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05.00.00 - Texnika fanlari
08.00.00 - Iqtisodiyot fanlar

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2025-yil, 17-oktyabr,

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05.01.00 – Axborot texnologiyalari, boshqaruv va kompyuter grafikasi
05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
05.01.03 – Informatikaning nazariy asoslari
05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
05.01.06 – Hisoblash texnikasi va boshqaruv tizimlarining elementlari va qurilmalari
05.01.07 – Matematik modellashtirish
05.01.11 – Raqamli texnologiyalar va sun'iy intellekt
05.02.00 – Mashinasozlik va mashinashunoslik
05.02.08 – Yer usti majmualari va uchish apparatlari
05.03.02 – Metrologiya va metrologiya ta'minoti
05.04.01 – Telekommunikasiya va kompyuter tizimlari, telekommunikasiya tarmoqlari va qurilmalari. Axborotlarni taqsimlash
05.05.03 – Yorug'lik texnikasi. Maxsus yoritish texnologiyasi
05.05.05 – Issiqlik texnikasining nazariy asoslari
05.05.06 – Qayta tiklanadigan energiya turlari asosidagi energiya qurilmalari
05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
05.08.03 – Temir yo'l transportini ishlatish
05.09.01 – Qurilish konstruksiyalari, bino va inshootlar
05.09.04 – Suv ta'minoti. Kanalizatsiya. Suv havzalarini muhofazalovchi qurilish tizimlari
10.00.06 – Qiyosiy adabiyotshunoslik, chog'ishtirma tilshunoslik va tarjimashunoslik
10.00.04 – Yevropa, Amerika va Avstraliya xalqlari tili va adabiyoti
08.00.01 – Iqtisodiyot nazariyasi
08.00.02 – Makroiqtisodiyot
08.00.03 – Sanoat iqtisodiyoti
08.00.04 – Qishloq xo'jaligi iqtisodiyoti
08.00.05 – Xizmat ko'rsatish tarmoqlari iqtisodiyoti
08.00.06 – Ekonometrika va statistika
08.00.07 – Moliya, pul muomalasi va kredit
08.00.08 – Buxgalteriya hisobi, iqtisodiy tahlil va audit
08.00.09 – Jahon iqtisodiyoti
08.00.10 – Demografiya. Mehnat iqtisodiyoti
08.00.11 – Marketing
08.00.12 – Mintaqaviy iqtisodiyot
08.00.13 – Menejment
08.00.14 – Iqtisodiyotda axborot tizimlari va texnologiyalari
08.00.15 – Tadbirkorlik va kichik biznes iqtisodiyoti
08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
08.00.17 – Turizm va mehmonxona faoliyati

Ma'lumot uchun, OAK Rayosatining 2024-yil 28-avgustdagi 360/5-son qarori bilan "Dissertatsiyalar asosiy ilmiy natijalarini chop etishga tavsiya etilgan milliy ilmiy nashrlar ro'yxati"ga texnika va iqtisodiyot fanlari bo'yicha "Muhandislik va iqtisodiyot" jurnali ro'yxatga kiritilgan.

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QUESTIONS ABOUT THE STUDY OF PERFORMANCE AND EFFICIENCY OF APPLICATION OF LOADING AND EXTRACTING EQUIPMENT

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Abstract. In this article there are study and analysis of the issues on the study of the performance and efficiency of the use of excavation and loading equipment based on open mining. On this basis, the relationships of the parameters of loading and transport equipment with the completeness of reserves extraction were studied taking into account the natural variability of the qualitative characteristics of the mineral, the intensity of extraction, the parameters of the development system, the level of economic costs for obtaining the finished product from the extracted volume and environmental requirements. It was established that the main method for assessing the options for integrated mechanization of process flows in quarries is the method of mathematical modeling based on quantitative dependencies of the parameters of technological processes on the mining and geological and mining-technical characteristics of a particular quarry. In this case, the comparison of competing options for quarries with difficult natural conditions should be carried out on the basis of a multi-criteria assessment using private criteria, and the final decision should be made on the basis of an economic assessment using an integral criterion, the most appropriate of which is the total profit, determined taking into account the damage to the natural environment.

