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THE VALUATION OF POWER EFFICIENCY OF MINING-TRANSPORT SYSTEMS WORK OF OPEN-PITS

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ABSTRACT: The most necessity of operative valuation of work efficiency of the open-pit mining-transpqrt complex arises during operative and current planning. It can be made on main technological and economical parameters, but, as practice shows, the given approach gives not sharper representation about its potential opportunities. In this connection, now, in the given direction actually is the development of more objective methods, enabling to see basic defects in organisation of mining-transport work. To one of such directions offers use of power criteria for valuation of efficiency of mining-transport work on open-pits.

1. INTRODUCTION

Now the increase of power consumption at a simultaneous rise in prices on power resources becomes one of the main factors, which limiting development of opened mining work. In the deep open-pits the main charge of energy have on open-pit's transport. As criterion of power efficiency valuation of transport systems of the deep open-pits the size of the specific charge of energy on the rise 1 ton of rock mass from the open-pit can be accepted. Then coefficient of energy efficiency *(T[*) is defined from expression

$$\eta = \frac{E_T}{E_F} \cdot 100\%$$

where E_T is theoretically r.&jossary size of energy charge on rise 1 ton of rock mass on height 1 m (£f-9,81 kJ/tm); E_F is actual charge of energy by the given type of transport, kJ/tm (Lely, 1996).

The calculation of coefficient of efficiency of energy use permits to define power efficiency of transport systems of open-pits rather theoretically necessary size of the energy charge. However in practical conditions of mining-transport work planning there is necessity finding of a real level of power efficiency rather minimum possible significance of energy charge on the enterprise, or on planning variants, which can be achieved in present economic conditions, at accepted technology of mining and transport work and technical condition of the equipment.

In the given article the main theoretical principles of realisation, so-called "power" direction on the basis of the system approach with application of logical-statistical simulation modelling method are stated.

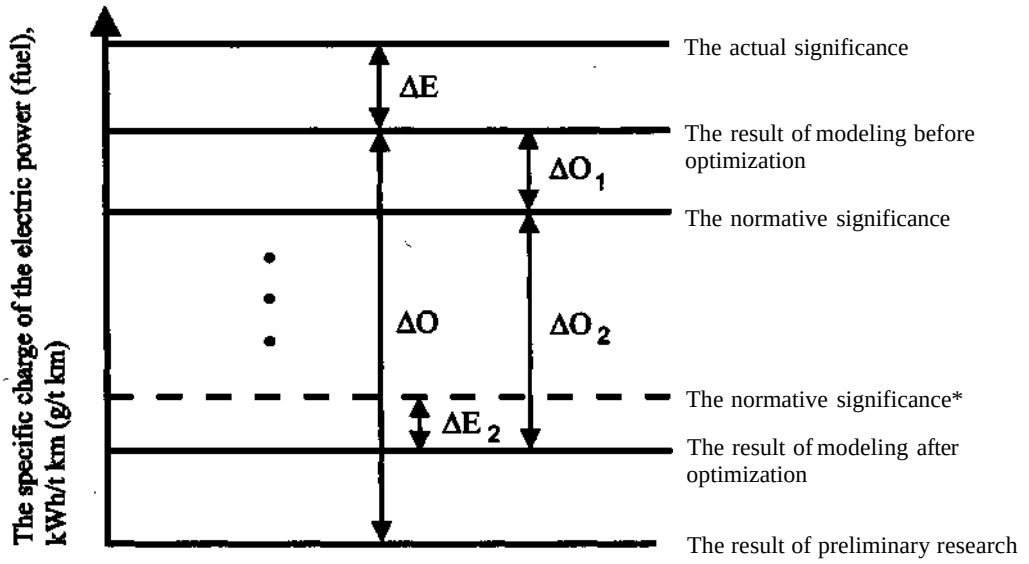
2. THE CRITERIA OF POWER EFFICIENCY

The feature of an offered method is combined use of analytical methods and results of logical-statistical simulation modelling on computer at accounts of specific energy charge on transport work, in view of interaction cf the mining and transport equipment, in two stages. At the first stage with application of analytical methods the minimum significance of a sr- .x' i : parameter of energy charge on help (design) ^f.-p >:> established. In comparison with similar set-?..' ***lii-c*** normative and actual parameters a range of ^ible decrease of energy charge as in a subsystem - ,UTO" and in a subsystem "RAILWAY" emerges.

