanomaterials can also be employed to adsorb the heavy metals from the mine waste water rendering it fit for consumption. The treated mine wastewater can be used in landscaping, irrigation, dust control, and even drinking water. This will reduce wastewater-disposal expenses and protects local water sources while meeting the most stringent standards required for water resources protection by governing authorities [3].

Motivated by need to provide a low-cost natural way of treating acid mine drainage, this research work studies the viability of synthesizing quantum dots from ground coffee waste for detection of heavy minerals produced in an active iron mine in Kenya. Coffee wastes may offer considerable promise as a low-cost natural medium for mine waste water treatment.

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SCIENTIFIC BASIS OF THE PROSPECTS FOR UTILIZATION OF INDUSTRIAL AND MUNICIPAL WASTE IN COMPOSITION FUELS WITH ENERGY GENERATION

Nowadays, one of the world's major environmental problems is pollution by industrial waste and municipal solid waste (MSW). Only in Russian Federation more than $94 \cdot 10^9$ tons of waste are stored at landfills. According to experts [1,2], with a constant current disposal rate of used materials, the annual global increase in solid municipal waste (MSW) will increase from 2.1 billion tons at present to 3.4 billion tons by 2050. About 70% of municipal waste is not recycled and is stored at landfills, polluting the environment as a result of a slow process of natural decomposition [1]. Their relatively high energy potential, as well as the need to reduce landfill loading and improve the environmental situation characterizes the prospects for waste utilization by burning as part of composite liquid fuels (a mixture of fine coal, water, and used industrial oils).

Experimental studies of the combustion process of composite fuel [3–6] have been carried out to substantiate the prospects for practical application of the developed strategy. The analysis of high-speed video recording made it possible to highlight the following main stages of interaction between a single droplet of composite liquid fuel with the motionless pre-heated air [3]: inert heating; moisture evaporation from the near-surface layer; thermal decomposition of solid combustible components (coal and municipal waste); mixing combustible gases with oxidizer vapors; gaseous mixture ignition and burnout; solid residue heating; heterogeneous ignition and combustion of the solid residue. The obtained result is explained by the decisive influence of a fine solid combustible component (coal) in the fuel mixture composition on the consistent patterns of physical and chemical processes taking place during fuel heating. Single 2 mm droplets of composite fuel are reliably ignited and burn out in a motionless air at temperatures 600–1000 °C. The minimum values of the gas-phase ignition delay time are 3 s, the maximum are 25 s. The maximum temperature in the combustion process reaches 1300 °C [4]. The burning temperatures of fuel compositions without adding used oil are 200–300 °C lower. When varying the component composition of the fuel, the threshold ignition conditions were established at which the fuel sample disperses, which intensifies its burnout (the minimum values of the ignition delay time are 1 s, the maximum are 4 s.) [5]. They are necessary for micro-explosive breakup of droplets for a group of waste-derived fuel compositions, based on wet coal processing waste (fine coal + 50 wt% of water) with vegetable oils (rapeseed, castor) and used petroleum-based oils (motor, turbine, transformer, hydraulic, and compressor) [5]: 1) oil concentration in the fuel is no less than 40 wt%; 2) the temperature of the air medium, in which combustion is initiated, is no less than 850 °C. A high-speed video recording system is used to establish consistent patterns of physical and chemical processes, as well as ignition and combustion characteristics (ignition delay times, burnout time, velocity of breakup products, and size of their burnout area) for a group of fuels under the conditions of droplet breakup. A hypothesis about how the composition of the component affects the breakup of droplets during ignition was formulated based on the results of analyzing the properties (initial boiling point and evaporation rates of oils, their surface tension and surface free energy, as well as wettability of dry coal processing waste) of separate fuel components.

In this research [6], we have analyzed the concentrations of harmful gases in composite fuel combustion products. The maximum concentrations of the main anthropogenic emissions (CO_2 – 16–18%; CO – 180–370 ppm; NO_x – 190–400 ppm; SO_x – 75–135 ppm) in flue gases from composite fuel combustion do not exceed those from dry coal combustion. The addition of

used oils to the composition of fuels, on the one hand, has a positive effect on reducing the concentration of dioxins and furans in the flue gases when burning out typical MSW in the fuel composition due to higher combustion temperatures; on the other hand, it negatively affects the increase in anthropogenic emissions. But this deterioration of environmental characteristics does not lead to exceeding the maximum permissible regulatory emissions of pollutants from TPPs for burning solid fuels (CO_2 – 16–18%; CO – 258–344 ppm; NO_x – 340–513 ppm; SO_x – 450–526 ppm).

Based on the experimental research findings, we have elaborated the main elements of the strategy [6] of combined industrial and municipal waste recovery by burning it as part of composite fuels, as illustrated by three neighboring industrialized regions of the RF with different levels of social development and industrial structures. This strategy suggests switching three typical coal-fired TPPs (one in each of the regions) to composite liquid fuel. It will reduce the negative impact of waste on the environment, on the one hand, and diminish the consumption volume of high-quality coals for heat and electricity generation, on the other hand. Implementing the developed strategy for 25 years will save 145 mln. t of coal, recover 190–260 mln. t of industrial and municipal waste, and generate $10.1 \cdot 10^9$ kW·h of electricity and $9.7 \cdot 10^6$ Gcal of heat energy. The positive economic effect, considering the modernization of fuel handling systems at TPPs and the construction of a central fuel preparation plant, will make up from 5.7 to 6.9 billion dollars, or 65–78%, respectively, of the main costs of three TPPs operating on coal within the identical period.

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LAND APPLICATION OF SEWAGE SLUDGE FOR POST- MINING RECLAMATION

Mining leads to severe disturbances in landscape and soil properties, which cause the formation of technogenic-polluted and disturbed lands. For 2020 (in the Russian Federation), more than 437.4 thousand hectares are technogenic disturbed lands [1] with low socio-economic value and an adverse impact on the environment. The ecosystem reclamation can restore soil quality over time with return public safety and land productivity. The main challenges of biological reclamation of post-mining lands are soil contamination, low soil fertility, and a lack of moisture, nutrients and organic matter. Thus, innovative reclamation techniques and new soil amendments in disturbed lands are essential to understanding effective ecosystem restoration approaches.

One of the implemented land reclamation methods that combine mines land restoration and waste reuse is applying composted municipal sewage sludge as fertilizer for low-nutrient lands. A potential reclamation method is to use sewage sludge from pulp and paper mills for the reclamation of post-mines lands. Pulp and paper mill wastewater sludge (PWS – pH 6), like municipal sludge (MS – pH 6,0-7,5), contains high nitrogen (average ~5-20% MS), and organic carbon (>90% PWS; 25-80% MS) content. Additionally, a quarter of the sewage consists of lignin fibre, which increases soil fertility during humification processes in suitable conditions. Thus, this soil improver is classified as a long-release amendment which reduces the need for further re-fertilizations.

PWS is a grey moisture-absorbing mass (70-75%), which can be used as an ameliorant due to its high organic matter content, the presence of optimal nutrient concentrations (nitrogen ~ 0.36%, carbon ~ 47%, phosphorus ~ 0.16% and calcium> 7%); Moreover, PWS improves water retention capacity, reduces soil density (PWS ~ 0.72 g/cm3 in soil). The disadvantages of the substrate are potential environmental hazards: the possible presence of heavy metals and the number of bacterial pathogens.

The assessment of sewage sludge fertilizing efficiency and environmental safety can be conducted by two main approaches: 1) the assessment of the effect on soil properties, 2) the effect on plants vegetation. The parameters for analysis "time-response" and "dose-response" considers such factors as physicochemical parameters of the soil, prolonged action, growth and vegetation of plants, ecological safety of composition, the qualitative and quantitative composition of soil microflora.

The theoretical and experimental assessments of PWS showed that a single application of PWS to the soil does not lead to the accumulation of heavy metals above the permissible standards (Cu – 210/750* mg/kg; Zn – 430/1750* mg/kg; * – GOST R 54651-2011 for reforestation) improves the growth and vegetation of herbaceous plants without negative impact (accelerate plant growth – by 15% and increases aerial biomass – by 25% [2]; and is not inferior to the most common soil amendments (as peat). However, over-application of unfavourable climatic conditions (soil moisture > 70%, air temperature < 20^{o}C) can lead to the phytopathogens growth.

Thus, with proper consideration of conditions and calculation of doses, PWS can be a similar analogue to traditional soil amendments. Potentially, using PWS as a soil additive reduces remediation costs, conserves “clean” fertilizer resources, disposes of pulp and paper waste and restores disturbed land, which is consistent with the principles of the Circular Economy (EC) model.

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ASSESSMENT OF TURBIDITY AS A PARAMETER INDICATOR OF TREATMENT IN A DRINKING WATER TREATMENT PLANT IN ECUADOR

The efficiency of a drinking water treatment plant is linked to compliance with legislation on the quality of supplied water regardless of changes in the quality of the influent water. This is how turbidity has been positioned as an important physico-chemical parameter to measure the water quality in the supply sources and in the supplied water to users. Turbidity as an optical property is not a direct health risk, but it has been associated with the presence of bacteria, with increased demand for chlorine, with the formation of disinfection by products (DBPs) and with promoting biological growth in the distribution system, therefore, it is suggested to use this parameter as an indirect indicator of the quality of water collected from surface sources [1-2]. The main objective of this research was to analyze turbidity as an indicator of the quality of raw water entering the purification process of the treatment plant in the canton of Pedro Vicente Maldonado (Ecuador). The research goal was to determine the correlation level that presented turbidity with parameters such as pH, apparent color, total suspended solids, iron, nitrites, nitrates, ammoniacal nitrogen, sulfates, manganese, electrical conductivity, total coliforms and fecal coliforms; to analyze the dynamic variation of the raw water turbidity, to identify the critical months during the operation of the plant and to determine if the treated water meets the limits established by the Ecuadorian standard and the WHO.

The canton Pedro Vicente Maldonado is located in the northwest of Pichincha province at an average altitude of 620 meters above sea level and has an area of 656.5 km^2. The zone has a warm humid climate, without registering major changes in temperature, with an average temperature between 20°C to 25°C. Intense rains are recorded in winter, from December to May, while from June to November there are a smaller number of rains. The raw water entering the water treatment plant comes from the Talala River. The catchment area is located on the E28 road in the canton Los Bancos at coordinates of 0 ° 04'41,5 "N 78 ° 56'14,8" W. Owing to the force of gravity the water flows 17 km through the pipeline to the water treatment plant, which is situated on the eastern part of the town's outskirts, in the commune of La Celica, at coordinates 0 ° 04'42.9 "N 79 °. 01'51.9 "W. The water treatment plant was opened in 2012. It is a conventional plant treating 30 liters of water per second through flocculation (aluminium polychloride), precipitation, filtration (4 sand filters) and chlorine gas disinfection. Water samples were collected at a location where water is pumped from reservoir to the water treatment plant during 2017 and 2019 years as prescribed by the recommendations of the Ecuadorian standard INEN 2176:98.

According to the calculated Pearson's correlation coefficients it is evident that there is a moderate correlation between turbidity and fecal coliforms ($r = 0.44$), turbidity and nitrites ($r = -0.49$), turbidity and pH ($r = -0.53$); and a good correlation between turbidity and color ($r = 0.69$) and turbidity and conductivity ($r = 0.69$). Suspended solids are responsible for the turbidity and water color, both are related to the presence of fulvic and humic acids, that are main precursors of the formation of byproducts of the water disinfection with chlorine [3]. On the other hand, conductivity is used as a substitute for the concentration of total dissolved solids in water [4]. Therefore, its concentration defines dissolved solids referred to salts and organic residues. In this sense, we can say that the turbidity of the incoming water is largely related to the organic matter presented in the water that enters the treatment plant of the canton.

The highest concentrations of turbidity were observed in the period from January to April (January: 3.29 NTU, February: 5.19 NTU, March: 4.26, April: 4.28 NTU). This coincides with the winter period in the canton, where February is the month with the highest average amount of rainfall (816 mm.). The lowest concentrations of turbidity were recorded in the months July (2.53 NTU), August (2.24 NTU), September (2.25 NTU) and October (2.84 NTU), coinciding with the period when the lowest amount of rainfall was recorded. Since the turbidity concentration was low in this period, the water treatment process was only reduced to filtration and chlorination processes. On average, it was determined that the turbidity removal efficiency remained higher than 80% during 60% of evaluated period. The lowest removal rates were recorded in August, September and October.

There were obtained the following parameters for the treated water during the study period: pH = 7.1, turbidity = 0.62 NTU, color = 5.5, total suspended solids = 6.71 mg/l, iron = 0.2 mg/l, nitrates = 0.05 mg/l, nitrites = 0.08 mg/l, ammoniacal nitrogen = 0.15 mg/l, total coliforms = 0 CFU/100 ml, fecal coliforms = 0 CFU/100 ml, sulphates= 8.08 mg/l, electrical conductivity = 24.06 mg/l, manganese = 0.024 mg/l. All evaluated parameters meet the requirements established by Ecuador and WHO.

Based on the obtained results, it is determined that there is a positive linear correlation of medium to strong between the turbidity and the following parameters: electrical conductivity, apparent color and fecal coliforms. These parameters could be considered as indicators within the operational evaluation of a water treatment plant with characteristics similar to those of the study. The influent's turbidity is possibly affected by variations in precipitation. On average, the turbidity removal efficiency of the water treatment plant is 80%. In general, the treated water meets the requirements established in the Ecuadorian regulations and WHO guidelines on water suitable for human consumption.

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A STUDY OF ZN^{2+} AND CU^{2+} IONS ADSORPTION BY NATIVE AND CHEMICALLY MODIFIED PEA (PISUM SATIVUM) PODS

Environmental pollution by various pollutants is becoming increasingly threatening. One of the most severe pollutants are heavy metal ions that enter water bodies with production wastewater. Zinc and copper ions are often present in the wastewater of machinery production, ore dressing plants, chemical, pharmaceutical, and other industries. Getting into natural water sources, zinc and copper ions can subsequently enter living organisms, including humans, through water supply systems. One of the most effective ways to remove metal ions from various aqueous media is the adsorption method based on extended surface absorption [1]. However, activated carbon used in industry for organic compounds removal are not very effective for

heavy metal ions extraction. The solution to this situation is the use of cheap sorption materials from industrial and agricultural production waste as reagents for removal of various pollutants from natural and wastewater. By-products of agricultural raw materials are very promising as adsorption materials for heavy metal ions extraction. By-products of legumes are very promising as sorption materials to remove heavy metal ions from water [2]. The latter contain proteins that are known to form complex compounds with metal ions, which increases their sorption capacity. In connection with the above, this work was devoted to Zn^{2+} and Cu^{2+} adsorption by native and chemically treated shells of pea (*Pisum sativum*) pods.

Initially, pea pods were treated with 1, 2, and 3% sulfuric acid and sodium hydroxide solutions. To this end, the pea pods were finely cut (to a size of 1 to 10mm), washed with distilled water and placed in an acid or alkali solution for 5 hours at 20°C. After the above period, the sorption material was extracted, washed with distilled water to a neutral pH, and dried at room temperature. The effect of treating pea pods with solutions of sulfuric acid and sodium hydroxide on the chemical composition and structure of the material was studied using the elemental analysis, X-ray diffraction analysis, and IR spectroscopy methods. Based on the obtained data, was obtained such data as sorption capacity, degree of crystallinity and sorbent composition.

Cu (II) and Zn (II) ions were absorbed with native and modified pea (*Pisum sativum*) pods at 20°C (the room temperature). To this end, the suspended sorption material weighing 1 g was placed in flat-bottomed 250 cm^3 flasks. Then 100cm^3 of copper (II) sulfate and zinc (II) sulfate solutions was added, the concentration of Cu (II) and Zn (II) ions in which varied from 100 to 1500mg/dm^3. It was found that the modification of pea pod surface with sulfuric acid and sodium hydroxide solutions resulted in the formation of a more rough surface. It is known that sorption materials with a more developed surface show better sorption properties compared to materials with a uniform surface.

Processing the adsorption isotherms in the framework of the monomolecular adsorption models, i.e. Langmuir, Freundlich, and Dubinin-Radushkevich, showed that almost all the processes studied are best described by the Langmuir model, that is, adsorption occurs on a uniform surface of the sorption material, where all active centers have the same sorption energy and the sorption process occurs uniformly throughout the material surface. In some cases, there is a better similarity with the Freundlich model [3]. This phenomenon can be accounted for by the fact that the modification of the material in this case did not proceed evenly, which resulted in the formation of active centers with a higher sorption energy and the uneven process of copper (II) ions adsorption. The calculated values of the thermodynamic values of the processes (sorption energy and Gibbs energy) indicate that in all cases spontaneous physical adsorption occurs and in modifying pea pods with sulfuric acid and sodium hydroxide solutions the sorption process is more preferable.

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RECYCLING OF METALLURGICAL SLAGS FOR WASTEWATER TREATMENT

Steelmaking slag and blast-furnace slag are the most voluminous wastes of ironmaking and steelmaking processes. More than 5 billion tons of metallurgical slugs are produced in Russia every year [1]. At the Novolipetsk Steel this waste is generated in amount of more than two million tons annually. The storage of a large volume of slag has become a significant issue for enterprises. In addition, the collection and dumping of the slags lead to considerable influence on the environment and its components.

There are several large steel companies in Russia, one of which is Novolipetsk Steel (NLMK Group). The company is an international producer of iron, steel, and steel product. NLMK Group has branches in Russia, the USA, and Europe. For a long time, the Group has created a chain of recycling production and consumption wastes by building collection points for scarp metal in large cities. It helps to recycle up to 65% of metal wastes [2]. But the major waste of the industry is steelmaking slag and blast furnace slag. On the main production site of NLMK, this waste is generated in the amount of 2 million tons annually. Because of the long history of the industry, major chemical and physics characteristics of the slag were investigated, which helps to implement the material in some production processes. For example, the slag can be used in drainage systems, in Portland cement, in the layers of roads. But not all of the fractions of the slag are suitable for such production. The major part of the waste is fractions smaller than 10 millimeters, and they are not applicable in any process. NLMK produces about 1 million tons of steelmaking slag with a particle size of less than 10 mm. As the slag does not use in further processes, it is stored on the enterprise`s territory. Slag heaps also affect the quality of air, soil, and groundwater. Thus, there is an issue of recycling or reuse of the small fraction of steelmaking slag.