Keywords: open pit mining, dynamic conditioning, efficient mining technology, loading and transport, quarry, reserve, development systems, environmental requirements.

Annotatsiya. Ushbu maqolada ochiq qazib olish asosida qazish va yuklash uskunalaridan foydalanish samaradorligi va samaradorligini o'rganish masalalari o'rganiladi va tahlil qilinadi. Shu asosda foydali qazilmaning sifat ko‘rsatkichlarining tabiiy o‘zgaruvchanligi, qazib olish intensivligi, o‘zlashtirish tizimining parametrlari, qazib olingan hajmdan tayyor mahsulot olish uchun iqtisodiy xarajatlar darajasi va ekologik talablar hisobga olingan holda yuklash va transport uskunalari parametrlarining zaxiralarni qazib olishning to‘liqligi bilan bog‘liqligi o‘rganildi. Texnologik jarayonlar parametrlarining ma'lum bir karerning kon-geologik va kon-texnik xususiyatlariga miqdoriy bog'liqligiga asoslangan matematik modellashtirish usuli karerlarda texnologik oqimlarni kompleks mexanizatsiyalash variantlarini baholashning asosiy usuli ekanligi aniqlandi. Bunday holda, qiyin tabiiy sharoitlarga ega karerlar uchun raqobatbardosh variantlarni taqqoslash xususiy mezonlar bo'yicha ko'p mezonli baholash asosida amalga oshirilishi kerak va yakuniy qaror tabiiy muhitga etkazilgan zararni hisobga olgan holda aniqlangan umumiy foyda bo'lgan integral mezondan foydalangan holda iqtisodiy baholash asosida qabul qilinishi kerak.

Kalit so‘zlar: ochiq usulda qazib olish, dinamik konditsionerlik, samarali kon texnologiyasi, yuklash va tashish, karer, zahira, o'zlashtirish tizimlari, ekologik talablar.

Аннотация. В данной статье проведены исследование и анализ вопросов по исследованию производительности и эффективности использования выемочно-погрузочного оборудования на базе открытых горных работ. На этой основе изучены взаимосвязи параметров погрузочно-транспортного оборудования с полнотой извлечения запасов с учетом естественной изменчивости качественных характеристик полезного ископаемого, интенсивности добычи, параметров системы разработки, уровня экономических затрат на получение готового продукта из добытого объема и экологических требований. Установлено, что основным методом оценки вариантов комплексной механизации технологических потоков на карьерах является метод математического моделирования, основанный на количественных зависимостях параметров технологических процессов от горно-геологических и горно-технических характеристик конкретного карьера. При этом сравнение конкурирующих вариантов для карьеров со сложными природными условиями должно проводиться на основе многокритериальной оценки с использованием частных критериев, а окончательное решение приниматься на основе экономической оценки с использованием интегрального критерия, наиболее приемлемым из которых является совокупная прибыль, определяемая с учетом ущерба, наносимого природной среде.

Ключевые слова: открытые горные работы, динамическое кондиционирование, эффективные технологии добычи, погрузка и транспортировка, карьер, запас, системы разработки, экологические требования.

INTRODUCTION

The peculiarity of choosing a set of mining and transport equipment for production of mining operations is that it must ensure the required completeness of extraction of mineral reserves from the mining block. In this case, it is necessary to take into account the following factors:

natural variability of the qualitative characteristics of the mineral;
extraction intensity;
parameters of the development system;
the level of economic costs for obtaining the finished product from the extracted volume;
environmental requirements.

Sorting these volumes by assigning the unloading address - a processing plant, a warehouse of off-balance ores - a dump, allows to meet the basic requirements for rational completeness of extraction of reserves [1-3]. As a rule, the extraction of minerals at complex-structure deposits is carried out in several faces with elementary extracted volumes equal to the capacity of the transport vessels. Sorting these volumes by assigning the unloading address - a processing plant, a warehouse of off-balance ores - a dump, allows to meet the basic requirements for the rational completeness of the extraction of reserves.

