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Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

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В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект *Ozgeris powered by Halyk Fund* – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в *Astana IT University*, а также помог казахстанским школьникам принять участие в престижном конкурсе «*USTEM Robotics*» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «*Almaty Digital Ustaz*».

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными

возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением, Благотворительный Фонд «Халык»!

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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ENERGY EFFICIENCY AND ENVIRONMENTAL FRIENDLINESS OF FUNCTIONING OF GEOTECHNOLOGICAL COMPLEXES AT QUARRIES: DIRECTIONS AND WAYS OF MANAGEMENT

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Abstract. The article considers ways and directions of increasing energy efficiency and environmental friendliness of functioning of geotechnological complexes at open-pit mines, gives substantiation, supported by specific examples, of expediency and conditions of transition to process management based on in-depth analytics with appropriate digitalization, information support and automation, reveals the effectiveness of using the method of simulation modeling in the process of formation of digital analogues for solving this set of problems. The paper notes the fundamental importance of adequate consideration in modeling, design and planning of mining transportation

works of specific mining-technical, mining-geological, mining-geometric, organizational and mining-economic conditions of operation of geotechnological complexes. On the example of one of the quarries the potential and possible directions of increasing the efficiency and reducing the cost of mining transportation works are revealed. The economic effect is achieved by optimizing the modes and conditions of operation of the main technological equipment, resulting in the reduction of diesel fuel consumption and environmental emissions. The main conclusion in the article is the expediency of transition of enterprises with an open method of development of mineral deposits to the process approach in the management of functioning of geotechnological complexes with appropriate information support.

Keywords: quarry, geotechnological complex, energy efficiency, process management, process management economics, efficiency, simulation modeling, environmental friendliness

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КАРЬЕРЛЕРДЕ ГЕОТЕХНОЛОГИЯЛЫҚ КЕШЕНДЕРДІҢ ЖҰМЫС ЖАСАУ ЭНЕРГИЯЛЫҚ ТИІМДІЛІГІ ЖӘНЕ ЭКОЛОГИЯЛЫЛЫҒЫ

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Аннотация. Мақалада ашық әдіспен геотехнологиялық кешендерінің энергиялық тиімділігін және экологиялық жұмыс істеу тәсілдері мен бағыттарын арттыру жолдары қарастырылып отыр, тиісті цифрландыру, ақпараттық камтамасыз ету және автоматтандыру кезінде терең талдауында негізделген үдерістік басқаруға көшу шартында және нысаналылығында нақты мысалдармен толықтырылған негіздеме беріледі. Жұмыста геотехнологиялық кешендерінде тау кен - экономикалық және ұйымдық, тау кен - геометриялық, тау кен - геологиялық, нақты тау кен - техникалық тау кен - көліктік жұмыстарын жоспарлау және жобалау, үлгілеу кезінде пайдалану шарты бойынша сайма-сай есеп жасаудың түбегейлі маңыздылығы аталып отыр. Карьерлердің бірінің мысалында тау-кен көлігі жұмыстарының тиімділігін арттырудың және өзіндік құнын төмендетудің әлеуеті мен ықтимал бағыттары ашылады. Экономикалық тиімділікке дизель отынының шығыны мен экологиялық шығарындылар көлемінің төмендеуін анықтайтын негізгі технологиялық жабдықты пайдалану режимдері мен жағдайларын онтайландыру арқылы қол жеткізіледі. Мақаладағы негізгі қорытынды пайдалы қазбалар кен орындары ашық тәсілімен игеру кәсіпорындарын тиісті ақпараттық камтамасыз етумен геотехнологиялық кешендердің жұмыс істеуін басқарудағы процесстік тәсілге көшуінің орындылығы болып табылады.

Түйін сөздер: карьер, геотехнологиялық кешен, энергиялық тиімділік, процесстік (үдерістік) басқару, үдерістік басқарудың экономикасы, тиімділік, имитациялық үлгілеу, экологиялық

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ЭНЕРГОЭФФЕКТИВНОСТЬ И ЭКОЛОГИЧНОСТЬ ФУНКЦИОНИРОВАНИЯ ГЕОТЕХНОЛОГИЧЕСКИХ КОМПЛЕКСОВ НА КАРЬЕРАХ: НАПРАВЛЕНИЯ И СПОСОБЫ УПРАВЛЕНИЯ

