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RATIONAL PLANNING OF ORE MINING WITH RESPECT TO IMPROVING THE PERFORMANCE OF A PROCESSING PLANT

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ABSTRACT. The basis of a mathematical'model which could be used to plan the mining sequence so as to improve the performance of a downstream processing plant are presented in the paper.

The effect of metal grade of run of mine ore on the concentration process has not been well studied. Therefore, İt has not been possible to form a rational coordination between mining activities and mineral processing plants.

A study carried out to examine the effect of feed grade on a processing plant performance showed that the relationship between the mass recovery of a metal and its feed grade was different for low and high grade ores (Figure 1).

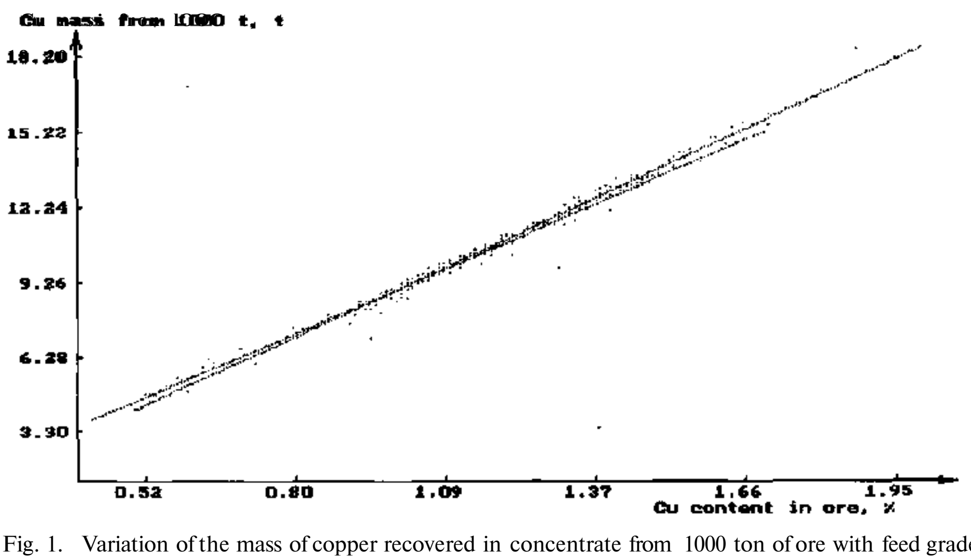

Fig. 1. Variation of the mass of copper recovered in concentrate from 1000 ton of ore with feed grade.

The non-ferrous metal ores mined different faces of a mine show large variation (sometimes by an order of magnitude) in terms of its valuable metal content.

Even though ore is excavated and transported to a mineral processing plant using modem technological schemes, if the ore is not mixed in a rational way, this might have a negative effect particularly on flotation process and cause increased metal losses in tailing.

This difference is more noticeable when the metal losses corresponding to a fixed flow rate to a plant are plotted against the feed grade (Figure 2).

These figures show that the performance of a processing plant could be improved by planning the mining activities to dispatch the low and high grade ores separately. The planning of a material flow from mine to processing plants depends on the composition of ore blends, their behavior in concentration process and market values. This kind of optimization should be done separately for every

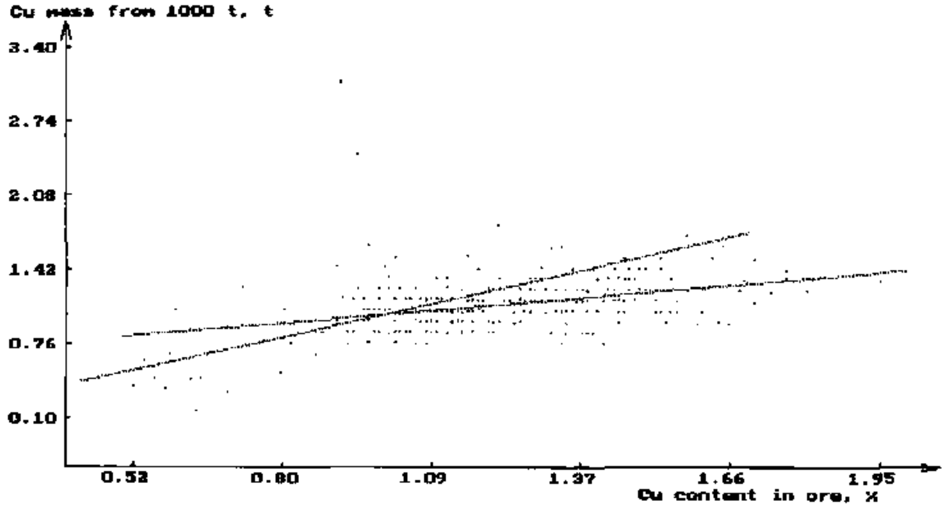

Fig.2. Variation of the mass of copper lost in the tailing from 1000 ton of ore with feed grade.

particular case by taking the transportation facilities, the presence or otherwise of underground and surface hopper and stockpiling facilities, and other technological characteristics of the operation.

