

OPTIMIZATION OF PARAMETERS OF RELOADING STORES ON OPEN-PITS VIA SIMULATION MODELING

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ABSTRACTS: The optimization of parameters of reloading stores is carried out within the framework of the complex approach to research of open-pit's mining-transport systems with truck, railway and combined truck-railway transport on the basis of simulation modeling. It is offering to reach the increasing of efficiency of the mining-transport systems work at the expense of perfection of organization of interaction of two large and complex subsystems - "Truck" and "Railway". During optimization can vary types and parities of the mining and transport equipment, to change organization of their interaction. Main criterion of efficiency is a specific index of the carrying costs on rock mass, considered as concerning subsystems and for a system as a whole.

1. INTRODUCTION

Considering an open-pit mining-transport system during research as a totality of element, incorporated by uniform process of functioning, i.e. in view of that the influence of all factors, having a place, directly or by means of something has an effect for results of its work, it is necessary to execute the complex approach in methods of the decision those or other problems, having local character, in the same way, as, in a total, uniform final purpose, directed on increase to general efficiency of object is here pursued. The observation and perfection of functional connections of subsystems and elements should be carried out in view of character of change of functional properties and qualities of a system as a whole. The local approach at the decision of the given problems not always in a sufficient degree permits to take into account interrelation and presence of mutual conditional connects a lot of the factors. The researches realized on the basis of separate tasks not always in a sum give optimum results from a position of a technological complex and a quarry as a whole. And the unoptimum decisions and allowed errors at the substantiation those or other actions during designing and planning of mining work result to significant complications at construction and operation of open-pits, to increasing of the costs and as a whole in reduction of efficiency. In turn the successful realization of the system approach with application of the method of simulation modeling during research of open-pit's mining-transport systems in an essential degree depends on stages of preparation of the initial

information and formation of model. Consideration them out of touch with main process of researches conducts to reduction of quality of last ones, increase of time at their realization because of insufficient of intercommunication of accepted measures. It is necessary also in an uniform complex to coordinate and decision of questions of extrapolation of simulated shift indexes to their month, quarter, annual and further meanings, substantiation of criteria of efficiency of a system by choice of variants. In these conditions the association of all these stages within the framework of one methodology is solely necessary.

2 MAIN PRINCIPLES OF THE COMPLEX APPROACH

The common structure of the offered method is submitted on fig. 1. From the drawing follows, that the given method covers practically all stages of research of object from the tax and preparation of the information before choice of the optimum decision. The fulfillment of the first stage - tax and preparation of the information is carried out depending on a stage of fulfillment of work on object and requirements presented to initial data given by methodical maintenance of the following stage - formation of mining-transport system's model. At fulfillment of work at the stage of designing the quarry in attention are taken data of instructive character, in a kind of the norms of designing and meanings of indexes stipulated by construction norm of projecting. At the stage of operation - the problems, as a rule, are connected to perfection of a system or to research of

prospects of their development. In this case as the initial data are served principally actual data on each considered object - it is can be an accepted organization of interaction of the mining and transport equipment, replacement of the equipment on horizons of quarry, physics and mechanical properties of fulfilled rock mass, duration of time of loading and unloading of means of transport, structure of the transport communications, current operational and scheduled indexes on a complex and etc. At the stage of reconstruction of open-pits, depending on worth tasks as initial data can serve one of both described groups

At the second stage of realization of researches an information structure of a open-pit's mining-transport system model is formed. Appropriate attributes of organization of traffics of means of transport are mortgaged, the possible routes of their movement are developed, initial data on particularly accepted of the equipment are determined, fastening of the loading and unloading equipment at breasts, reloading stores and items on dumps is carried out, the data on the contents of an useful component in ore on breasts and necessary meaning of the given index on factory and etc. are mortgaged. At stages of verification and valuation of adequacy of model on a output data of modeling by method of comparison with actual or experienced meanings of technical and economic indexes the check of reliability • of reproduction of the order and sequence of simulated operations of technological processes is carried out, but also degree of an error of received thus results is evaluated

At a stage of an establishment of a problem and of complex of soluble tasks the initial plan of realization of machine experiments with the purpose of finding out of a common picture of a condition of a mining-transport system is established. The "narrow" places in its structure are reveal, the complex of specific measures directed on search of optimum or rational parameters of work of the equipment is planned. The complex of soluble tasks thus can include a various combination and quantity of specific researches depending on an established problem. As a final moment of the given stage is realization of a series of machine experiments on PC under the certain program.

