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deep pits; automobile and railway transport; dump stations and its stocks capa city

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SIMULATION OF THE DUMP TRUCKS IN DEEP PITS

Summary. A mathematical model, which allows determining the optimal traffic flows for daily planning intervals is developed, approach to the faces in the deep part of the working area to substantially reduce the costs of mining is taken into account. Optimal operational management of transport complex involves minimizing transport costs and reloading of ore, providing the smallest size of stock piles at dump stations. The mathematical model allows to organize the work of all dump stations (DS) in pit and define the stocks capacity. The studies show that there is no need to arrange all DS with stocks of large capacity in pit.

МОДЕЛИРОВАНИЕ РАБОТЫ АВТОСАМОСВАЛОВ В ГЛУБОКИХ КАРЬЕРАХ

Аннотация. Разработана математическая модель, позволяющая определять оптимальные грузопотоки для суточных интервалов планирования с учетом максимального их приближения к забоям в глубинной части рабочей зоны карьера для существенного снижения затрат на добычные работы. Оптимальное оперативное управление транспортным комплексом предполагает минимизацию издержек на транспортировку и перегрузку руды, обеспечивающую наименьшие размеры складов на перегрузочных пунктах. Математическая модель позволяет организовать работу всех перегрузочных пунктов (ПП) в карьере и определить объемы их складов. Выполненные исследования показывают, что в карьере нет необходимости устраивать все ПП с большой вместимостью складов.

1. INTRODUCTION

Automobile transport (dump trucks) is the connecting link between the face excavators in the deep part of the pits and line-haul types of haulage by railway transport and belt conveyors.

Statistics show that assembly carriage constitutes 80-100% of the total volume transported by trucks when the iron ore pits get depth of 200 meters or more. Currently, assembly carriage constitutes 81.1% of the total technological haulage in CIS. The most common are a combination of railway

(84,0%) and the conveyor (15,5%) modes. The conditions of operation of technological transport have significant differences from the line-haul, which determines the specific requirements for design parameters of trucks [1-6].

Annual haulage of the rock mass by trucks reaches 45-50% in pits of five mining and processing complexes (MPC) in Ukraine [7]. The average haul distance varies from 3,1 km (PMPC) to 2,68 km (InMPC) at a depth of 360 m. Number of trucks varies from 59 (CenMPC) to 91 (NorMPC). Using of truck fleet varies from 0,25 (NorMPC) to 0,66 (PMPC). Average annual output of one truck – from 277 000 tons (NorMPC) to 720 000 tons (PMPC). Annual capacity of ND-1200 truck varies from 206 000 tons (NorMPC) to 827 000 tons (PMPC). Overloading of the rock mass produced at 4-6 dumping station (DS) places around the perimeter of the working area of pit.

Increasing of truck capacity and reducing their number to perform routine tasks can be solved by technical and organizational methods. Elongation of conveyor lifts with boulder crushers and deep input of railway communications, DS transferring to lower horizons requires huge capital costs and time. Organizational activities do not require large capital investments and involve management of trucks. In this case the dispatcher distributes the trucks to load points at the face and unload points at the DS or crusher. The distribution is carried out at the beginning of each shift and adjusted during the production program if it is necessary. Trucking route is chosen from the condition of the minimum distance of transportation and the possibility of taking the rock mass by DS.

Rational structure of mining and transportation system can be achieved by reducing the current levels of overburden, rational design of railway transport communications and dumping station, ensuring the minimum possible distance of rock mass delivery by trucks. Creating a rational constructions of dumping station with storage stocks and the closest approach to faces in the deepest part of the pits working area will significantly reduce the cost of mining operations [7, 8].

Analysis of production costs of ore shows that energy costs account 32-35 % last years. In this regard, a decrease haulage distance and release of the bulldozers at reloading works will impact positively on reducing the consumption of diesel fuel. This will affect indirectly to the payments for atmosphere gas pollution. Since the costs of excavation, loading and haulage consist 60-70 % of the production costs, developing the structure of the haulage system in deep pits is the main focus of maintaining their market competitiveness.

2. MATHEMATICAL MODEL

Rock haulage from deep horizons of iron ore pits is characterized by considerable unevenness of traffic flow of truck and railway transport. However, the average monthly rate of this traffic flows is same. Some days and weeks deviate from the average level. The optimal operational management of transport complex involves minimizing transport and reloading costs, providing the smallest size of stocks at dumping station. For this purpose, a mathematical model is developed that allows determining the optimal traffic flows for daily intervals of planning (Fig. 1).