The presented work is devoted to the actual topic of utilization of steel-making slag of fine fractions. The fractions are formed during the production of steel by the converter steelmaking process. To solve the issue, chemical and physical characteristics were investigated and measured. Exploration of the chemical composition of two fractions of the slag showed the presence of the Fe-, Mn-, Cr-, Co-, Cu-, Zn-containing compounds. To exclude the possibility of the contamination of treating water the desorption experiment was held. Due to the results of the experiment, the leaching of heavy metals compounds does not occur. That makes it possible to apply the material in the water treatment processes. The surface of the fractions was surveyed and surface areas were measured to identify sorption qualities. Statics experiments were held with model solutions to determine components that can be removed by slag. The results showed that removing metal ions is realized by increasing the pH level and sedimentation of insoluble hydroxides of metal ions. Also, the optimal time of treatment and the amount of the slag was determined. Several metal cations generate hydroxides in strongly alkaline conditions while others can be dissolved at high pH levels. As a consequence, the treatment process needs to be held partly, by using a stepwise purification system with gradually increasing the pH level.

Applying the slag in wastewater treatment processes allows for the rational use of resources and high-quality disposal of a large amount of production waste. This consequently helps to achieve Sustainable Development Goal 12, which is devoted to the insurance of sustainable consumption and production patterns. Several propositions were highlighted to achieve the goal. One of the propositions is to reduce production and consumption wastes by recycling, reducing, and reuse of them. Also, the mechanical and physicochemical impact on the surrounding soils and ground water can be lowered. Reducing the impact on land is also influence on the SDG 15 which is dedicated to the rational use of land resources. And since this

waste is used in wastewater treatment, it partially affects the fulfillment of goal 6 related to sanitation and clean water [3].

Recycling of the steelmaking slag in wastewater treatment processes allows to reduce the load on environmental components and reduce the cost of negative impact. Besides, recycling of the steelmaking slag in wastewater treatment processes allows to reduce the load on environmental components and reduce the cost of negative impact.

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COMPREHENSIVE PROCESSING OF TECHNOGENIC RAW MATERIALS TO OBTAIN PRODUCTS WITH DESIRED PROPERTIES

More and more land areas have to be alienated for the disposal of technogenic waste. These territories often exceed the size of the enterprises industrial sites. Disposed waste is a complex source of environmental pollution. Utilization of large-tonnage industrial waste is one of the most pressing environmental issue in the world.

An example is the production of phosphoric acid and various phosphorus-containing fertilizers. As a result of the extraction of phosphorus from raw materials, a large-tonnage phosphogypsum (PG) waste is formed, which contains more than 80% $CaSO_4$ * $2H_2O$. The global annual output of PG per year is more than 150 million tons. In Russia, the annual output reaches 14 million tons. According to the UN, up to 4% of PG are processed in the world. In Russia, the average level of beneficial utilization of this waste is no more than 2.0% [3].

3 huge phosphogypsum dumps are located in the Northwestern Federal District of Russia. The mass of the disposed waste is 150 million tons. This amount is growing by 4 million tons per year. In the humid climate of the region, complete isolation of the dumps from the environment is impossible. The issue of waste utilization in conjunction with the need to monitor disposal facilities is one of the most relevant for the Northwestern Federal District and Russia as a whole.

The study deals with the urgent problem of utilization of the large-tonnage technogenic waste of the mining and processing industry. The aim is to develop a technical solution for the effective use of phosphogypsum as a secondary material resource.

The scientific novelty of the research is:

– the establishment of physicochemical laws underlying the processes of extracting valuable components from PG. Special attention is paid to the issue of obtaining products with desired properties. Namely, it is regulation of the particle size of finely dispersed phosphochalk ($CaCO_3$);

– the use of the PG industrial carbonization to reduce the carbon footprint of an enterprise.

The practical significance of the study lies in the development of rational compositions of commercial products based on PG, promising for use in various industries, as well as in the joint utilization of PG and CO_2.

There are known studies devoted to the production of ammonium sulfate $(NH_4)_2SO_4$, phosphochalk ($CaCO_3$) and a concentrate of rare earth metals from PG in a solution of ammonium carbonate $(NH_4)_2CO_3$ with additional supply of CO_2 [4]. Finely dispersed phosphochalk is formed as a result of the precipitation process. As a product of hydrochemical synthesis, it has increased chemical activity and can be directly used instead of limestone to obtain alumina, chemical products, cement and in other industries [2]. $CaCO_3$ is in great demand in metallurgy. It is used as a flux for converting refractory natural silicates into more low-melting slags. As part of the analysis of the potential sales market in the Northwestern Federal District, it was established that phosphomel may be in demand by the Cherepovets Metallurgical Plant. When organizing PG-processing at Apatit JSC (in Cherepovets as well), logistics costs are minimized, which increases the competitiveness of product and technology.

The modern industry is interested in a product like phosphochalk. The size of phosphochalk particles is 2-6 microns. Its use allows to reduce the number of raw material preparation stages. However, the finely dispersed $CaCO_3$ crystals is also the main disadvantage of existing technological solutions for processing PG to phosphochalk. The separation of the product from the solution becomes more difficult. The wear of the equipment increases, which requires more frequent maintenance.

Within the framework of this study, it is proposed to assess the possibility of producing phosphochalk from PG by the gas-liquid method. The essence of the method is the saturation of the PG-suspension in the $(NH_4)_2CO_3$ solution with carbon dioxide. As a source of CO_2, it is proposed to use waste industrial gases formed during the production of mineral fertilizers [1]. This will help to reduce the carbon footprint of technological processes.

Thus, the development of the proposed research topic can be considered promising and relevant for the mineral resource complex.

The following tasks are performed during the research: 1) review of the chemical composition and properties of industrial gases; 2) laboratory analysis of the composition and properties of PG samples; 3) study of the kinetics of $CaCO_3$ formation and crystallization by controlling parameters in the course of experimental tests; 4) analysis of the obtained phosphochalk. The study was carried out on the laboratory and experimental base of the accredited Center for the Collective Use of High-Tech Equipment of the St. Petersburg Mining University

The result of the research is the development of new technical solutions to obtain products with desired properties based on technogenic low-grade raw materials with the substantiation of economic and environmental prospects for their beneficial use in the North-West region of Russia. Thus, the implementation of these technological solutions will lead to a more rational use of the country's mineral resource base and an increase in the efficiency of its reproduction, as well as a decrease in the level of environmental pollution.

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STUDY OF TECHNOLOGIES FOR PROCESSING SOLID WASTE ON A POLYMER BASIS

In all developed countries, there are and are very significant problems associated with the increase in the amount of solid household waste. Various types of plastic waste, automobile tires, and other polymer - based materials classified as recycled materials poison the air, soil, and water bodies of cities. As the main method of processing such waste, it is traditionally accepted to use disposal in the form of incineration or burial. The authors of the article consider alternative options for the processing of human waste, the use of secondary raw materials, in particular the processing of solid household waste, with the production of marketable products.

As you know, the reserves of organic oil are not unlimited. All over the world, people are moving from land to sea in search of new deposits, while at the same time they are looking for alternative ways to meet the growing energy needs. Currently, traditional fuels are widely used in industry and technology: gasoline, kerosene, diesel fuel, liquefied gas (LNG), methane.

In connection with the aggravation of the environmental situation around the world, the question of finding effective ways to dispose of household waste has become a question. One of these methods can be the method of waste processing proposed by us to obtain, in the form of a final product, an energy carrier from plastic. (Figure 1)

Plastic is, first of all, garbage, and it is environmentally harmful and practically non-recyclable for a long time. In 2005, Japanese scientists proposed a technology for recycling plastic waste and producing raw oil from it. However, the first industrial Envion Envion Oil Generator line was created in the United States in 2009, which allowed generating more than 150 million barrels of synthetic oil annually on a national scale. From 1 ton of plastic raw materials using Envion Oil Generator technology, 500-600 liters of high-quality synthetic oil, light or medium fractions are obtained.

Many countries are planning to start recycling plastic waste, but only a few countries are actually implementing new technologies in this area. One of them is Israel. According to rough estimates, the population of Israel throws 1,500 tons of plastic waste into garbage bins every day – general or special. [1]

Polymers are substances that consist of repeating groups of atoms (units), from which long macromolecules (polystyrene, polyvinyldene chloride, celluloid) are assembled. Such links are connected to each other by chains, through chemical bonds. Polymer-based materials are mostly used in the production of packaging and construction materials. A distinctive feature of such materials is their low ability to decompose. The level of use of polymer materials in Russia is one of the highest in the world, and the degree of utilization and recycling of such materials is low. It follows that the problem of environmental pollution from polymer waste is much more acute than in other developed countries.

Given the constant population growth, we can safely say that the demand for polymer-based packaging materials will only grow. This dependence is directly proportional to food and other industries, the number of which is steadily increasing from year to year. Consequently, the level of environmental pollution will also rise [2].

The category of industries that pollute the environment with this kind of waste is water transport. This category also includes waste from the production and operation of vessels for various purposes that are generated during the transportation of passengers and cargo. In addition to the above, the source of waste generation is the ships themselves, decommissioned from

operation. In the production of ships, the lion's share of waste is metal. However, in addition to metal waste, waste from other accompanying materials (for example, plastics) is present in this production. If we take as a percentage the amount of waste from polymer materials is small, then in absolute terms the amount of waste from them is significant due to the fact that the ship is generally a very material-intensive structure. During the operation of ships, waste from polymer materials is also generated in the form of broken cables and nets, plastic packaging of cargo, food and other polypropylene-based waste [3]

Interest in the processing of solid household waste, primarily by processing enterprises, is assessed in terms of the economic benefits of the process. Experts determine the price of secondary raw materials based on the following features, such as the degree of processing of raw materials and the color of plastic materials. Natural and white materials are rated much higher than colored ones. In addition, the cost is also affected by the type of material-pressed form, crushed, agglomerate and in the form of pellets. The cost of granulated raw materials is much higher than that of other types. Also, the cost of polymer materials is affected by the degree of their purity and uniformity of the material. There are quite a lot of problems associated with the disposal of polymer waste. First of all, it is necessary to organize the collection, sorting and primary treatment of solid waste (garbage). It is also necessary to take into account the system of prices for secondary raw materials, which is a stimulator for waste processing enterprises, take into account the need to design or purchase special equipment for MSW processing, develop a product range obtained from secondary polymer raw materials, etc. These problems have their own specific features, but at the same time they are quite solvable.

Currently, some developed countries have designed and successfully used installations for automatic sorting of solid waste.

In some countries, inventors have developed and used techniques for automatic waste sorting. A special feature of this technique is the presence of an optical recognition system for various types of materials. The ability to recognize materials by color and chemical composition will allow you to effectively apply such technologies in industrial enterprises. In recent years, special attention has been paid to the problem of solid waste disposal and recycling in our country. Focusing attention to this problem on the part of the state makes it possible to benefit from the disposal of solid waste and obtaining energy raw materials from recycling. Based on the above, it can be concluded that the most promising methods at this stage of industrial development are optical waste sorting methods with subsequent production of marketable products from the resulting raw materials. Automatic waste sorting using an optical effect for waste separation is used in the equipment of some manufacturers, both in European countries and in some Asian countries. The equipment used is focused on sorting separately collected waste. In Russia, since there is no separate garbage collection, the issue of using this technology for mixed solid waste is relevant. Another research task that can be solved using opto-mechanical sorting lines is the study of the composition of plastic waste. The availability of data on the component composition of municipal solid waste for each region separately makes it possible to estimate the prospective volumes of recovery of secondary raw materials. It is also possible to make a preliminary assessment of the quality of secondary raw materials expected to be obtained in the waste processing process [4].

Analysis and research of the component composition of solid household waste have acquired a special status since the country's President declared 2017 the Year of Ecology. Research in this area is becoming relevant in almost all industries, as the possibility of developing technologies for using their resource potential has been proven by various researchers. In this regard, there is a need to optimize such studies both from the point of view of minimizing time, labor and financial costs, and from the point of view of increasing the reliability and accuracy of the results. The use of automatic waste sorting lines for estimating the percentage of individual components in MSW is a promising area of research.

The use of automatic selective sorting of waste, using elements of optical recognition of materials in our country is constrained by a number of factors. First of all, these are the

distinctive features of the chemical composition of materials produced in our country in comparison with their foreign counterparts. This leads to the fact that optical sensors are not programmed to recognize this type of material. Secondly, the technology of selective selection of materials from the general flow of mixed MSW typical for localities in our country has not yet been developed. At the same time, separate garbage collection prevails in Europe and some other countries.

Along with these factors, unfortunately, industrial methods of MSW processing with subsequent recovery of secondary raw materials are still not being implemented. All the interest in such processes is based on the interests of individual researchers or a group of enthusiasts who are engaged in obtaining secondary raw materials from polyethylene, plastic, used car tires and other raw materials. There are many facts of recycling plastic bottles and other waste on the territory of Russia, with the subsequent receipt of products for further processing. Based on the fact that there are whole mountains of waste, and only a few people are engaged in processing waste into useful raw materials, then showing interest in the type of fuel obtained from waste is quite reasonable.

The authors propose a method for processing solid household waste with subsequent production of synthetic oil.

The technological process of obtaining the product is as follows:

recycled plastic, rubber, synthetic materials, etc. are loaded into the container 1. After that, the loading container (1) is tightly closed. The condensation system (2)must be filled with the required amount of coolant. The gas filter is also filled with water up to a certain level. The shut-off valve (8,9) must be closed at the beginning of the technological process, and the tap (6) must be open during the entire process. The start of the process is carried out with the supply of an additional energy carrier (PDE). As an energy carrier, combustible gas or electric current can be used. In the container (1), the loaded material gradually turns into a viscous and gaseous state as a result of heating. Next, the vapor-gas mixture enters the cooling system (2), where it breaks down into a gaseous and liquid phase. The liquid component flows into the final product container (5), and the combined-cycle gas mixture, passing through the cleaning filter (4), is fed to the gas burner (3) and the tap (7) is closed on the PDE. Then the system completely switches to a closed loop.

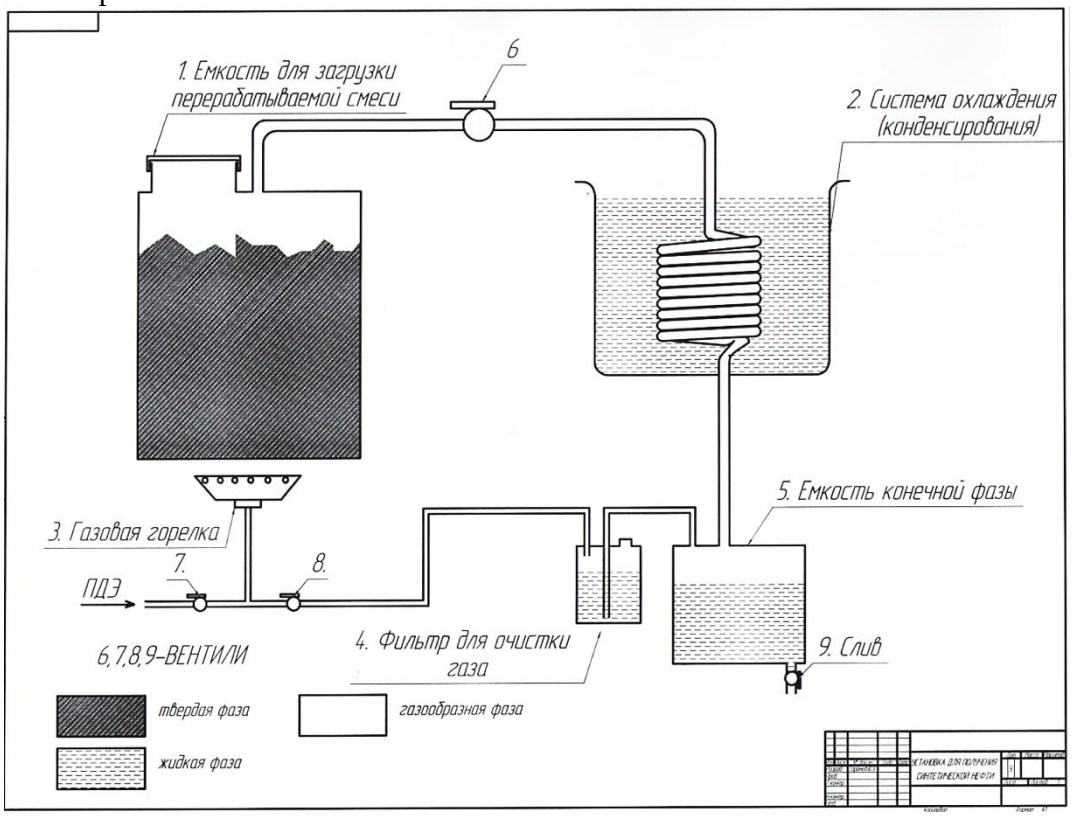

Figure 1 – Installation for producing synthetic oil.

1-container for loading the processed mixture. 2-condensation system. 3-gas purification filter. 4-gas burner. 5-final phase capacity. 6,7,8,9 valves.

The final product is a combustible dark greenish liquid. This liquid can be used as fuel for preheating furnaces without further processing, after additional processing for internal combustion engines.

Table 1 shows the annual level of accumulation and use of the main types of waste in the Russian Federation, the level of utilization of which is relatively low.

Recently, due to the increase in environmental requirements, enterprises for the collection of recyclable materials have begun to appear. (Figure 2)

Figure 2 – Plastic bottles

Table 1 – Annual level of accumulation and use of the main types of waste in the Russian Federation [5]

Waste	Education volume, mln tons	Recycling rate %	Main target product	For secondary raw materials in the target product in fact, %
Car tires	1	4,7	Rubber products, metal	3,6
Polymers	0.71	12	Thermoplastics	4,2

In our opinion, such a form of recycling of rubber and plastic waste would be a solution to several problems. First, the elimination of plastic and rubber waste, and secondly, the production of a useful product, in particular synthetic oil, which can be processed into commercial fuel for internal combustion engines.

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THE REPROCESSING OF HISTORIC MINE TAILINGS

Billions of tons of mine tailings are being produced every year. With the increase of demand in metals and an ever-decreasing grade in conventional mines, the volume of tailings production is only expected to increase further [1]. Mine tailings are a major source of a wide range of risks. It is, therefore, becoming ever more important to increase the production of metals from secondary sources to reduce the production of mine tailings. Historically, mined grades had been much higher and metal recovery had been lower in comparison with today's mining operations [2]. This left a tremendous wealth of unrecovered metals in waste streams. Consequently, historic mine tailings are now being recognized as a viable source of responsible metals production. Theoretical frameworks on the reprocessing of mine tailings have been described in recent scientific literature [3] [4]. This paper aims to apply that knowledge, and to effectively turn liabilities into assets.

This thesis investigated the feasibility of the remining and reprocessing of historic mine tailings. A techno-economic case study was performed to assess the technical and economic viability of a tailings reprocessing project, following a cost-benefit approach. The research was undertaken in Nevada on a real tailings deposit. The exact name and location of the studied tailings cannot be disclosed, due to restrictions in given permissions. Historic operating data has been analyzed, resulting in a preliminary resource prediction. Field reconnaissance has been performed to collect samples of the tailings for assay analysis. Resource models were created from the spatial assay database, which allowed for accurate resource estimation and the validation of the preliminary resource prediction. A conceptual process flowsheet was designed for the extraction of precious metals, reflecting an earlier successful reprocessing operation. Design improvements were incorporated to increase plant efficiency and reduce potential environmental impacts. Capital and operational expenditures were estimated, which together with the projected revenues, formed the basis of a discounted cash flow analysis. This multidisciplinary series of activities demonstrated the technical and economic feasibility of the tailings reprocessing project.

