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OPTIMIZATION PRINCIPLES OF MINING AND TRANSPORTATION SYSTEM OF OPEN PITS WITH APPLICATION OF SIMULATION MODELLING

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ABSTRACTS: The present article deals with the main principles of optimization of open pits mining - transport systems, carried out on the basis of the systematic approach applying imitative modelling method done on PC by means of the universal information program complex of "CEBADAN" (1994). All major factors of defining the mining - transport complex productivity including excavators at the loading and the discharging points, also motor and railway or the combined motor-railway transport are taken into account Methods of complex analysis and of mining-transport system work evaluation, its subsystems and elements have been worked out. A number of integrated and local indices, serving as criteria of the system efficacy has been suggested and substantiated that allow its condition and potential abilities to be objectively evaluated.

1. INTRODUCTION

The problem of mining - transport work organization at big open pits poses the biggest challenge. Its efficacy is determined by a considerable number of factors, most of which have the probability nature. The complexity and range of modern mining production in combination with the traditionally employed methods of its planning do not allow at present the highly productive and expensive equipment to be effectively used. The absence of the effective methods of complex analysis and evaluation results in the insufficient consideration of major technological equipment adaptation to the created conditions while designing, doing the current and long-term planning of mining and transport work at the pits. In this aspect the main thing to be done is to take such factors into account as the structure of the transport development scheme and the organisation principles of mining and transport equipment interaction, their dislocation in the pit space, qualitative and quantitative characteristics. In order to make a rational technological decision taking into account the abovegiven factors it is necessary to be guided by the system of authentic integrated generalized and individual technic economic indices, that permit in its complex and with great precision to analyse and evaluate the work of the system a of its separate sections. To do this on the basis of traditionally employed methods is extremely complicated. They presuppose the local and far simplified consideration of the processes and operations and thus fail to provide the required efficacy of the adopted technological decisions.

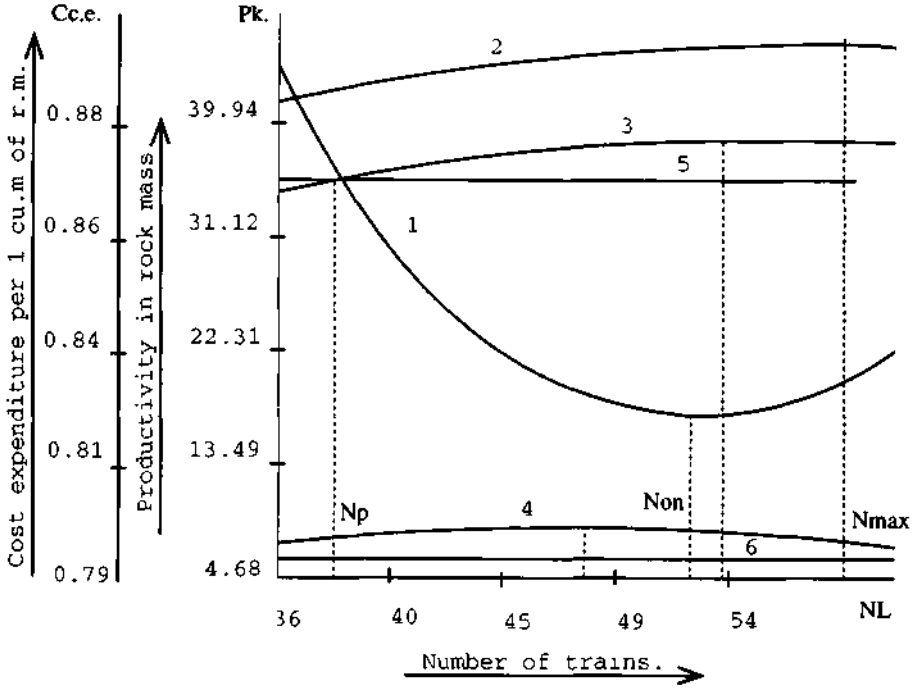
The development of electronics and calculating machines makes it feaseble to elaborate highly effective methods of investigation and to optimize similar complex systems.

2. CRITERIA OF MINING-TRANSPORT SYSTEM OPTIMIZATION OF PITS

One of the main indices, characterising the work of the system as a whole is to be the one of specific expenditures by the mining mass (1994). It makes it possible to carry ont the alternative option of the effective variant of mining-transport work organization. Howeves, the given indiex won't allow to conclude on weak and strong points of the obtained variant, as well as of the extent and ways of the realisation of the system potential opportunities. For the development of this a number of basically new methods of analysis and the evaluation of the work of the mining-transport system of pits.

substantiated by the results of the imitative modelling on PC was applied. There were suggested integrated indices, reflecting the quantitative and the qualitative reaction of the system to the change in its paramètres and thus, giving the possibility to sense the rationality of the decisions made.