The following variables are introduced for the functioning of model:

$x_1 \ldots x_k$ – optimal amount of cargo transported by trucks from m excavators to s dumping station, $k=m \cdot f$, t;

$x'_1 \ldots x'_l$ - optimal amount of cargo transported by railway transport from f stocks, t;

l_{ai} – distances of haulage by trucks from the i-th excavator in the pit, km;

c_a – transportation cost of one ton of cargo by trucks, \$/km;

l_{rj} – distances of haulage by railway transport from the j-th stocks, km;

c_r – transportation cost of one ton of cargo by railway transport, \$/km;

c_e – reloading costs of one ton of cargo by excavator, \$/ton;

P – trucks working plan, ton;

P_r – throughput capacity of rail transport, ton;

P_k – trucks working plan, ton;

c_c – transportation cost of one ton of cargo by conveyor, \$/km;

c_d – crushing costs of one ton of cargo, \$/ton.

As the objective function (optimization criterion) taken minimum costs of transportation and reloading of ore and mined rock

$$Z = \sum_{i=1}^{k} x_i \left(l_{ai} \cdot c_a + c_э \right) + \sum_{j=1}^{s} x_j^{,} l_{жсj} c_{жс} + \sum_{p=1}^{r} x_j \cdot \left(c_c + c_д \right) \rightarrow \min . \quad (1)$$

In this case the following restrictions on the model:

- working plan of trucks must be executed or overfulfiled

$$\sum_{i=1}^{k} x_i^{,} \geq P; \quad (2)$$

- all received trains must be loaded in accordance with their capacity

$$\sum_{j=1}^{s} x_i^{,} = P_{ć} \ ; \quad (3)$$

- working plan of conveyor lift must be executed

$$\sum_{p=1}^{r} x_j = P_к \ ; \quad (4)$$

- restriction of the maximum capacity of stocks of dumping station and ratio (amount of cargo coming into the stock and shipped by rail / maximum capacity of stocks) shall be determined from the following expressions:

The first stock $0 \leq \sum_{i=1}^{k} x_i + o_1 - x_1^{,} \leq F_1;$ the second stock $0 \leq \sum_{i=1}^{k} x_1 + o_2 - x_2^{,} \leq F_2;$ *s*-th stock $0 \leq \sum_{i=1}^{k} x_1 + o_s - x_l^{,} \leq F_s,$

$O_1, O_2, \ldots O_s$ – remnants of ore in stock, tons;
$F_1, F_2, \ldots F_s$ – maximum capacity of stocks, tons.
- restrictions on trucks productivity

$$0 \leq x_i \leq G_1, i = 1 \ldots k.$$

G_1 – maximum cargo capacity of individual faces;
- restrictions on crusher productivity

$$0 \leq x_i \leq G_д; \text{j=1,2…r.}$$

- restrictions on railway transport productivity, transporting cargo from DS stocks

$$0 < x_1^{,} \leq T_1; \ 0 < x_2^{,} \leq T_2, 0 \leq x_l^{,} \leq T_s.$$

$T_1, T_2, \ldots T_s$ – maximum volume of cargo transportation from individual faces, t/day;
- cargo volumes transported by trucks shall not exceed the real productivity of trucks

$$\sum_{i=1}^{k} x_i \leq G_{auto}. \quad (5)$$

3. TESTING OF THE MODEL IN PIT

This model can be used for planning truck-railway, truck-conveyor transport and determining stocks capacity in the pit. Reloading operations are carried out by dump stations equipped specially for this purpose. Transfer points are mainly located on the non-working wall of pit, occupying the site with width of 60-80 m and length of 120-150 meters or more when it is used truck-railway transport. Excavator DS has capacity of 25-30 m^3, which allows smooth uneven movement of both modes of transport during their joint operation. Also it allows to create buffer stocks of the mined rock. Backhoes PP have a capacity of 25-30 m^3, which allows smooth uneven movement of both modes of transport during their joint operation, to create buffer stocks of the rock mass. The daily optimal planning of haulage to dump stations No. 50, 60 and 71 (Poltava MPC) is performed for real data with a time interval of 10 days (Fig. 2).

The average productivity of trucks was selected for the first four days. It was equal to the right border of their confidence intervals. The productivity of railway transport was taken equal to the left boundary. Then truck haulage volumes were taken equal to the right boundary and productivity of railway transport was taken equal to the right boundary. Thus, we have simulated the situation of mutual excess of productivities of trucks and railway transport relative to each other. Residues accumulated in O_i stock give optimum values of stocks for individual dump stations in the pit.

The introduction of DS without bulldozer and eventually without excavator is of great importance. Also the minimum possible volume of separation of non-working wall of pit is taken into account. It is associated with the smallest gauge size.