Preliminary resource predictions based on a historical data analysis has been proven to be a time and cost-effective method. It is an appropriate starting point for research, given that sufficient and reliable data is available. Modern resource estimation techniques can be successfully used on tailings deposits. The exploration phase for tailings reprocessing projects carry significantly lower risk due to the visibly finite deposit size. Tailings reprocessing projects could benefit from modifications made to resource estimation guidelines, as man-made deposits are inherently different to sub-terranean deposits made by geological processes. The main challenges associated with the reprocessing of historic mine tailings are related to the mineralogy and grain size. Refractory or complex minerals are a common occurrence in tailings deposits because the easy recoverable metals had been extracted during initial processing. Materials with small grain size often exhibit issues related to dust emissions, high viscosities, and poor solid-liquid separation rates. This can result in an overly complex process design with potentially a poor economic outlook. Factors that make the reprocessing of historic mine tailings feasible include improved market conditions, advancements in process technologies, and a reduction in costs for exploration, excavation, and comminution. The reprocessing of historic mine tailings creates numerous value-creation opportunities, well beyond the conventional scope of mining. Land reclamation, responsible metal production, economic benefit for local communities, and smaller carbon footprints are a few examples of the wide range of benefits the reprocessing of historic mine tailings has.

The results of this study show that mining companies may benefit from following a similar approach presented in this thesis. This will allow for the identification and appraisal of

other historic tailings deposits, resulting in additional responsible metals production and decreased primary mining waste. This combination of environmental management and recovery of metals from secondary sources support the aspirations for a circular economy.

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RESEARCH REGARDING SALT WATER DISPOSED AS WASTE, TRANSFORMED INTO THE PRIMARY SALT EXTRACTION RESOURCE

The research focuses on mining in the town of Slanic, Prahova region, and approch at the situation of salt water discharged as waste. In the actual location of the salt mine, there are two mines, respectively the actual salt mine that is in operation, and the old mine that has a tourist and recreational role. In the foreground the recreation mine, it has various cracks in the salt blocks, facilitating the infiltration of water inside it. In the water route to the lower level of the mine, and through the mine shaft we have the second infiltration by condensation action. By these two factors the water in the salt mine requires constant discharge depending on the weekly flow of infiltration.[1]

Under the current conditions the discharged water is released to the surface of the mine, considered to be waste and useless. The discharged water is a saturated saline solution considered wast, can be used as the primary source of extracting the salt from it. Saturated salt solution with a concentration of more than 40 %, can provide a fine salt of very good quality by simply removing water from it. The discharge of saline water is done through the Unirea mine shaft, and is discharged over an area of 1-1.5 km^2 around the mine shaft, and this action has been perpetuated for at least 20 years. [3].

The mining town also has salt water pools near the location, and is used for medical remedies, but the salt water that feeds these pools, springs and is captured from near the pools, and it has several points of captation. Therefore, transport by pipelines and the use of salt water discharged from the mine is not necessary for salt water pools.

By one of my previous research in the mine, the volume of salt water discharged from the tourist mine is 1296.2 m^3 per week. This volume of water captured in various basins, and can be the subject of the main resource for a plant of extracting the salt from the water, by thermal treatments and finally by total dehumidification, resulting in a volume of fine salt used in various domains. On the other hand, a second system can be adapted, i.e. by adding water to the saline solution up to an exact and rigorously controlled concentration, resulting in the necessary salt solution in the medical purposes.

The installation needed to obtain salt from the salt water, is one of small complexity and can be mounted on the surface near the shaft mine. The installation consists of a container in which water is based on a hatch, a heating source, and a mechanism for removing the extracted

salt and stored villages. Following the path of renewable energy, the installation can be supplied with electricity obtained from renewable resources, by installing photovoltaic panels on the field next to the installation. Constantly used in the current form, the profit from the sale of extracted salt can be divided to maintain the installation, and also to add an annex for a new product. [2]

The general fomula by which we can determine the aproximate amount of salt extracted from the salt water that we undergo to a thermal treatment is:

$$Q_s = Q_w \cdot 40\% = 1296.2 \cdot 40\% = 0.05\ m^3$$

where Q_s –quantity of the extracted salt, Q_w- quantity of the salt wather wast.

Knowing the week's amount of salt that can be obtained by the plant, in a month can be a production of 0.2 m^3 of salt.

The addition of a second production system for a salt derivative f, i.e. for the production of saline solution with various concentrations. This system using today's automation technology can produce this salt solution in the most rigorous way. At the same time being an additional energy power installed, it requires addition adding of some more of photovoltaic panels.

The adaptation and addition of installations can be extensive, and waste can be the primary source of production for various products, with minimal investment and effort for a maximum profit of the mining enterprise.

By developing the current research in a large process, it is shown that the salt water that we consider waste, can be the primary source of salt extraction, and the addition of new systems for various other derivatives of this product, can raise the production and general income of the mining enterprises. By adapting the DC system from renewable resources, it would be ideal to be able to step and continue in this global trend.

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LOVE AS MOTIVATION FORSE

The notion of love remains relevant for every generation, but its standards and ideas about it are changing.

Platon in his work "The Feast" is represented love in the form of the ancient Greek god Eros. And it is not for nothing that love is represented in the image of God, because love can govern a person in the same way that God encourages a person to various actions.

Phaedrus speaks about the ancient origin of Eros: "Eros is the greatest god. He is existence and love.

Pausanias saying that Eros has two beginnings: The highest beginning, i.e. falling in love in the realm of the soul and mind for the sake of wisdom and perfection, and not for the sake of the body. The lower beginning, i.e., love for the sake of the body, not the soul.

After him, Eriksamakh expressed his point of view, saying that Erot is poured aii over the earth, i.e. people can express love not only to each other, but also to everything around them: nature, animals, etc.

Here he speaks about something more than just love for a person, we feel in this speech love for the world around us. After all, it is true: we can love everything that surrounds us, and what we care about. So what comes first: care or love? Do we care because we love, or do we love because we care about the object of love?

In order to answer these questions, let's think about the relationship between these concepts using the example of feelings and actions. Love is a feeling, care is an action. Feelings drive us to action. Let's take a simple example: we are hungry – this is the feeling that drives us to action: we're going to eat. Mother loves her child and that's why she cares. Therefore, if something is dear to us, we want to show our feelings and the best manifestation is care. Thus, love breeds care.

An example of the chain "feeling-action - higher feeling" can be traced back to the novel of Antoine de Saint-Exupery "The Little Prince". It is here that it is shown how compassion causes care, and care, in its turn, generates higher feeling-love.

Thus, the primary is love, which gives rise to care.

Aristophanes expresses his theory, telling the myth of the separation of man by the gods, and concludes: "love is the thirst for wholeness and the desire for it."

Agathon enumerates the qualities that make Eros perfect: beauty, eternal youth, tenderness, perfection, justice, prudence, courage, wisdom, rejection of any violence.

Here the important idea is that some qualities can make Eros perfect. Let's start with the fact that if we love is represented as God (and God in our perception is something perfect), then why talk about his qualities? Even if we admit that there are qualities that make GOD perfect, will everybody accept that it is these qualities that make him perfect? Each person has his own qualities that, in his opinion, make love perfect.

Let us try to challenge the quality that makes Eros perfect: the rejection of any violence. If a person loves his state, he will defende it. Usually the state demands protection in times of war, but war is already violence. Now we can say that Eros is not perfect, because love breeds violence.

Love breeds violence because of a person's basic desire to protect the object of his love. But can such violence be justified? Is there a possibility of protection without violence?

And Socrates ends this conversation. In his opinion, Eros is the love of eternal creation in beauty for the sake of immortality. A mortal being wants to overcome his mortal nature, thus there are two types of immortality: spiritual (to make his name immortal) and physical (to leave offspring) [1].

Analyzing the statements of philosophers, we see that love is something abstract, and for everyone it is different. Love is a spiritual state of a person, for this reason there is no clear definition of it.

Now let's see what modern philosopher Immanuel Kant said about love. For him, love is an extra-moral phenomenon. He points out two kinds of love: empirical love and practical love.

Again, as Plato wrote, we see the division of love into a lower and a higher begining. Only now it is empirical and practical love.

But can empirical love develop into practical love, the lower beginning into the higher? If we consider empirical love as falling in love, and practical love as love itself, then love can either remain at the same level or grow into love ifself.

Empirical love (falling in love) is the initial feeling of sympathy, exactly what do we fall in love with: communication manners, physique, smile, etc.

Practical (actually love) is precisely the kind of love that loves not the body, but the soul. It gives rise to such feelings as responsibility, loyalty, sacrifice, dedication and care.

Thus, empirical love is not something base, but a product of the higher level, the possibility of development and the achievement of nirvana.

For Arthur Schopenhauer, love is the" thrill "of a new generation, the" will of a new individual to live. "Love attraction must overcome all obstacles, disregard the concepts of honor, duty, loyalty-for the sake of the birth of a new harmonious individual. Loving people sacrifice their happiness for the sake of the family; in return for themselves, they do not receive the bliss that they could expect. The feeling of love fades away when its goal is achieved, and then it may be found that, apart from blind passion, nothing connected two people. They don't need each other anymore. Schopenhauer believes that a marriage of convenience is usually happier than a marriage of love, because self-serving calculation remains valid even when the illusion of love is dispelled. However, a marriage of love, even an unhappy one, is still more sublime – it corresponds to the natural purpose [3].

So what is love and does it at all exist? At the beginning, for me, love was just a chemical reaction in the human body. Something that can be explained scientifically and is quite difficult to challenge. This theory is ideal in our world, where everything is based on numbers, statistics, the refutation of old ideals, but it is only necessary to think a little and you realize that only reactions are not enough, there is still something more that motivates people to the detriment of themselves. It is unlikely that the human body will kill itself. However, people who really love tend to sacrifice themselves for the sake of others.

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USE OF THE LEXEMES "GRANITE" AND "MARBLE" IN MODERN SPEECH

Interest in the study of human speech originated at the end of the 19th century. At this time in linguistics, the anthropocentric approach, in which language is studied through its speaker, was widespread. One of the first fundamental works, which influenced the further development of anthropocentrism, was the work of the German scientist W. von Humboldt "Language and Philosophy of Culture". W. von Humboldt calls language "the activity of the human spirit" [1]. In Russian linguistics his ideas were supported by A.A. Potebnya. He argued that language can only develop in society. In this paper the use of the lexemes "granite" and "marble" in the speech of students of geological exploration, mining and construction departments of St. Petersburg Mining University is considered. The obtained results are compared with the results of the use of the lexemes "granite" and "marble" in modern texts presented in the National Corpus of the Russian language. The relevance of the research lies in the fact that the use of the lexemes "granite" and "marble" are considered in the professional environment (St. Petersburg Mining University), in fiction and popular science texts (National Corpus of the Russian language), which provides an opportunity to draw conclusions about the functioning of these lexemes.

The paper presents the results of the survey among the students of geological exploration, mining and construction faculties of St. Petersburg Mining University, as these lexemes are basic in the speech portrait of the representatives of these professions. Y.N. Karaulov was one of the first philologists to apply the method of linguistic experiment, which allowed to study the language under the conditions controlled by the researcher [2]. The research survey was conducted among the second-year students of the three main faculties of the Mining University. Understanding how the lexemes "granite" and "marble" function in their speech creates conditions for effective communication between specialists of different profiles.

The results obtained in the course of the survey are compared with the data obtained by corpus analysis of modern texts. Nowadays corpus analysis method has become one of the main methods in linguistic, social and cultural studies [3]. The National Corpus of the Russian language [4] includes about 350 thousand texts in electronic form. Modern texts including the lexemes "granite" and "marble" of the main subcorpus (more than 85 thousand texts) are analyzed in the work. In the process of lexeme analysis a high frequency of combinations "like marble" and "like granite" was established. These combinations became the subject of the analysis. It is defined, that expressions are metaphorical and reflect physical properties of marble and granite. For marble - white color, smoothness, luster, a cold surface, for a granite - hardness, fortress. Most often the character of the person is compared with granite, and parts of a body, in particular a face is compared to marble.

Thus, in the course of the study we managed to compare the functioning of the lexemes "granite" and "marble" in the speech of students of profile specialties of St. Petersburg Mining University in the scientific context and in the National Corpus of the Russian language in fiction and popular scientific contexts. The results obtained in the analysis create more favorable conditions for communication of specialists in geology, mining and construction and representatives of other specialties and trace the functioning of these lexemes outside of professional use.

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HAPPINESS AS A MEANING OF LIFE IN ARTHUR SCHOPENHAUER`S PHILOSOPHY

What is the sense of life? Years, centuries are passing by, the history and culture of each nation changes every day. But the question of human existence worries our mind to this day.

Growing up, a small child begins to learn everything that surrounds him, revealing for himself each time more and more new sides of our world. Sooner or later, the individual will begin to generate thoughts and questions of a more global type, such as, for example: "Why do I still exist?" It is definitely especially important for a person to understand what the meaning of life is and in what key aspects of his life it manifests itself.

Arthur Schopenhauer was no exception, who in his pessimistic philosophy raised the issue of such things as "will to live", human egoism, etc. Arthur Schopenhauer is, based on his philosophical ideas and statements, an adherent of loneliness and hopelessness. However, although Schopenhauer's philosophy is rather pessimistic, it allows us to rethink our life and reflect on what is truly valuable and important.

Like many philosophers, Arthur Schopenhauer paid attention to the issue of the life meaning and human existence. The meaning of life, according to Schopenhauer, is precisely happiness, that is, to become happy, or to be happy. "Happiness is a feeling of freedom from pain" [1], the philosopher argued. Whatever it was, our interlocutor will find his own formulations and associations with the concept of "happiness." So what is this will and where does it originate from? According to him, the will to live is manifested "in the power that feeds the plants, gives shape to the crystal, attracts the magnetic arrow to the north and heterogeneous metals to each other ... the stone to the earth, and the earth to the sky" [2], and also, that it is completely blind.

According to Schopenhauer, it is the will that prevents us from becoming happy, since the purpose of this will is precisely the continuation of the human race, and not to make the individual happy. Thus, the philosopher says that our existence is happier when we do not notice it, and it follows that it is better not to exist at all. This is the conclusion that Schopenhauer comes to in his philosophical work "The World as Will and Representation". It should be noted, of course, that here we are talking about a man as the highest form of existence, and not about his animal principle, the existence meaning of which is clear and is revealed by Schopenhauer in all its truth - this is only the desire to continue the race. Striving is to continue striving. Now everyone has the right to make a conclusion for himself - who I am: an animal or a person.

It turns out that Arthur Schopenhauer proclaims the nature of happiness as negative one, that is, consisting in the rejection of all kinds of pleasures. “Any satisfaction, or what is usually called happiness, in essence always has only a negative, not a positive character” [3]. Thus, satisfaction or happiness can never be anything other than liberation from sorrow and from

needs, the philosopher declared. On the other hand, our thinker insists that there is only one innate mistake - the belief that we were born to be happy. It turns out that the author of this conviction is trying to assure us that our whole life is nothing more than a continuous struggle with death, survival and constant suffering. It turns out that a person lives only because his life is living, and we will never know either the goal or the initial premise of our own life.

However, one can still disagree with Schopenhauer regarding some moments. Is it really so difficult to achieve happiness, and a person does not deserve to live happily just like that? Probably, too pessimistic and gloomy judgments and views on life led the philosopher to such conclusions. If you look from the other side, isn`t it happiness that out of many millions of particles and atoms, life was awarded to us? Definitely, there is meaning in human life, and in order to make such categorical conclusions as our philosopher, it is worthwhile to think it over well. After all, happiness, often, is very close, and we simply do not see it. Still, it is probably worth taking a closer look and not inventing so-called "suffering" for yourself. Nobody argues, sometimes it is necessary to try and work to achieve a certain result, which will bring us a kind of "happiness". So, maybe the meaning of life lies precisely in this: to see happiness in small things and to enjoy life as it is given to us? In a conversation with Schopenhauer, we developed slightly different ideas and judgments about the meaning of life. For Arthur Schopenhauer, this is happiness that can be achieved only and only through suffering, for other philosophers such as Aristotle, Diogenes and Socrates, the meaning of everything was such things as getting happy emotions, peace of mind, purification, healing and development of your soul.

Everyone has their own vision, preferences and outlook on life. And as mentioned above, Arthur Schopenhauer was no exception, having expressed to us his most interesting thought about life and will, despite the fact that it is rather tragic and dull. Based on the resulting dialogue, we can conclude that to answer the question "So what is the meaning of life?" we can only ourselves and no one except ourselves.

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IN THE CHASE OF HAPPINESS

The aim of my research is to investigate the phenomenon of happiness. Everybody has thought about happiness, but it is not enough only to dream if you want to reach it. I decided to make a research and share with you my results. What do people need to be happy? I based my research on the following literature: first of all I took a «World Happiness Report 2020»[1] and «World Happiness Report 2021»[2], also I used the book «Lagom: The Swedish Secret of Living Well»[3] to show the concept of modern philosophy of happiness

In my research I involved 205 people. (The majority of interviewees are citizens of the Russian Federation and are under 30 years old) It consists of two parts.

Firstly, I asked if they feel happy in the country where they live. When the interviewees answered that they were happy in the country where they lived, I asked them about the country where they live. Also when the interviewees answered that they were not happy, I asked if they needed to move to another country for being happy. Next, if the interviewees answered that they

didn’t need to move to be happy I asked them where they live, on the other hand, I asked them about the country where they would be happy. Thanks to this research I came to the following conclusion: approximately 42% of the countries where people need to move for being happy are included in the top 10 of the World Happiness Report 2021.

There is the second part of my research, where I asked people about the things which they need to be happy, now you can see the top 5 things. It shows us next results they are happy when they have: love, money, family, friends and music.

To sum up, I decided that it is important to make all countries their own philosophical systems, which will be appropriate and will be right. Happy philosophy is the main secret of wellbeing.

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PROSPECTS FOR LOADING THE NORTHERN SEA ROUTE

The Northern Sea Route (further - NSR) has been developing since 1932, when the USSR SNC Decree of December 17, 1932 No.1873 «On the organization of the soviet Union's main administration of the Northern Sea Route» was adopted. Later in 1938 and 1950, clarifying changes were made regarding the work of the main administration and the improvement of its work. The volume of transportation in the territorial waters of the USSR and under the flag of the Union grew annually until 1990. With the collapse of the Union, the shipbuilding industry fell into disrepair, with the Russian Government's Decree of 19 June 1994 No.718 «Measures to improve the management of the Northern Sea Route» was supposed to be state support in accordance with the agreements in support of the costs of the maintenance and use of icebreakers and other unsuitable privatization of vessels and facilities of the Repair and Technology Enterprise «Atomflot» not covered by the proceeds of their operation.