For a monometal ore, the minimum number of material flow type is two. In general, the problem of separating ore flows to a mineral processing plant to optimize its performance can be formulated as described below. For this type of study the following information is required: total mass of to be produced within the planned period; maximum possible mass of to be mined from ith mine face and its chemical composition (this will be determined by sampling) ; the price of valuable minerals in the concentrate to be dispatched to consumers. Then it will be possible to calculate the mass of flows in each feed material (grade) type and their optimum combination that maximize the total sum to be gained from ith face by taking existing production and technical requirements into account. In accordance with the foregoing discussion, the mathematical treatment of this problem may be expressed in the following general form.

The aim is to maximize the objective function given below.

$$F=\sum_{p=1}^{P}\sum_{m=1}^{M} f_p(\alpha_{p,m}) \times Z_{con,m} \times Q_p \qquad (1)$$

which is subjected to the following constraints;

$$\sum_{p \in N_p} q_{i,p} = Q_p, \quad p=1,2,\ldots,P, \qquad (2)$$

$$\sum_{p=1}^{P} q_{i,p} \le q_o, \quad i=1,2,\ldots,I, \qquad (3)$$

$$\sum_{p=1}^{P} q_{i,p} \ge q_{i,min}, \quad i=1,2,\ldots,I, \qquad (4)$$

$$\sum_{p=1}^{P} Q_p = Q_o, \qquad (5)$$

$$\sum_{p \in N_p} q_{i,p} \times \alpha_{i,m} = \alpha_{p,m} \times Q_p,$$

$$p=1,2,\ldots,P, \quad m=1,2,\ldots,M, \qquad (6)$$

$$\alpha_{p,m}, \; q_{i,p}, \; Q_p \ge 0, \qquad (7)$$

where

$F_p(\alpha_{p,m})$ = function representing the relationship between the mass recovery of mth component in concentrate with its feed grade for 1000 tons of pth flow. It is determined by specially determined methods (Petrovitch, 1997), tons.

$\alpha_{p,m}$ = the average grade of mth component in pth flow, (%).

$Z_{con,m}$ = the price of per ton of mth component in the concentrate.

Q_p = the mass of ore in pth flow to be delivered during the planned period, (000 tons).

Q_0 = the total mass of ore to be mined during the planned period, (000 tons).

N_p = number of operating faces.

m = number of components which contribute to the value of concentrate when it is sold.

$q_{i,p}$ = the mass of material to be mined from ith operating face and sent to the pth material flow during the planned period (000 tons).

$q_{i,0}$ = the mass of material to be mined from ith operating face during the planned period (000 tons).

flLmin ~ t^n^c minimum mass of ore which must be mined during the planned period.

The solution of mathematical model for separation of ore flow into separate streams, even when there is only one valuable components present in the ore is quite tedious. It is a non-linear mathematical programming problem which includes non-linear function of non-separate form (Wagner, 1978) as (fp (ccp,m) x Qp; ap,mxQp).

A methodology was developed for its solution. It includes some procedures for defining possible variations in mass of different type of ore flows and the method of " branches and boundaries" (Petrovitch, 1986).

The use of this model in the planning stage of mining operation in Annenskyi mine of " Kazakhyms" corporation showed that separate mining of ore of different grade feeding to the processing plant increased mass of copper recovered in the concentrate by 0.7-1.9 %. Table 1. shows the result of separate and mixed feeding of poor and rich ores for a period of one month at this mine.

Table 1. A comparison of separate and mixed feeding of poor and rich ore to the processing plant.

Mode of ore dispatch	Mass of feed tons	Copper content of ore %	Copper mass recovered in concentrate, tons
Mixed feeding	381300	1.17	3943.13
Separation feeding			
poor ore	189100	0.73	1204.42
rich ore	192200	1.61	2776.51
Total	381300	1.17	3980.93

otyn = the grade of mth component in the ore to be mined from ith face during the planned period, (%)-

p = number of different type (grade) of ore flows providing rational operation of processing plant both from technical and organizational point of

As it is noted above, the objective function (Eq. 1.) should be maximized so as to get the maximum income from die concentrate obtained by processing different types of ore separately. Equation 2 defines the constraint on the mass of ore in the pth flow. The inequality type constraint (Eq. 3) determines the limit on the mass of ore to be mined from the operating face during the planned period. The constraint defined by equation 4 shows the minimum mass of ore to be mined from ith operating face during the same period. By the use of Equation 5, the total mass of ore to be mined during the same period is fixed. Equation 6 defines the average grade of ore in pth flow.

As it is shown in the table, separate feeding of the same mass of ore in the plant increases mass of copper recovered in concentrate up to 37.8 tons.

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