A METHOD OF TECHNICAL EFFICIENCY EVALUATION FOR FLOTATION CIRCUITS BY ANALYSIS OF LOSSES ASSOCIATED TO PARTICLE SIZE.

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ABSTRACT

Frequently the technical efficiency of flotation circuits is presented as general formulae which give expressions for the recovery, ratio of concentration, yield, etc. These expressions give only a global information and do not contribute to clarify the reasons and origin of the problems causing losses of a valuable metal.

The aim of the presente work is to describe a practical method to evaluate flotation circuits on the basis of a systematic size by size recovery with the purpose of obtaining a diagnostic of losses. The proposed method combines the recovery by size with the fractional losess by size to give a practical parameters, which are defined here, such as Particle Size For Maximum Recovery and Critical Particle Size of Losses. It is found that the main losses sources usually are associated to the coarse and very fine particles.

It is concluded that this method is a very useful tool to detect losses problems and to propose changes to optimize the plant operation. Practical examples for a Copper mineral processing plant is reported.

INTRODUCTION

The low floatability of fine and coarse particles is one of the more frequent reasons of losses in plant practice(1,2). The origin of these particles can be associated to an inadequate selection of fineness of grind to liberate the valuable minerals or inversely to an excessive generation of particles due to overgrinding.

In relation to this, King(3) clearly established that "in mineral processing plants, ores are ground to liberate minerals and not to produce fine powders. It is the degree of liberation and not the particle size distribution that is the important property of the product from a milling circuit".

It is clear that in a plant operation the quantitative evaluation of losses associated to particle size and the identification of the loss critical size, represents a valuable information to a project of diagnostic and optimisation.

Studies in this line were first reported by Cameron(4) and later by Kelsall(5) on Pb-Zn flotation at Broken Hill, Australia. Works on copper ores were carried out by Hartley(6) at the Mount Lyell Company plant; and by Tilyard(7) at Bouganville Copper Ltd.

All of them emphasize the advantage of this approach to the identification of problems and to the rationalization of the technical decisions pointing out improvements of recoveries.

However, despite of the importance and enormous potential of practical application that this method has in the evaluation and optimisation of a plant, a systematic treatment which defines stages and calculations has not been done.

The aim of the present work is just to define a sequence of calculations and graphical representations in order to obtain the necessary information to do a diagnostic of losses per size in a given circuit. Only the size analysis data and the copper metal degree by size fractions per bank, in the feed, concentrate and tailing are needed.

The present work will demonstrate the advantages of the proposed method by using, as an example, real data coming from rougher circuit sampling in a mainly chalcopyrite copper ore industrial plant. This paper will only show the basis of a simple evaluation of a 4 banks rougher circuit.

Since the calculation are time consumming, a computer programme, to be use in a minicomputer Apple III, was designed. All the tables and figures presented here were given by the computer.

EXPERIMENTAL

Samples were taken every 2 hours over a total period of 8 hours. The sampling points are shown in Figure 1. All pulp samples were filtered, dried and a representative head cut for size analysis on the Tyler sieves and cyclosizer, and then prepared for size fraction assays.

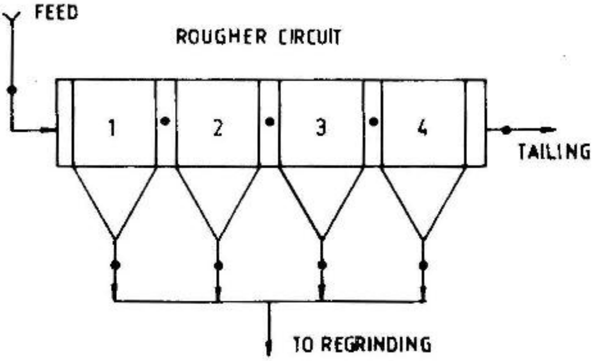


Figure 1. Rougher Circuit of 4 Banks.
• Sampling point.

RESULTS

The results of the plant sampling for the circuit feed, concentrates and tailings of the 4 banks are shown in Tables Ia y Ib.

TABLE Ia: Weight and Copper Grade in Concentrates Samples

BANK	1		2		3		4	
MESH	Weight g	Grade %	Weight g	Grade %	Weight g	Grade %	Weight g	Grade %
10/150	11.3	19.70	84.2	7.10	47.5	9.30	38.0	3.90
150/270	43.7	29.70	69.1	18.40	45.3	3.00	33.5	0.90
270/400	74.0	31.25	44.5	20.08	25,3	3,92	22.2	0.50
400/C_2	38.3	33.98	17.3	18.00	13.1	2.30	14.1	0.26
C_2/C_3	47.2	33.60	22.1	14.50	21.4	1.53	25.3	0.17
C_3/C_4	34.5	33.27	16.8	12.60	20.3	1.00	24.1	0.14
C_4/C_5	24.8	32.25	14.1	11.00	20.1	0.82	23.3	0.14
$-C_5$	76.3	26.25	81.9	8.64	157.0	1.20	169.5	0.34

TABLE Ib: Weight and Copper Grade of Tailings Samples per Bank .

