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THE MODEL OF COPPER FLOTATION MANAGEMENT

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Abstract

The main technological indicators of copper flotation which determine the level of revenue per mass unit of processed copper are utilization and the content of copper in concentration.

This study describes the economic-technological model of copper flotation which can help determine, for the given technological and market conditions, an optimal percentage of copper in concentration, whereby the maximum revenue is achieved per ton of the processed ore in the process of flotation.

Key words: *economy, copper flotation, economic-technological model, value of copper concentrate.*

1. Introduction

The model of managing copper flotation, which is given in the mathematical form that relates the value of concentrate (which is the result of processing a unit of ore) with significant technological and economic parameters, enables the economic efficiency of the process.

The only and basic parameters which influence the value of concentrate the exploitation of copper in concentrate and the price of copper in concentrate.

As a result of technology and process management, the higher the exploitation, the lower the copper content in concentrate, and vice versa.

Therefore, at the existing market price of copper, the exploitation is optimal; in other words, the copper content in concentrate is optimal, whereby the value

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of concentrate which is processed per mass unit of ore achieves its maximum.

The precondition of defining the model of copper flotation is the definition of the technological model of copper flotation which represents the correlative link between copper exploitation (I) and copper content in concentrate (k):

$$I = f(k) \tag{1}$$

The result of building economic parametres into the technological model of flotation, we have the techno-economic model of copper flotation management.

For the given market conditions, there is the optimal copper content in concentrate (k_o) at which the value of the concentrate which is processed per mass unit of ore achieves its maximum (Fig.1).

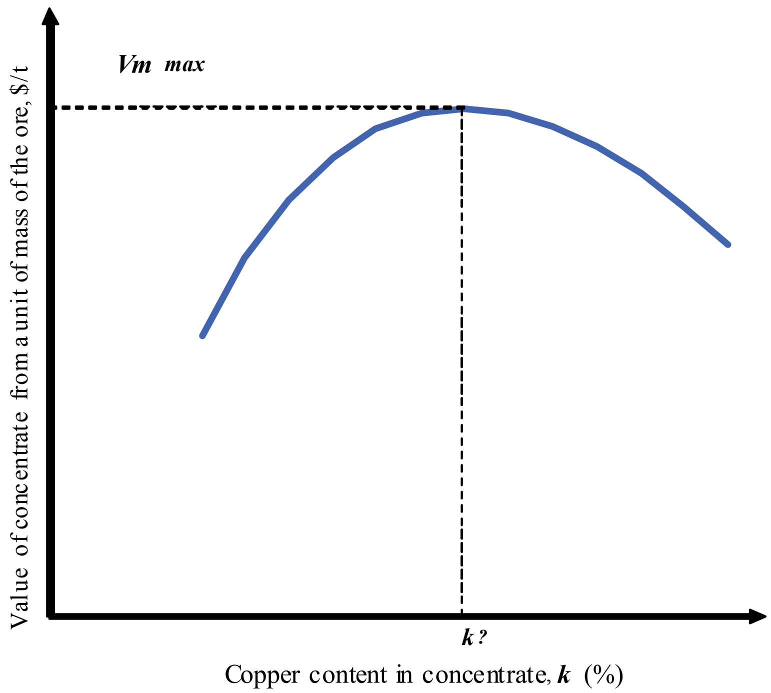

Fig. 1. Value of concentrate in dependence on copper content

2. The technological model of copper flotation

Industrial results of copper flotation of Veliki Krivelj can be seen in table 1 and graph 2.

The graphic representation in Figure 2 shows that there is a linear correlative dependence between copper exploitation (I) and copper content in concentrate (k) and it can be represented as follows:

Table 1. Exploitation and copper content in concentrate

No	Copper exploitation, *I* (%)	Copper content in concentrate, *k* (%)
1	84,6	20,5
2	85,1	19,6
3	85,0	20,6
4	84,7	21,6
5	86,0	19,4
6	85,9	19,7
7	83,1	23,7
8	86,0	18,7
9	85,4	22,5
10	86,1	19,3
11	86,3	18,9
12	82,7	24,3
13	84,5	21,6
14	84,1	22,5
15	84,7	22,2
16	84,0	22,3
17	84,5	21,0
18	82,0	25,4
19	84,1	21,5
20	85,1	20,2