LITERATURE REVIEW ON THE TOPIC

A. Petrov[4] analyzed the efficiency of mining and loading equipment using field experience and sensor monitoring data. The study showed the influence of various loading and transportation conditions, operator skills and technical parameters on efficiency. As a result, it was found that the optimal loading speed and maintenance mode significantly increase the efficiency of the equipment. Therefore, the systematic introduction of maintenance and operator training into production processes increases efficiency.

V. Kuznetsov[5] in his scientific research evaluated the energy efficiency and operational speed of mining and industrial loading equipment using an experimental method. Different load volumes and loading methods were tested in laboratory and field conditions. The results of the study show that optimal loading and unloading algorithms reduce energy consumption and increase labor productivity. Therefore, energy-saving modes should be integrated into production processes.

I. Zaitsev[6] analyzed the technical parameters of loading and unloading equipment in his article, studying their efficiency and service life. Statistical analysis and regression modeling were used as methods. The results show that the optimal combination of technical parameters and operator experience increases production efficiency. Therefore, it is necessary to introduce standard operating procedures for coordinating technical parameters and operator skills.

D. Smirnov[7] analyzes the impact of loading and unloading technologies on operational efficiency and safety. The study was conducted using field experience and simulation models. The results show that the

use of automated control systems increases operational efficiency and reduces safety risks. Therefore, it is important to introduce automated control systems into production processes.

P. Ivanov[8] develops an integrated indicator system to study the technical and operational efficiency of loading and unloading equipment. Multi-criteria analysis and field experience were used as methods. According to the results of the study, the use of systematic monitoring and performance indicators significantly increases process efficiency. Therefore, it is recommended to introduce an integrated indicator system in loading and unloading equipment.

RESEARCH METHODOLOGY

In carrying out this research work, methods widely used in scientific research methodology were used. In the process of scientific analysis, these scientific research methods were widely used, in particular, observation, generalization, grouping, comparison, and in analysis, synthesis and analysis methods were widely used.

ANALYSIS AND RESULTS

The choice of effective options for complex mechanization of process flows in quarries with complex mining and geological conditions is aimed at determining the rational area of application of loading and transport equipment. High variability of the physical and mechanical properties of rocks and parameters of ore bodies not only on the scale of a deposit, but also within local areas necessitate the use of such mechanization means, the characteristics of which correspond to the changing mining and geological conditions of development to the greatest extent.

An important condition for the effectiveness of complex mechanization is the consistency of the parameters of the machines performing related processes, which ultimately determines the technical and economic indicators of the complex.

The choice of complex mechanization of process flows is made by comparing various sets of mining and loading and transport equipment in order to achieve high productivity, reduce energy consumption, reduce mineral losses and admixture of waste rock[9-13].

In open-pit mining of deposits with complex mining and geological conditions, cyclical process flows are most common, the basis of the complex mechanization of which are single-bucket mining and loading equipment (electric and hydraulic shovels, front loaders) and dump trucks. This is primarily due to the fact that in terms of scale, deposits with such conditions, in particular gold ore, mainly belong to the category of small and medium with an annual productivity of 30 to 1,500 thousand tons, and their development is carried out selectively with the allocation of different grades of minerals by quality[14-18].

The situation is complicated by the fact that during even one shifts the grade of the mined ore can change several times, since the mining and geological situation changes significantly even within local areas. In this regard, one of the tasks of choosing a comprehensive mechanization of process flows in this case is to determine the range of effective use of mining and transport equipment with specific geometric and technological parameters.

Establishing the range of effective application of process flows in various mining and geological conditions allows selecting equipment whose parameters determine the possibility of its operation with the greatest efficiency in significant intervals of change in the physical and mechanical properties of rocks, complexity of the structure of ore bodies, parameters of natural and technological zones and development technology. Determining the range of change in the basic characteristics and technological parameters of rocks at deposits with complex mining and geological conditions allowed us to obtain the following results (Figure 1).

