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A Mathematical Model of Simple Flotation Circuits

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ABSTRACT: This paper presents our results concerning the elaboration of a mamematical model of simple flotation circuits based on material balance equations. We identified the general form of the concentrate and waste quantities as well as the content expressions in different points of the circuits. We elaborated the general program, which makes it possible to calculate any simple flotation circuit. Using this program, comparative studies of different configurations can be made in a very short time and the optimum configuration may be chosen.

1 INTRODUCTION

In .order to calculate a flotation technological scheme, we should know beforehand the following elements:

- The quantities of material in the feeding, output products and all intermediate points,
- Useful mineral contents in all of the formerly mentioned products,
- Water quantities, that is dilution, for each product.

It becomes necessary to calculate technological schemes in the following situations:

- To design an installation or a new section in an installation;
- To know the product characteristics all along a technological line for a certain functioning regime.

From time to time, we must know the characteristics of an installation in order to be able to modify or to correct the existing technological scheme without supplementary investments and in order to improve the technical and economical indexes. This may be needed when the raw material quality has been changed or the customers' requirements are different.

2 SIMPLE FLOTATION CIRCUITS MODEL

Using the balance equations [1] written for different types of monometallic mineral simple flotation circuits, we tried to evaluate the useful metal quantities and contents at each point of the circuit.

We expressed these parameters only depending on extractions in weight for each operation (v^*, v_{cj}), total extraction İn weight (v), feed quantity (A) and contents in: feed (a), concentrate (c), floated products of each enriching operation (d^*) and cleaning operation (g,).

From our point of view, a flotation circuit can be represented as in Figure 1, where:
k - enriching operations number;
j - cleaning operations number;
(Xk) - vector of enriching operation parameters;
(y,) - vector of cleaning operation parameters.

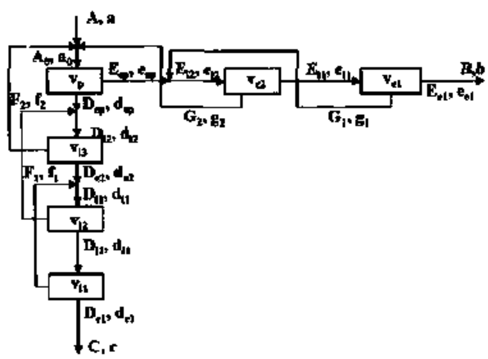

Figure 1. A floabon circuit

Analysing the calculation results, we observed the existence of some general relations. This was possible by noting the input and the output parameters in each block representing a flotation operation as in Figure 2.

The indexes are:
- "i" means "input";
- "e" means output.

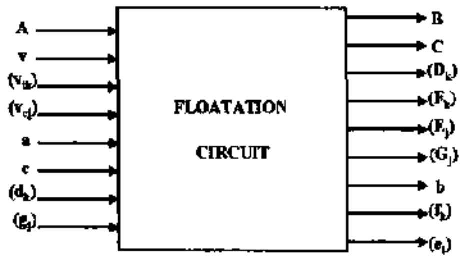

Figure 2 Input and output parameters in a flotation operation.

It must be said that the operations were numbered from the circuit end to the beginning, in order to express the relations in a simpler form.

The relation between the output and the input material quantity for an enriching block is:

$$D_{ik}=\frac{100 D_{ek}}{v_{ik}} \quad (1)$$

The recirculated quantity in the enriching circuit is:

$$F_k=D_{ik}-D_{ek} \quad (2)$$

The output quantity for the primary flotation is:

$$D_{ep}=D_{i,k-1}-F_{k-2} \quad (3)$$

The output material quantities from enriching blocks 2 and 3 (if they exist) are:

$$D_{e2}=D_{i1}\ ;\quad D_{e3}=D_{i2}-F_1 \quad (4)$$

The relation between the input quantity for a cleaning block and the output quantity for the same block, k, is:

$$E_{ik}=\frac{100 E_{ek}}{100-v_{ek}} \quad (5)$$

The floated material quantity in the cleaning circuit, which is recirculated, is:

$$G_k=\frac{v_{ek} E_{ik}}{100} \quad (6)$$

If there are two cleaning operations, output 2 is equal to input 1 and the waste quantity from the primary flotation is:

$$E_{e2}=E_{i1}\ ;\quad E_{ep}=E_{i,k-1}-G_{k-2} \quad (7)$$

The waste content and the input content in an enriching operation are:

$$f_k=\frac{D_{ik} d_{ik}-D_{ek} d_{ek}}{F_k} \quad (8)$$

$$d_{ik}=\frac{D_{e,k+1} d_{e,k+1}+F_{k-1} f_{k-1}}{D_{ik}} \quad (9)$$

The input content for a cleaning operation is:

$$e_{ik}=\frac{E_{ek} e_{ek}+G_k g_k}{E_{ik}} \quad (10)$$

The waste content from the primary flotation, when there are one or two cleaning operations, is:

$$e_{ep}=e_{ik}$$

$$e_{ep}=\frac{E_{i2} e_{i2}-G_1 g_1}{E_{ep}} \quad (11)$$

3. RESULTS

Using Turbo Pascal, we wrote a program, named SLOT, for calculating the specific values of contents and quantities all along a simple flotation circuit. It was verified for different kind of circuits, with different number of cleaning and enriching operations.