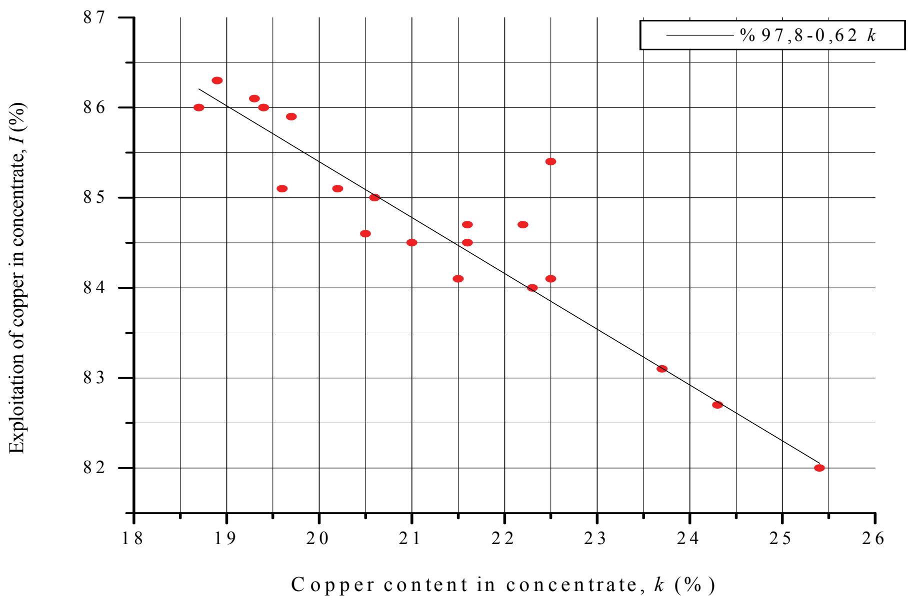

Fig. 2. Dependence of exploitation on copper content in concentrate in flotation in Veliki Krivelj

$$I = I_O - b \cdot k \text{, (\%)} \qquad (2)$$

$$k \in [19...26\%]$$

where: I: stands for copper exploitation in concentrate, (%)

k: stands for copper content in concentrate, (%), and

I_o and b: are parameters which depend on technological conditions of flotation and physical and chemical characteristics of the ore.

Using the method of the smallest squares based on the results from Table 1, it is possible to determine the numerical form of the technological model of flotation in Veliki Krivelj, and it is:

$$I = 97{,}8 - 0{,}62 \cdot k \text{, (\%)} \qquad (3)$$

with the very high correlation degree (R = - 0,94).

3. The techno-economic model of copper flotation

The value of copper (Vm) in concentrate which is obtained after one ton of ore has been processed is:

$$V_m = M_m \cdot C_{mk} \qquad (4)$$

Whereby M_m: stands for mass of copper in concentrate, (t)

C_{mk}: stands for price of copper in concentrate, ($/t)

The mass of copper in concentrate (M_m) is:

$$M_m = \frac{u \cdot I}{10^4} \text{, (t)} \qquad (5)$$

where:

u: stands for copper content in the ore, (%)

The price of copper in concentrate (C_{mk}) is defined by the smeltery and is calculated in the following way:

$$C_{mk} = C_m + 10^2 \cdot T \cdot \left(\frac{1}{k_r} - \frac{1}{k} \right) \qquad (6)$$

where:

C_m: stands for the basic price of copper in concentrate at standard copper content in concentrate (k_r), ($/t)

T: stands for smeltery coefficient

k_r: stands for standard copper content in concentrate, (%); for Bor smeltery and Veliki Krivelj the concentrate is k_r=20,7%, and

k: stands for copper content in concentrate, (%).

Taking into consideration equations (2), (5) and (6), the formula for calculating the value of copper in concentrate (4) gets its final form and is as follows:

$$V_m = \frac{u \cdot (I_O - b \cdot k)}{10^4} \cdot \left[C_m + 10^2 \cdot T \cdot \left(\frac{1}{k_r} - \frac{1}{k} \right) \right] \qquad (7)$$

$$k \in [19...26\%]$$

At the given market conditions the value of copper in concentrate, which is obtained after processing one ton of ore, depends only on the copper content in concentrate.

