STUDY OF THE PRODUCTION AND EFFICIENCY OF VARIABLE AND LOADING EQUIPMENT IN THE MINING OF MINERALS

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Abstract. This article reviewed and analyzed the study of performance and efficiency of exchange-loading equipment. Despite a number of previous studies in this area, many issues require further in-depth study. In particular, the influence of operational factors on the nature of the total resistances overcome by the drive for the use of excavation and loading equipment has not been sufficiently studied, the dependence of the change in the power component of the diesel load mode during the technological cycle and its influence on the energy intensity of the process have not been determined.

Keywords: efficiency, research, loading equipment, indicators, application.

1.INTRODUCTION.

In the process of moving a vehicle along a certain road, the parts and components of its transmission transfer energy from the engine to the drive wheels. The transmission is an intermediate link between the engine and the propeller, and therefore, perceiving the loads from one, transfers them to the shaft of the other, changing and transforming them, taking into account its specifics. Therefore, in order to know the moment of resistance transmitted to the motor shaft, it is necessary to determine the magnitude and nature of its change in the connecting link. For transmissions of mining and transport machines, there is something in common, which allows us to speak of two modes: transient processes (IT) and conditionally steady operation (CUR). The first mode is characterized by periods of work with high

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accelerations, with a sharp change in the power and speed characteristics of the transmission, which is usually accompanied by increased dynamic loads. The USD mode is characterized by small accelerations and a smooth change in power and speed characteristics, low dynamic loads. An analytical description of the load on a given transmission link as a complex random function is almost impossible [1-8]. Nevertheless, at present, on the basis of extensive experimental material on the assessment of the load modes of transmissions of vehicles for various purposes, it is customary to represent the total load mode as a superposition of three processes: quasi-static, dynamic cyclic and dynamic impulsive. The first process is low-frequency, it does not excite oscillations in the elastic-inertial transmission system of the vehicle, due to external resistance to movement and the technical parameters of the machine. The second and third processes are high-frequency in nature, they determine the amplitude (dynamic) voltage fluctuations. At the same time, the dynamic cyclic process is due to the peculiarities of the operation of the internal combustion engine, the impact of the road microprofile, cardan transmission, technological errors in the manufacture of parts and assemblies, self-oscillatory and resonant phenomena, etc. The dynamic pulse loading process is determined by oscillatory processes in the transmission in transient modes, slipping of the driving wheels, moving single irregularities, braking, the process of introducing the bucket into the collapse).
The type of transmission is of great importance for the formation of the load mode of the diesel engine. Most modern mining and transport self-propelled machines use a hydromechanical transmission with automatic or manual blocking. The process of driving a car begins with starting and accelerating with gear changes. This is a transition type process, characterized by a rapid transition of the transmission from one state to another. Therefore, in order to adequately assess the load modes of both the transmission and the engine, it is necessary to know the structure of the production cycle, the specific weight of the components and their relationship with each other on each route of movement [9-16].

2.RESEARCH METHODS.

The general theoretical and methodological basis of the article is an integrated approach, including the analysis and generalization of fundamental research in the field of open pit design methodology, generalization of production and design practice of open pit mining. The main research methods used were: analytical and graphic-analytical methods; mining-geometric modeling of the end walls of a quarry and the development of its working area; economic and mathematical modeling; system analysis, laboratory and pilot experiments in the study of the parameters of technological processes, depending on the accepted ledge height; methods of mathematical statistics and expert assessments; technical and economic analysis.

3.RESULTS AND DISCUSSION

Qualitative and quantitative characteristics of an elementary recoverable volume should take into account the specific technological and economic situation that develops during the development of a deposit, for example, free capacities at a processing complex or a characteristic of a mineral in other mining faces. At the same time, it is necessary to adhere to the fulfillment of the condition of excess or equality of the extracted value from the extracted volume of S_{rm}, over the upcoming costs of obtaining the finished product from the extracted elementary volume $\Sigma\ C_{i.}$:

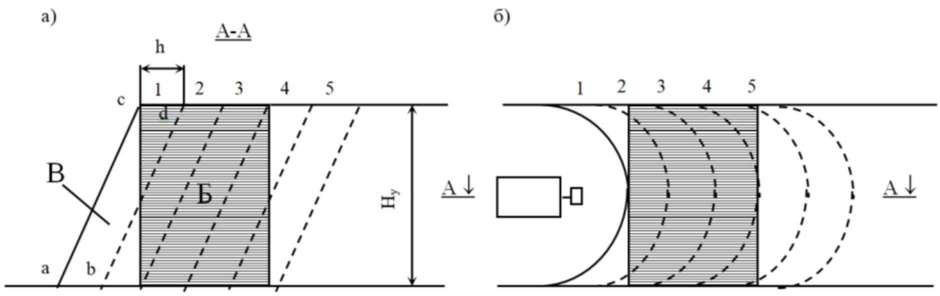
$$\Sigma S_{rm} > \Sigma C_i \qquad (1.1)$$

$$\sum S_{rm} = \sum_{1}^{п} \alpha_{rmi}^{э.о} \cdot \varepsilon_{obi}^{эо} \cdot \varepsilon_{мпi} \cdot S_{отпi,} \text{ sum/t,}$$

where $\alpha_{рмi}^{э.о}$ – is the content of *i* useful component in an elementary extractable volume;
$\varepsilon_{obi}^{э.о.}$ – extraction during enrichment of *i* useful component;
$\varepsilon_{мпi}$ – extraction at metallurgical processing;
$Ц_{отпi}$ – selling price per unit *i* of finished products, sum/t;

$$\sum_{1}^{m} C_i = \sum C_д + \sum C_{tr} + \sum_{1} С_п + \sum С_{pr} \quad ,sum/t;$$

$\Sigma C_д$ – total cost of production, sum/t;
$\Sigma С_{tr}$ – total transportation costs, sum/t;
$\Sigma C_п$ – total costs for processing, sum/t;
ΣC_{pr} – other costs (including environmental costs, sum/t).
In the general case, the elementary recoverable volume $\mathbf{V_e}$ includes waste rock and an ore-bearing mass - a parallelogram ***abdc*** (Fig. 1.1).



h – chip thickness of the elementary extractable volume;
1–4 – numbers of recoverable volumes

Fig. 1.1. Scheme of allocation of elementary recoverable volumes in the production block

Due to the imperfection of mining technology in the ore mass, the ratio of minerals (B) and waste rocks (C) is different, and, consequently, the value of the extracted elementary volumes is different [17-24].
The rejection limit of the value of S^{br}_{rm} of recoverable elementary volumes can be established from the equation for the balance of the values of resources interacting during the development of the deposit.
Establishing a rejection limit and sorting elementary recoverable volumes by level α_{rm}^{br} make it possible to identify the completeness of the extraction of reserves from the production block.
The optimal completeness can be established in the process of planning and performing mining operations by choosing the following rational parameters: the height of the bench, the width of the mining stop, the elementary recoverable volume (i.e. the capacity of transport vessels) and the number of simultaneously working faces (including transshipment warehouses of balance ore).
The optimal completeness of reserves extraction ($К_n^s$), taking into account the complexity of the use of raw materials, the environmental friendliness of the technology and economic costs, is established according to the criterion of rational use of resources $К_{res}$:
$К_n^s = К_{res} - К_{isp} \cdot К^s_{kpl} - (1 - К_{ек}^b)\, К_{ек}^s - К_{cp}^{fr} \cdot К_{fr}^{s} = К_{res} - П^s_{kpl} + П^t_{ек} + П^s_{fr}$,
where $К^s_n$ is the coefficient of extraction of balance reserves by value ;$К^s_n \le 1$;

K_{res} – indicator showing what total profit in relation to the value of the concluded balance reserves will be received during the development of the deposit;
$K_{isp} \cdot K_{kpl} = \Pi^s_{kpl}$ – indicator of the use of the values of the incidentally obtained products (overburden, slag, sludge);
$1 \geq K^s_n \geq 0$ – coefficient of use of values of incidentally received products;
$K^s_{kpl} = D_{kpl} \cdot S_{kpl} / B \cdot S_b$ – coefficient of value of by-products obtained in the course of complex development of reserves;
B – amount of balance reserves, t;
S_b - the value of balance reserves sum/t;
D_{klp}– the number of by-products received;
S_{klp}– the value of the resulting products;
$(1\text{-}K^b_{ек}) \cdot K^s_{ек} = P^t_{ек}$ – indicator of environmental friendliness of technology;
$0 \leq K^в_{эк} \leq 1$ – indicator of environmental friendliness of technology;
$K^s_{ек} = D^n_{ек} \cdot S^n_{ек} / B \cdot S_b$ – coefficient of values of disturbed ecological components of the natural environment;
$D^n_{ек}$ – the number of violated environmental values (land, water, air), per, t, m^3;
$S^n_{ек}$ – values of disturbed ecological components of the natural environment; sum/per; sum/t; sum/m^3;
$K^{fs}_{cp} \cdot K^s_{fr} = P^s_{fr}$ – indicator of the use of the values of economic resources;
$K^n_{fr} = \frac{D_{rf} \cdot Ц_{фр}}{B \cdot S_b}$ – coefficient of value of economic resources;
$0 \leq K_{sp} \leq 1$ – demand coefficient of economic resources.
The optimal value of K_{res} provides the necessary rate of return in the development of the field, taking into account all the resources involved.
On Figure 1.3 illustrates the dependence of the criterion for the rational use of resources Kres on the value of the elementary recoverable volume V_e at different degrees of recovery of reserves K^s_n

