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CONTROL OF MINING OPERATIONS AT ANNANSKYI MINE TO IMPROVE THE PERFORMANCE OF PROCESSING PLANT

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ABSTRACT: An application of the mathematical model for planning mining operations for separate feeding of a poor and rich ores to the processing plant at Annenskyi mine is presented in the paper.

The investigations carried out by Kunaev Institute of Mining have revealed that there exists a relationship between the performance indices of the plant processing a copper ore and metal content of its feed. These relationships are embedded into a special model ensuring mass balance and defining the changes in performance indices under varying feed grade and feed flow rate conditions (Petrovich, 1997). The model İs in non-linear character.

An analysis of the relationships showed that run of mine ores of two different grade ranges should be fed to the plant separately in order to increase mass of copper recovered in concentrate (or decrease the mass of copper lost in the tailings).

The effectiveness of separate mining the ores of different grade grade range and feeding them to the processing plant separately depends on particular production and technical conditions (possibility of simultaneously operating several faces, their ore grades, number and volume of underground and surface hoppers, their level of filling at the time of planning, the facilities for transport communications, etc).

For daily planning of ore mining and dispatching to the plant, the foregoing problem is formulated by the following manner.

At the beginning of the current day, the volume of ore chutes and hoppers not filled by ore and the quantity and average metal grades (Cu,Pb,Zn) of the ore remained in them are known. The chemical composition of ore masses that could be mined from a set of operating faces during the next 24 hours should also be required. The total volume of ore to be dispatched from a face during the next 24 hours must not exceed the remaining or newly burst volume of rock. By taking the aforementioned and other case specific conditions into account, the daily volumes of ore to be dispatched from each face should be arranged in such a way to allow for separate processing different grade types that eventually it will result in maximum mass of copper recovery into concentrate (decreasing losses in the tailings)

The mathematical mode! of this problem may be formulated as follows.

The aim İs to find the maximum of the objective function (F) given below

$$F = Q_I \times f(\beta_{I,cu}) + Q_{II} \times f(\beta_{II,cu}), \qquad (1)$$

Which is subjected to the following constraints

$$\sum_{i \in N} q_{i,I} + q_3 = Q_I. \qquad (2)$$

$$\sum_{i \in N} q_{i,II} + q_4 = Q_{II}, \qquad (3)$$

$$q_{i,I} + q_{i,II} \geq q_{i,min}, \qquad i = 1,2, \ldots, N, \qquad (4)$$

$$q_{i,I} + q_{i,II} \leq q_{i,br}, \qquad i = 1,2, \ldots, N, \qquad (5)$$

$$\sum_{i \in N} (q_{i,I} + q_{i,II}) < Q_I, \qquad (6)$$

$$\sum_{i \in N} q_{i,I} \times \alpha_{i,cu} + q_3 \times \beta_{3,cu} - Q_I \times \beta_{I,cu} = 0, \qquad (7)$$

$$\sum_{i \in N} q_{i,II} \times \alpha_{i,cu} + q_4 \times \beta_{4,cu} - Q_{II} \times \beta_{II,cu} = 0, \qquad (8)$$

$$\beta_{sel,cu} \geq \beta_{I,cu} \geq 0, \qquad (9)$$

$$\beta_{max,cu} \geq \beta_{II,cu} \geq \beta_{sel,cu}, \qquad (10)$$

$$Q_I, Q_{II}, \beta_{I,cu}, \beta_{II,cu}, q_{i,I}, q_{i,II} \geq 0, \quad (11)$$

where.
Qo = The fixed total mass of ore to be dispatched from Annenskyi mine (000 tons)

Q, = The ore mass of lst type planned to be dispatched from Annenskyi mine during the next 24 hours (transferring hopper N3 of Annenski-skip shaft N1), (000 tons).

Qn =The ore mass of lind type planned to be dispatched from Annenskyi mine during the next 24 hours (transferring hopper N4 of Annen sky i-skip shaft N1 ,(Qii=Qo-Qi)), (000 tons)

F(P_I,Cu)=The mass of copper to be recovered in the concentrate when 1000 tons of ore to be dispatched via hopper N4 of Annenskyi skip shaft Nl is processed in the plant (000 tons).

qn=The ore mass left İn nth hopper in the beginning of the current day (000 tons)

$q_{i,I}$=The ore mass to be dispatched from ith face during the next 24 hours via hopper N3 of Annenskyi skip shaft N1, (000 tons)

qi,ii=The ore mass to be dispatched from ith face during the next 24 hours via hopper N4 of Annenskyi skip shaft N1 (000 tons)

qi,bi=The mass of broken ore remained at ith face at the beginning of current 24 hours, (000 tons).

q_{min}=The minimum ore mass which must be transported from ith face during the next 24 hours (000 tons)

q_T=The total transport capacity of the vehicles in the mine (ton/day)

$\alpha_{i,Cu}$=Current copper content of ith face(%)

Bn,cu=Copper grade of the ore remained in 11th tipper of the hopper at the beginning of current day (%)I1
Bi,cu and B2,cu=Copper grades of lst and II and type of ores to be dispatched during the next 24 hours from Annenskyi mine(%).

$B_{sel,cu}$ = The boundary copper grade for directing q flow to either streams.

$B_{max,cu}$= The maximum copper grade of lind type of ore (%)

N = Number of faces from which ore could be dispatched during the next 24 hours.

The maximization of the objective function (Eq. 1) ensures that two ore types should be dispatched separately in order to increase the mass of metal recovered in concentrate. The mass of lst grade type is defined using, constraint 2, and constraint 3 defines the limit on the ore mass of Und type. Constraint 4 and 5 give the upper and lower limits to be dispatched from ith face during the next 24 hours. The inequality type constraint 6 shows the limitation on the ore flowrate coming from ith face due to the existing transport facilities. The ore masses in lst and Und grade type of flows are calculated using equation 7 and 8. The inequality type constraints 9 and 10 controls the limits of possible combinations.

As it is clear from the model presented above this is a non-linear optimization problem. Its solution developed by the authors involves sequential solutfon using separable programming (Wagner 1978) by selecting a set of flowrates for each grade type and using the method of "branches and boundaries" (Petrovich, 1986),

The method is applied to the conditions of Annenskyi mine using the data from the processing

Table 1 .Comparison of the mass of copper recovered in the concentrate under different modes of dispatching.

Mode of dispatching	Ore type	Number of shifts	Ore mass, tons	Copper content İn ore, %	Copper mass in concentrate, tons
Separate	Poor ore	13	28004.65	0.78	187.08
	Rich ore	12	26511.52	1.87	456.80
Total		25	54516.17	1.31	643.88
Mixed		26	53286.23	1.31	618.67

plant N3 and passive expenment technique. The results are presented in Table 1. They show mat separate dispatch of poor and rich ores to the plant increase the mass of copper recovered in the concentrate up to 0.7-1.8 %. This correspond to a decrease of 6-15% in the mass of copper lost in the tailings.

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