The process of optimization is founded on the simulation results is performed with, the grapico-analytical application method as it is shown in the figure.



Graph-analytical method of defining the optimum amount of stocks circulating in the pit transport system. 1-4 are graphical dependeces corresponingly: according to specific expenditures, according to the rock mass, according to the opened mass, according to ore; 5,6 - plan indices of the overboding mass and ore. N_p, N« , Nmax - accordingly rational, optimal and maximum possible amount of locomotive compounds.

3. MINING EQUIPMENT WORKING TIME REALIZATION ANALYSIS

The method of the evaluation of the extent of the realization loading equipment power presupposes the detailedanalysis of using the working time by the excavators at loading points.

Besides the paramètres and the charater of train streams at the exchange points are taken into account. As a result of the waste calculations may serve the indice of the organizational waste of the loading equipment working time (1991).

$$K_{o1} = 1 - (\Sigma t_o + \Sigma t_e + \Sigma t_{em})/T \quad (1)$$

where Σt_o, Σt_e, Σt_{em} = are correspondingly the working lime, the idling time in connection with the locomotive exchange and the emergency idling of the equipment; T= time of a shift.

The index is reflecing the impact of the transport development scheme structure, the principles of train movement organization, the quantity of the locomotives used in the system on the mining equipment work and present the time quota of the equipment demurrage owing to the locomotive nonarrival to the loading dead end exchange point. The given index can be determined both by each excavator individually and for the group of excavators or by the whole pit. This gives an opportunity to define accurately the available system

reserves and ways of their realization, to seek for optimal variants more purposefully and it considerably reduces time of the researches conducted in this direction. The availability of such information also clarifies the character of the necessary practical decisions made, because, for example, untapped reserves speak to the effect of the expediency of adopting more global measures, which basically change these or other regulations in the mining-transport work organization.

The index can serve as an additional critérium while investigating the system work efficacy, the transport development scheme optimization, the substantiation of the rational combination and the numerical mining and transport equipment ratio.

4. ANALYSIS AND EVALUATION OF THE TRANSPORT DEVELOPMENT SCHEME FUNCTIONING CAPACITY

At present a Serions problem is posing it self also in solving the tasks of the evaluation and fixing the character of the functioning capacity of the transport development scheme elements, this being extremely important while forming the perspectives of theis development, determining traffic and carrying capacity, establishing the rational transport system productivity. Suffice it to note that for about 50% of direct expenditures on the mining - transport system maintenance in working condition is related to the railway factors maintenance.

The common extension of tracks used in the technological process makes up hundreds of kilometres. Morover, the structure of the track development pit schemes is extremely complicatated and diversified, especially at deep pits. To investigate this on the basis of the programmed complex the method of evaluating and analyzing the track development of pit schemes functioning capacity is worked out.

In the process of the imitative simulation of each of the track development scheme sections the locomotive employment lime information is fixed. Morover, the employment time is considered to be both actual, i.e. the locomotive being immediately on the section and indirect, that is when the section was included in the route of some train bul was unable lo be used for passing *o(* another train. In ils turn the actual employment of the .section is divided into Ihm of demurrage on the section and thai *ol'* the Irani moving on il.

The index scheme .specific functioning capacity serves as a generali/ed index, cluiacleri/ing the common functioning capacity of the track development scheme and it permits judging about the reserves availability to increase its efficacy. Similar indices can be defined by each station of the track development scheme or a post. The comparison of these indices with the common specific functioning capacity index enables one to judge about their steadiness and the rational loading and also to have a notion of the distribution character of the effective reserves of the track scheme.

The established degree of the functioning capacity of each of the sections the track development scheme in its turn appears to be a token of their differentiation into groups. Depending upon die differentiation of the sections the indices of common track development scheme length and its sections by each of such groups is defined. By the results of the calculations made the screen displays the diagram of the functioning capacity of the track development scheme that allows to have a clear notion of the specific quality of the railway network sections with this or that degree of functioning capacity.

The definition of the functioning capacity character of the track development scheme is carried out by means of the programm-model "Max", which selects the most loaded by time sections and forms all the information available on each of them both on the whole and in directions (empties and freight) including: the time of employment, the amount of trains having passed on the section, the number of detentions and their common length, the loading extent of the section. As the most loaded sections seem as a rule to be the bottle-neck in the structure of the track development scheme or point out to such in case of the considerable time demurrage. The obtained information permits to reveal the bottle-neck of the system and to analyze their conditions, to understand the causes of created situations.

For the concrete consideration of the revealed bottle-necks according to the desire of the user the local analysis can be made, in the result of which is formed and displayed the diagram of the train movement intervals which gives the notion of the character of paramètres of trainstreames on each of the sections entering the zone of the local consideration of the station, post, of the run , etc. and in general in the directions (freight, emptees) is established ihe inner shift index of the unsfediness of the train movements.