In deposits with complex natural conditions, the blockings of rocks in the massif varies within the range of d_o = 0.05÷0.90 m at $\sigma_{сж}$ compression = 60÷180 MPa (Figure 1), and its most probable values are in the range of 0.15-0.50 m.

From the point of view of the efficient use of mining, loading and transport equipment, the average size of a piece of blasted rock mass is related to the width of the excavator bucket by the dependence $d_{ср}$ = 0.152B and in the range of changes in the capacity of excavator buckets at deposits with complex natural conditions ($E_к$ = 4÷16 м^3) is from 0.29 to 0.46 m (Figure 1). Comparison of the standard sizes of a piece with those actually obtained during blast loosening of rocks shows that for the actual range of changes in the capacity of an excavator bucket, the degree of crushing in the general case is n=1,45÷10, and at deposits with complex natural conditions - n=1,45÷3,2 (Figure 1).

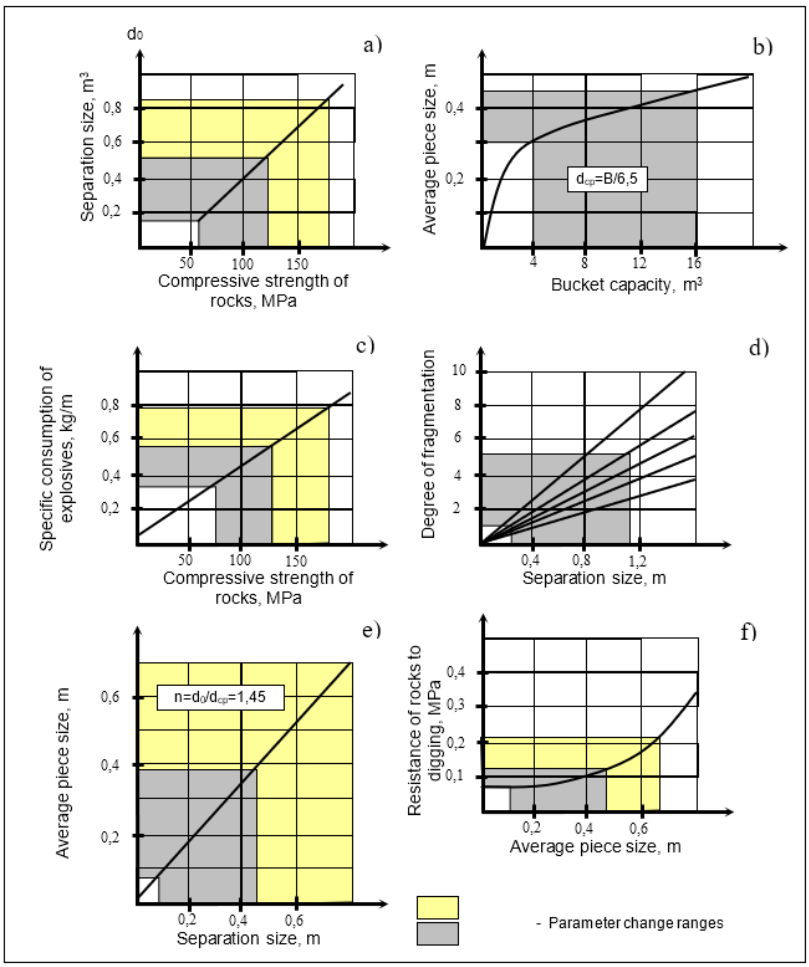

Figure 1. Ranges of change of technological parameters in quarries with complex natural conditions.