The following stage of researches consists of realization of the technical and economical analysis of variants of work of a system developed during realization of simulation modeling. Within the

framework of the given stage, on the basis of integrating during modeling of the information, *indexes*, serving by individual and local criteria, describing work of elements, subsystems and system as a whole, are considered. Character of congestion of sites of the transport communications and their specific parameters is established the indexes of the total costs on groups of the equipment, on each of them separately and as a whole on a technological complex, are compared, the indexes of use of the equipment in time and etc. are analyzed. Further in view of received results of the technical and economic analysis the experiments are conducted already aimed at improvement of specific indexes, enabling to increase of efficiency of a mining-transport system as a whole.

At a stage of choice of variants their economic valuation, connected in view of the costs of realization of developed measures and proposals, is made. In case if neither of variants is not satisfying the complex of researches is lasted.

All of aforementioned stages are not considered as separately taken- They have rigid interrelation among themselves and are subject to fulfillment in that order and sequence as it is required by conditions, intuition and experience of the user.

Main criterion of efficiency of work of a mining-transport system within the framework of optimized working shift is a generalizing index of the specific carrying costs on extraction of rock mass, enabled to do economic valuation of eventual demurrages of the mining and transport equipment at given organization of mining-transport work, structure of the transport communications and types of the equipment.

The novelty of the given complex method of optimization of mining-transport systems can be reflected by the following moment:

- basing on the theory of simulation logic-statistical modeling;
- by using to research of open-pit's mining-transport systems with combined automobile-railway and a combination last with automobile and railway types of transport,
- by complex approach not only concerning object of research, but all stages of its research - preparation of data, modeling, experimental part, technical and economic analysis and choice of the optimum decision;