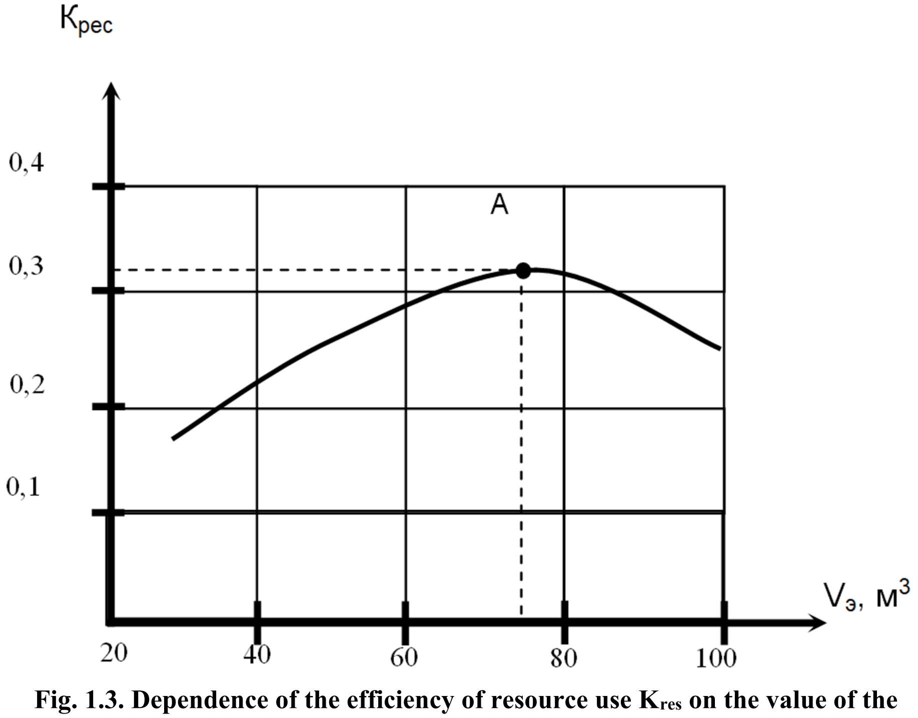


Fig. 1.3. Dependence of the efficiency of resource use K_{res} on the value of the elementary recoverable volume V_e

Reducing the completeness of reserves extraction from 0.94 to 0.82 makes it possible to increase V_e from 45 to 100 m^3.

Studies have shown that the optimal completeness of reserves extraction at the current level of prices for finished products is the completeness of K $\frac{s}{n}$= 0.92, while K_{res} = 0.32, the elementary recoverable volume is ≈ 80 m^3.

The determining parameter influencing the choice of mining equipment and the elementary recoverable volume is the height of the N_u bench.

Figures 2.1 and 2.2 illustrate the dependence of the height of the bench on the indicators of the use of values contained in the resources involved in the development of the field.

Figure 2.1a shows the relationship between the completeness of the extraction of values from balance reserves (K >$\frac{s}{n}$) and the height of the ledge (N_u) Dependence N_u =f(K$\frac{s}{n}$), obtained by modeling the development of a mining block in layers of 2.5 m by various sets of mining and transport equipment.

With a decrease in the ledge height (H_u), there is an increase in the completeness of the extraction of valuables from the balance reserves, however, an increase in the completeness of the extraction of valuables is higher than the value of K$\frac{s}{n}$ = 0,92 and requires a sharp increase in the cost of obtaining finished products, while the profit from the development of reserves decreases (Fig. 2.1b). The results of the study of the influence of the completeness of the use of the values of the incidentally obtained products K$\frac{s}{isp}$K$\frac{s}{kpl}$ on the value of N_u are graphically illustrated in fig. 2.1c, from which it follows that the level of use of by-products obtained does not directly affect the height of the ledge.

At the same time, an increase in the use of values of incidentally extracted products ensures profit, and its maximum value corresponds to the level K$\frac{s}{isp}$K$\frac{s}{kpl}$=0,3, (fig. 2.1g). The relationship between the amount of compensation for environmental damage caused to the environment during the development of the (K$\frac{v}{ek}$)K$\frac{s}{ek}$ field and the height of the ledge is shown in fig. 2.1d.