According to the results of 2018, the volume of cargo transport through ports and points in the northern sea route amounted to 20,180.2 thousand tons (a double increase to the level of 2017, but compared to 1990 the drop), including transit - 491.3 thousand tons. In 2018, the hydrographic study in the NSR water area has been continued, 287 navigation equipment facilities have been maintained, and 3 sets of autonomous power sources based on LED technologies, solar panels and wind generators have been installed and operate. The level of technical equipment of the Northern Sea Route was 40%. The total volume of freight traffic under NSR was 17 million tons, in 2019 - 31.5 million tons. In 2024, NSR cargo flow should reach 80 million tons, by 2030 - 120 million tons, and by 2035 - 180 million tons. The bulk of the traffic should be coal, liquefied natural gas, oil and gas condensate, as well as equipment for field development and infrastructure construction. In 2019, the turnover of NSR increased significantly mainly due to the increase in LNG shipments from the port of Sabetta [1,2].

The main problems that may arise in the area of NSR loading are related to the decline in world energy demand and prices due to the coronavirus pandemic. Arctic projects are very expensive, and in today's situation there is a high probability of postponement of their launch. The loading of NSR will be provided by the development of Arctic fields, mainly hydrocarbons, but according to Anton Usov, head of KPMG's international practice of providing services to oil and gas companies: «Arctic projects are capital-intensive, their promotion is impossible in the conditions of low oil prices» [3]. At the same time, companies declare their readiness to implement them, as they are strategically important both for themselves and for the country, so they hope for measures of state support.

If oil and gas prices rise, it is possible to return to the planned indicators in the medium term. NovaTEK confirms the commissioning of two liquefied natural gas (LNG) transshipment terminals in Murmansk and Kamchatka in 2022. The launch date remains unchanged - in 2023 the first stage is much more powerful than Obsky LNG, the Arctic LNG plant with a capacity of 19.8 million tons per year (three lines of 6.6 million tons per year each). So far, the launch of the LNG plant «Obsky LNG» with a capacity of 5 million tons per year, which was to reach full capacity by 2024, has been postponed for two years. Now in 2024 it is expected only to launch the first stage - the capacity of 2.5 million tons per year.

But the main impact on traffic volumes will be the change in plans for the production of the Vostokugol project, which was to provide 25% of the loading of NSR in 2024. Instead of 20 million tons of coal by this time, it is now expected that by 2025 the project will produce 5 million tons. Even so, the total loss of NSR loading in 2024 will be about 20 million tonnes in the worst case scenario. A significant increase in NSR loading is expected after 2024, when the full capacity of the largest Arctic commodity projects, primarily East Coal and Arctic LNG 2, is planned.

It is impossible not to say about the principle, which is in a competitive economic race, if you can not overtake the opponent, «pour him broken glass in his shoes». The jam of an oil tanker in the Suez Strait is proof of that. Until recently, the strait was the minimum route from Europe to China. Unfavorable situations require a review of logistics routes. «Every hour of tanker downtime costs world trade $400 million», Bloomberg writes [4]. At the moment the delivery of shipping containers from China to Europe rose fourfold, oil rose by 3%. Russian oil tankers with a total value of $160 million are also in the Gulf of Suez.

Thus, the loading of the Northern Sea Route is a favorable development factor for Russia. Under this, the infrastructure is already being created: the seabed is cleared, the program of compensation of companies operating icebreakers is implemented, broadband Internet and 5G communication come to the Arctic. Despite the negative external factors, there are also positive ones. It is necessary to continue to promote at the political level the expediency of trade relations through the Northern Sea Route. Now there is a permissive procedure for the admission of courts, courts provide documents to the Administration of the Northern Sea Route, which are considered within 5 days.

It should be noted that without strengthening interstate cooperation, the positive effect of the implementation of the activities under the Russian Government's Order of December 21, 2019 N 3120-r «On the approval of the northern sea route infrastructure development plan for the period up to 2035» will be minimal. At the moment, the list includes key activities of extractive companies and infrastructure activities, which cannot be implemented without reaching agreements between states and companies [5]. External factors continue to have a significant impact, but the climate agenda also encourages the need for tight environmental controls in the Arctic.

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GEOPOLITICAL ASPECTS OF THE FUNCTIONING OF A RUSSIAN OIL AND GAS COMPANY

The aim of this work is to assess the impact of the geopolitical situation and geopolitical instruments on the oil industry of the Russian Federation. Until recently, the world energy market depended 90% on economic factors and only 10% on geopolitical ones. Today the situation has changed radically: geopolitics dominates. It affects supply and demand, prices and the functioning of the oil and gas transportation infrastructure, and the implementation of several pipeline projects, such as, for example, the Nord Stream 2.

The sanctions imposed on the Russian oil and gas industry in 2014 created serious difficulties for deep-water drilling, exploration of the Arctic shelves, and the development of viscous oil fields. In order to reduce dependence on equipment and services in the oil and gas industry, Russia has made a "turn to the east" - now oil and gas companies have begun to seek funding and project partners in China, India and other countries that do not apply sanctions against Russia.

An important consequence of the sanctions against the Russian energy sector was the withdrawal from Russia of western companies involved in the implementation of projects in the field of unconventional oil. As a result, there is the suspension of all developments in this area. The main reason is the lack of experience of Russian companies in the implementation of such projects, as well as the need in use of special technologies and equipment in their implementation.

Notable difficulties caused by the current geopolitical situation are in the implementation of the already mentioned the Nord Stream 2 (NS-2) gas pipeline project in the Baltic Sea, aimed to expand gas supplies from Russia to Germany and other EU countries.

The main geopolitical advantages of this project include the following:

1) the absence of mediators between the producer and the consumer, what excludes the political component of the project.

2) development of gas transportation infrastructure between the Russian Federation and the EU, which will contribute to strengthening of the EU's energy security, as well as geopolitical stability in the region.

In addition to Germany, the supporters of the project include Austria, France and the Czech Republic. The opponents of NS-2, like NS-1, include: 1) transit countries that suffer losses for gas transit: Ukraine, Poland; 2) countries remote from the place of gas supply: Hungary, Moldova, for them transit payments may increase; Baltic countries: Estonia, Latvia, Lithuania; Denmark, as well as the USA, which believe that the implementation of this project will hinder the supply of American LNG to the EU in the future.

The geopolitical realities that will affect the development of the world economy and energy in the first half of the 21st century include the development of hydrocarbon resources in the Arctic, in particular its shelf. This hard-to-reach region attracts the attention of oil and gas companies like no other in the world.

The resources of the shelf and hard-to-recover oil make up a significant part in the structure of reserves and in the future should provide a significant share in the structure of production.

Up to this day many states lay claim to the Arctic shelf zone, although there is the UN jurisdiction from 1982, which states that the shelf zone belongs to states according to a sectoral approach.

Summing up, we note that the current geopolitical situation actualizes the development of the production of domestic equipment and services in the field of oil and gas exploration and production, i.e., comprehensive import substitution. In addition, in the coming years, we can expect an intensification of the competition for a place in the energy balance of hydrocarbons produced on the shelf of the Arctic seas, produced as a result of increased oil and gas recovery of developed fields and the development of deep-sea and unconventional sources of oil and gas. This circumstance should further stimulate the independence of the Russian energy sector.

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REQUIRING A MULTI-LEVEL APPROACH

Sustainable development was defined in 1987 by the World Commission on Environment and Development [1]. The term means the socio-economic development of modern societies, meeting their needs while preserving the status quo for future generations. The theory of this definition is relatively simple to understand by the public while being difficult to implement in one's actions and those of the environment. Other important concepts partially derived from sustainable development are Corporate Social Responsibility (CSR) and the Circular Economy. Corporate Social Responsibility was defined in the Green Book of the European Commission in 2001 as a concept for the functioning of enterprises, according to which they will implement their strategies taking into account social and environmental aspects, putting particular emphasis on these factors in their commercial activities and contacts with stakeholders [2]. On the other hand, the Circular Economy is "a concept aiming at the rational use of resources and limiting the negative environmental impact of manufactured products which, similarly to materials and raw materials, should remain in the economy as long as possible, and the generation of waste should be minimized as much as possible" [3].

Due to the growing demand for knowledge in the above-mentioned topics, resulting from global regulations and irreversible climate or economic changes, it is necessary to create effective methods of educating society at different stages of development - from school age to

adulthood. However, the complexity of the topics requires a multi-level approach and education to start at the early levels of society's development.

To gain more insight into the existing demand for integrating sustainable development issues into education, a survey was conducted among students of higher education institutions in Poland within the EnAct-SDGs project [4]. This study was a kind of confirmation of the thesis that there is a clear demand for educational content related to the topic of sustainable development in the broadest sense. There are clear shortcomings in education programmes, which do not include sustainable development in the core curriculum. Hence the growing demand for alternative educational activities supported by modern and innovative forms of teaching.

The answer to the indicated needs is concrete proposals presented by the authors of the chapter, which have a positive influence on raising social awareness of sustainable development.

The article presents a needs analysis of the inclusion of the topic of sustainable development and proposed ways to meet the resulting educational needs.

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PROSPECTS FOR INTERNATIONAL COOPERATION BETWEEN THE ARCTIC COUNCIL COUNTRIES IN THE CONTEXT OF THE RUSSIAN ARCTIC DEVELOPMENT

Introduction. The relevance of the topic is primarily due to Arctic region demonstrates an unprecedented intensification of international cooperation and initiatives. It is a priority not only in Russia, but also in the other 7 countries that are members of the Arctic Council: Canada, the Kingdom of Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, Sweden and, of course, the United States. These countries have developed and continue to work on strategic documents for the development of their territories. For instance, in Russia there is a «Strategy for the development of the Arctic zone of the Russian Federation and ensuring national security for the period up to 2035» [1]. To understand all ongoing processes and initiatives on Arctic territories it is necessary to read strategic documents of these countries and study growing interest of permanent observers. For example, we cannot ignore the growing interest of China and other Asian non-Arctic countries. In May 2013, China, South Korea, Singapore and Japan received the status of permanent observers of the Arctic Council, which significantly affected the development of the Arctic and the expansion of economic cooperation.

Constant monitoring of the actions of countries in the Arctic will help Russia to develop these territories successfully and pay attention to the actions of other states, to design its own unique Arctic policy.

Main body. In order to successfully reveal the topic of the study, the following tasks were set:

1. To focus on the countries of the Arctic Council, their strategies, as well as to draw attention to the importance of Asian observer countries.

2. To analyze the concept of the frontier in the Arctic and its special significance.

3. To refer to such important Russian frontiers of development as Murmansk [2] and Arkhangelsk.

4. To determine the features of Arctic construction and the latest developments for high-rise construction on permafrost soils.

5. To talk about the psychology of Arctic partnership because sharp temperature changes, weak soil mineralization, short daylight hours, frequent changes in the atmospheric pressure and ultraviolet insufficiency lead to a decrease in the capabilities of the human body [3].

6. To identify some behavioral features of states in the Arctic territories and their models for implementing economic policy and business.[4]

7. As a result, the author will try to make a forecast for the future in the development of the Arctic.

Each task is defined in a separate chapter and considered in detail on the basis of current sources and literature.

Conclusion. The development of the Arctic is combined with a complex of controversial issues. Among them it is necessary to highlight the problems of forecasting for the near future, taking into account the instability of the Arctic region, the prospects for the development of the Russian part of these territories and the possibility of changing Russia's own strategy in the near future or maintaining the current path of development. It will not be possible to give an unambiguous answer to these questions due to the specific features of the Arctic territories. It is necessary to use special forecasting methods here. The infrastructure is gradually adapting to the constant migration movement and changing population by expanding urban agglomerations and strengthening their role. In addition to it there is an increase in scientific potential by funding research centers, attracting talents, as well as countries outside the Arctic Council, such as Belarus, which have considerable potential of their own. Moreover, an important factor is the study of human psychosomatics, especially in harsh natural conditions to ensure the comfort of work in the future. In conclusion, the author emphasize that the Russian Arctic is at a new stage of development. It differs significantly from the trends that were observed in the Soviet era. It is a major innovation platform which is literally destined to give a boost to the development of science, industry, economy and international cooperation.

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ACTUAL PROBLEMS OF LAW-BASED CONFLICT RESOLUTION IN THE COMPETITIVE ECONOMIC ENVIRONMENT

The relevance of this study is that at the present time, market mechanisms are developing very rapidly and constantly changing, and this is inextricably linked with the emergence of

various conflicts in the interaction of competing participants. In turn, conflict resolution in the modern state is carried out through the law, which establishes the rules of conduct between market participants and measures of responsibility for violating laws. The market economy is closely related to such a concept as competition, and competitive interaction is always associated with a possible clash of interests, which can lead to a conflict between participants, that is, competition in its own way acts as a generator of economic conflicts. Therefore, the state uses the law to find ways to regulate relations, creating a legal system that includes many aspects of the interaction of market participants, thereby reducing its conflict potential This multidisciplinary problem was considered by many scientists, so one of the first authors to formulate the foundations of perfect competition was A. Smith, K. Marx began to consider competition as a form of conflict. F. Scherer, D. Ross considered competition as an active rivalry. In turn, among the first and domestic civilists who laid the foundations for the development of domestic civil and commercial law are I. Pokrovsky, G. Shershenevich, O. Ioffe, S. Bratus. Separately, we can note the importance of the development of competition law by such authors as I. Artemyev, A. Kinev, M. Yegorova, Y. Franskevich.

Economist Galina Gukasyan describes competition as a confrontation in the market to achieve their goals, increase capital, strive to achieve domination over their competitors[1], and depending on both moral foundations and material capabilities, economic agents decide how to achieve an advantage in a competitive market, use fair methods approved by the majority, use the tools of honest, conscientious competition, or use unfair methods and overstate their position, violating both established market customs, so are the laws of the state. Extremely active activity aimed at suppressing the consumer demand of its competitor destroys the established norms in the organization of society, which accordingly leads to conflicts[2]. The market itself can be represented as a set of economic conflicts, which are expressed in the form of competition, positional bargaining, deals that involve negotiations, agreements and compromises. We can say that competition is a conflict in the economic sphere of activity, a conflict of interests, of the parties who, whether on the local market, are fighting for an increase in demand and profit, or on the global market for the division of spheres of influence.[3].

How exactly does the conflicting interaction of market participants manifest itself? At the moment, from the point of view of the law, we can distinguish such forms as abuse of a dominant position, anti-competitive agreements and concerted actions, unfair competition, actions of head that restrict competition. The above aspects help to assert that competition has a quite extensive conflict potential, accordingly, in order for competition to work for the common good of the economy and society, the state, through an exclusive monopoly on the law, forms codes, laws and other regulatory legal acts, thanks to which competitive interaction does not cross the generally recognized border of interaction between economic agents, does not violate market customs, does not create an atmosphere of anarchy[4]. Referring to Federal Law No. 135 "On Protection of Competition", it can be argued that the idea of improving the legal regulation of relations in the economic competitive environment is in the interests of the state. Therefore, it is necessary to explain how the law determines the competitive environment and what laws exist that build the border of the legal interaction of economic agents and how these laws resolve conflicts in market relations. The main law regulating competition is the regulatory legal act "On Protection of Competition". This Federal Law defines the organizational and legal basis for the protection of competition, including the prevention and restraint of: monopolistic activities and unfair competition, in addition, the state ensures that the federal authorities of all branches of government, including the Federal bodies controlled by them, do not restrict or eliminate competition. The main purpose of this Federal Law is to ensure the unity of the economic space, free movement of goods, freedom of economic activity in the Russian Federation, protection and creation of conditions for the effective functioning of commodity markets. The main body regulating competition is the Federal Antimonopoly Service.

As we can see from this law, it follows that it is the state, through the law, that determines what competition is and what actions of market participants violate the boundaries of law, and in

connection with the fact of violating the boundaries of bylaws, legitimate competition develops into a state of non-competition, in a situation where the conflict in the conditions of market relations ceases to be legitimate. The antimonopoly control keeps the conflict within the framework of the law, preventing legal, legally sanctioned competition from outgrowing itself and turning into unfair competition, or turning into a monopoly, perhaps this is the main reason why this antimonopoly serves exists in almost all states based on private property, private law and free market relations. Therefore, we can say that the conflict in the economy is reflected in the law as competition, which means that competition is the legal definition of economic conflict, and in accordance with this, it receives a legal and legitimate form, expressed as competition for profit. But when an economic conflict goes beyond the area of law, the competitive environment changes accordingly from sufficient and not destroying the competitive mode of interaction itself to excessive, constantly working to destroy it, weakening to the point of complete abolition.

In this report we conducted a study aimed at identifying the relationship between competition and conflict, as these market relations are regulated by the state. It follows from the above that competition is a struggle, and the result of the struggle is someone's victory and someone's defeat, but since competition is a part of the market, and the market forms the usual understanding of the economy, this aspect is directly subject to law, so the role of the state should be understood as the role of an arbitrator, the state can not eradicate competition and all the conflicts resulting from it, it can only regulate these relations and define the limits of what is allowed for them.

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EFFECTIVE COMMUNICATION IN SOCIAL MEDIA ON THE EXAMPLE OF THE MINING INDUSTRY IN POLAND

Nowadays, social media plays a crucial role in promoting both industrial and service businesses. With an informed, engaged community on a brand's social media profiles, there is an opportunity to grow and improve image. A great option is to introduce users to the brand's products, how to use them, interesting facts or messages. The company can find out the audience's opinion on a specific topic, related to the brand or product. By utilizing the various features and tools that social networking sites offer, there is an opportunity for an interesting, creative and effective way to communicate with your audience. [1, 4]

However, many industries avoid frequent social media posts. This paper focuses on the analysis of the mining industry. Social profiles of companies involved in hard coal mining in Poland have been analysed. A comparison of the best and the worst run social profiles from the discussed industry was conducted. It was found which companies are active on their social media regularly. Three selected channels that are most used by businesses, i. e. Facebook, Instagram and LinkedIn, were analyzed. The paper presents the main objectives of communication, ways of image building through social media and strategies for creating an engaged community. It also discusses the principles of creating a marketing strategy, distinguishes tools and functions that give the opportunity to communicate effectively with the profile audience. [2, 3, 4]

Based on the analysis of scientific research, it was determined what types of tools and messages are most effective in communicating with audiences on social media. The focus was on the perception of social media by young people and the education of this age group by the above mentioned portals. The topic of mining companies avoiding responding to global "heckling" was also raised. [3]

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ORIENTAL MOTIVES IN ST. PETERSBURG'S DÉCOR AS A REFLECTION OF THE DIALOG OF CULTURES. DEVELOPMENT OF AN EDUTAINMENT QUIZ FOR STUDENTS' INDIVIDUAL STUDIES

We surveyed a hundred of the Mining University students about their favorite humanities subjects. The respondents were asked three questions: "Which subjects would you remove from the curriculum?", "Which humanities subjects do you like the most?", "Are you interested in cultural studies?"