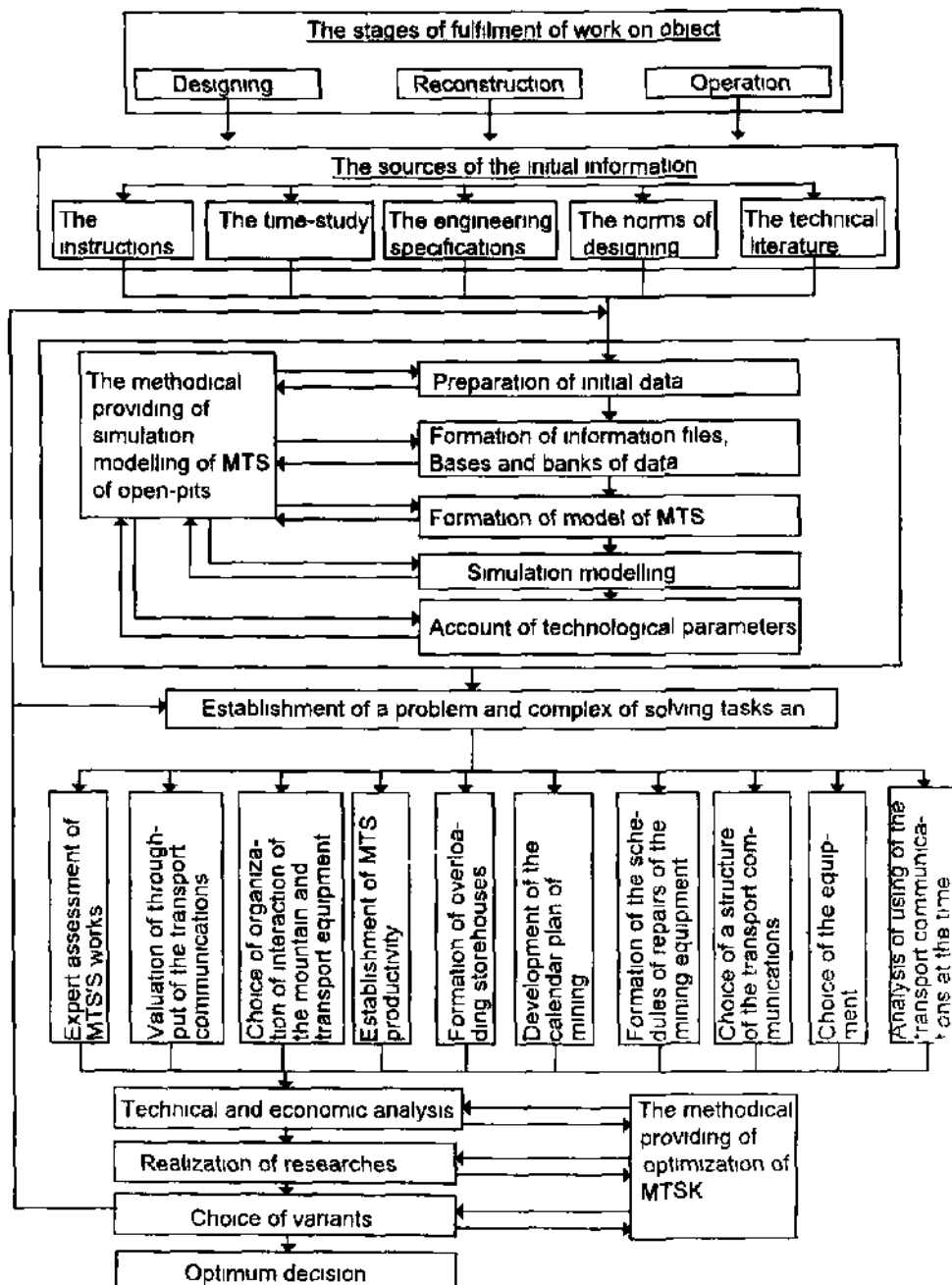


Figure 1 The structure of a complex method of open-pit mining transport systems optimization

- basing of accounts on integrated during modeling common and local indexes serving as criteria of efficiency work of a system as a whole its subsystems and elements
- by adequating to reality detail of the account of a structure and character of change of parameters of the system
 - b\ opportunity of adequate management by quality of ore flows during modeling of work of mining-transport systems,
- cumulative record-keeping of such factors as a structure of the transport communications (automobile and railway) quantity and types of *means of transport* working in a system organization of interaction of the mining and transport equipment and its replacement in open-pits space work of open-pits internal reloading stores physic-mechanical properties and qualitative characteristics of rock mass and etc

Thus the new apparatus of research of operations and theoretical method of complex optimization of open-pits excavator-automobile-railway systems is developed enabling authentic to justify the decisions for modern opened mining work at stages of designing construction reconstruction and operation of open-pits with use of simulation logic-statistical modeling of object's work ensuring the consideration of elements and subsystems of a system from uniform positions

Conducted experiments with use of developed methodical and theoretical materials but also software have allowed to establish that the increase of efficiency of purposeful search of the optimum decisions at designing, planning and management of excavator-transport complexes of cyclic action on open-pits with use of a method of simulation modeling is reached by the logic-statistical description of algorithm of reproduction of the order and sequence of operations of technological processes of extraction and loading transportation and overloading of rock mass. It permits at realization of researches rather precisely to establish character and causal and consequential connection of occurring events to receive in result of experiments, of meaning of parameters of a system, adequately and authentically reflecting its reaction to this or that scheduled changes in a structure organization of interaction of the mining and transport equipment and etc. By the most favorable condition enabling to achieve the best effect from application of a complex method of optimization of open-pit's mining-transport systems is the high level of automation and

mechanization themselves of productions, when they are precisely divided on operations and the operative decisions are taken under the known script. In this case the heaviest degree of adequacy of reproduction of real processes on model is reached, that will be naturally reflected on reliability of received during realization results of researches, will increase a level of validity of the accepted technical and technological decisions