The areas of possible decrease of energy charge are schematically given in figure 1. From the figure it is clear, that the interesting area *AO* is within the range of significance «the fact» and «the result of preliminary research». It is here supposed, that A£ rather a little and is described only by a degree of model adequacy, which locating in range 5%. The result of preliminary research is account of minimum significance specific energy charge, based on definition of work on moving 1 ton from open-pit to dump (or factory) on help (design) data.

Knowing the norm of specific energy charge, volume of transported rock mass V_{rm} and common extent of the technological transport communications L_{comm}, can be defined base criteria parameter of power efficiency of a mining-transport system

Areas of possible decrease of energy charge



AE = AE$_1$+ AE 2 is area of significances including in self undiscounted sources of a current consumption (fuel), but also divergence in frameworks of model adequacy

AO is area of optimization;

* is prospective new normative significance after fulfilment of all optimization actions.

Figure 1.

$$K^{n}_{\text{▒}} = \frac{E^{n}_{s.c.} \cdot V_{r.m.}}{L_{comm.}} \qquad (2)$$

which showing quantity of energy spent on rise of rock mass volume which concern on 1 km of the technological transport communications, i.e. describing their power consumption. The equation (2) takes into account a structure weight flows and their sizes, average weighted height of rise and length of transportation of rock mass, but also structure and extent of the transport communications.

3. THE METHOD OF VALUATION OF POWER EFFICIENCY

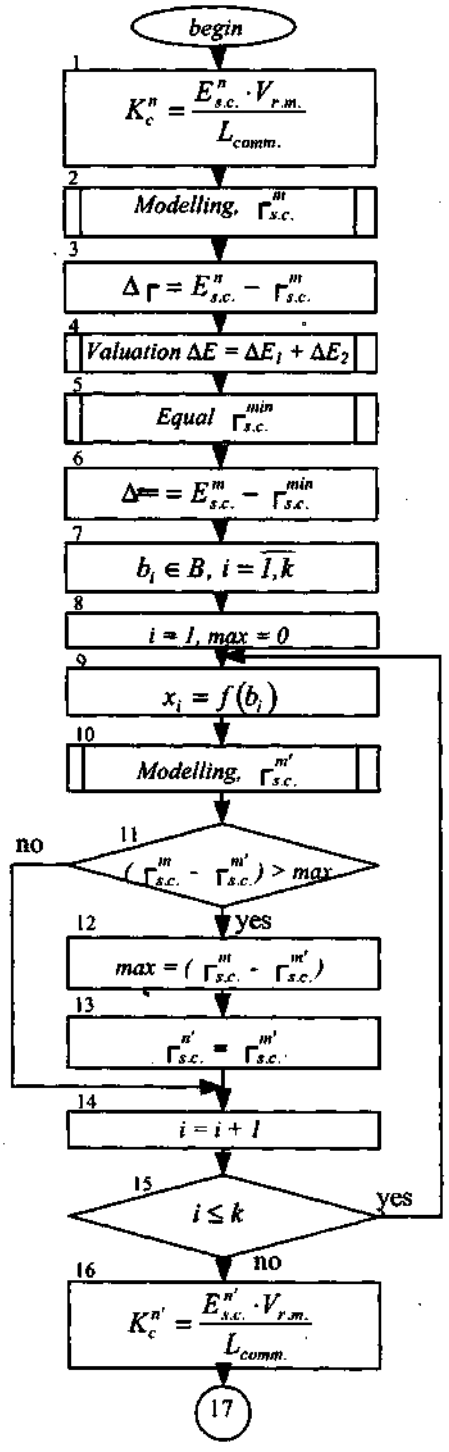
As follows from the block diagram of algorithm submitted on a figure 2, the method of power efficiency valuation of mining-transport systems of open-pits consists in following:

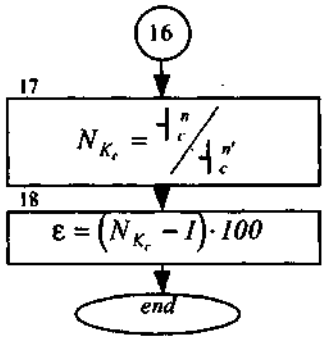
1. The calculation of criterion significance $K^{n}_{\text{▒}}$ (block 1). It is here supposed, that $E^{n}_{s.c.} = E^{f}_{s.c.}$, i.e. $\Delta E_f = 0$, where $E^{f}_{s.c.}$ is significance of actual specific energy charge at the enterprise.