Research has established that in deposits with complex mining and geological conditions, in order to achieve good blast mining of the rock mass with the degree of loosening required by the technology, the specific consumption of explosives, depending on the compressive strength of the rocks, varies from 0.37 to 0.80 kg/m³ (Figure 1). In this case, the average size of a piece of blasted rock mass reaches 0.63 m, and its most probable value is in the range of 0,10÷0,35m. The degree of rock crushing in this case for a real change in the capacity of the excavator bucket is shown in Figure 1.

The average size of a piece of blasted rock mass has a significant impact on such a technological indicator as the specific resistance of rocks to digging. According to reference data, this indicator during development with preliminary blast loosening of rocks with mechanical shovels varies from 0.17 to 0.42 MPa, and in deposits with complex natural conditions (Figure 1) - on average from 0.10 to 0.20 MPa, reaching in some cases 0.28 MPa on easily blasted rocks, 0.30 MPa on moderately blasted rocks, and 0.37 MPa on difficult to blast rocks.

Thus, to ensure efficient operation of the mining and loading equipment at the Muruntau deposit, the average size of a piece of blasted rock mass should be d_{cp}= 0.1÷0.35 m with a specific resistance of the destroyed massif to digging of K_F=0.1÷0.37 MPa. The range of bench height variation for each excavator model is determined based on the following calculations.

The excavator's digging height is directly dependent on the bucket capacity $H_ч=f(E_к)$. It is also known that, according to the bucket filling condition, the rational bench height is $H_{урац}=2/3H_ч$ ($H_ч$ – excavator digging height, m), and the minimum should be greater than three times the bucket height нymin $H_{ymin} \approx \sqrt[3]{Г_ђ}$.

The maximum bench height is determined based on the conditions of safe operation on a loosened face, the height of which, taking into account the loosening of rocks, is $H_{заб}=1,5H_ч$. In this case, for the ore zone, in which blast loosening is carried out in a "clamped" environment, with a coefficient of loosening of rocks in the massif $K_г$ = 1.3, the maximum bench height is $H_y=\frac{1,5H_ч}{K_p} \approx 1,1H_ч$. In the rock zone, the required face height is formed by forming a collapse of the massif with the specified parameters.

For the effective placement of the required number of explosives in the massif, the borehole diameter must correspond to the height of the bench being developed. The relationship between the borehole diameter and the bench height with the same physical and mechanical properties of the rocks is linear, i.e. with an increase in the bench height, the borehole diameter will also increase.

Using the specified relationships between the bucket capacity and the borehole diameter with the bench height, a nomogram was compiled (Figure 1) that allows one to determine, depending on the bucket capacity, the range of possible changes in the bench height and the corresponding rational borehole diameters. For example, an excavator with a bucket capacity of E_k=12.5 m³ can work on benches with a height from H_{ymin}=7,3 m to H_{ymax}=16,8 m with a range of changes in the rational bench height Nurac from 12.5 m to 16.8 m (in practice, the bench height is usually taken in a rounded form in the form of values convenient for production purposes). The specified ranges of changes in the bench height correspond to the ranges of changes in the borehole diameters: $d_{скв}$=0,11÷0,25 m and $d_{скв}$=0,18÷0,25 m.

Figure 1 shows the relationship between the excavator bucket capacity and the dump truck lifting capacity. It should be borne in mind that the indicated dependencies characterize the average value of the vehicle lifting capacity W_o, corresponding to the excavator bucket capacity.

The compiled nomogram, shown in Figure 1, allows solving this problem. For example, when using an excavator with a bucket capacity of E_k=12.5 m³, 100-120 thousand m² of working area are required to ensure its operation [19-21].

Basic characteristics of ore bodies have a significant impact on such process indicators as the bench height through the admixture of waste rock and ore losses, and the coefficient of complexity of the ore body structure. For example, depending on the required ore losses and admixture of waste rock for ore bodies with a coefficient of complexity of the structure of K_c=0.2, the maximum permissible bench height is 8 m, while ensuring the permissible minimum content of the useful component in the mined ore (Figure 2).