The results were discouraging: 39 percent would exclude cultural studies, the same fraction named the Russian language and speech culture, philosophy took the second place with 33 percent, and sociology came third with 32 percent. Most students would like to study psychology, fewest — cultural studies, every third respondent said they were not interested in this subject.

The lack of interest in cultural studies made us genuinely concerned. The students explained that the knowledge they would gain from the subject was not directly related to their profession of choice. The "techies" also said that humanities were boring and hard for technical minds. As practical benefits of the subject are not obvious to students, an extra motivation to study the subject may be worth. Hence, teaching humanities at a technical university requires special attention.

A solution to the problem may lay in edutainment: to create a set of entertaining logic tasks that resemble intellectual games. The tasks would reveal different aspects of cultural studies and could be offered to students for individual work. That form of tasks would be perceived more favorably than formal listening to lecture material in the classroom or writing reports and abstracts where effort is reduced to copying information from the Internet. The knowledge received independently is assimilated more firmly, as familiarization with the material makes more sense.

Search for an answer requires effort. On the way to solve the quiz, students use not only the accumulated potential of knowledge, but also include logic. The questions are designed so that, based on the information contained in the task description, it would be possible to come to the correct answer through logical conclusions.

For such a set of entertaining tasks, we selected a narrow topic: Oriental motifs in St. Petersburg decor. Within our course of cultural studies, that topic is of a particular importance: first, we try to get our students (many of whom come from different regions of Russia and the

world) acquainted with the cultural heritage of St. Petersburg; second, according to the requirements of the Federal State Educational Standard, students of all specialties must learn to positively (tolerantly) perceive cultural diversity. Thus, the acquaintance with various Oriental motifs in the architecture of St. Petersburg contributes to the realization of the historical value of intercultural interaction. In the tasks created by the author of the work, we are talking about the culture of Egypt (monuments of the ancient civilization and heritage of the Muslim culture) and Central Asia, as well as motifs related to the culture of the Muslim world and China. In future, we plan to create tasks related to Assyrian, Turkish motifs in architecture and Korean sculptures.

Here is an example of the tasks to illustrate the logic of its construction.

Task: In St. Petersburg, there are many sculptures depicting various animals, real and mythical. A facade of a building, which is the world's Northernmost and Europe's largest temple of a religion, is decorated with sculptures of deer. This animal is immortalized by the legend, according to which two deer listened to the first sermon of a great sage who became a spiritual teacher for millions of people. His first followers to arrive in St. Petersburg were the Volga Kalmyks, who came to build the Peter and Paul Fortress [1, 2, 3, 4]. Where can you see those deer?

Answer: Datsan (Buddhist temple).

Methodological comment: The question is about a temple of a multi-million religion. The most numerous beliefs are the three world religions: Christianity, Islam, and Buddhism. Logically excluding the wrong options, we will come to the correct answer. Christian churches of St. Petersburg are not the world's Northernmost. In the culture of Islam, there is no mention of deer, and the sculptural compositions of those animals do not adorn facades of mosques. Hence, the religion in question is Buddhism, and its founder is the said great sage Buddha. Accordingly, the building is a Buddhist temple, which bears the name *datsan*.

As we have experienced from presenting the concept at conferences, the research topics and developed tasks create genuine interest and excitement of the game among students with different level of humanitarian training, which shows their practical significance.

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SYNERGY OF MOTIVATION AS A CONDITION FOR THE FORMATION OF A COMPETITIVE SPECIALIST IN A TECHNICAL UNIVERSITY

It is obvious that the formation of a competitive specialist in a technical university remains a very relevant and significant task, since in the 21st century engineering education can no longer be quoted simply because a graduate of a technical university has a diploma. Practice has shown that enterprises need competitive specialists who are able to use the knowledge gained

at the university in practice, who are mobile and ready to constantly develop and improve their own skills and competencies. This is evident in all industries, but the mineral sector has its own specifics. The question remains open: “How to increase the motivation to study among students of technical universities, so that later they become competitive specialists?” There are a great many discussions on these issues.

It is important to note that there is an indissoluble connection between the concepts of "motivation" and "competitiveness" [4], which implies that a student of a technical university can become a competitive specialist when he has the motivation and desire to study, as well as to be implemented in the professional sphere. This idea is reflected in many works [2], in which the authors, for example, propose a model for the formation of the competitiveness of university students, one of the criteria for the effectiveness of which is motivational, and its indicators are the orientation of the individual to avoid failures or achieve success [1]. According to their estimates, a competitive specialist is someone who is motivated by results, who is focused on the continuous process of gaining knowledge and on their subsequent application in practice.

Analyzing the problem of increasing motivation to study among students of technical universities, the study identified the following factors that have a serious impact on the degree of motivation of students:

1. Material incentives. As practice shows, if a student receives a financial reward from the university (in the form of an increased scholarship for successful studies, participation in scientific conferences, sports competitions, etc.) or from his parents, his level of motivation increases, the student begins to try even more, moving more successfully along the path of becoming a competitive specialist, because additional favorable conditions are created for this.
2. Socio-psychological environment. Recognition of the importance of the student's work and praise from, for example, family and friends is a very important aspect of increasing his motivation to study, as the student will feel that he is not studying in vain. As for the psychological aspects, we are talking about the social environment in which the student is in the process of studying. If the staff at the university is friendly, open, and the environment in general is good-pleasant for the development and acquisition of knowledge, then the student will not feel nervous tension, which will positively affect his motivation to learn [3].
3. The factor of physical health. The health factor is also important for increasing the motivation of the student. Of course, if a student has health problems, he will not have enough energy and time for a fruitful studying process, since his thoughts will be occupied with health problems. High demands are placed on the health of graduates of technical universities, since their work will often be associated with high risks and dangerous production, therefore, the physical and mental health of graduates should be strong.
4. Scientific and personal authority of the university teacher. Perhaps one of the central factors in increasing student motivation is the role of the university teacher in the educational process. A university teacher is a person who can instill love and interest in their subject or, on the contrary, cause a complete rejection of the student to the discipline being studied. The response that the university teacher can elicit from the student is influenced by many aspects, such as the attitude to the audience, appearance, oratorical skills, his level of scientific competence and mastery of the material, as well as his ability to justify the practical significance of studying the discipline.
5. Time-organizational factor. A rational approach to the time spent on studying also has an impact on the degree of motivation of the student. If a student is able to correctly allocate his time, allocating a certain number of hours for study, research, sports, additional education and entertainment, he will feel like a full-fledged person, developed in many areas of life, which will give him the opportunity to increase his motivation for learning.
6. Professional internships. A technical university can significantly increase a student's motivation to study if they are interested in organizing places for internships in their specialty. This will allow the student to join the work process in advance, get acquainted with his specialty,

which will allow the student to understand the importance of their future competitiveness in the labor market.

Thus, the synergistic effect of these factors should give the result that will lead to an increase in the level of competitiveness of the specialist among the "competitors". It should be noted that this problem is of an applied nature, since in the era of the fourth industrial revolution, in particular in the mineral resource complex, competitive specialists are especially needed, who will be able to bring production and the enterprise as a whole to a qualitatively new level. That is why it is so important to understand how you can "grow" and "educate" a specialist of the future at the early stages of studying in a technical university.

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STUDENTS 'LOOK AT DISTANCE LEARNING AT TECHNICAL UNIVERSITIES

Development of modern society led to the fact that all mans' activities are steadily connected with ever-evolving computer technologies. They simplified human labor and also worked towards reduction of time spent for different actions.

The development of multimedia and information technologies, as well as the use internet as a new technique of teaching, has made radical changes in the traditional process of teaching [1].

While the scientific-technical revolution has been developed and Bologna process implementation, distance learning broke swiftly into the learning process. The first process led to fast implementation of new information technologies, communications systems, first of all of the internet, into higher school. The second process got Russian education to be compared with west trends, where distance learning became widespread.

In 2020 distance learning became a way out of (pandemics) for all types of education, starting from schools and ending with universities.

The article considers history of distance learning development. Normative legal documents which validate this form of education in Russian Federation are referenced in this article.

A comparison study of distance learning in the world was conducted. Table 1 represents indexes used in the comparison study of distance learning.

Table 1 – A comparison analysis of distance learning (DL) development in different countries of the world

Index	USA, Canada	Western Europe	Asia
A level of DL technologies	High	High	Medium/Low

development			
Demand of alumni on job market	In-demand	In-demand	In-demand
Quality of education	High	High	Medium/Low
Demand of DL on job market	Востребовано	Востребовано	Much needed
Affordability of education	Affordable	Affordable	Affordable
Average age of students	30 plus	35 plus	Under 30

We can draw a conclusion from table 1 that both the level of distance education and its' quality are high in developed countries. Demand of alumni distance learning on job market is also at a high level. It is worth mentioning that this form of education is in demand on education market and it is ever-improving.

In USA, Canada and also in countries of Western Europe students of distance type of education are 30-35 plus. This is due to that the second or even the third higher education is required for career progression.

And it is easier to go into higher education in extramural form or form of distance learning. This form of education gives employers an opportunity to go into higher education on-job and upgrade their qualification.

We chose online questionnaire of students of Industrial University of Tyumen as a result of application of empiric method of study. The studies were conducted in the interest of necessity of distance learning implementation in technical universities.

We used anonymous survey, because it gives respondents an opportunity to offer their opinion, keeping it out of researcher criticism.

The questionnaire was conducted in two stages:

- until implementation of distance learning;
- after implementation of distance learning in universities.

Consequently, 480 people offered their opinion at the first stage and 507 people offered their opinion at the second stage. Students of different training programs and courses of studies were questioned. Questionnaire of so many students gave an opportunity to study more thoroughly the opinion of educational process participants about distance learning.

The respondents were offered to:

- estimate efficiency of distant form of education;
- choose most relevant messengers and platforms for education realization;
- choose educational services which can be realized by means of distance learning;
- identify positive and negative factors of this type of education.

After an analysis of the first stage of the questionnaire it was identified that about 10% of students had a practical experience of distance learning. According to the results of the second stage percentage of students who had the practical experience of distance learning increased and was at 100%.

According to the results of the survey basic factors affecting on quality of distance learning were identified:

- a level of distance learning programs and inline-courses;
- a way and quality of an educational process management;
- motivation and discipline of students in the educational process.

Generally, from the point of view of the respondents, distance learning is acceptable as an additional element and technology to a full-time mode of study, because quality of education of traditional form has no equal. Absence of direct interaction "teacher - student", lack of living speech and emotional exchange deteriorate information perception and lower strength of grasp of material.

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TYPOLOGY OF EMPLOYEES BASED ON THEIR NEEDS

The main source of profit for an entrepreneur is a person and his professional resources. Neither the most expensive equipment nor the most modern technologies will help you achieve the desired result in business if you do not have the right employees with you and the ability to handle them. Understanding people, you can easily predict a person's ability to act and entrust such work with which he can do the best and will bring benefits to production.

Understanding people means understanding his interests and needs. Abraham Maslow's generally recognized hierarchy of human needs can help us with this. Studying it [1, P. 35-59; 2.S. 45-52; 3.], let's try to understand what drives a person and how to apply this knowledge to create a motivational typology of workers. After all, our behavior in various areas of life is formed under the influence of our needs in the first place.

Maslow argued that the basic five types of needs almost always come in the order shown in Figure 1:

1. Physiological needs. They consist of basic, primary human needs, necessary for existence.
2. The need for security. Once the physiological needs are met, the need for safety comes to the fore.
3. Social needs. The need for friendship, love and belonging.
4. Needs for respect: self-esteem and respect from others.
5. Needs for self-realization and self-expression.

According to prof. Yu. M. Bubnova [4], each person at the same time has needs of all five types, but the strength of each need at any particular time depends on the person's personal priorities. Depending on these priorities, an individual hierarchy of needs of a particular individual is built. Developing the idea of Yu.M. Bubnov about the typology of workers, all people can be divided into 5 types.

Type 1: people who have physiological needs in the first place. As a rule, these are individuals who live one day. They do not make plans for the future, but want to get everything they need at a given moment in time. Such people as workers can be defined by the following factors: they try to complete their volume of work as soon as possible and shorten their working day, so that there is more time for relaxation and rest. They prefer routine work. An important component for them is material values. This type of employee can be motivated by issuing bonuses or providing additional days off, as well as holidays.

Strict control by the manager is also important, since a type 1 employee can be late and sometimes have low performance due to a tendency to laziness. The position most suitable for such people is a worker who carries out orders "from above". The nature of the work should be constant, systematic, repetitive.

Type 2: people for whom safety and confidence in the future is an important part of life. They are afraid to make mistakes, they double-check the completed work many times before submitting it. They try to come to work earlier than the specified time in order to avoid being late. They do everything according to the rules. They want to be sure that after getting a job, they will stay on it for a long time. People of this type can be confidently put on responsible work that requires strict execution on time.

As a motivation, an excellent approach would be the conviction of a stable wage and the reliability of the workplace, the provision of a system of benefits, health insurance, additional payments for seniority, you can provide travel to work. Threats of loss of bonuses and, in extreme cases, dismissal can be used as an incentive. Such people are very holding on to their work and will do almost anything to keep their place.

Type 3: outgoing personality. They need a pleasant, cheerful and friendly social circle and a feeling of being needed in it. They are happy about the upcoming events, they actively participate in them. A well-coordinated team is more important for this type of employee than salary and other values. Knowing the preferences of workers of type 3, it is easy to assume that their work should mostly consist in interaction with other people. The ability to win over a person and find a common language is not an easy task for most people, but at the time of this type.

Type 4: dominants. Strong personalities who want to control others, and who do not like to obey someone else. In all matters, they strive to take everything under their control and do not tolerate competition. Work hard to be successful. They have a predisposition to a good organization of work, to set goals and show the will of character to achieve them. As a rule, such people have high self-esteem. It requires a special attitude to itself in order to feel its significance and importance. They want public praise for their work. They often ignore the opinions of others, and impose their own on them.

Personalities-dominants in life become leaders, and the positions that they should occupy are leading, requiring subordination. Career growth is important for them, therefore, the authorities need to indicate the prospects for the future.

5th type: creative individuals. They can be recognized by their out-of-the-box thinking and approach to business. By asking the right questions, you can hear interesting answers and immediately understand that this is exactly the creative type. Creative people do not stand still and constantly develop, learn something new. On the way to achieving the goal, they follow different paths, not similar to the usual ones. They work a lot and leave little time for rest, because only after reaching the goal they feel satisfaction. But a problem typical of such people may arise - a creative crisis. And the way out of this situation must be correctly chosen: to give time to "reboot". The leader should pay attention to creative people, psychologically support and point out the high importance of their work. The creative type can be used in different ways in an enterprise. His ability to generate ideas is very useful for creating new projects, improving and finalizing existing ones.

A manager who knows the priority type of needs of his subordinate and selects the right motivators and incentives will keep the work process under control and increase labor productivity. And the satisfied needs will contribute to the personal growth of employees. Ultimately, two sides will remain in the black: both the employee and the employer.

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THE ESSENCE AND MAIN FEATURES OF DUAL TRAINING

In Kazakhstan, in recent years, the topic of the dual education system has become relevant. The dual system of education is a system of education that provides for a combination of training in an educational institution with periods of industrial activity. The educational process is organized as follows: in parallel with the usual classes at a university, college or other professional educational institution (general education training), students go to work at a specific enterprise or firm, where they gain practical experience (professional training). The purpose of the introduction of the dual education system is to develop technical and vocational education by creating a highly effective competitive system of training and retraining of workers and technical specialists, introducing new training technologies into the educational process of vocational education organizations, further developing the system of continuing professional education, stimulating the development, processing and improvement of professional standards for workers and technical specialties[1].

The dual training system is one of the possible ways to combine the interests of business, future specialists and the state. Dual training is a type of training in which the theoretical part of training takes place on the basis of an educational organization, and the practical part - at the workplace. This system of training specialists is aimed at improving the model of training professional personnel taking into account the economic needs of specialists in order to increase investment interests in the regions.

The main tasks of the dual training system include:creating models aimed at financial participation of enterprises in the implementation of personnel training programs, training of qualified workers.

Principles of the dual training system:

– scientific justification and high quality of fundamental-subject, psychological, pedagogical and professional training;

– integration-interdisciplinary communication aimed at the formation of the necessary competencies built on the basis of modular educational programs;

– universality-completeness of a set of disciplines that ensure the unity of theoretical and practical aspects of training future specialists.

Concept of development of the dual training system:

– continuity and continuity of stages and stages of Professional Education, which justify the continuity of levels of formation of specialists;

– flexibility and variability of educational process technologies in the vocational education system;

– adaptation-development of the specialist's ability to socialize in changing production conditions;

– the developing nature of education is to meet the professional needs of a person and their needs for personal growth.

Dual training is a product of close cooperation between educational institutions and employers in the professional and social adaptation of the future specialist. At the initial stage of the educational process, the trainee is introduced into the production process as an employee who manages the resources allocated in accordance with their functional responsibilities, Bears official responsibility, acquires professional skills and receives a salary under certain conditions. Analyzing labor resources in different countries, it can be seen that students are able to form a creative personality capable of implementing new ideas within the framework of the chosen profession, preparing for the social roles of an employee or entrepreneur who is competent in

interaction with production technologies and the professional environment, has entrepreneurial and enterprise management skills[2].

At the initial preparatory stage of the implementation of the dual training system, the following activities are carried out: - preparation of regulatory documents; - development of educational programs in specific specialties; - conclusion of contracts with enterprises; - determination of the student body.

The second - organizational - determination of training programs for each specialty; - drawing up a schedule of classes; - determination of control measures based on the results of training.

At the third and final stage, students will get used to the production environment in the educational institution and at the workplace on variable training programs.

Advantages of the dual training system:

– the system of dual training of specialists eliminates the gap between theory and practice;

– the mechanism of the dual training system includes the influence of a specialist on the individual, the creation of a new psychology of the future employee;

– the dual training system for employees creates high motivation to acquire knowledge and skills while working;

– interest of enterprise managers in hiring a theoretically and practically trained specialist;

– professional education organizations working in a professional partnership take into account the requirements of employers proposed by specialists in the future in training[3].

The widespread use of the dual training system allows college graduates, on the one hand, to find a job in their chosen specialty, and on the other hand, it is possible to observe what specialties and in what quantity are in demand on the labor market.

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MINING ISSUES IN SELF-PROCLAIMED REPUBLIC OF KOSOVO: RIGHT TIME FOR MORATORIUM?