3 PLANNING OF OPEN-PIT INTERNAL RELOADING STORES

The problem of an establishment of time and place of formation of reloading stores in open-pit's space was and remains as one of important during opened production of deposits of useful mineral. In conditions of Kazakhstan it is yet in a greater degree urgent as on the majority of the enterprises, engaged on production of ore and color metals, but also building materials in republic, principally in parallel with railway a combined automobile-railway type of transport is applied. The reloading stores, as intermediate links in work of excavator-automobile and excavator-rail way subsystems, render essential influence to their joint work and determine efficiency of each of them and mining-transport system as a whole. The decision of the given problem is connected to necessity of the account of the numerous factors what to execute with a high degree of adequacy to real process applying traditional methods of accounts is extremely complexly. It requires processing of large volumes of the information, expenses of significant means and time

One of real ways to achieve of increase of efficiency in the decision of this problem is the using of a method of simulation modeling. Now by the introduction of which in the theory and practice of opened mining work the employees of Mining Institute of the National center on complex re-making of mineral resources of the Ministry of sciences-Academy of sciences of Kazakhstan are actively engaged. Here the universal informational-program complex of optimization of open-pit's mining-transport systems - "CEBADAN" is developed. It permits adequately to reproduce the processes of extraction and loading, transportation and unloading of rock mass, to simulate work of excavators in breasts and on dump items, the organization of traffic of trains and movement of a auto transports

The planning of formation of open-pits internal reloading stores includes the decision of such tasks as determination of quantity of items of transshipment and their accommodation in open-pits space, determination of rational capacity and order of realization of operations of neutralization. For this purpose the count of necessary volumes of taken out rock mass on horizons is previously earned out and its qualitative structure is determined. In view of an accepted system of opening of the lower horizons the transport communications are formed. Preliminary selection is made of existing variant of a combination and numerical ratio of the main technological equipment is taken. The necessary productivity of a technological complex is considered or taken accordingly to the project. Then the simulation modeling of work of a mining-transport system is carried out. During modeling the record-keeping of the expenses on all modeling operations is conducted which then are summarized for determination of specific indexes of the cost price of extraction of rock mass as separately on excavator-railway and excavator-automobile complexes and on a mining-transport system as a whole. It is possible to interpret integrated in a kind of the formulas (1-

$$3) S_{vi} = \frac{S_{gi} + A_{git}}{V_{gi}} \quad S_{ri} = \frac{S_{ei} + A_{ei}}{V_{ei}}$$

$$S_{\sigma} = \frac{S_{\sigma} + A_{\sigma\sigma}}{V_{\sigma\sigma}} \quad (1-3)$$

where S_{vi} , S_{ri} , S_{σ} - specific carrying expenses accordingly to a mining-transport system excavator-automobile and excavator-railway subsystems, tenge, S_{gi} , S_{ei} , S_{σ} - current working expenses tenge, A_{git} , A_{ei} , A_{σ} - current exploitation expenses, tenge. Working out of the various variants of organization of interaction of the mining and transport equipment connected with accommodation of open-pits internal reloading stores and bemi, guided on a general specific index of the expenses on extraction of rock mass the most economic or rational from them can be chosen. The types of excavators on transshipment, quantity of items of unloading in reloading store, number of reloading stores types and quantity of trucks arrangement of ones in open-pits space as on a vertical and on horizontal types and quantity of excavators on extraction and loading quantity of trains the structures of the transport communications and organization of interaction of the mining and transport equipment are varied.