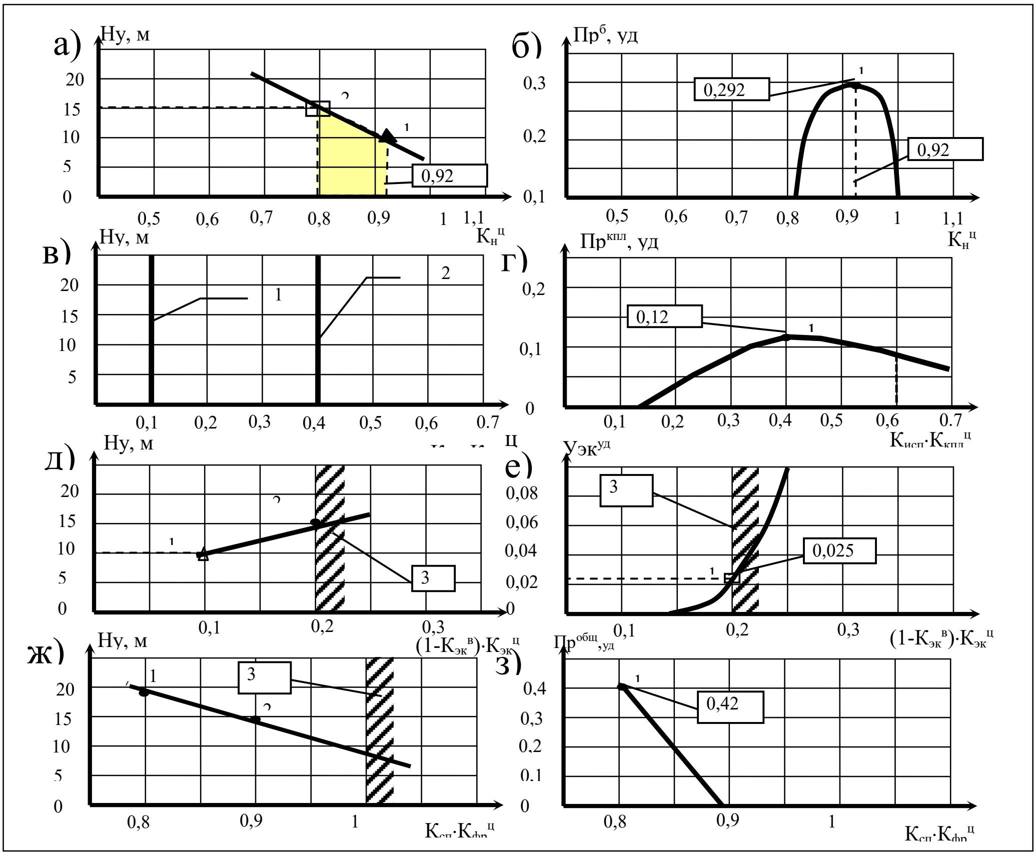


Fig. 2.1. Relationship between bench height and resource utilization rates
a – completeness of extraction of valuables from balance reserves; b - the completeness and efficiency of the use of PPP; c - environmental friendliness of technology; d - the amount of financial costs; 1 - optimal value; 2 - actual value of the ledge height; 3 - the level of permissible environmental violations and financial costs.