It goes without saying that the aim of every flotation is achieving the maximum value of copper in concentrate.

Therefore, the main task is to determine the value (k) at which equation (7) achieves its maximum. The solution consists in differentiating the equation (7) at (k) and equating the first derivative to zero.

$$\frac{\partial V_m}{\partial k} = \frac{u \cdot T \cdot I_o}{k^2} - u \cdot b \cdot \left(\frac{C_m}{10^2} + \frac{T}{k_r} \right) = 0 \qquad (8)$$

Now the formula for the optimal copper content in concentrate (k_o) can be derived:

$$k_o = \sqrt{\frac{T \cdot I_o}{b \cdot \left(\frac{C_m}{10^2} + \frac{T}{k_r} \right)}} \text{, (\%)} \qquad (9)$$

Taking into account the price of copper at the world market which is $5,000 per ton, the following is true for flotation in Veliki Krivelj:

C_m = 3840 $/t
T = 150 $/t
k_r = 20,7 %
I_o = 97,8 %
b = 0,62

As a result of equation (9) we can seen that the optimal copper content in concentrate (k_o) is 23.72%. With such copper content in concentrate, the value of copper in concentrate achieves its maximum value which according to equation (7) is V_m = 8.905 $/t. The graphic representation of equation (7) related to flotation in Veliki Krivelj is shown in Figure 3.

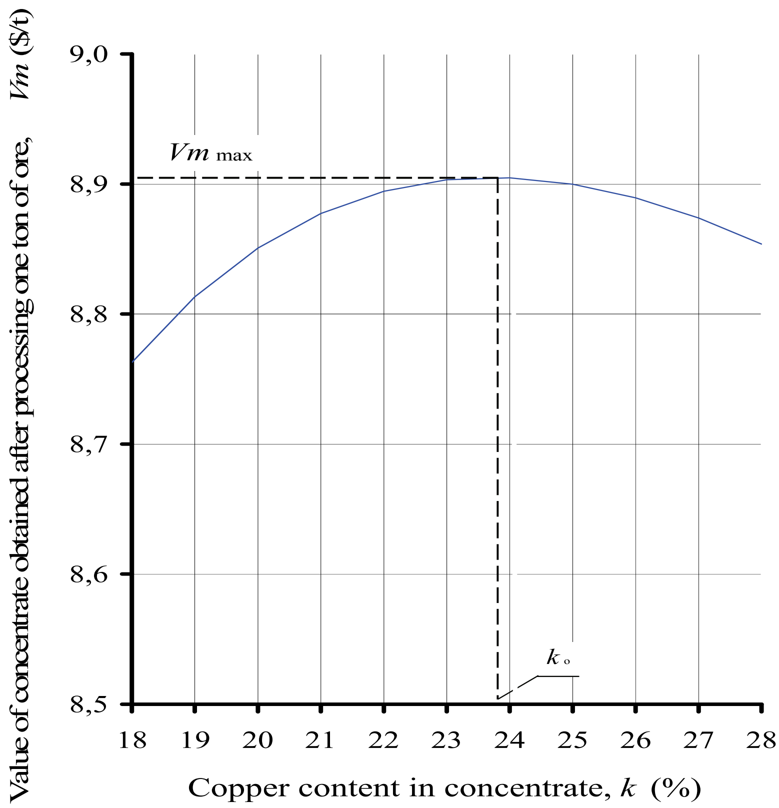

Fig. 3. The value of copper in concentrate which is obtained from one ton of ore in Veliki Krivelj depending on the copper content in concentrate (k)

Equation (9) shows that the optimal copper content in concentrate does not depend on the copper content in the ore (u).

Equation (9) enables the management in charge of flotation to handle the process in the most efficient way possible.

Taking into account the market price of copper as well as the price of processing concentrate in the smeltery, this equation helps determine the optimal copper content in concentrate (k_o) when flotation achieves its highest revenue.

4. Conclusion

The result of the optimal correlative link between exploitation (I) and copper content in concentrate (k) built in the value of copper in concentrate is the techno-economic model of copper flotation.

The given model enables the optimal management of the copper flotation process.

Taking into account the trends in prices at the copper market and the prices of industrial processing of concentrate, this model makes it possible to determine, at any time, the optimal copper content in concentrate when flotation records the highest revenue.

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