The important part of spent researches takes the current technical and economic analysis of worked out variants. It provides particular selectivity and

drive in questions of tactics and strategy of realization of researches that permits to avoid viewing of many unnecessary variants. On a parity of technological indexes on excavator-railway and excavator-automobile complexes it is possible to establish at the expense of which of them, and further in this connection the reduction or increase of efficiency of work of a system occurs. On both subsystems during modeling such indexes are formed as amount of executed works on processes, average weighted distances of transportation, using by the equipment of average shift working time, the time of trips and their quantity, the organizational losses on excavators in items of loading, congestion of the circuit of railway development and its block-sites, quantity of trams and automobile means of transport passing through the sites of the circuit of railway development and line. All of them in a complex with indexes of the expenses permit to make by results of modeling the qualitative technical and economic analysis of work of a system and its elements with a high degree of reliability.

One of important indexes at the decision of a question of formation of reloading stores is the transport work determined directly by results of modeling and which is considered by results of modeling under the following common formula

$$A_{gik} = A_k + A_k^k + A_{\sigma}^k + A_{\sigma}, \quad (4)$$

where A_{gik} - the transport work as a whole on a mining-transport complex tkm, A and A_{σ} - work according to railway and motor transport used in a complex with combined, tkm, A^* and A_{σ}^k - too, but working in a combination. With the one hand the given index serves as auxiliary criterion at an assessment of works of a mining-transport system, on the other hand it serves as the restriction for the control at uniformity of distribution of transport work on periods, if it is not provided the additional commissioning of the again acquired equipment.

The account of transport work is earned out proceeding from the record-keeping of distances and volumes of transported rock mass in each trip considering of types of trucks. Thus volumes of rock mass on each of concentrational horizon are taken into account, average weighted distances of transportation for each of involved types of machines are determined. The mathematical interpretation of these accounts is submitted by the formulas (5-7). On the railway transport

$$A_k^k = \frac{\sum_{i=1}^k l_k^k}{k} V_{qm}^k, \quad (5)$$

where l_k^k - distance of transportation in K-th trip, km; V_{qm}^k - volume of rock mass transported by railway, cub m; K - quantity of trips for shift
On the railway transport working in a combination with automobile

$$A_z^k = \frac{\sum_{z=1}^Z l_z^k}{Z} V_{qm}^k, \quad (6)$$

where l_z^k - distance of transportation in z-th trip, km, V_{qm}^k - volume of rock mass transported by rail way from reloading stores, cub m, Z - quantity of trips for shift
On motor transport working in a combination with automobile

$$A_u^k = \frac{\sum_{r=1}^R l_{r1}^k}{R_{u1}^k} V_{qm1}^k + \frac{\sum_{p=1}^P l_{p2}^k}{P_{u2}^k} V_{qm2}^k + \frac{\sum_{s=1}^S l_{s3}^k}{S_{u3}^k} V_{qm3}^k, \quad (7)$$

where $l_{r1}^k, l_{p2}^k, l_{s3}^k$ - according to distance of transportation in each r, p and s-th trips of a ln-th type of truck, km., $V_{qm1}^k, V_{qm2}^k, V_{qm3}^k$ - accordingly volumes of rock mass removed from breasts on reloading stores of a ln-th type of truck, cub.m. The work on motor transport working in parallel with combined can be determined substituting appropriate meanings in the formula 7.

Meanings of the index of work on the automobile and railway transport permit quantitatively to evaluate a parity of two transport arms. Knowing the expenses of transport work it is possible with large accuracy to assume about expected economic benefit from increase or reduction of a parity of transport arms on prospective size or in connection with change of quality of cover of ways. Follows to note, that at realization of an offered technique the transport work is established in view of organization of exportation of taken out rock mass, instead of by simple multiplication of distance from a surface up to center of weights of concentration horizons on taken out volumes of rock mass. Here it is taken into account types of the transport equipment (the park of trucks can be various) and quality of cover of ways and structure of the circuits of railway development and quantity of transport units on types of transport, idle times of the mining and transport equipment, charge of energy on types of transport. The expenses of transportation per tkm are