The assessment of the transport capacities of the track development scheme.

In order to have ihc opportunity of analyzing the work of the section of the track development scheme qualitatively a effectively it's necessary to have a

clear notion of the character of its development during the working hour of the shift. For this purpose the shift-time work of the railway block-section is subdivided into the following constituents: 1) actual employment; 2) indirect employment; 3) active employment time; 4) employment during the train demurrage time; 5) route employment time; 6) unrealized working time.

The time of actual section employment presents by itself the quota of its general employment time during the whole working period of time.

Under the time of indirect employment is understood the period when the loose section Is included in the route and can't be used for a passage of other trains out. The time of actual employment is the time of the immediate stay of the trains on it. In its turn, the time of indirect a actual employment of the section make up the time of its route employment, i.e. the quota of the lime during which it has entered this or that route. All of the rest working time belongs to the unrealized working period of time of the section.

The calculation of the maximum possible in the given variant of the train movement organization passing capacity of the section of the track development scheme is made according to the formula:

$$N_{max}=(N_f T_s)/T \qquad (2)$$

where N_f = stands for the number of the trains passed on the section in both directions per shift

The degree of the realization of the potential transport capacities of the section is fixed out of the following calculation:

$$P=N_f / N_{max} \qquad (3)$$

It is evident that the latter index can be lowered if there are emptees and if the need to abolish them on the section arises.

In evaluating the work of the stations runs and posts, on which, as a rule there are several defining sections, the degree of the passing capacity realization on the whole is established depending upon the lime of the aclual employment of laese sections and the amount of the trains passed on them according to the formula:

$$P_c = (n^1 + n^2 + \ldots + n^k) / T_{sm} (n^1 / T^1_{f.b} + n^2 / T^2_{f.b} + \ldots + n^k / T^k_{f.b}) \qquad (4)$$

where 1,2, ... k = are numbers ol the limiting sections; n', n\ .... n^k = the number of trains passed per shift; TVn, $T^2_{f.b}$, ..., $T^k_{f.b}$ = the actual employment time of the section, min.

The maximum possible technologically stipulated passing capacity is defined out of the expression:

$$N_{„«} = N . r / P « \qquad (5)$$

where $N_{s.f}$ = the number of trains passing through the station in both directions per shift

In case of the non-equivalent defining sections their actual (route) employment time in formula (3) is taken with the consideration of the individual potentials of those significant among them according to the followingrules:

- in one significant section for each of the defined is taken the time of actual employment of the given significant section;
- in two or more significant sections the actual employment time is established for them correspondingly, but for the rest of the defined according to the most significant;
- in that case when a limited number of trains can be driven on a significant (one or more) defining section, the assessment of the passing capacity is conducted in two stages: first is determined the transport potential of the significant sections and then the obtained result is increased to the limitation size.

The maximum theoretically possible passing capacity of the station is established discounting the trains demurrage at the defining sections. For this in formula (3) the actual employment time is substituted by their route employment time $T_{f.b}$

The ratio of freight and emptees directions is established proceeding either from the account of actually passed trains on the model by the object, or from the average route time of the section. The first variant is applied in consideration of absolutely equal train streams. The second one - in independent trainstreams.

Thus, the working time realization of the track development scheme section can be regulated actually by two constituents, i.e. at the expense of the indirect employment time reduction of the section, the amonnt and the duration of demurrages on it.

The indices calculated according to formulas 1...4 speak to the availability or the absence of unrealized transport potentials of the section. As the meanings of Ihese indices are defined by the mining-transport work organization, by the order of forming routes at the stations and the train streams at the pits, then the need of more detailed indices appears which permint lo express numerically the influence of the ahove-memioned I actors on the transport potentials ol the

section and to establish the ways of their effective realization. For this such indices are suggested as the average employment time of the section during the passage of one train on it in the directions, counting and discounting demurrages.

Jaking into account the fact that in the day shift during the week, excluding week-ends, the index of using the shifting fond of time amounts to 0,7 - 0,75, and on the day of the explosion to 0,35, then the average twenty - four hours max, possible realizations of the passing capacity can be established according to the formula:

$$N_{24hours}=2N_p(K_1 n_1+K_2n_2+K_3n_3)/(n_1 + n_2 + n_3) \quad (6)$$

where K, , K_2, K_3 - coefficients of the time usage correspondingly at nights and on weekends, the day time during the working week, and also in days of completing shifts explosion; n_1, n_2, n_3 = the number of the enumerated shifts in the week.