2. The creation of logical-statistical simulation model of a mining-transport system of open-pit (block 2). E^{TM}_{c} is significance of specific energy charge, received by results of simulation modelling, which necessary for valuation of model reliability, which made in the block 3.

3. The valuation of deviations of significance received in result of simulation modelling from actual and normative, enabling to evaluate as model reliability, and accuracy of fixing of the information at

The method of valuation power efficiency of mining-transport work





B is set of areas of increase of power efficiency of mining-transport system of open-pit.

Xj = /(ZJ$_X$ j is input significance appropriate to action *bj*.

Figure 2.

the enterprise on specific energy charge, availability of not established sources of energy consumption (block 4).

4. The calculation of minimum possible specific energy charge, basing on definition of work on moving 1 ton from open-pit to dump (or factory).

For open-pit's railway transport, as against from surface transport, is the most rational account to conduct in function from depth moving of rock mass (H).

In a common kind the charge of the electric power on draft of trains A, can be expressed as following:

$$A_t = A_P + A_{TA} + A_{CC} + A_{PP} + A_{DP} + A_{DC} + A_{EPC} + A_{CH} + A_{PR} + A_{MX} \quad (3)$$

where A_P is useful charge of the electric power on moving of a payload (rock mass) on average weighted height H; A_{TA} is charge of the electric power on moving of weight of trains container on height H, kgm; Ac_C is charge of the electric power on overcoming of main forces of resistance (including from curve); A_{PP} is charge of the electric power on movement of empty trains; A_{DP} is charge of the electric power on indemnification of losses on force electric substations; A^ is charge of the electric power on indemnification of losses in a contact network; A_{EPC} is charge of the electric power on indemnification of losses in pull aggregate; A_{CH} is charge of the electric power on own needs; A_{PR} is charge of the electric power on indemnification of losses at idle times, including in places of loading and unloading; AMX is charge of the electric power by manufacture various manoeuvre and auxiliary work (agree of a method of account of the specific norms of the charge of fuel and energy resources, accepted for accounts in JSC «SSGPO»).

As follows from the formula (3), the account all making total energy charge permits to consider a specific parameter is rather close to actual. The truth, only under condition of use actual, instead the help data at the account making, fixing indications of which is directly impossible. In a method described by us is offered to use help (design) data. Thus the main difference consists that the actual data already comprise all negative moments of technology and technical condition of the equipment and transport communications, as against from help (design) data.

The similar actions are made for open-pit's auto transport on a method of definition of the minimum charge of energy on moving of rock mass (Dovzhenok, 1992).

5. The definition of area of optimisation of significance specific energy charge A0.

The areas of significance À0/ and $A0_2$ describe accordingly two stages of optimisation: preliminary and detailed. The preliminary stage includes the analysis of accounts of a normative parameter of energy charge and actual indications of counters of the electric power on force electric substations (data on the specific charge of fuel). At realisation of detailed research the main attention is given to areas of increase of power efficiency of mining-transport systems of open-pits, submitted on a figure 3.

6. Knowing a divergence simulated (actual, normative) significance of specific energy charge and minimum possible is further offered to consider a number actions (6,e *B)* on its possible decrease (figure 3), the introduction of which will allow to increase power efficiency of mining-transport systems of open-pits.

As follows from a figure, there are two possible directions of increase of power efficiency, conditionally belonging to technologies of productions and of mining work.

The most attractive with the economic point of view is the area of technology of productions, because it permits, at least at an initial stage, to do without the essential lumps costs and includes a complex organisational and technical measures directed on increase of efficiency of control, scheduling and realisation of mining-transport work.

We shall consider detail each area of possible decrease of energy charge.

On the speed of movement of transport means the main influence there are the following factors: a technical condition of the transport comrrîunications and mobile transport means, determining rigid restrictions movements imposed on the order under the safety precautions; short routes on the railway transport or autoroad with frequently change of a movement direction, causing operation of transport means in uneconomic mode of operations and in particular of their engines (increased energy charge at acceleration); quantity of transport means in circulation, rendering restrain influence.