MESH	FEED		BANK							
			1		2		3		4	
	Weight g	Grade %	Weight g	Grade %	Weight g	Grade %	Weight g	Grade %	Weight g	Grade %
10/150	144,5	0.65	158.5	0.58	147.7	0.54	160.3	0.43	154.8	0.39
150/270	42.6	1.64	41.0	1.00	40.9	0.48	40.2	0.17	41.3	0.13
270/400	20.0	3.10	19.5	1.20	20.4	0.46	18.5	0.15	19.0	0.12
400/C_2	13.5	2.54	11.0	0.62	12.0	0.25	10.4	0.09	11.1	0.08
C_2/C_3	18.6	2.10	16.9	0.46	18.1	0.19	17.0	0.07	17.5	0.06
C_3/C_4	15.1	2.24	13.6	0.40	15.1	0.19	13.3	0.07	14.2	0.06
C_4/C_5	12.6	2.19	11.0	0.36	12.7	0.18	11.4	0.07	11.5	0.07
$-C_5$	83.1	1.00	78.5	0.50	83.1	0.38	78.9	0.29	80.6	0.23

On the basis of this data set the copper and weight distributions in the circuit feed are calculated and shown in Fig. 2.

The independent bank copper recoveries per size and the cumulative recovery in the circuit are shown in Figures 3 and 4. In addition, the fractional copper losses per size are presented.

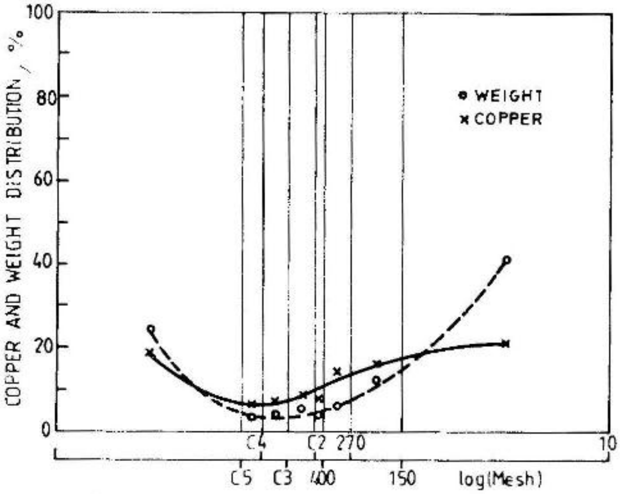
The results reveal that the global copper recovery in the circuit is 83.2%.

Three regions of size fractions can be identified:

- fine particles region: size under cyclon 5.
- intermediate particle size region: 150 mesh/cyclon5.
- coarse particles region: 10/150 mesh.

The loss critical sizes are 105 µm (150 mesh) and 12 µm (-Cyclon 5).

FIG. 2: Percentage of copper distribution and weight distribution by mesh in the circuit feed.



The main characteristics of the flotation in this particular rougher circuit are:

TABLE II: Some Characteristics of the Circuit by Size Regions.

Characteristics	10/150 mesh	150 Cyclon5	-Cyclon5
Feed weight distribution,%	41.3	35.0	23.7
Feed copper distribution,%	21.2	60.1	18.7
% Cumulative recovery in the circuit	51.7	94.8	81.8
% Fractional Losses in the circuit	10.2	3.2	3.4

A general view of copper losses by size through the circuit is shown in the tridimensional plot of the Figure 5 and in the complementary information presented in Figures 6 and 7.

The cumulative recovery per bank and simultaneously the fractional contribution of each of the three regions are presented in Figure 8. The 10/150 mesh fraction practically did not float in banks 1 and 2; and its fractional cumulative recovery in the circuit reached only 10.9 points in recovery units.