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Аннотация. В статье рассмотрены способы и направления повышения энергоэффективности и экологичности функционирования геотехнологических комплексов на открытых разработках, даётся обоснование, подкреплённое конкретными примерами, целесообразности и условий перехода к процессному управлению, основанному на углубленной аналитике при соответствующих цифровизации, информационном обеспечении и автоматизации, раскрывается эффективность применения для решения данного комплекса задач метода имитационного моделирования в процессе формирования цифровых аналогов исследуемых горнотранспортных процессов. В работе отмечается принципиальная важность адекватного учёта при моделировании, проектировании и планировании горнотранспортных работ конкретных горнотехнических, горно-геологических, горно-геометрических, организационных и горно-экономических условий эксплуатации геотехнологических комплексов. На примере одного из карьеров раскрывается потенциал и возможные направления повышения эффективности и снижения себестоимости горнотранспортных работ. Экономический эффект достигается оптимизацией режимов и условий эксплуатации основного технологического оборудования, обуславливающей снижение расхода дизельного топлива и объёма экологических выбросов. Основным выводом в статье является целесообразность перехода предприятий с открытым способом разработки месторождений полезных ископаемых на процессный подход в управлении функционированием геотехнологическими комплексами с соответствующим информационным обеспечением.

Ключевые слова: карьер, геотехнологический комплекс, энергоэффективность, процессное управление, экономика процессного управления, эффективность, имитационное моделирование, экологичность

Introduction

In recent years in Kazakhstan is increasingly acute issue of scientific and technological development. It is especially important for mining and mining and metallurgical industries. The country is developing a specialized bill in this direction. The main factors and drivers of technological modernization, as is known, are digitalization, information technology, automation, analytics and management, which are united and provided at

the methodological level by science. Energy efficiency and environmental friendliness of implemented technologies are at the top priority level.

At present, in Kazakhstan, in conditions when the country has assumed obligations to reduce emissions into the atmosphere by 15–25 % until 2030, about 86.6 % of emissions fall on industry, including mining –53.45 % or 11, 2 million tons per year. The energy intensity of MMC products exceeds the similar indicator of OECD by more than 2 times. The most energy-intensive is the production of metal products. The energy intensity of non-ferrous metallurgy products is higher than in CIS countries. The highest emissions and fuel consumption are attributable to motor transportation. In the total production costs of MMC, diesel fuel and electricity costs account for about 50 %. (Bauernhansl , 2014).

At the same time, the current potential for improving energy efficiency and reducing environmental emissions, for example, in open-pit mining of mineral deposits is 10–15 % with a simultaneous reduction in the cost of mining transportation in the range of 5–30 %.

Methods and materials

Process management of geotechnological complexes in surface mining has great potential for improving their efficiency. Geotechnological complexes include various engineering methods and technologies used in the process of development of mineral deposits, design, planning and reconstruction of mine workings. (Galiev et al., 2021).

Process management implies optimization of all stages of the complex operation, starting from planning and continuing up to the control of task performance. There are several ways to improve the efficiency of process management of geotechnological complexes. The first is optimization at the stages of design and planning of mining operations: clear definition of goals and requirements of geotechnological development allows to focus on important tasks and eliminate inefficient operations. The second is automation and digitalization. The introduction of modern technologies and automation systems can improve the accuracy and speed of operations. The third is the wider use of data analytics, which consists in collecting and analyzing large volumes of data from various sources, such as geological measurements and monitoring of mining transportation processes and the state of the geotechnological complex, its subsystems and elements. This makes it possible to identify trends, forecast operating conditions and make informed management decisions. Fourth, monitoring and control, which includes regular observation and operational control of work progress, help identify potential problems at an early stage and take measures to eliminate them. Multiple sensors and monitoring systems can provide continuous tracking of mine parameters and behavior. Fifth, continuous process development and optimization. Application of continuous improvement principles allows to identify weaknesses in processes and find ways to optimize them. The introduction of new technologies and methodologies helps to improve the efficiency of the geotechnological complex (Galiev et al., 2020).

Implementation of these approaches to the management of geotechnological complexes at open pit mines will increase efficiency and reduce risks in this area, improve the quality and reliability of development, as well as reduce the time to complete tasks.

Environmental friendliness and energy efficiency of geotechnological complexes at open pit mines is an urgent task in the modern world, where more and more attention is paid to environmental protection and efficient use of resources. As practice shows, one of the directions of improving the environmental friendliness of geotechnological complexes is the optimization of energy consumption. It is also possible to use modern energy-saving technologies such as heat recovery systems or smart devices that allow to regulate energy consumption depending on actual needs (Khayitov et al., 2023).