determined also by results of modeling, instead of are taken under the norms or actual, as last have developed under other conditions and specific characters working out again of variants of organization of mining-transport work do not take into account. The necessity of the complex approach in the decision of questions of formation of reloading stores is evidently demonstrated on an example of results received during researches and submitted on Fig 2. The work of the mining-transport complex with parallel use automobile (from breasts to dumps), railway (from breasts and reloading stores to dumps and unloading items on a factory) and combined (from breasts to reloading stores and farther to factory and dumps) types of transport was simulated. At constant parameters and the organizations of work of a excavator-railway complex types and quantity of trucks are had been varied. The system was saturated by them up to optimum meanings, i.e. the specific carrying costs on a system as a whole were minimum. The results of the given research have shown, that at different types of trucks the optimum indexes of the specific costs on subsystems do not coincide. Their approach can come with forestallment in that or other subsystem depending on productive capacity of the used transport equipment, sizes of its cost and working expenses on it.

The productivity of a excavators on transshipment by consideration of efficiency of a system from uniform positions is reduced on 50-100 % and more in comparison with a similar index at the work irrespective of the railway transport. The exportation of volumes of rock mass unrealized through reloading store in dump menacingly increases a local index of the specific carrying costs on a excavator complex. On the other hand the construction of additional reloading store and commissioning of one more excavator on transshipment can negatively have an effect on a similar index concerning the excavator-railway complex, as besides the specified additional expenses it is necessary to increase quantity of working trains and to build one more railway impasse under transshipment (not speaking about necessity of allocation of the areas in open-pit's space). The other way of reduction of the general specific carrying costs it is alteration of combinations and quantity of various types trucks. The qualitative decision of the given task is possible only by joint and detailed consideration of work of subsystems "Auto" and "Railway".