To complete the description, the weight and copper content distributions per bank in concentrates and tailings

FIG. 3: Copper recovery by mesh and by bank
curve 1, bank No.1 curve 2, bank No.2
curve 3, bank No.3 curve 4, bank No.4

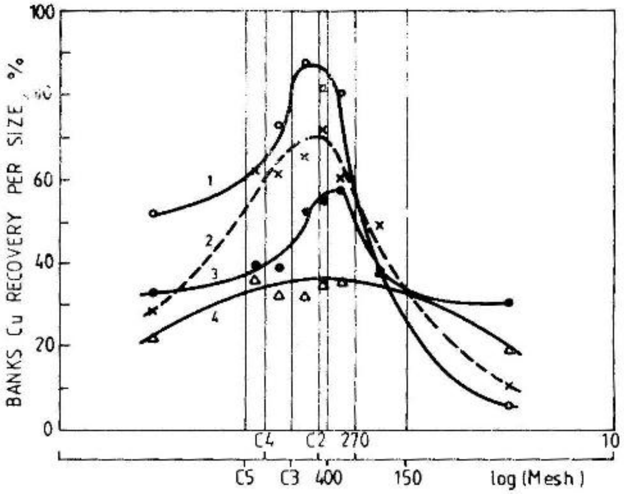
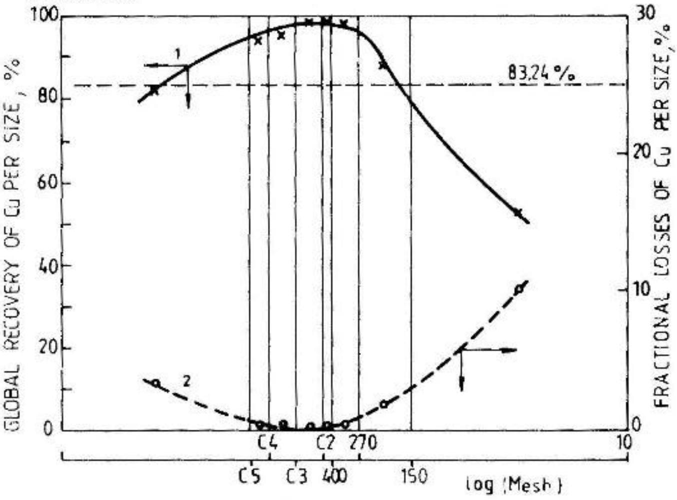


FIG 4: Cumulative circuit recovery by size (curve 1) and fractional copper losses by size (curve 2). The dotted line denotes the % R global in the circuit.



are shown in Tables III and IV. The concentrate and tailing copper degree per bank is presented in Figure 9.

TABLA III. Bank distribution of weight and Copper content in concentrates

BANK / MESH	1		2		3		4	
	Weight retained %	Distribution Cu, %	Weight retained %	Distribution Cu, %	Weight retained %	Distribution Cu, %	Weight retained %	Distribution Cu, %
10/150	3.2	2.1	24.1	13.4	13.6	45,8	10.9	56.6
150/270	12.5	12.2	19.7	28.5	12.9	14.1	9.6	11.5
270/400	21.1	21.7	12.7	20,0	7.2	10.3	6.3	4.2
400/C_2	10.9	12.2	4.9	7.0	3.7	3.1	4.0	1.4
C_2/C_3	13.5	14.9	6.3	7.2	6.1	3.4	7.2	1.6
C_3/C_4	9.9	10.8	4.8	4.7	5.8	2.1	6.9	1.3
C_4/C_5	7.1	7.5	4.0	3.5	5.7	1.7	6.7	1.3
-C_5	21.8	18.8	23.4	15.8	44.9	19.5	48.4	22,0

TABLE IV: Bank distribution of weight and copper content in tailings.

BANK / MESH	1		2		3		4	
	Weight retained %	Distribution Cu %	Weight retained %	Distribution Cu, %	Weight retained %	Distribution Cu, %	Weight retained %	Distribution Cu, %
10/150	45.3	41.9	42.2	52.5	45.8	65.5	44.2	67.0
150/270	11.7	18.7	11.7	12,9	11.5	6.5	11.8	6.0
270/400	5.6	10.7	5.8	6,2	5.3	2,6	5.4	2.5
400/C_2	3.1	3.1	3.4	2,0	3,0	0,9	3.2	1.0
C_2/C_3	4.3	3.5	5.2	2,3	4.9	1.1	5.0	1.2
C_3/C_4	3,9	2.5	4.3	1.9	3.8	0.9	4.1	1.0
C_4/C_5	3.1	1.8	3.6	1.5	3.3	0.8	3.3	0.9
- C_5	22.4	17.9	23.7	20.8	22.5	21.7	23.0	20.6

FIG. 5: Tridimensional representation of non-floated copper by size and by bank.