This requires a higher level of organization of mining transportation works, which can be ensured only when elements of the process approach are introduced into the practice of management of geotechnological complexes of quarries, and it is also possible to use environmentally friendly materials for filling the developed areas, such as biologically active additives or reagents that do not contaminate soil and water.

An important direction for improving the environmental friendliness of geotechnological complexes at open-pit mines is also the development and implementation of a system for monitoring and controlling emissions of harmful substances into the atmosphere, soil and water. This will allow timely identification and elimination of possible leaks or pollution, which helps to reduce the negative impact on the environment.

To achieve the goals of improving the environmental friendliness and energy efficiency of geotechnological complexes, it is necessary to conduct research and development of new technologies, as well as to implement already existing innovative solutions. In addition, it is important to educate and train personnel so that they have the necessary knowledge and skills to work with modern energy efficient technologies and equipment.

In general, improving the environmental friendliness and energy efficiency of geotechnological complexes at open pit mines requires a comprehensive approach and efforts on the part of enterprises, government agencies and research institutes. However, the achievement of these very goals will actually reduce the negative impact on the environment and rationally use resources, which is an important step towards sustainable development. (Kaplan et al., 2006).

Another important factor in the effective implementation of the process approach in the management of geotechnological complexes at open-pit mines is an appropriately developed analytics, which allows to record the current state of the elements and subsystems of the system in an operational mode, on a step-by-step basis, objectively and reliably, and on this basis to qualitatively assess the situation and justify effective management decisions. The organization of production processes at open pit mines based on advanced analytics and digitalization is an approach to the management and optimization of production operations using advanced analytical methods and digitalization technologies. The main principles of such process organization include:

- advanced analytics, which involves the use of data analytics algorithms and techniques to collect, process and analyze large volumes of information about production operations, which helps identify trends, improve the efficiency and quality of production processes, and predict potential problems and risks.

- digitalization of manufacturing operations, involving the application of modern digital technologies such as Internet of Things (IoT), Big Data, artificial intelligence and automation to improve operations and optimize production, which also includes process automation, real-time data collection and analysis, digital modeling and forecasting.

- open information-analytical and software and methodological developments, enabling the involvement of external participants, such as startups, universities, research organizations and developer communities, to work together on projects and create innovative solutions, which provides an opportunity to gain access to new ideas, competencies and resources, as well as to accelerate the process of innovation implementation. (Kaplan et al., 2017).

Benefits of open source manufacturing processes based on in-depth analytics and digitalization include:

- Improved efficiency: analytics and digitalization help optimize production processes, improve resource utilization, reduce costs and increase productivity;

- quality improvement: analytics helps identify and eliminate the causes of defects and malfunctions, thereby improving the quality of finished products;

- innovation: open development facilitates the creation of innovative solutions through the involvement of external stakeholders, which can lead to the development of new products and technologies;

- flexibility and adaptability: digital modeling and analytics enable rapid adaptation to changes in market requirements and rapid implementation of changes in production processes;

- risk mitigation: analytics and digitalization help identify potential problems and risks before they arise, so that timely action can be taken to minimize them.

Results and discussion

As a substantiation of actually available potential, as well as specific directions of its realization, the article gives a number of results of research conducted in recent years on the enterprises of Kazakhstan, on the example of one of them.

In the process of assessment the method of simulation logical-statistical modeling, effective for these goals and tasks, used for creation of reliable digital analogs of functioning of geotechnological complexes and allowing qualitatively and operationally to investigate complex and large-scale, probabilistic technological processes, was used. The economic-mathematical model integrated into digital analogues allows to take into account all current operating costs on a step-by-step and adequate basis and to evaluate the efficiency of those or other variants of organization of geotechnological complexes operation according to the main criterion - the indicator of specific current costs (Kaplan et al., 2015).

For example, for one of Kazakhstan gold mines, the main technical and economic effects on open pits and the enterprise as a whole are step-by-step presented in Table 1.

As follows from the data in Table 1, in the variant with depreciation of the main technological equipment according to the generally accepted in the mining industry norms, the reduction in the total amount of costs for the functioning of geotechnological complex per year, due to the reduction of depreciation charges, is 2221.78 thousand

tenge. Accumulated in the possible depreciation fund of the enterprise, for the considered period of development of the deposit by open method could be reduced by 13330,68 thousand tenge, which would be transferred to the residual value of the equipment at the end of this period of mining and at this price it could be realized, or transferred to the balance of another subordinate enterprise. The final economic effect from the expedient variant of depreciation of the main technological equipment can be established depending on the adopted scenario of realization of the depreciation fund and this equipment. So far it is possible to establish only the fact that the cost of mining transportation works was artificially overestimated by 7.41%. In the total economic effect of the proposed measures to improve the efficiency of the geotechnological complex of the Bakyrchik quarry is not taken into account. (Hayitov et al., 2018).