The index of the shifts fund time usage is divided into its two constituents. Since the passage of the subsidiary transport means is similar to the technological transport passage organization and knowing their number it's easy to fix the corrected coefficient associated only with their influence on the passing and carrying capacity of the track development scheme section - the coefficient of the time reserve for the passage of the subsidiary transport means K^i».. For this purpose it is necessary to define the amount ratio of subsidiary and technological transport means passing on the object per a definite period of time.

Knowing the average monthly or the average annual time meaning spent on the technical service of the section index K_To can be calculated out of the ratio with the time of the shift.

With this in mind the calculation of the passing capacity formula in relation to the technological trains in day shifts (except holidays and week-ends) will look like this:

$$N^{days}_{c.max}=(N_c \cdot K_{sub} K_{TO})/P_c \quad (7)$$

The above - staled method differs from the traditionally employed ones in the way of considering the factor of irregularity train streams. Traditionally, the index of the irregularity of train streams is taken for normatively constant independent of the disposition of the station in the pit, the track development scheme structure, the amount of the locomotives used in the system of the locomotive compound, the train movement organization at the station and soon. Early as well as some of the modern investigations are directed only to the correction of its meaning. Such an approach, in our opinion is unable to meet the requirements of the mining production, for the fault with such methods of the evaluation of the passing capacity can reach 15.-20% and more.

The offered method presupposes the stock reproduction during the process of the imitative simulation, initiating events depending upon the state of the mining - transport system formed at the present moment thus, the reliability of the obtained result increases and there appears the possibility to investigate the system from the point of view of the effective realization of its transport potentials in different variants of the train movement organization with the immediate connection of loading and discharging works at the pit

The experience in the analysis of the work and the assessment of the carrying capacity of the pit railway transport systems shows that the realization of station transport facilities (post, run) in different variants of mining-transport work organization varies.

It is stipulated, in the longrun, by changes in the paramètres of stocks at the pit, which are, in their turn, defined by the amount of the used stocks, by the track development scheme structure, by the amount of loading - discharging points and by their equipment power, the train movement organization, the ratio of trainstreams at the pit and so on.

Thus, the realization of potential facilities of any of the sections and units of the track development scheme is connected with governing all these factors.

The efficacy of the mining-transport system on the whole is the main criteria parametre that defines the rationality of the realization of the transport facilities of the track development scheme, of its stations, runs, posts and separate sections.

5. STOCKS OPTIMIZATION

The average time spent on the passing of one stock through the section in cargo and empty directions taking demurrages into account is calculated proceeding from the ratio of actual (route) employment time. These indices make it possible to conclude about the rationality of the adopted variant of the train movement organization in relation to the section under consideration. For example, the lesser average shift time of the route employment in one of its directions proves the expediency of the orientation lo pass the compounds mainly in this direction. However, it is possible that taking into account the slock demurrages on the section the average actual

employment time in this direction may be greater. It is indicative of the discrepancy between structural and organization factors. To be convinced additionally we must calculate the passing capacity of the section in pairs of trains $N_{raa}xp$. If $N_{max} > N_{maxp}$., then the priority is fixed correctly. The reverse variant may prove to be good only in case of the increasing efficacy of the work of the system on the whole.

Rational parameters of the stocks at a concrete station can be obtained only on condition of the economically substantiated and technologically stipulated realization of its potential facilities. A more intensive train stream makes it possible to exercise the station facilities, however it is connected with the graoth of the locomotives amount, with the quantity and duration of their demurrages at the approaches to the station and, consequently, with the growth of expenditures for transportation.

CONCLUSION

It is necessary to note that to conduct such investigations in reality is practically impossible besides, trying a great number of different variants of mining-transport work organization on the model permints to establish more rational ones with the greates degree of substantiation.

The time scale of the imitative simulation with the help of the program complex "CEBADAN" may vary from 1:1000, when modelling with the precision to 1 min., till 1:6 - with the precision to 1 sec., i.e. practically, the modelling period can make up a shift, 24 hours, a week, a month.

Universal muti-purpose information programme complex "CEBADAN" can reproduce the main processes at the open mining works successfully and with the high degree of reliability, it means that it is capable of: carrying out loading, transportation and discharging; defining the productivity of the mining-transport technological complex and of its separate agregates; establishing the extent of the track development scheme loading; revealing effective variants of the main technological equipment interaction; performing a multi-aspect analysis of their work and seeking for ways of the effective elimination of the revealed drawfacks on its basis; defining numerically the extent of transport facilities realization at the inner - pit stations, posts and runs that are founded in the structure and are technologically stipulated.

The program complex is one of the factors of productivity in working out the deposits with mineral products by the open way and it can foster successfully a considerable increasein the mining productivity efficacy.

The whole complex of optimizing measures can effectively be applied at the stages of designing, reconstructing, employing of pits, coal slits and in the processes of current and perspective planning of mining-transport works.

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