The optimum organisation of movement of transport means permits to reduce average weighted distance of transportation, but also idle times and slow movement of the transport in «narrow» places of the transport communications.

The measures on research of interaction organisation of the mining and transport equipment, but also
parity of their types is directed on decrease of idle times of the high-duty equipment, that in turn influences decrease specific energy charge.

The definition of useful weight of the transport means should proceed from the following principles: nominal carrying capacity, physical-technical properties of mining rock mass, technical condition of the transport means, technical condition and structure of the transport communications.

Areas of increase of power efficiency of mining-transport systems of open-pits

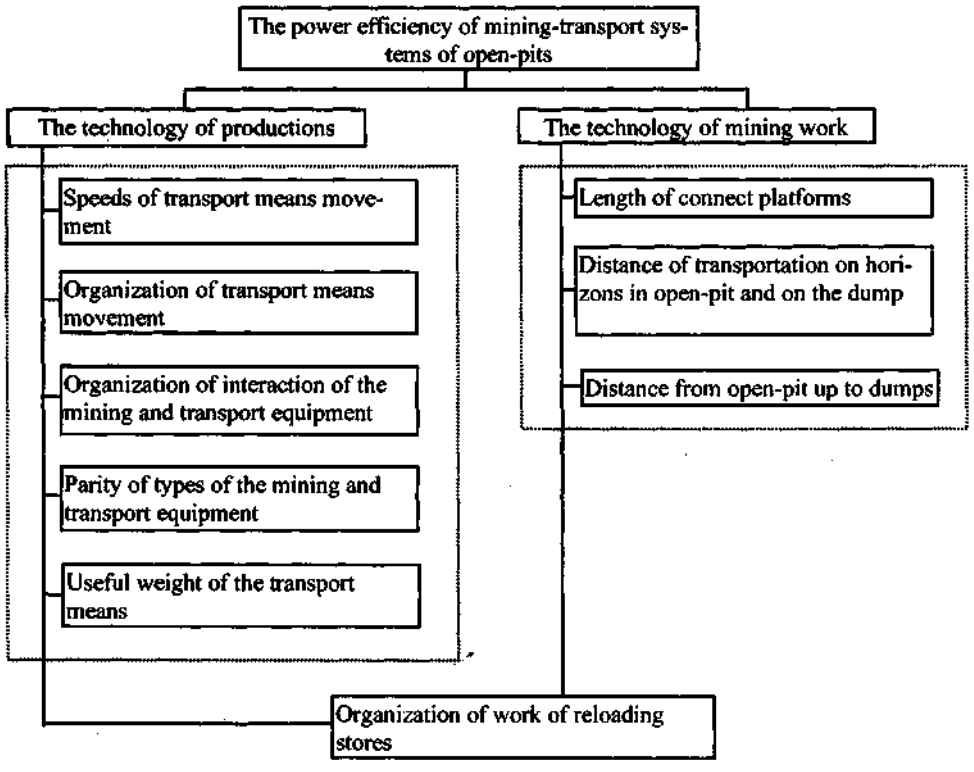


Figure 3.

The consecutive research on model of effects of parameters from each of described area by a way changes of their significance results in development of the particular proposals on opportunities of decrease of energy charge.

As a rule, at the present mining enterprises, whole complex of optimisation measures for reception of an acceptable level increase of power efficiency of mining-transport systems of open-pits and in the end of economic benefit is required. It is for this purpose necessary to consider mining-transport systems as a whole in interrelation of its subsystems, the change of one parameter of which renders influence to set of parameters of other subsystems.

The reserves of increase of power efficiency of mining-transport systems at the expense of technology of mining work consists of minimisation of energy charge on direct sites of the transport communications of open-pit, on dumps and distance between open-pit and dumps.

7. In a cycle we research reaction of a system (submitted in a kind of simulation model) on input signals *Xi~f(bj)* appropriate to introduction of actions *bj*. The cycle is described by blocks 8-15. The block 10 corresponds to a complex method of optimisation of mining-transport systems of open-pits, developed by prof. S.Galiyev (Galiyev, 1997).