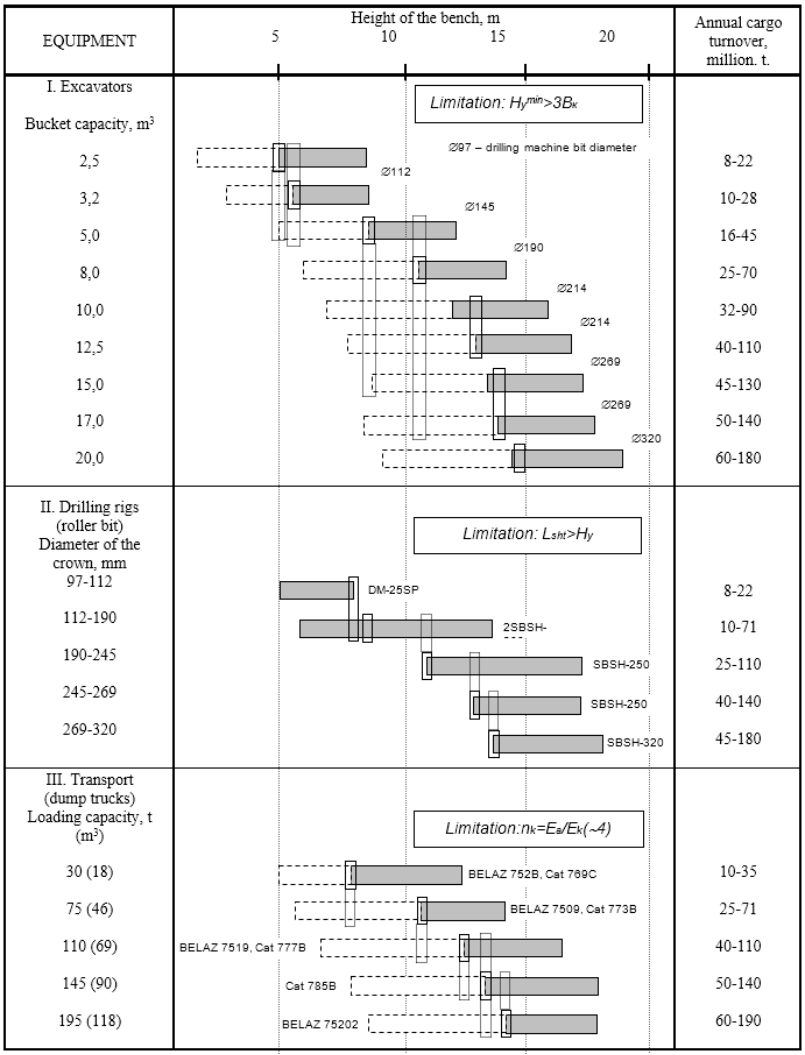

Figure 2. Areas of rational relationships between mining and loading drilling and transport equipment.

Thus, studies of the complex mechanization of process flows made it possible to determine the ranges of effective use of cyclic mining and transport equipment.

CONCLUSION AND SUGGESTIONS

As a result of the conducted research it was established that the choice of complex mechanization of quarry process flows is possible taking into account the following fundamental provisions:

the choice of parameters of mining and transport equipment should be reduced to the search for a rational ratio of the degree of influence of each factor on the final result;

the structure of complex mechanization in quarry process flows should be determined by the mining and technical conditions of a specific quarry;

the process flow should be filled with mining and transport equipment for conducting work, to the greatest extent corresponding to the quarry conditions;

the mining and technical conditions should ensure the efficiency of mining and transport equipment.

An important condition is the degree of crushing of the rock mass, and specific energy consumption is most suitable as a criterion for selecting and designing complex mechanization in quarry process flows, allowing for a quantitative characterization of the relationship between the parameters of technological processes and the mining and geological conditions of not only the quarry as a whole, but also its individual zones.

An analysis of methods for operational management of the mineral resource base, technology for developing low-capacity gold ore deposits was carried out, and a comparison of costs for the acquisition of mining equipment by methods of deposit development was made.

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