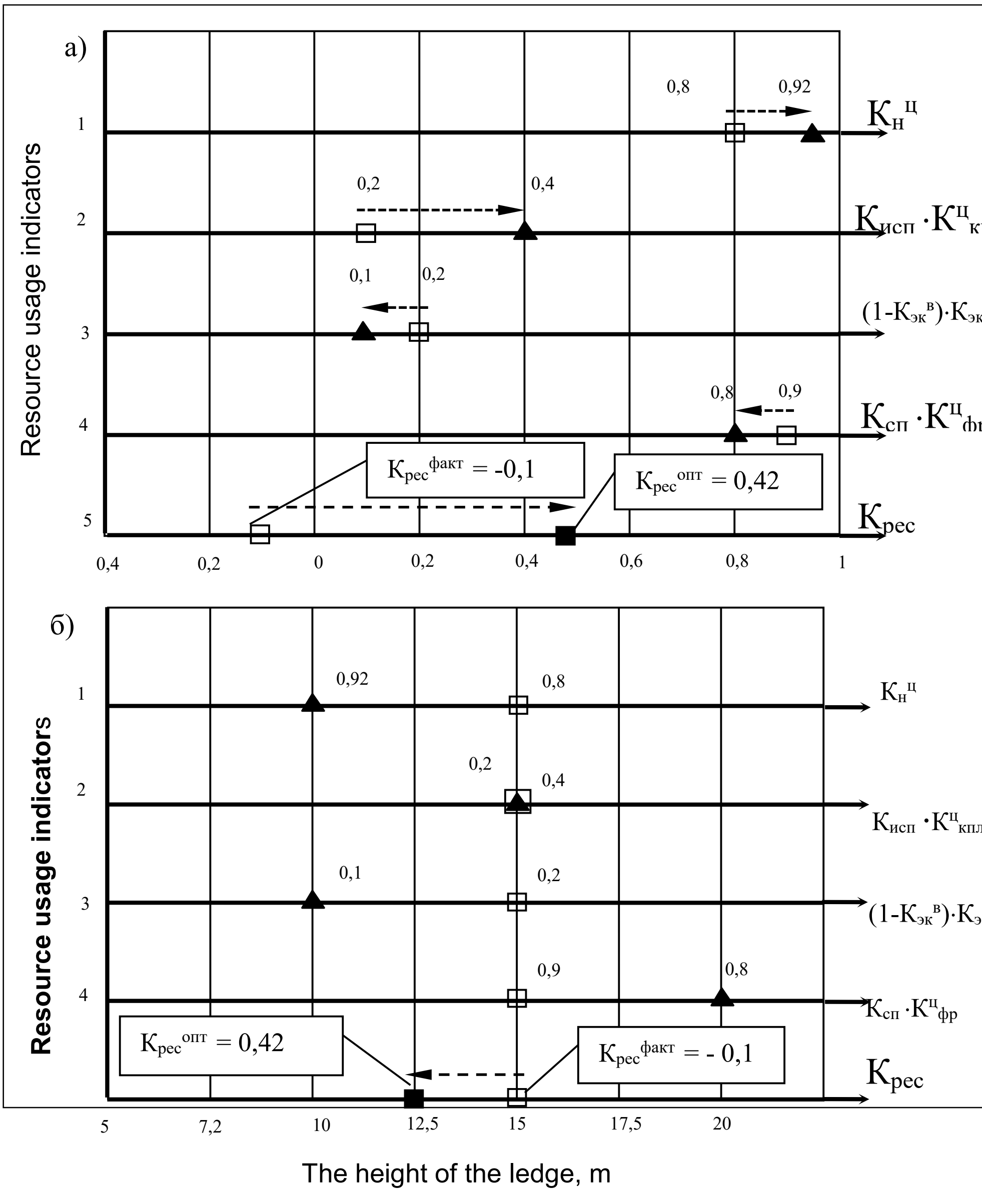


Fig. 2.2. Estimation of the levels of resource use when choosing the height of the ledge before (□) and after (▲) optimization (K_{res}^{fact} = □0.1; K_{res}^{opt} = 0.42) (a); actual (□) and rational (■) ledge heights (b)

1 - extraction of valuables from the balance reserves; 2 - the use of incidentally obtained products; 3 - restoration of the values of the natural environment; 4 - demand for financial values; 5 - rational use of resources[25-35].

Thus, having substantiated the optimal parameters of the ledge height and the elementary recoverable volume, we have a range of requirements for the parameters of mining and transport equipment for mining operations in a quarry[35-40]

4.CONCLUSIONS.

The proposed approach allows a more accurate study of the relationship between the parameters of handling equipment and the completeness of the extraction of reserves. The differences shown can be used as an information basis for the development of technological and organizational solutions aimed at improving the efficiency of using the parameters of loading and transport equipment, including by reducing its stocks, and improving the quality management systems of loading and transport equipment.

To optimize the load mode of a diesel engine according to the criterion of energy consumption, a method has been developed, which is based on the study of the power static component of the load mode and it has been proved that the dynamic component of efforts during the periods of scooping, unloading the bucket, movement does not have a significant effect on the energy intensity of the process.

To take into account all the main factors affecting the drive of the machine during the technological cycle, in the study of regime parameters, a piecewise-integral deterministic approach was used, which made it possible to describe in a formalized form the change in the total resistances for elementary technological operations, as a result of which the greatest correspondence to the real process was achieved. A computational integral mathematical model of the working process of a load-dump machine has been developed, based on the static power loading of the drive depending on external and internal factors, taking into account the possible directions of the power flow from the drive to the nodes of external and internal disturbances. Developed, manufactured and tested experimental samples of loading and transport modules of a new technical level based on the use of a translational hydraulic drive in combination with excavation and loading equipment.

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