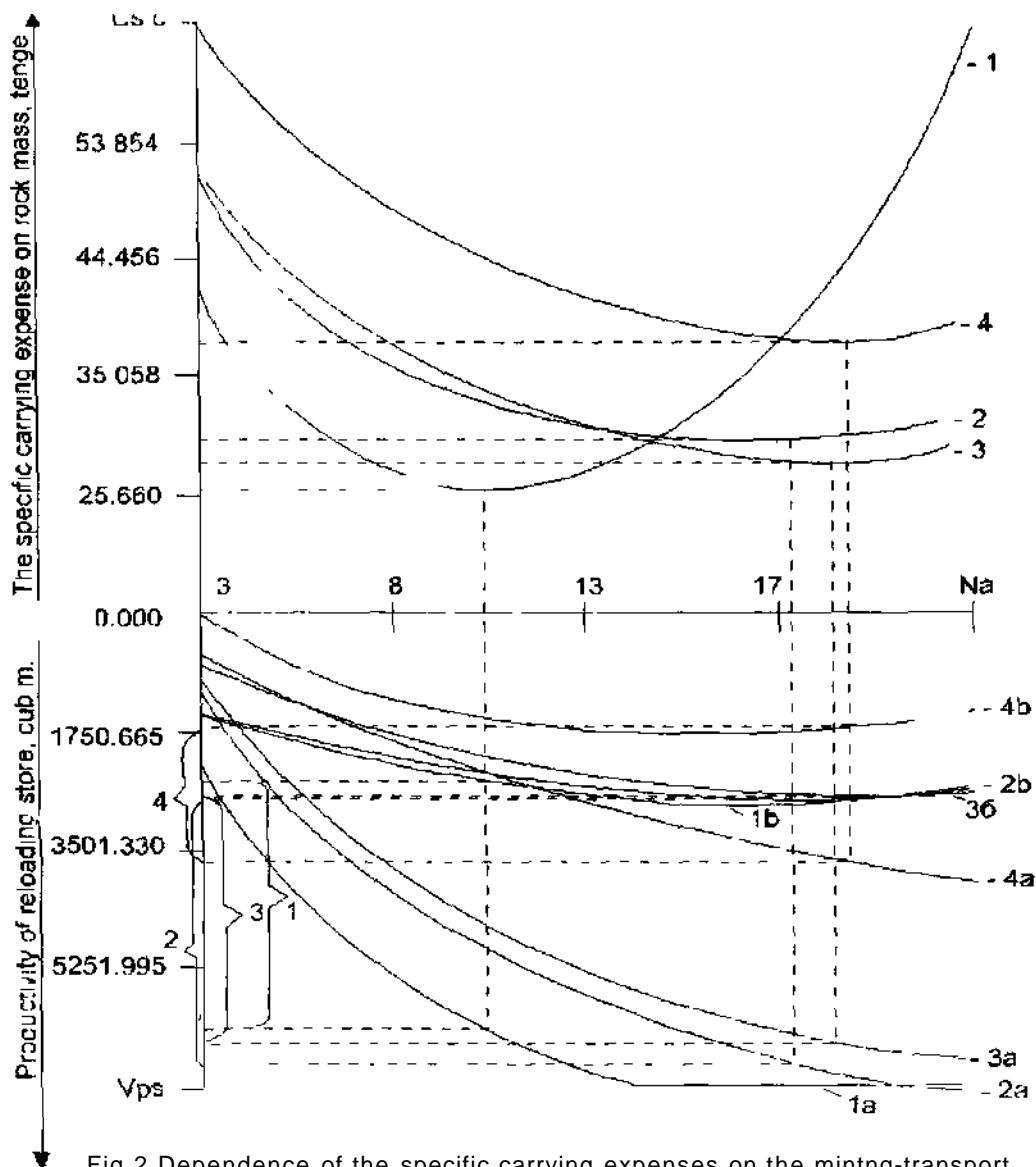


Fig 2 Dependence of the specific carrying expenses on the mintnq-transport complex and volumes of rock mass in reloading store from quantity servicing trucks
 The note- 1 - BelA7-7521; 2 - BelAZ-7519, 3 - BelAZ 548A

Volumes of transhipped rock mass' a concerning work of the exca-
 vator-automobile complex; b - concerning work of the excavator-rail
 w;iy complex
 Na - quantity of trucks <i> work.

By results of spent of the analysis and researches it is possible to conclude that the effective decision of problems of reloading stores connected to formation on open-pits with combined automobile-railway transport is provided by consideration of interaction excavator-automobile and ex cava tor-rail way of complexes on the basts of the system approach sold by means of simulation logic statistical modeling on PC It permits to increase adequacy of the record-keeping of such important factors as a structure of the circuit of railway development and highways, parameters of a system of opening of horizons and order of their improvement organization of transportation of rock mass and quality of cover of ways, quantity and combination of means of transport The valuation of efficiency of the accepted thus decisions should be made from positions of a mining-transport system as a whole

CONCLUSION

Thus, at current or perspective planning of mining and transport of work it is possible with a high degree of accuracy to determine time of necessary carry and location in open-pits space of reloading stores but also rational combination and numerical parity of the mining and transport equipment Taking into account that the cost price of transportation on the railway transport in 3-4 times is lower than at automobile the economic benefit of the duly decision

of the given question can make tens of millions tenge on the average in a year For this purpose in processes of exploitation of the quarry it is necessary, periodically to fill up and to correct bases initial given and to analyze target technical and economic indexes

Such complex approach to optimization of excavator-automobile-railway systems opens large opportunities in the plan of increase of efficiency of planning of carry and accommodation of open-pit's internal reloading stores that is extremely important at realization of mining work on open-pits It can successfully be applied at stages of designing, reconstruction and operation of open-pits

The developed method together with a information-program part of the given research can successfully be applied in educational process connected to preparation of the experts in the given area of a science and of practice It will allow as much as possible to approach it to real manufacture and to give more qualitative knowledge of specific character of main technological processes on opened development of deposits of useful mineral