Table 1 – The main technical and economic indicators by variants

Options	Capacity, by rock mass, thousand m3.	Total operating costs, tg.	Specific operating costs, tg.	Economic effect, thousand tg
Base case.	30771,00	33280,16	1081,6	-
Optimal performance of MTSQ.	30187,27	32475,27	1067,01	440,43
Normal amortization.	30187,27	29988,27	993,41	2221,78
Road surface quality.	30194,91	29400,76	973,70	594,99
Optimization of the structure of the list fleet of excavators.	29813,07	28798,93	965,98	233,05
Quality of rock preparation.	29813,07	28798,93	965,98	-
Design option.	25179,28	33881,17	1330,36	-6263,60
Total for the enterprise.				1268,47

As the general practice and the experience of researching the efficiency of geotechnological complexes of open-pit mines shows, traditionally, the areas related to compliance with the depreciation policy in relation to dump trucks and optimization of their loading mode by optimizing the schedule of equipment replacement and maintaining the shop profitability of the mining transport complex at the optimal level have a significant potential in this regard. In this case, due to the insignificant period of open pit mining, this direction can be realized only in a small part of the available total potential.

A full-fledged economic assessment of the geotechnological complex functioning efficiency from the quality of rock preparation for excavation at the stage of drilling and blasting operations requires adequate accounting of the corresponding changes in the excavators' tractive forces in the process of rock excavation with the subsequent reliable identification of energy consumption, as well as the corresponding amount of costs for drilling and blasting operations. In this direction, additional research is required with appropriate variation of bucket and dump truck body volumes.

The most valuable in carrying out a set of studies is the identification of the economic effect realized by the enterprise from the deviation from the design decision on opening

the open pit and organization of transport of overburden rock mass to the dump. This economic effect is about 6263.60 million tenge per year with a significant decrease in the optimal performance of geotechnological complex.

The analysis of other economic effects shows that the greatest potential for reducing the cost of mining transportation works in the established mining, mining-geometric, mining-geological, organizational and economic conditions have the directions of improving the quality of road surface of intra-carrier roads, as well as the optimization of the structure and number of the list fleet of the main technological equipment. The total potential economic effect is about 1268,27 thousand tenge per year. Given the lack of practical possibility of replacing the diesel fleet of excavators to electric with the appropriate technological parameters, the real achievable maximum economic effect from the implementation of possible measures to improve the efficiency of the geotechnological complex of the quarry is 1035.42 million tenge per year, which can be realized by improving the quality of road surfaces and optimizing the structure and number of the list of the main mining transport equipment. (Akramov et al., 2022).

One of the most important social, economic and environmental drawbacks of the project of development of the field developed by the enterprise is the justification of the use of diesel excavators for loading operations. At optimal productivity of the geotechnological complex, the volume of environmental emissions could be about 2488.73 tons/year. Reduction of annual environmental load due to the use of electric loading equipment is 9.94 %.

The obvious positive moments in the practical organization of work at the enterprise include the fact that the management has implemented an unplanned project exit in the western part of the quarry, which caused a significant increase in the possible optimal productivity of the geotechnological complex, due to a significant reduction in the average weighted distance of transportation of overburden rock mass - to 2.69 km from 3.93 or by 46.1 %. The optimal productivity could be reduced to 25179.28 thousand m³/year, and the indicative unit cost of mining transportation works was increased to 1330.36 tenge.

Conclusion

Thus, the organization of production processes at open pit mines on the basis of process management, in-depth analytics and appropriate digitalization is an effective approach to production management, allowing to improve the efficiency, quality, innovation, environmental friendliness and adaptability of processes. On average for mining enterprises of the Republic of Kazakhstan, the potential to improve efficiency and reduce energy and carbon intensity of mining operations is about 10–15 % with a simultaneous reduction in the cost of mining transportation with economic effects of \$ 1–2 million and more. Enterprises need to interact more closely and purposefully in this direction with scientific organizations, to train analytical engineers, to develop their own scientific and methodological potential, to make more active use of government tools and mechanisms to promote innovation and industrial development.

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