In 2008 so-called Republic of Kosovo (below as the “Republic of Kosovo”) proclaimed its own independence (including mineral resources ownership) and took de facto control of territory out of the International Law. Currently, the self-proclaimed government is establishing mining law legislative and regulates exploitation of resources like coal, gold, chrome, nickel, silver, bauxite, etc. [1]. The major interest for this topic — the contemporary lack of solutions in existing regulation and legal literature to protect the Serbian right to permanent sovereignty over natural wealth and resources.

Mining governing in the „Republic of Kosovo“ is composed of the regulatory organ (Ministry of Economic Development) and executive organ – mining licenses and permits issues

(Independent Commission for Mines and Minerals - ICMM) — both reports to the General Assembly of Kosovo for their work [2]. Considering controversial mining practices, attention should be paid to Kosovo Energy Corporation (KEK). That is the biggest state lignite mining company in Kosovo which operates electricity generation and distribution, too. Lignite mining consequently provides about 90% of total electricity needs [3]. It is worth noting that the Kosovo and Metohija has the 5th largest reserves of lignite coal in the world. Secondly, ICMM licensed Slivovo gold mining project managed by a joint venture between Avrupa Minerals and Byrnecut International (Canadian and Australian mineral companies). ICMM license in the Slivovo project permits these companies to exploit lead, zinc, silver, and gold at Peshter's field. Another example is Beowulf – the UK registered Nordic mining company. Beowulf has 46% in private limited company Vardar Minerals which formed several licenses in "Republic of Kosovo" including a license for The Viti project – to exploit fields a wealth of porphyry, gold, and copper and The Mitrovica project – the license area is prospective for porphyry related mineralization types as well as epithermal gold and low sulphidation lead-zinc-silver.

Bearing in mind International Law regulation, we should pay attention that General Assembly Resolution 1803 (XVII) of 1952 established the right to permanent sovereignty over natural wealth and resources. According to the Resolution, every type of disposition, including foreign capital import, shall be in conformity with regulation which peoples and nation consider as desirable and also, be strictly respected by states and international organizations [4]. Furthermore, the International Covenant on Economic, Social and Cultural Rights of 1966, provided that all people may "freely dispose of their natural wealth and resources". For this reason, we recommend a moratorium on mining in Kosovo and Metohija, with the exception of the coal exploit for the electricity needs of local people.

The simplest solution for Serbia to protect its own rights is to develop a new legal framework. On the one side, Serbian should bring up legislation to prohibit illegal ore mining (in particular to impose a moratorium). On the other side, the lawmaker has to regulate compensation issues for any illegal exploit in the Autonomous Province of Kosovo and Metohija. Thus, the Serbian law will allow Serbian courts to resolve claims of the authorized state body against the legal entity carrying out the extraction of minerals. For example, it may be a lawsuit between the Republic of Serbia Ministry of Mining and Energy and the mining company Beowulf. Another variant of solving the problem is more authoritative and effective in practice — it is a moratorium established by the UN Resolution. For an instance, in the deep-seabed mining practice, environmental problems can be the reason for the moratorium. Concurrently, the importance of the above-mentioned rights, political tension, and potential economical damage should be the reason for the UN moratorium on mining in Kosovo and Metohija. At present, UNMIK Regulation act 20005/3 from 21 of January 2005 proclaimed „exploration, extraction, and processing of mineral resources in Kosovo for the benefit of Kosovo". New UN Resolution can solve the current conflict of interest [5].

By the reason of the lack of sovereignty, the „Republic of Kosovo“ should not exploit Kosovo's mineral resources in any way. Each mining license given by Independent Commission for Mines and Minerals disables Serbia in a right to permanent sovereignty over natural wealth and resources and, therefore, represents an internationally wrongful act. Considered this fact, the international institution should impose a moratorium on mining on this territory since the final solution of the Kosovo issue.

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NEGLECTED URBAN SPACES, A CALL FOR REGENERATION

Long since public spaces in cities have been developed, their common purpose was to encourage the relation between inhabitants and their built environment. Open spaces in dense urban neighborhoods have catered people from varied backgrounds and emphasized social interaction. However, such spaces today no longer accommodate user's needs due to the segregation and neglection they have witnessed.

This thesis seeks to explore the potential of neglected urban spaces to spark economic development in dense neighborhoods and their capability of transforming the surrounding environment into a vibrant, social, and active whole. Within the context of residential neighborhoods with historic urban cores, the city of Tripoli, Lebanon, is the main case study where interstitial spaces have been marginalized in the urban fabric.

The paper caries out a study over different examples of neglected spaces, such as odd shaped leftover lands, un-constructable parcels, empty parking lots, and others. Accordingly, this thesis investigates an integrated approach that combines two disciplines, architecture and urban design, to formulate sustainable solutions that help revive such residual spaces and improve their quality of use.

To achieve the paper's goals, classifications of neglected urban spaces are extracted from theories, case studies, and research based on urban planning and landscape literature. Such classifications include the grouping of residual spaces into different scales, in addition to other functional and physical typologies.

Consequently, results of this paper show that various networks of sustainable regenerations consist of a synergy between society, ecology, and economy to reach the goal of interconnection between neglected urban parcels. In addition to conveying the idea that sustainability is not achieved in the short term of time, but rather needs slow growth.

On this basis, findings suggest that the strategies of sustainable regeneration are not limited to the tactics mentioned in this thesis, such as space programming, urban agriculture, and placemaking. Adopted approaches are abundant and constantly developing, thus permanent studies should be caried out to discover innovative strategies to regenerate neglected spaces.

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BASES FOR FORMING A BUSINESS TOURISM COMPLEX WITH SPORTING FUNCTION IN THE CITY OF EL-MUKALLA (YEMEN REPUBLIC)

Business tourism is one of the most important and rapidly developing elements in the Yemeni economy. With the ever-growing demand for the tourism industry and the promotion of business tourism, the level of development of business tourism centers in the country does not allow us to fully provide this direction and requires improving the quality of the environment in accordance with international standards.

The Republic of Yemen is located in Southwest Asia, in the south of the Arabian Peninsula, and ranks 49th in the world in terms of population (over 30 million people) and land area (527,970km2). Yemen consists of 22 provinces, which are divided into municipalities and districts. Sanaa is the largest city and capital of Yemen.

The architecture of Yemen has a unique, oriental flavour, which is the result of preserving traditional principles and, construction technologies. The urban architectural and spatial environment was formed taking into account the peculiarities of folk architecture and regional traditions. The fusion of the architectural traditions of Great Britain has been evident in the southern provinces of the country for almost 130 years, starting in 1839 года.

At the present time, Yemen has all the resources (country status, location, climate features, a variety of mountain and coastal natural landscapes, topography, the presence of a large number of islands, including the closest to El Mukalla: the island of Socotra) to bring the business tourism sector to a high level and integrate it into the global community.

The concept of creating a state -of-the-art business tourism infrastructure with a sports function that, meets current needs, meets international standards for the quality of services in this area. The sports function in the project will be represented by a ski complex that includes the first ski park in Yemen and the second in the Middle East after *Ski Dubai*. The name of the park is also suggested – *Ski Mukalla*.

Business tourism today means business meetings, conferences, seminars, exhibitions and search for business partners, cooperation and professional development of specialists, exchange of experience, information and valuable ideas for further business development. It includes individual and group business trips of managers and employees, participation in events organized by industrial and commercial corporations, participation in congresses, conferences, seminars organized by political, economic, scientific, cultural, religious and other organizations, visits to trade and industrial exhibitions and fairs and participation in their work, business courses, business trainings, incentive trips for employees and clients. Usually the business part is combined with an extensive excursion program. At the moment, the multifunctional business complexes that were implemented did not include sports functions in their structures.

The multifunctional business tourism complex is expected to cover a total area of more than 5000m^2, and will include social and business, sports, cultural and entertainment activities. The ski resort will play a major role in the structure of the multifunctional complex and will be a tourist attraction. It is supposed to be the first park in the country that provides an experience of skiing on artificial snow , despite the climatic zone.

For the full functioning of a modern business center and meeting all the needs of society, several important criteria for architectural and spatial planning solutions should be identified:

– -versatility;

– -changing the traditional functional dominance in the structure of a multifunctional tourist complex and providing a mechanism for flexible transformation of functions;

– the architectural and artistic image and functional planningpsolution of all the components of the complex are designed to synthesize national traditions and global trends in architectural practice;

– -conditions for work and communication should be organized on the basis of a single universal model.

Thus, the functional orientation of business centers should take into account the modern popularity of business as an independent structure and the possibility of business development from almost any branch of human activity, which implies a multifunctional orientation of business complexes. Cultural heritage sites and their transport and pedestrian accessibility relative to the business complex directly affect the level of service provided and, as a result, the possibility of sustainable development. A well-developed transport infrastructure, including land and sea, is one of the fundamental factors in the design and development of multifunctional business tourism complexes. Adaptive design and hybridity of modern business complexes is a necessary condition for long-term operation. The implementation of this multifunctional complex will contribute to overcoming the social isolation and functional monotony of the depressive territory adjacent to the west, and will affect the sustainable development of the urban environment. of El-Mukalla and the region as a whole.

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VIRTUAL REALITY TECHNOLOGIES AS A TOOL FOR VISUALIZING THE RESULTS OF CFD MODELING IN URBAN PLANNING

This paper describes the implementation of a software and hardware solution designed for interactive visualization and post-processing the results of computer modeling of aerodynamic processes in buildings using computational fluid dynamics methods (CFD). Due to the steady increase in the environmental load on urbanized territories, the theory and practice of urban planning is increasingly clearly tracing the problem of planning and designing large cities, taking into account their local climatic and environmental factors. As is known, human bioclimatic comfort is determined not only by natural and climatic factors, but also by the urban microclimate, which can change locally, and therefore, it is possible to optimize and take into account its parameters when performing urban or district planning tasks.

Methods of computational fluid dynamics (CFD) are increasingly used in the study and modeling of microclimatic parameters of the city as part of the general task of creating a comfortable and safe urban environment. Currently, there are many software packages for CFD modeling tasks, mainly based on finite element or finite volume modeling methods. Functionally, most of the existing software solutions are aimed at professional CAE-engineers, and the built-in tools for postprocessing results are usually quite complex for researchers and specialists in architectural or urban planning. Also, the provision of remote interaction of researchers when working on joint projects is particularly relevant during the pandemic period. Remote visualization and postprocessing of CFD tasks are a particularly complex process, due to the large size and complexity of synchronous reproduction of each calculated case.

Currently, there are many software for CFD modeling tasks, mainly based on finite element or finite volume modeling methods. Most of this solutions are aimed at professional CAE-engineers, and the built-in tools for postprocessing results are usually quite complex for end researchers and specialists in architectural or urban planning. Also, the provision of remote interaction of researchers when working on joint projects is particularly relevant during the pandemic period. Remote visualization and postprocessing of CFD tasks are a particularly complex process, due to the large size and complexity of synchronous reproduction of each case study.

We can say that there are a number of technological barriers for specialists in the effective use of CFD-methods in urban planning. Existing modeling packages have a high entry threshold for non-professional users, are poorly compatible with each other, and do not provide a flexible mechanism for joint interaction for remote work

These factors determine the need to create a new class of interactive visualization tools in the form external postprocessor that supports virtual reality (VR) and network interaction technologies. In order to overcome these barriers, a number of research studies were conducted to create a simplified CFD-postprocessor that is aimed at non-professional users and has the capabilities of interactive interaction and visualization of results using VR technologies. This study is based on the hypothesis that measuring local air flow parameters at the individual scale

using virtual reality technologies can significantly increase the visibility of the microclimate modeling process.

As test data for testing and debugging, a task from an applied study on computer modeling of the residential building's aeration was selected. The object of the study was the process of wind flow around a series of several variants of the architectural and planning composition consisting of 5 parallel buildings with a height of 5 floors.

The proposed solution was built on the basis of the Unity3D environment, and the Ansys Fluent was used as a data source. The architecture of the PLT-Sim system complex was developed, as well as algorithms for the main subsystems of data visualization in the form of vectors, particle systems, streamlines, and planes were implemented. This study offers an implementation of main interactive visualization-tools for air flow parameters in virtual reality mode, as well as a description of systems for importing and interpolating scattered data from different CFD-modeling systems.

Results, obtained from the prototype allowed us test the basic ideas of using VR technologies for visualizing hydrodynamic models in context of urban planning studies. We also tested a client-server model for network interaction mode. The obtained results were compared with the original data from standard postprocessing packages. A generalized representation of the complex architecture and tests of operation in VR mode are shown in Figure 1.

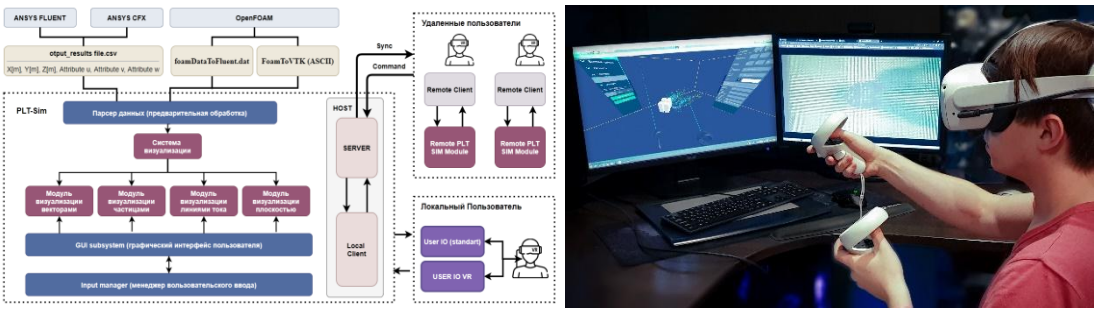

Figure 1 – Flowchart of the system architecture (left) and prototype operation(right)

In the current version, the prototype has confirmed its viability as a simplified tool for VR visualization of CFD-results, with a calculated grid density of more than 10 million cells within a single scene. Furthermore, additional optimization is planned to bring the peak performance of the complex to 1 billion nodes. Presented solution was one of the first to develop the concept of using VR technologies for architectural and urban planning visualization beyond the simple demonstration of spatial planning solutions. The results of this study were patented as program product. Suggested methods and technologies will be useful for further researches of urban microclimate and urban planning, as they will greatly facilitate the process of finding the optimal solution for layout of buildings for maximum bioclimatic and wind comfort.

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THE ORGANIZATION OF A "SMART" HOSPITAL, FOCUSED ON THE LEVELS OF PATIENT NEEDS

Worldwide, there is an annual increase in various diseases, which is a significant social and economic problem in all countries [1]. All this places a huge burden on the health care system and makes it necessary to build new hospitals, which, in order to achieve the goal of full-fledged treatment of patients, must perform numerous functions and correspond to the concept of a "smart" hospital. When planning the internal structure, it is necessary to take into account numerous aspects, depending on the tasks set: the creation of operating rooms or intensive care units, clinical units with conventional or boxed wards, or infectious diseases units. An important aspect is also the rational location of the premises in relation to each other, depending on the nature of the interaction of the departments with each other. In this review, we want to highlight the topic of organizing a "smart" hospital, focused on the levels of patient needs [Maslow A. H. Motivation and Personality. — New York: Harpaer& Row, 1954.].

According to the research of Abraham Maslow, human motives are set at different levels in accordance with the hierarchy of needs and contain 5 levels: the first 3 belong to the group of deficit coverage, the 4th and 5th levels - to the group of growth opportunities [3]. At the bottom of this hierarchy (1st level) are the needs that must be met first of all - physiological. They are fundamental to human survival and adaptation. The next, 2nd level is the need for security. Social needs occupy the 3rd and last level in the deficit coverage group. This level concerns connections that provide support, such as family, loved ones, and friends [3]. The group of growth opportunities (the 4th level of the hierarchy of needs) is represented by the need for self-esteem and recognition, the possibility of personal growth. At the top of the hierarchy levels (the 5th level) is self-actualization. People must realize their abilities and their potential [3]. Maslow's hierarchy of needs helps the designer evaluate patients as complete individuals, with their physiological, intellectual, emotional traits, social capabilities, and spiritual and moral guidelines.

To ensure the 1st level, first of all, it is necessary to have a source of water and food. They should be in a place accessible to the patient at any time. In the absence of epidemiological danger, food consumption zones should imitate public food outlets (cafes and restaurants), so that the patient can be distracted from the hospital environment for a while. Air quality, supported by a properly designed ventilation system and the ability to ventilate the room, is of great importance in human life. Also, hospitalized patients have an increased need for rest and especially sleep. The well-thought-out layout of the space, the choice of sound-absorbing materials, the creation of sound-absorbing partitions and silent alarm systems contribute to the creation of a calm environment. Another means of providing comfort for patients is to provide them with access to natural light through the windows, control the illumination of the room and the temperature regime within the permissible norms in accordance with preferences. Ensuring the 2nd level of the hierarchy of needs is carried out by creating a sense of security in the patient, in this case, by protecting them from potential physiologically and psychologically harmful effects. The visual qualities of the rooms and furniture should combine aesthetics, since they will affect the assessment of the level of medical care received by the patient, and practicality – the structures and materials used should be easily disinfected. The patient should be able to go into an enclosed space while maintaining the ability of the staff to easily access this room if necessary, which is ensured by the installation of electronic locks [2].

To ensure the 3rd, social, level of the hierarchy of needs, it is necessary to take into account the psychological aspects of an individual. In each department, as well as in the common spaces, zones are required that allow the patient to communicate with visitors and other patients at will. The design of these spaces should be suitable for both formal and informal settings. For family visits to a serious patient, a ward may also be suitable, in which it is necessary to provide a sufficient number of seats. If it is necessary to create confidentiality, patients should be placed in a single room, and within a multi-bed room, it is advisable to provide partitions that protect patients from each other. Quick and effective interaction of the patient with the medical staff can be ensured by placing the post in close proximity to the wards.

The need for self-actualization and personal growth is somewhat more difficult to realize, however, creating an inspiring atmosphere of space can help. Art objects, access to nature and leisure can give the patient the opportunity to focus on themselves and their abilities. Maintaining the patient's sense of self-identity is facilitated by the possibility of the patient's participation in the organization of the surrounding space with the help of personal belongings. When designing hospital rooms, disorienting design should be avoided, especially long and dark corridors.

Thus, the creation of a "smart hospital" implies the correct consideration of all needs, consistency, structure and predictability of the stimuli of the hospital environment, promotes the understanding of the patient that the available resources exist to meet their needs [4] and makes it easier to bear the stress associated with the need to stay in hospital.

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STRUCTURAL FEATURES OF SMALL GREEN SPACES OF MODERN CITIES

In most modern large cities, a gradual reduction in the area of green areas is observed: the territories of parks and forest parks are decreasing, the number of landscaping objects is decreasing, new buildings and structures appear in their place, engineering networks are being laid, and the existing buildings are being compacted, which is due to the economic development of the city. In view of this, it becomes impossible to form large green areas, preserve and develop the traditional "green frame" of the city. This problem sounds especially acute for the central regions of megalopolises [1].