8. The calculation of criterion significance K'' is criterion significance appropriate minimum possible significance specific energy charge, which can be achieved in present economic conditions, at accepted technology of mining and transport work and technical condition of the equipment (block 16). Thus always a parity $E''_c > E''''''$ is correct.

9. The valuation of power efficiency.

$$N_{K_c} = \frac{K''_c}{K''_c} \geq 1, \qquad (4)$$

The parameter (4) permits to make a conclusion about efficiency of a open-pit's transport system, and having received numerical significance of a deviation actual (normative) condition from minimum possible signifiaiince specific energy charge E''_c, which can be achieved in present economic conditions, at accepted technology of mining and transport work and technical condition of the equipment:

$$\varepsilon = \left(N_{K_r} - 1\right) \cdot 100, \%. \quad (5)$$

ε is valuation, showing real potential of increase of power efficiency in percentage.

The level of power efficiency is equal

$$L = \left(100 - \varepsilon\right), \%. \quad (6)$$

If the method is applied to valuation of scheduling variants of a mining-transport system one open-pit, K'' can be accepted equal $K'' = E''_c$, since planned volumes V_{rm} and the common extent of the technological transport communications L_{comm} remains constant. Sense K'' in deployed record acquires at comparison of power efficiency of mining-transport systems of various open-pits.

Knowing the significance N_K, £ or I on various open-pits can be made the comparative analysis of efficiency of their mining-transport systems without risk to confront with problems of metrological incompatibility of data.

The described method can be used as independently, and in a complex as the gear of efficiency valuation of planned variants. It is in the latter case necessary to execute steps 1 -6 prior to the beginning planning, and steps 7-9 during comparative valuation of planning variants.

The data by results of conducted power valuation and search of ways increase of power efficiency of mining-transport work on Kazakhstan's open-pits by rail transport submitted in table 1.

4. CONCLUSION

The method of power efficiency valuation of work of mining-transport systems of open-pits permits on the basis of offered criterion to make the comparative analysis of planning variants, but also power efficiency of various open-pits, the result of which is numerical significance of a power efficiency level rather minimum possible significance energy charge on the enterprise, at accepted technology of mining and transport work and technical condition of the equipment.

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Table 1. The valuation of power efficiency of excavator-railway systems of open-pits.

Parameters	Objects			
	DAGOK JSC «Kustanai-asbest»	Kachar JSC «SSGPO»	Sarbai JSC «SSGPO»	Itauz JSC «Jeskaz-gan-zvetmet»
Input data				
a) Average weighted height of rise of rock mass, m	104	118	322,2	95,8
b) Average weighted distance of transportation of rock mass, km	8,7	8,1	17,2	5,5
c) Useful weight of the train, t	1030* 1030	855,58 945	948,54 1035	990 990
d) Coefficient of container of the train	0,748	0,842	0,759	0,800
Output data				
	Specific energy charge			
on normative, kWh/t kWh/tkm	1,914 0,220	1,600 0,198	3,000 0,174	1,920 0,349
on the fact, kWh/t kWh/t-km	2,132 0,245	1,610 0,199	2,900 0,169	-
on precomputation **, kWh/t kWh/t-km	1,305 0,150	1,480 0,180	2,740 0,159	1,089 0,200
by results of modelling before optimisation, kWh/t kWh/t-km	2,088 0,240	1,590 0,196	2,880 0,167	1,920 0,349
by results of modelling after optimisation ***, kWh/t kWh/tkm	1,418 0,163		2,779 0,162	-
the level of power efficiency ****, %	65,03/ /49,69	-	92,59/ /95,68	-

* In numerator average significance of useful weight of the train for different kinds of transported of rock mass in view of a difference in volumes, in a denominator - maximum. For example, for Sarbai open-pit JSC «SSGPO». Useful weight of the train makes: on ore -1035 ton, on rock - 920 ton; for Kachar open-pit: on ore - 945 ton, on rock - 897 ton, on friable rock mass 836,6 ton.

** The method of account of the specific norms of the charge of fuel and energy resources, accepted for accounts in JSC «SSGPO».

*** The data on significance of the specific charge of the electric power after optimisation are present only on those objects, on which special surveys by the order of these enterprises were conducted.

**** In numerator - concerning the norm, in a denominator - concerning the fact.