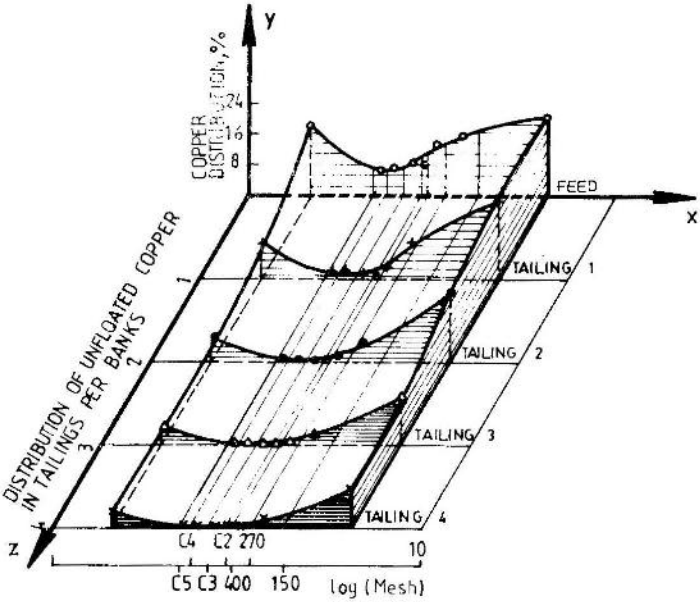


FIG. 6: Projection in the x-y plane of the residual copper distribution in tailings of the banks 1-4, by size regions.

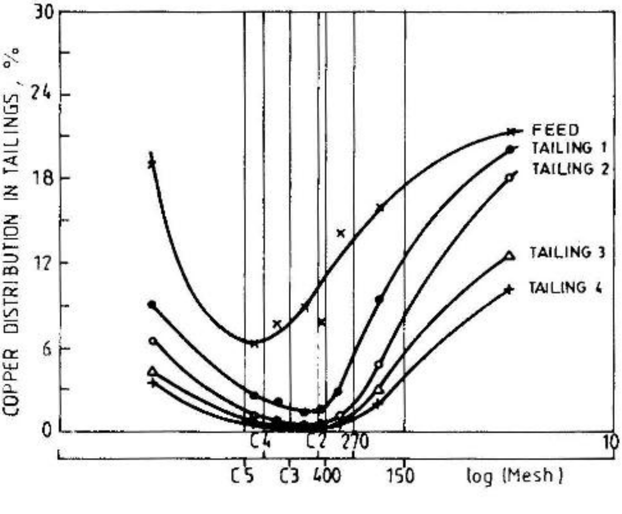


FIG. 7: Projection in the y-z plane of the residual copper distribution in tailings, of the banks 1-4, by size regions.

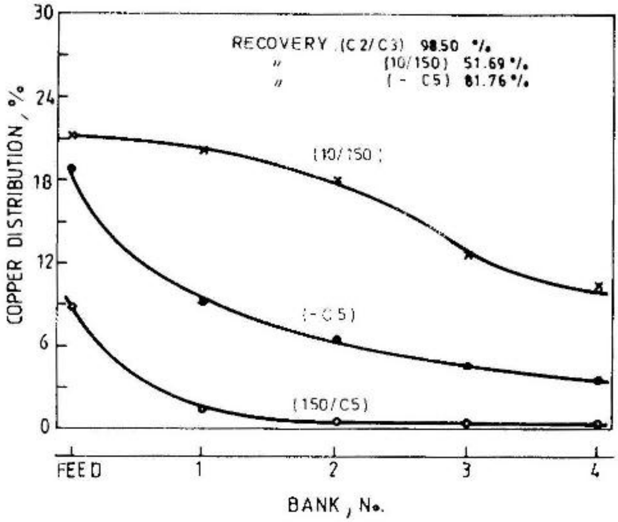


FIG. 8: Cumulative and fractional recoveries by bank and by size region.