In table 1, we present the characteristics of 5 types of raw material from Rosia Poieni mining area.

Table I Characteristics of 5 types of raw material from Rosia Poieni mining area

Product	$\%Cu_1$	$\%Cu_2$	$\%Cu_3$	$\%Cu_4$	$\%Cu_5$
Concentrate	6 710	13 91	8 94	11.66	14.53
Waste	0.075	0.095	0.085	0 080	0 112
Feeding	0 310	0 310	0.309	0 370	0 330
Extraction	3.542	1556	2 769	2 504	1512

Table 2. Input parameters for 5 types of raw material from Rosia Poieni mining area

Input	Material				
	İ	2~	3	4	5
A	240	240	240	240	240
v	3.542	1.556	2.769	2.504	1.512
v,|	60	55	60	60	60
v,2	45	45	45	45	45
v,3	0	0	0	0	0
v_{ci}	25	25	25	25	25
v_c2	0	0	0	0	0
a	0.31	0.31	0.309	0.37	0.33
c	6.71	13.91	8.94	11.66	14.53
<Ui	4.7	10.2	6.5	8.7	10.5
à*	0	0	0	0	0
d*	2.8	4.5	4.2	4.5	5.1
gl	0.5	0.6	0.5	0.5	0.9
&	0	0	0	0	0

Table 3. Computed parameters for 5 types of raw material from Rosia Poieni mining area

Computed parameters	Material				
	1	2	3	4	5
B	231.499	236.266	233.354	233.990	236.371
C	8.501	3.734	6.646	6.010	3.629
b	0.0750	0.0950	0.0632	0.0800	0.1120
Dei	8.501	3.734	6.646	6.010	3.629
Drf	14.168	6.790	11.076	10.016	6.048
D_{c3}	25.817	12.033	20.183	18.251	11.021
Du	14.168	6.790	11.076	10.016	6.048
D,!	31.484	15.088	24.613	22.258	13.440
D,,	0.000	0.000	0.000	0.000	0.000
F,	5.667	3.055	4.430	4.006	2.419
Fî	17.316	8.299	13.537	12.242	7.392
F_3	0.000	0.000	0.000	0.000	0.000
E.I	231.499	236.266	233.354	233.9%	236.375
Ec	0.000	0.000	0.000	0.000	0.000
E,t	308.666	315.021	311.139	311.987	315.162
E,:	0.000	0.000	0.000	0.000	0.000
G,	77.166	78.755	77.785	77.997	78.790
Gi	0.000	0.000	0.000	0.000	0.000
D*	25.817	12.033	20.183	18.251	11.021
E,	308.666	315.021	311.139	311.987	315.162
'PP	0.18!	0.221	0.172	0.185	0.309
d,,	4.700	10.200	6.500	8.700	10.500
du	2.599	4.736	3.955	4.457	4.984
du	0.000	0.000	0.000	0.000	0.000
fi	1.685	5.666	2.840	4.260	4.455
F;	0.881	0.266	1.873	0.985	0.471
fj	0.000	0.000	0.000	0.000	0.000
e,ı	0.181	0.22!	0.172	0.185	0.309
e,,2	0.000	0.000	0.000	0.000	0.000
e,i	0.075	0,095	0.063	0.080	0.112
e_{rf}	0.000	0.000	0.000	0.000	0.000

The flotation circuit from Rosia Poieni has two enriching and one cleaning operations.

We mention that this is only one example, but the program was tested on more practical situations.

4 CONCLUSIONS

In order to use computers in flotation circuits calculation, we elaborated the mathematical model for simple circuits which made it possible to determine the relations between the material quantities and between the metal contents. We also wrote the programme to calculate any kind of circuit. As any real flotation circuit, no matter how complicated, may be decomposed in simple circuits, like the types we studied, the calculation can be simpler and faster using this programme.

In attempting to identify the algorithm, we found some new general relations between parameters, as well as restrictive conditions in the circuit calculation. We this programme, we created new possibilities for analysing and optimising the flotation circuit configuration and operations number.

REFERENCE

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