However, a greening system that performs urban planning, environmental, social and many other necessary functions is one of the most important factors in ensuring comfort in an urban environment [2]. A possible solution in this situation may be the creation of a set of small green spaces that do not require large areas, capable of integrating into complex urban systems and creating links between disparate "green" elements. Small green areas include gardens of districts and microdistricts, squares, courtyards, buffer adjacent zones, roof gardens, and others

[3]. These territories occupy a relatively small area (from several square meters to several hectares), while performing the required functions of an urban greening system [4], can repeat the structure of large landscaping objects and differ in a wide typology, which allows them to be located in different parts of the city. Hence, the definition of a small green space (SGS) is an artificially created green space with an area of up to 5 hectares, consisting of various recreational zones with a set of green spaces, filled with the necessary equipment (in accordance with the typology of spaces), connected by pedestrian paths with each other and with adjacent urban territories; designed for short-term rest in a natural environment and the organization of social processes.

Such landscape elements are used as:

– a set of green spaces (woody, shrubby, herbaceous vegetation, which occupy most of the territory),

– relief (natural and artificial),

– water surfaces and devices for improving microclimatic conditions and making picturesque;

– small architectural forms (outdoor furniture; lighting, navigation, video surveillance systems; sculptures, etc.);

– coatings (various ways of decorating the surfaces of zones and links);

– separate spaces - zones (areas for the implementation of various functional processes: active and quiet rest, waiting, sports, playing with children, walking animals, etc.);

– connections between separate spaces (transit walking paths, jogging and cycling paths, walking paths).

SGS can consist of a single space or a set of different zones (mono- or polyfunctional). Also, the structure of the SGS can include universal spaces that are easily adaptable to various functions, for example, they involve the organization of festivals, fairs, competitions, competitions, etc.

The types and number of functional zones, filling them with landscape elements and equipment are determined by the need of local residents for recreational activities. The architectural and planning structure of the (SGS) is created taking into account the surrounding buildings: the location of entrance nodes, transit routes is determined according to the directions of human flows from public transport stops, public buildings, educational institutions, etc.

A distinctive feature of the SGS is its compactness, the possibility of placing recreational areas with greenery inside dense urban development. However, since the area of the SGS is relatively small, it is not possible to place all the required functional zones on the territory of these objects. Also, a limited number of green spaces only partially meet environmental requirements. Therefore, it is necessary to form a system of SGS, which complement each other with various social functions (recreation, events, education, movement), urban planning (shaping the architectural and artistic appearance of the city, creating a comfortable urban environment, etc.) and environmental (improving microclimatic conditions, air basin cities, etc.). Green pedestrian links should be established between them and with other larger green spaces in the city to create an additional green network and improve the comfort of the urban environment. Separately, it should be noted that such an approach is possible for the development of green structures in areas with a relatively favorable and unfavorable climate, including in the zones of the Russian North and other territories with extreme natural conditions.

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GENERATIVE DESIGN METHOD IN THE STRUCTURAL ORGANIZATION OF THE SPATIAL ENVIRONMENT

Generative methods of searching for forms existed in architecture long before the digital revolution. Already at the beginning of the twentieth century, many architects, engineers, and designers were applying design techniques that were very similar to modern computational approaches. The use of digital tools in architectural design has significantly reduced the process of transition from the concept stage to the implementation stage of the object, expanding the influence of the method on the future development of the profession. Time, which was once seen as an obstacle or a source of delay for construction, has taken on a new role in architecture – it is now involved in the kinematic modeling of space [4]. Today, time and motion have become tools in architecture thanks to powerful software. Instead of creating an architecture that is essentially an organization of stationary, inert forms, architects begin to shape space as a highly plastic, flexible matter, in which the very form of the building continuously evolves through movement and transformation with complex time sequences and simulations. Shapes are no longer defined by simple scale, volume, and size parameters [1].

Using software procedures that track time-related factors, such as pedestrian and car traffic, environmental conditions (wind and sun movement), and the nature of urban development, architects model spaces in which virtual and real-world media technologies are inextricably linked. A similar idea can be traced in ancient philosophy, where the concept of "discrete" interprets being as a divisible reality in motion [1]. At the beginning of the XXI century, in 2008, the manifesto of parametrism of the current head of the architectural studio Zaha Hadid Architects, architect Patrick Schumacher, finally approved these provisions. In addition to the question of style, the origins of discretism, according to P. Schumacher, relate to the totality of theoretical and practical achievements of logic, mathematics, and physics, which led humanity to the era of efficiency, while digital production occupies a dominant role. The similarity of a discrete architecture created according to the laws of artificial logic with a real one should not be misleading. Nevertheless, the synthesis of these techniques led to the emergence of "neo-neorationalist" architectural idealism ("post-digital architecture") and neo-positivist biomimetic architecture, reproducing natural phenomena in the form of anthropomorphic transformations, referring to the Renaissance era [3].

The generative architecture is based on mereology. This means that the design is done through wholes, parts, and compositions [2]. Mereology allows you to describe a building through its fragments, using the properties of transfer, reflection, and bonding. This term, derived from the Greek word meros, meaning "part", refers to the study of the whole through the relations between its parts. "The whole is greater than the sum of its parts" is a phrase attributed to Aristotle.

Parametric architecture is characterized by a high degree of freedom in creating architectural forms. At the same time, architects such as Neri Oxman and Greg Lynn note the "dissolution" of tectonics, as the architectural-spatial environment has become more "fluid" and continuous, eliminating the need for parts. In doing so, matter can be manipulated with a high degree of precision by enhancing the properties of the material at a microscopic scale – a task of morphoecology that applies the rhetoric of sustainability specifically interpreted to optimize performance at the building scale [2].

The theoretical core for the application of the latest technologies in architecture is the publications of the three founders of the EmTech studio of the Architectural Association (AA) – Michael Weinstock, Michael Hensel, and Achim Menges. Michael Hensel describes digital morphogenesis as the process of self-organization that underlies the growth of living organisms, from which architects can extract all the necessary knowledge [2]. Digital morphogenesis is considered as the use of generative media to obtain a material form and its evolutionary mutation. Its key concepts include topological geometry, genetic algorithms, parametric design, and performance analysis [4].

Currently, there is no single definition of the term "generative design", but there are many complementary definitions that, according to architectural theorists, are common. In general, it can be described as a design method where form generation is based on rules or algorithms, often derived from computational tools such as Processing, Rhinoceros, Grasshopper, and other scripting platforms. Generative design is a logical synthesis of the creative process using the rules (algorithms) of transformation. Like all creative processes, this method involves subjectivity in determining how the process works, and how the transformation rules are created and organized into a system. Computational evolutionary algorithms can be applied to analyze the relationship of an object with a number of criteria for ecological suitability and impact on the environment.

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CREATING A COMFORTABLE AESTHETIC AND PSYCHOLOGICAL ENVIRONMENT FOR PEOPLE WITH LIMITED MOBILITY AND MAINTAINING EQUALITY BETWEEN HEALTHY PEOPLE AND PEOPLE WITH DISABILITIES IN SOCIETY

Development of principles for designing a comfortable aesthetic and psychological inclusive environment.

Keywords: inclusive environment, public space, accessibility.

The problem of the chosen topic is the lack of equal conditions for the perception of the world and the presence of people with disabilities in society.

In our work, we will touch on the stay, the feeling of the environment, not only for children and not only for the disabled. Identify the principles by which it is possible to design spaces for everyone equally.

Objective: to identify the principles of designing an aesthetic and psychological inclusive architectural space.

Tasks:

1. study the problem and determine its relevance
2. read the relevant literature
3. sum up the statistics and make an analysis

4. propose the principles of architectural design of an inclusive environment
5. demonstrate the identified principles on the example of the IAF's own project in the public space.

In the course of the work, the peculiarities of perception of various nosologies were studied. The following subjects were accepted for study: blindness, deafness, psychology of a wheelchair user.

In addition to the literature, a survey was conducted to verify and clarify the facts.

The results of the survey confirmed the relevance of the problem.

Based on studies of the psychology of people with these nosologies, the following principles were proposed for the following problems: solving detachment, eliminating the typification of special equipment for the disabled in public spaces, dynamics, texture, field of view, color solutions.

To demonstrate these principles, the project of the art space "Ritual-return to the roots"was created. An attempt was made to convey the message in an inclusive manner. On the basis of the proposed principles, interaction with the object is designed, which is also focused on the considered health deviations

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AI/ML IN ARCHITECTURE & ROBOTICS

AI/ML in Architecture & Robotics. We would like to present two projects which were done at the FGDE Department at the Brandenburg University of Technology. One of them is a highly theoretical work at the intersection of architecture and AI. The second is applied ML methods in the robotics field.

Architecture Gridworld Testbed. This project wants to address the representational problems of architecture combined with architecture-related AI systems and missing standardized tests for such systems. For this, we suggest a standardized computational testbed that can serve for developing, testing and benchmarking design solutions for abstracted architectural problems with various AI approaches in a game-like environment. It aims to help achieve automation of specific design workflow phases, then in the longer term to optimize and propose alternative design solutions and improve the architectural community's overall work.

The ability for abstract thinking is one of the crucial skills of an architect. It means the reduction of detailed information in dependency of the process phase, and this concerns not only the subject of the architectural design but also the architectural process itself. Abstraction helps us to keep in mind the "big" goal of the architectural problem. Following this, we will not start with a staircase core design before we have a house's footprint. Still, broad architectural knowledge is necessary to successfully abstract certain dispositions, like the approximate size and location of a staircase in the house footprint's dependency. Furthermore, architectural design problems involve performing a series of actions where the goal state is not known in advance (Chan, 1990).

For the AI field to apply those action steps, we have to limit the analyzed problems and used tools. In this research, we are dealing with the spatial, volume, and connectivity scope of problems. We also assume that architects can formulate architecture design problems with a certain degree of simplification that is also beneficial in formulating the goals in specific AI-compatible mathematical definitions.

In the last years, researchers conducted AI-related spatial and architecture-related experiments using the voxelized world of Minecraft (López Méndez et al., 2017), and one team developed a competition to generate settlements (Salge et al., 2020). Their experiments showed that the main problem of setting such multi-objective settlement-related goals is the provision of a quantitative analysis of delivered solutions. Although the aim is high, this work shows the applicability of gamelike tools for solving complex architecture problems. The ability of AI-driven intrinsic motivation to change an environment can be observed in other Salge research work (Salge and Polani, 2013) and serves as a basis for diverse scenarios.

Complex robot path planning. One of our projects at FGDE is an automated concrete spraying system. It is a complex IoT-powered system with emergent complexity. In the showcase of this we would like to address the following topics:

- Concrete spraying using 6-axis robots
- Interconnection of separated IoT components
- Point cloud scanner application
- Complex robot path planning

The complex path planning in this work used a multi-optimization strategy with the use of different ML methods. For instance, during the decomposing of the overall problem, we formulate part of the solution in terms of the Travel salesman problem, which enables us to find an optimal path based on different geometries.

In the conclusion we show various simulation data as well as media from the real-world test site.

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NOISE REDUCTION SOLUTION ON THE EXAMPLE OF THE MAIN VENTILATION FAN STATION MODEL

Noise is an integral part of human life. It is encountered in almost every aspect of life. It is a burdensome phenomenon that affects the comfort of household members or employees. Noise is defined as any undesirable vibrations of the elastic medium affecting the hearing organ, other senses and elements of the human body [1]. The most common negative effects of noise in the work environment are various ailments experienced by employees, such as: stress, decreased concentration, anxiety, irritability, aggression, sleep disorders and physiological effects (e.g. increased blood pressure), and even permanent hearing impairment [2]. People working in the presence of a noisy ventilation system are also exposed to such ailments. The main purpose of the work was to test the effectiveness of one of the methods of soundproofing ventilation systems.

The main source of noise in ventilation systems is the fan, it is also emitted from ventilation ducts and air diffusers. In practice, a set of good practices is applied in the context of obtaining the lowest possible noise levels by the ventilation system. However, it is not always possible to apply all of them. There are many constraints in the facilities that may prevent the installation from being designed according to these conditions [3]. The subject of the research was the ventilating laboratory stand of the fan station, performed as part of the Rector's Grant. It was made by the "Kliwent" Scientific Circle operating at the Faculty of Mining and Geoengineering of AGH. The stand will be used to download the characteristic of ventilation fans working in series and in parallel and to determine the reverse index The stand was made with the use of PVC ventilation ducts with a circular cross-section and a diameter of 125 mm. The channels are equipped with gate valves, enabling the station to work in a suction and reverse system.

It was found that a high level of noise is generated at the laboratory stand, which may pose a threat to the health of people performing measurements working until it is reduced. In order to reduce the emission of undesirable sounds, potential noise sources were analyzed. After getting acquainted with the tested ventilation system, it was found that the increase in noise generated by the fan was caused by the formation of turbulences at sharp edges and corners, as well as in places where the direction and velocity of air flow were changed. After analyzing the methods of reducing the noise level, it was decided to use sound-absorbing materials and to mute the knee behind the fan. To determine the impact of the applied soundproofing method on the operation of the main ventilation fan network, an analysis of the fan's performance characteristics was carried out.

Based on the analysis performed, it can be concluded that the knee soundproofing was an effective solution aimed at reducing the noise generated by the fan station, because with the increase of the knee soundproofing level, the generated level decreased. On the basis of the electric power, damming and efficiency curves, it can be seen that the applied soundproofing has little effect on the characteristics of the station. The fan station achieves the highest efficiency values with the use of a soundproofed knee, and the lowest with the use of a partially soundproofed knee. These values do not differ significantly from each other, which can be considered a positive aspect of the application of this type of soundproofing. The fan consumes the least electrical power when a partially soundproofed bend is used. Unfortunately, despite the soundproofing applied, the noise level at the test stand and its immediate vicinity still exceeds the value of 70 dB. In the literature, it is assumed that prolonged exposure to noise at this level

may lead to hearing impairment, headaches and nervous discomfort. Therefore, when taking measurements at the stand, it is absolutely necessary to use personal protective equipment.

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DEVELOPMENT OF STANDARD MODELS OF COMMERCIAL AND PUBLIC PAVILIONS FOR ARCHITECTURAL CONCEPTS OF PARK ZONES IN THE REPUBLIC OF CRIMEA (ON THE EXAMPLE OF THE YURI GAGARIN PARK IN SIMFEROPOL)

Proposal of a typological model of awning frame structures as adaptable modular trade and public pavilions. Development of a parameterization system for optimized binding of object data to the initial data of the territory.

Problematics. One of the main problems of the chosen territory is the aesthetic fragmentation and the non-coincidence of the given style of the park with the commercial and public pavilions. Also, another problem that may be relevant not only on the territory of the park named after Yuri Gagarin in Simferopol, is the inability to adapt some of these objects to the change of seasons. The problem is that such objects are mainly focused on the warm season. Such objects are usually functional stalls for ice cream, various refreshing drinks, etc. In winter, such services become irrelevant and often, uselessly occupy areas in parks that can be adapted to the necessary functional needs.

Purpose: to develop a typological model using the parametrization of the principle of shaping for commercial and public areas that adapt to the change of the season.

Tasks: to choose construction materials for ease of assembly (modularity) of structures and ease of operation; to collect a group of standard parameters, on the basis of which the search for the formation of the necessary objects will be carried out; to find out the necessary dimensions, based on the functionality of each zone, to determine the input dimensions and proportions, to enter the initial data in the standard parameters; using the Archicad - grasshopper – live connection, based on the analysis of the territory, to link the developed objects to the existing terrain.

The first necessary object (from the analysis) was a public gazebo with an atrium. Based on the initial data, the architectural and artistic concept of the park was determined. After making some design sketches, it was revealed that the coating materials of dynamic structures should have some textile qualities: stretching, pliability, flowability, high deformation limit, light transmission ability, wind protection, fire resistance. The most suitable material was the PVC awning. The supporting material was a supporting frame on bolted and hinged movable joints. In the rhinoceros (grasshopper) software, a node system for parameterizing the shaping of this object is compiled. Thanks to this, we were able to reconstruct the three-dimensional model per second by entering the necessary numbers (dimensions, proportions). Based on the algorithm, it was convenient to visualize the schemes of the principles of adaptation (transformation into a horizontal plane) and to think through the structural scheme of the moving parts of the frame. In the object, an important role is played by the atrium in the role of a chimney for a fire pit.

Trade pavilions are based on the same principle of adaptation to the winter period, since these objects have similar problems: a partial loss of relevance in parks in winter. This type is designed exclusively for those pavilions that are provided only for the summer season of operation. The design scheme here is somewhat different, because the supporting element here is the awning itself. This object can also be transformed into a horizontal plane. When it is in the position of functioning as intended, the awning attached to the frame belt is stretched under the action of the load installed at the extreme corners. Due to the algorithm, it was possible to optimally select the dimensions of this canopy. The place for the faceting of the product is taken into account, as well as the crossbar and mounting brackets for the counter board are designed. The canopy itself in this position creates a feeling as if it is suspended in the air, which attracts the attention of customers.

Recreation and privacy areas were also necessary for the planned territory. But you can consider the possibility and need to place such zones in any parks in the world. For this typological model, the binding conditions that exist in all park territories are chosen. This condition is the tree trunk. Such conditions make it possible not only to simply type the model, but also to carry its direct purpose-privacy. The object consists of 2 parts: an awning and a wooden seat. Both are mounted to the tree trunk. In the software, it was easy, based on the initial data, to link the model to the diameters of tree trunks and their location. This also made it easy to visualize the information and make estimates. The awning is provided with the possibility of folding it to the center of the trunk, if the visitor does not want to sit in the shade or there are possible snow loads.

Conclusion: using the example of the conceptual project of the Yuri Gagarin Park in Simferopol, we demonstrated the possibilities of the developed trade and public typological models. Awning components can be integrated into the environment, starting from architectural concepts, choosing color solutions from manufacturers. This allows you to further typify this model. Also, tubular rolled metal, which is a component of the frame, currently already has a wide demand and is widely used in production. The principle of adapting these objects for the winter period allows you to apply the technology in different regions.

In the future, taking this concept as a basis, namely, methods and approaches to the design of this territory, we plan to develop a parametric system that will help at a more automated level, based on the basic design standards, to zone and analyze such territories in a more optimized way. Also, the developed typological models will be further developed from the functional, industrial, technical, and climatic side more extensively.

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ADAPTIVE URBAN DEVELOPMENT: FUTURE LIVING IN AMPHIBIOUS CITY

Cities are ever-changing environments. They are actively adapting to the current realities while still creating new opportunities, guided by social and physical processes. Coastal towns

seem to be changing at a higher rate than ever before. This study looks at how to adapt coastal communities to key problems in the twenty-first century, such as resource shortages, flood risk, land supply, and climate change, by examining what methods and technology should be used.