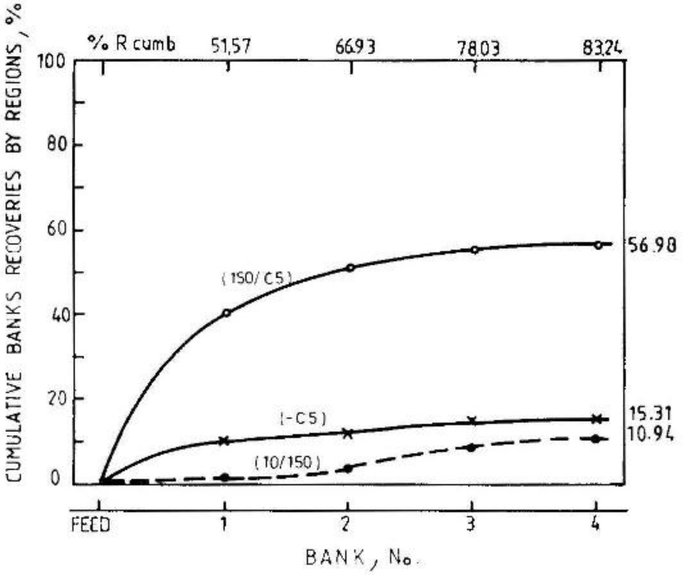
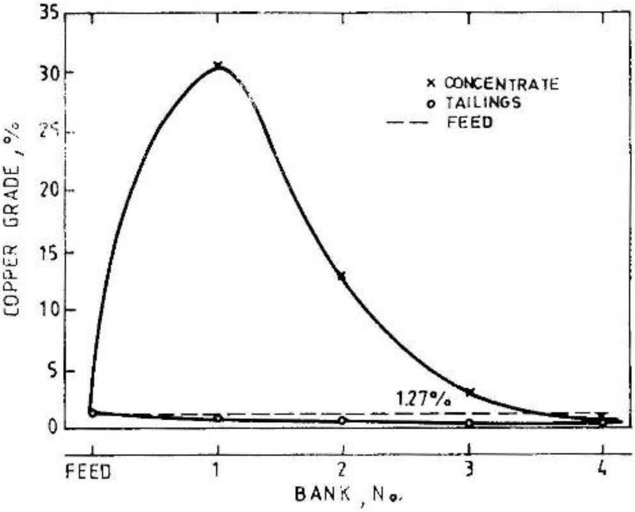


FIG. 9: Profile of Copper grade in concentrates and tailings. The dotted line denotes the copper grade in the feed circuit.



DISCUSION

The present work shows that particles of similar size exhibit different recoveries through the various banks of the circuit. This probably means that a fraction with lack of liberation exits in every bank and that it floats slowly, and that even it may not float. This is the case of the 10/150 mesh fraction in the example presented above.

The diagnostic test additionally showed that the coarse fraction (10/150 mesh) is barely recovered in banks 1 and 2; however, this fraction represents 41 weight percent of the circuit feed material. These results strongly suggest that this fraction lacks of liberation and so we classified it as an undergrinding region.

In addition, about 3.4 points in recovery units are lost as fine particles and would correspond to the overgrinding region. It is also established that the 150/cyclon 5 fraction is the optimum grinding region, which is characterized by recoveries greater than 90%.

The particle size for maximum recovery is the fraction C_2/C_3 (27 µm) and the critical particle sizes of losses are 150 mesh (105 µm) and cyclon 5 (12µm). The results of copper degree and copper contents distribution in concentrates per bank suggest that the concentrate of the first bank can go directly to the final concentrate or else to the last cleaner circuit. The +270 mesh fraction in the concentrates of bank 2, 3 and 4 necessarily needs a regrinding step to continue the next cleaner circuits. Finally, an increase in recovery can be expected if the fineness of the ground ore changes, in such a way that the copper distribution curve of the feed is modified and that copper distributes mainly in the optimum grinding region.

The complete information on recoveries and losses per mesh and per bank obtained in this test leads to a review of the strategy of the classification-grinding circuit and its adequation to the actual needs of particle size distribution demanded by the flotation process.

REFERENCES

1. W.J. Trahar and L.J. Warren. The flotability of very fine particles - a review. Int. J. Min. Process, 3: 103-131, 1976.
2. W.J. Trahar. A Rational Interpretation of the Role of Particle Size in Flotation. Int. J. Min. Process. 8:289-327, 1981.
3. R.P. King. A model for the Quantitative Estimation of mineral Liberation by Grinding. Int. J. Min. Process, 6: 207-220, 1979.
4. A.W. Cameron, D.F. Kelsall, C.J. Restarick and S.B. Stewart. A Detailed Assessment of Concentrator Performance at Broken Hill South Limited. The Australasian Institute of Mining and Metallurgy, N°240, 53-67, 1971.
5. D.F. Kelsall, P.S.B. Stewart and W.J. Trahar. "Diagnostic Metallurgy". A systematic Method of Plant Optimisation. A.M.I.R.A., Optimisation and Control, Brisbane, July, 1974.
6. D.G. Hartley, W.J. Trahar and K.R. Weller. Analysis of Concentrator Operations at Mount Lyell. The Aus. IMM Conference, Tasmania, 155-169. May 1977.
7. P.A. Tilyard. Bougainville Copper, Ltd. Flotation circuit: recent improvement and current investigations. Trans. IMM. C_6 - C_{15}, March, 1978.

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