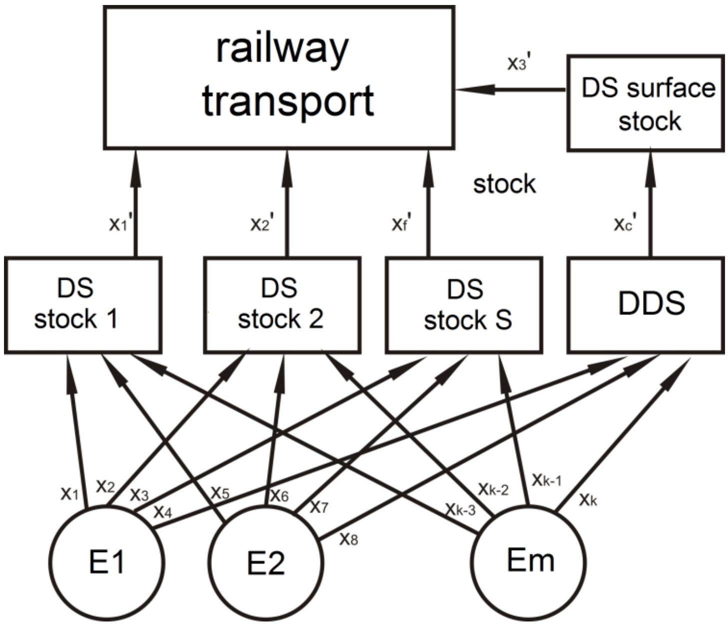

Fig. 1. Structural scheme of modeling haulage and reloading processes of mined rock in the deep pits

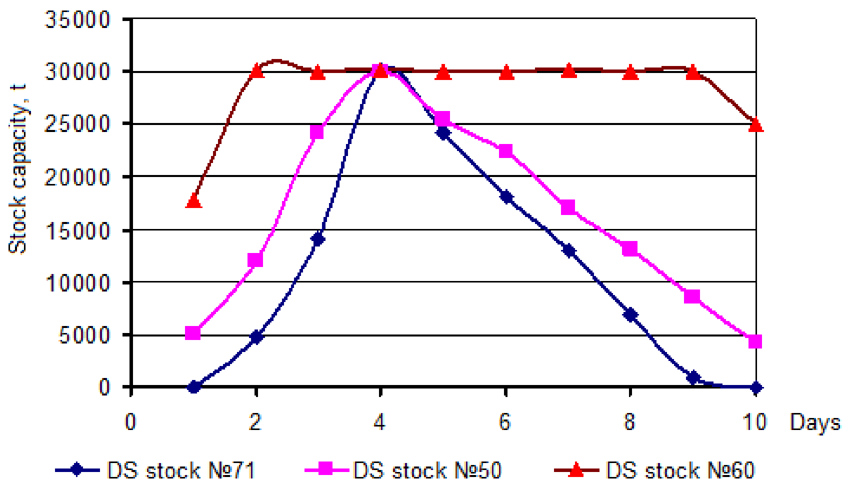

Fig. 2. Dynamic of DS volumes in the pit of PMPC

Considered mathematical model allows to organize the work of all DS in the pit and to define the value of their stocks. The studies show that there is no need to arrange all DS with stocks, which have large capacity.

4. CONCLUSIONS

There is enough to have one or two DS with capacity 30 000 tons to achieve minimum costs of the construction of DS and transporting the mined rock by combined truck-railway transport in the center of gravity. The remaining stores may have a capacity of up to 10000-15000 tons. So the areas occupied by stocks are significantly reduced. This leads to an increase of the angles of slopes of the non-working walls and reducing overburden volumes mined when there are being formed.

Bibliography

1. Kuleshov, A.A. *Huge excavator-truck complexes*. Moscow: Nedra, 1980.
2. Yakovlev, V.L. *Theory and practice of transport selecting in deep pits.* Novosibirsk: Nauka. 1989.
3. Stolyarov, V.F. *Theory of mining systems development.* Ekaterinburg: UB RAS. 2009.
4. Stolyarov, V.F. *Problems of cyclic-flow technology of deep pits.* Ekaterinburg: UB RAS, 2003.
5. Melnikov, N.N. & Usynin, V.I. & Reshetnyak, S.P. *Cyclic-flow technology with mobile crushing and reloading complexes for deep pits.* Apatites: GI KSC RAS, 1995.
6. Tomakov, P.I. *Structure of complex mechanization with cyclic techniques in pits.* Moscow: Nedra, 1976.
7. Drizhenko, A.Y. *Opencast technological mining and transport systems.* Dnipropetrovsk: NGU, 2011.
8. Rakishev, B.R. & Moldabayev, S.K. *Resource saving technologies in coal mines*. Almaty: KazNTU, 2012.