With some ambiguity about the future of population inflation in coastal cities and the accompanying exacerbation of the climate crisis and the reality of rising sea levels, some theories appear under what is known as "FLOATING ARCHITECTURE", as this term is not in a new, but it may constitute a solution to the future of cities Thus, the research problem explores the validity of this approach and examines its applied reality in Lebanon and the changes that follow in terms of the adopted urban policies.

While new horizons are opened of questions about the different reality of this architecture in the world in general and Lebanon in particular, and to what extent can it be able to reflect its positive image in order to reach sustainable future solutions despite all the challenges that accompany? What are the policies that must be developed within the framework of using this architecture at the local level in relation to the laws and the environment? What are the foundations for its design and how can it benefit from previous experiences and studies that are currently developed? To what extent is it possible to benefit from modern technology in order to achieve the economic viability of floating architecture on the scale of the Lebanese coasts?

Accordingly, many hypotheses will be resorted to in order to answer the previous problems, by highlighting the endeavors towards adaptive urban development (1) on land by modifying existing cities to adapt to future changes and (2) on water through the inclusion of floating city architecture up to the conclusion of the hypotheses to the application of the experimental architectural project as a practical solution to the previous problems.

In order to verify the presented hypotheses, the methodological research adopts the approach based on the forward-looking approach through research and study with the aim of uncovering problems of a future nature, such as coastal cities threatened with extinction due to high sea levels, and working to find practical solutions to them such as hypothetical resorting to floating architecture that can be not related to the land, and also to determine the trends of events that may affect various variables and then analyze these variables that may be multiple and have an impact on the course, viability and necessity of applying the idea of floating architecture in Lebanon.

Subsequently, the research plan is based on three chapters: Starting with "Chapter One" which deals with the future of cities between land and water, which includes discussion about the urban future towards smart cities or cities made of waste and issues that affect large cities, especially showing urban development at the land level, from building dams and other solutions, and urban development on water all the way to a new architectural vision: architecture that floats on water that can be used as a future solution. Then, a history of the idea of floating architecture and the foundations of its design, and an analysis of similar floating architecture projects in “Chapter Two”. As for the "third chapter", it will deal with each of the economic aspects of green floating architecture from its constituents and challenges; Up to "Chapter Four", where the problems are approached on the Lebanese reality, the problems resulting from the development of large Lebanese cities are highlighted, and how to apply adaptive urban development towards floating experimental architecture ... As for the "third chapter", it will deal with each of the economic aspects of green floating architecture from its constituents and challenges; Up to "Chapter Four", where the problems are approached on the Lebanese reality, the problems resulting from the development of large Lebanese cities are highlighted, and how to apply adaptive urban development towards floating experimental architecture ...

In conclusion, the content of this research has been presented in a systematic way to reach a good strategy for adopting floating architecture as a result and a realistic solution that meets the needs of the city and the various basic requirements of the person who will be among the pioneers of this future architecture.

“If at first an idea isn't absurd, there's no hope for it.” – Albert Einstein

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ARCHITECTURAL AND URBAN HERITAGE UNDERSTANDING AND PRESERVATION

Modern man approaches the realization of himself as a part of nature, but he does not deny the experience of his predecessors, trying to preserve and multiply it. The main objectives of the

discipline "Architectural and Historical Environment" are to introduce students to the architectural heritage and pay attention to issues related to the preservation and use of architectural monuments, as well as their placement in modern buildings.

Restoration, like any other type of human activity, is not an immutable system of principles and

methods, but has its own historical development and depends on what the monument is preserved and restored for.

The post-industrial civilization realized the highest potential of cultural heritage, the need for its conservation and effective use as one of the most important resources of the world economy. The loss of cultural property is irreparable and irreversible. Any loss of heritage will inevitably affect all areas of the life of the present and future generations, lead to spiritual impoverishment, gaps in historical memory, and impoverishment of society as a whole. [1]

In order to preserve the overall architectural and historical situation and the organic development of small and medium-sized cities, there are two fundamental approaches to their development:

- introduction of a new object in a row of the historical facade of a street or square
- placement of new ensembles or new neighborhoods in the historic city

Figure 1 – Pierrefonds Castle before restoration

The first approach – numerous buildings, solved in new building materials and not dissonant with the historical environment. The second is modern urban planning ensembles and new neighborhoods in old cities, but outside of their historical structure.

The Strategy defines the main priorities, criteria and directions of activities for the preservation of cultural heritage. It reveals the problems of protection, restoration and use of monuments, ensembles and urban environments, as well as reconstruction and new construction in historical areas. The strategy is designed to provide semantic, legal and procedural aspects of the transformation and improvement of the urban landscape, the essence of which is determined by the formula "conservation through development, development through conservation".

The integration of modern architecture into historical buildings periodically occurs in the theory and practice of security business. New architecture in the context of the historical environment is one of the important components of the heritage preservation strategy. [2]

The most effective way to preserve and promote the historical environment is to involve open spaces in social turnover through the development of pedestrian zones and their

infrastructure. The creation of a comfortable environment in the historical center is facilitated by its landscaping, landscaping, lighting and the introduction of small architectural forms that are close to the surrounding buildings and correspond to the aesthetics of the environment. Lack of harmony, disregard for traditions, and congestion of space can lead to perception problems, loss of a sense of security, and comfort, make the open space unattractive and unfriendly. [3]

Dedication to heritage is the hallmark of a culture. It is formed in the process of the interpenetration of the new and the old, the introduction of eternal values into modern cultural life. Each generation seeks its own interpretation of the past and extracts new ideas from it.

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RAMMED EARTH CONSTRUCTION TECHNOLOGY

Soil is one of the most readily available materials that can be used as a building material. Rammed earth structures have been built since ancient times in Ancient Rome, China and many African countries, including Morocco. Earth soil was also used in fortifications in the form of fortified ramparts [1].

In 1794, a book written by Francisco Coantero was published in Moscow, which describes the building construction technology from a mixture of sticky soil and sand with water, which are distinguished by durability, cheapness and high mechanical strength (according to the author, the service life of such structures can reach 165 years).

The period from the end of the 18th till the beginning of the 19th centuries was the heyday of rammed earth construction technology in the Russian Empire. A great enthusiast of such building is the famous Russian architect N.A. Lvov, who introduced many innovations in construction from scrap materials, particularly the so-called stone cardboard (in terms of functional properties it is a prototype of modern slate). At the end of the 18th century N.A. Lvov received a contract for the construction of the Priory Palace in Gatchina, which was built in 1799 and has survived to this day. The foundation of the palace is made of rubble. The composition of the soil mass used by the architect is shown in Table 1. The prepared mass was laid in a solid framework in layers 12-15 cm thick, then rammed, a layer of lime-stone mortar 6 mm thick was poured and the next layer of soil was laid. The walls were so strong that they were plastered only 100 years after construction [1].

Table 1 – The composition of the soil mass N.A. Lvov

Material	**Content,% by volume**
Gravel with a particle size of 3-7 mm	4
Sand	58
Dust	D
Soil	18

There is an alternative construction technology called *Earthbags*. Reinforcing material, such as barbed wire, was placed between the rows of cloth bags filled with soil. It should be noted that no water was used for tamping. Various building materials such as pumice, slag, rice

hulls and perlite have been used for thermal insulation. For strength, door and window openings were made in the form of an arch, the walls were rounded, and the roof (also from the ground) was made in the form of a dome with wide overhangs to protect the walls from precipitation. Traditionally, this method has been used in areas affected by floods. The walls of such houses are characterized by high thermal resistance [2].

The progressive SireWall (Stabilized Insulated Rammed Earth Wall) earth wall construction technology was proposed in the early 1990s by the American architect Meror Kraienhoff. This technology is protected by 86 international patents and has already been introduced into modern construction. A wall 45-61 cm wide consists of a material which contains a mixture of earth, cement and water; includes steel reinforcement and a thick layer of rigid insulation.

In conclusion, it should be noted that the main advantages of earth construction are cheapness, strength, fire and environmental safety, hygiene, low thermal conductivity, ease of disposal, increase in strength over time, seismic resistance, unusual design. The main disadvantages of earthen structures are the need for a solid foundation and thorough waterproofing, high labor intensity of construction.

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A METHOD FOR CALCULATING SUBSIDIES FOR INTERCITY PUBLIC TRANSPORTATION OPERATIONS WITH PUBLIC WELFARE

Introduction. In recent years, urban agglomeration areas have developed rapidly, and high-frequency intercity public transportation has become an important way to meet residents' travel needs. It is an important subject for the city how to subsidize it to make up for the loss caused by low fare operation. In this paper the subsidy methods of intercity public transportation in urban agglomerations are studied from the perspective of urban socio-economic development. The three types of indicators including operation indicators, social indicators, and public transport externality benefit indicators are selected, and an evaluation model for the factors affecting the share ratio of subsidy for intercity public transportation in urban agglomerations is built, and a method for calculating the share ratio of subsidies for intercity public transportation is proposed, which takes into account public welfare. Through case analysis, the rationality and implementability of the method are verified, and a new idea is provided for the responsibility division of intercity public transportation subsidy in urban agglomeration areas. Related research results mainly involve two issues, namely, public transportation financial subsidies influencing factors and calculation methods. Existing studies have proposed that the financial subsidies for intercity buses are mainly affected by the economic development level of urban agglomerations, the operating costs of intercity bus lines, intercity bus fares, and intercity bus passenger flow [1-3]. Some scholars have discussed how to formulate reasonable intercity bus fares by analyzing factors such as transportation costs, competitive factors, transportation demand, residents' ability to pay and choice, and government control [4].

Main part. This paper selects three types of indicators: operational indicators, social indicators, and public transportation externality benefit indicators to comprehensively, fairly and quantitatively evaluate the contribution of intercity public transportation operations to the economic development and social operation of different cities.

Based on the analysis of factors influencing the share ratio of inter-city public transport operation subsidies, combined with the characteristics of inter-city public transport in urban agglomeration areas, this paper uses the analytic hierarchy process to construct an evaluation model to calculate and determine the ratio of each indicator to the inter-city public transport operation subsidy share proportion of influencing factors. Based on the above analysis and weight calculation of the factors influencing the intercity public transportation operation subsidy sharing ratio, the calculation formula for the intercity public transportation operation subsidy sharing ratio was constructed.

$$\theta = \alpha_1 P' + \alpha_2 l'_{av} + \alpha_3 G' + \alpha_4 \rho' + \alpha_5 f'_{increase} + \alpha_6 E'_{increase}$$

In order to verify the practicability and operability of the method for calculating the proportion of subsidies for inter-city public transport operations studied in this paper, taking the Guangzhou-Foshan intercity rail transit line as an example, the amount of public transport subsidies that should be borne by each of Guangzhou and Foshan is calculated, and analyze the results of public transit subsidies.

Conclusion. The problem of public transport subsidies in urban agglomerations involves multiple subjects. The calculation of subsidies is not only related to the completion of operating costs, income and performance evaluation indicators, but also involves differences in the economic level of each city, and the impact of intercity public transportation on each city. The difference in the positive externalities and benefits. The thesis breaks through the limitations of the traditional urban public transportation service subsidy under the condition of a single subject. Based on the traditional reasonable remuneration method, the break-even method, the proportional subsidy to the loss, and the passenger traffic subsidy, a new type that takes into account the public welfare is proposed. The subsidy method embodies the basic principle of "beneficiaries pay subsidies", enhances the rationality of the sharing of public transport service subsidies between cities in urban agglomeration areas, and provides a reference for the calculation of financial subsidies in the actual operation of intercity public transport. There are many factors involved in the problem of public transport subsidies in urban agglomerations. The method for calculating the proportion of public transport subsidies designed in this article is relatively simple. The quantitative evaluation of the social benefits brought by public transportation, therefore, the establishment of a more comprehensive cross-city bus service subsidy measurement model based on regional public welfare differences is the focus of follow-up research.

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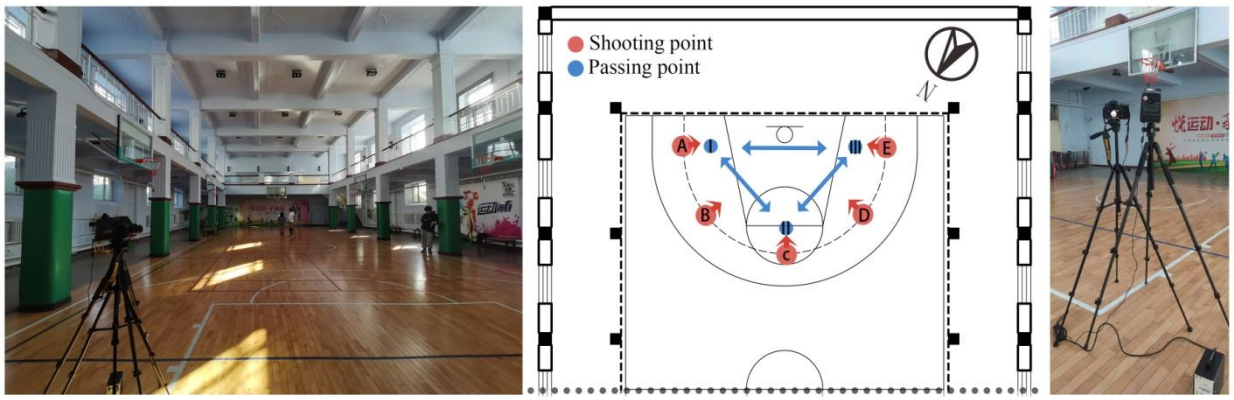
USER'S VISUAL COMFORT AND SIMULATION ANALYSIS BASED ON LUMINANCE PARAMETERS IN DAYLIT BASKETBALL HALL

Daylighting in sports space continue to be an important issue concerning energy conservation and users' health and comfort [1]. However, most research about user assessment in daylit space focus on office buildings that serves the working population, luminance parameters for user's visual comfort in basketball halls that serve the public for physical fitness have not been studied in detail. The exciting glare metrics, Daylight Glare Index (DGI), Daylight Glare Proability (DGP) and other luminance and contrast ratio thresholds, were all defined in office spaces [2-3]. In the process of China's transformation from competitive sports to mass sports, it is crucial to fully understand public's visual comfort parameters in daylit basketball hall and propose strategies according to numerical simulation results.

User assessment were conducted at a closed basketball hall at School of Architecture, Harbin Institute of Technology from October 11, 2020, to December 5, 2020 (Fig. 1a). 6 subjects were assigned to shot and pass the basketball in the test position to simulate the movement state of human in the actual basketball game. The tests were respectively carried out at 10:00 am, 11:00 am, 14:00 pm and 15:00 pm to create various daylight conditions. In each daylight condition, five shooting positions and three passing positions were set. In this way, each subject was tested in 32 different visual environments. In the shooting activity, the subjects shot twice at five test points which marked as "A", "B", "C", "D" and "E" in turn. In the passing test, three subjects stood at test point which marked as "I", "II" and "III", and respectively passed the ball to each other. They passed the ball for two rounds in the way of "I" → "II" → "III" (a 60-degree triangle). After that, they exchanged positions to ensure that each subject stopped at these three test points (Fig. 1b). At the end of each test group, their visual preferences were evaluated using Likert scale questionnaires.



(a) The selected closed basketball hall (b) The shooting and passing points in the test (c) Test equipments

Figure 1 – Experimental site and process

A total of 192 valid questionnaires were obtained and 32 different daylight conditions were recorded by HDR photography. 32 groups of pictures which consist of photos with different exposures of the same scene were used to synthesise HDR images to record the luminance information. A gray card was used as the reference for white balance and luminance calibration and a luminance colorimeter (BM-7A) was used to calibrate the luminance value of captured HDR images in Photosphere (Fig. 1c). Four luminance parameters in the images were calculated in HDRSCOPE software: average luminance in the entire field of view; maximum luminance in the entire field of view; average luminance of the target area and average

luminance of the windows area (Fig. 2). The correlation and the regression curve between luminance parameters and the questionnaire data were analyzed to obtain the luminance and contrast ratio thresholds, which were used as the indexes for optimizing the basketball court.

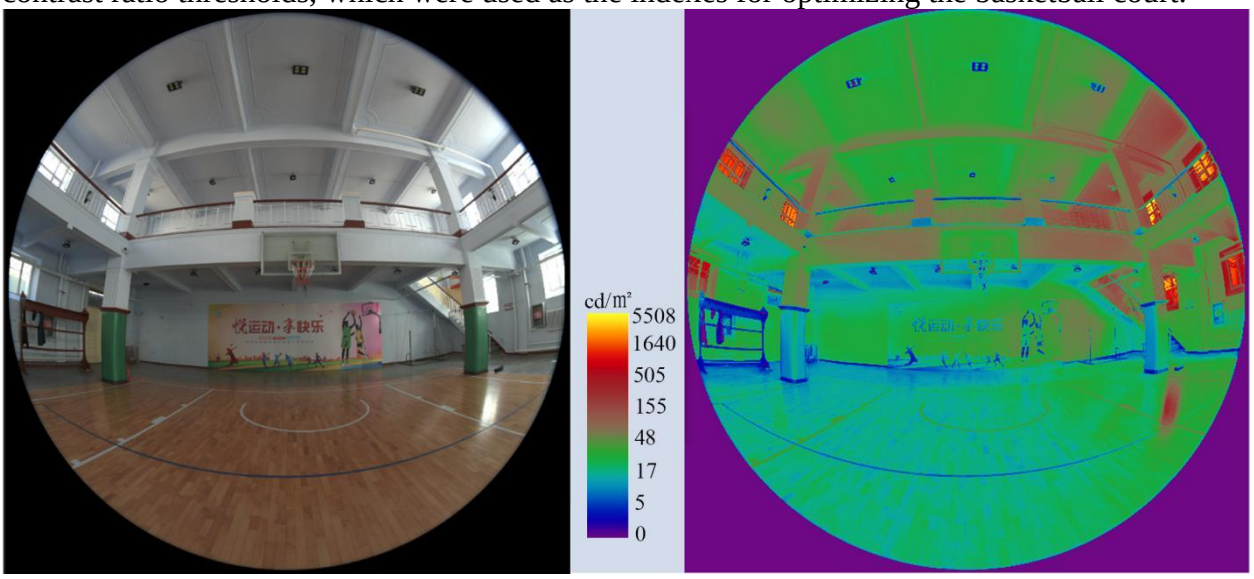


Figure 2 – HDR image and false color image in point C

Based on Rhino & Grasshopper parametric performance simulation platform, a basketball hall model was established. Under the premise of certain orientation and window-to-ground ratio, nine representative simulation models were established with windows positions (side windows, high side windows and skylights) and window forms (vertical windows, transverse windows and square windows) as experimental variables. Radiance and Daysim were invoked with Honeybee plug-in of Grasshopper platform to conduct parametric performance simulation, and the natural lighting design strategies of the basketball hall were proposed.

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