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Characterization of large size flotation cells

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Abstract

Design and operating conditions of large size mechanical flotation cells were evaluated by comparing it with the actual operating conditions in a plant. The objective was to determine the time scale-up factor, typically based on empirical rules. Experiments were conducted on the rougher flotation circuit at Minera Escondida Ltd. The circuit consisted of self-aerated mechanical cells of 160 m^3, arranged in six parallel banks with nine cells each.

The rougher circuit flotation kinetics was evaluated from direct sampling and local mass balances around each cell of the bank. Adjusted overall mass balances were also developed. This information was used to fit different kinetic flotation models, and it was found that the rectangular distribution function was the most appropriate to describe the distributed rate constant for industrial operation. Then, a rougher flotation simulator was developed to describe the actual operation in terms of the operating variables (mass flow rate, solid percentage, feed grade) and the actual volumetric flow rate entering to each cell. In this study feed pulp samples were taken in parallel from the rougher circuit and were simultaneously floated in laboratory. The kinetic behavior was then modeled at a laboratory batch scale in order to determine the time scale-up factor between laboratory batch flotation data and industrial size flotation. The time scale-up factor observed for large sized cells, 160 m^3, was found reasonably similar to those previously determined for self-aerated mechanical cells, but of lower size, operating at similar recoveries. In addition, the relative effect of mixing, between laboratory batch and an industrial flotation bank was quantified by the φ parameter, separating the impact that kinetic and mixing changes have on the time scale-up factor.

In general, the rougher flotation operation was found to reach the predicted metallurgical target, and that the optimal separability criterion was also respected.

The diagnostic generates information about the internal state of the process and helps to identify potential improvements for design, operation and control of the circuit.

Keywords: Flotation machines; Flotation kinetics; Modeling; Process optimization; Scale-up; Mass balancing

1. Introduction

In the last decade, flotation equipment has shown a significant increase in size. Since the 1980's, mechanical cells size have increased 10 times in size, reaching levels of over 200 m^3 per cell. At the present moment, most of the new concentrators in Chile have been fully equipped with 130–160 m^3 mechanical cells, as well as new cells of 250 m^3 are now in testing stage. A large number of pneumatic flotation columns of more than 200–250 m^3 are also in operation, mainly in cleaning stages. Thus, the dramatic increase in size of flotation equipment poses new challenges related to equipment design, in terms of mixing and pulp circulation, as well as optimizing bubble generation and dispersion, and froth mineral transport.

1.1. Industrial flotation process

The present study was developed in the Laguna Seca concentrator of the Minera Escondida Ltd. mining company, located at 3200 m above sea level in the Los Andes

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cordillera, Chile, and 160 km from Antofagasta. The typical plant feed tonnage was about 110,000 tpd. The ore containing an average feed grade of 1.26% copper produces a final concentrate of about 40% copper. The flotation circuit (shown in Fig. 1) consists of a rougher stage, with six parallel banks of nine Wemco cells, each 160 m^3. The rougher concentrate, together with the scavenger concentrate, goes to a regrinding circuit consisting of three parallel vertical mills. The rougher and scavenger tailings are the plant's final tail.

The first cleaner feed combines the regrinding mill discharge together with the second cleaner tail. The first cleaner tailing goes to the scavenger circuit. Both circuits consist of five parallel banks with four Wemco cells, each 160 m^3. The first cleaner concentrate goes to the second cleaner circuit consisting of eight parallel flotation columns, each 4.5 m in diameter and 13.5 m in height.

1.2. Large size flotation cells

Mechanical cells in the rougher flotation circuit are self-aerated, cylindrical in shape and are 6.8 m in diameter and 4.4 m in height giving a total volume of 160 m^3 per cell. The mixer is a vertical cylindrical rotor provided with rectangular blades and located near the pulp/froth interface. Two stators, an internal cylindrical one and an external conical one are used to prevent turbulence near the pulp–froth interface, where a rather stagnant zone is created. The rougher circuit consists of six parallel banks each of nine cells arranged as 1-1-1-1-2-2-1 for level control purposes. All cells are provided with froth crowders, a concentric inverted cone, which helps to accelerate the froth discharge. The first three cells of each bank were provided with 10 radial internal launders, while the remaining cells with eight radial launders. The purpose of the radial internal launders is to decrease the transport distance for the concentrate to reach the overflow lip. Thus, the froth residence time distribution becomes narrow and the froth recovery increases (Zheng et al., 2004).

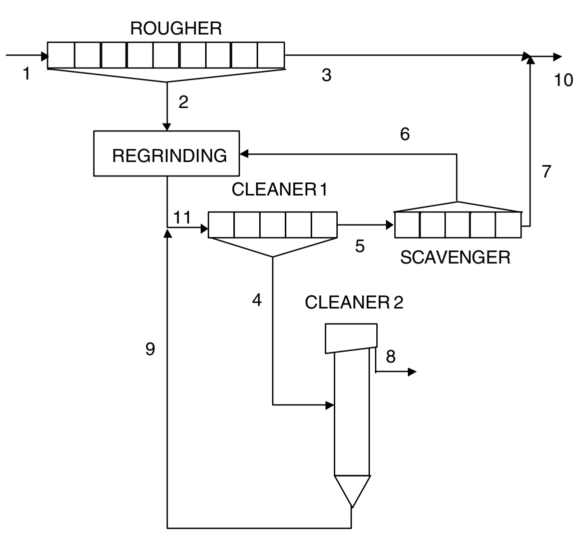

Fig. 1. Flotation circuit at Laguna Seca concentrator.

1.3. Control objectives

The targets of the rougher stage are to maximize the copper recovery, avoid the overloading of the regrinding and cleaning circuits, and to maintain a minimum concentrate grade. Rougher concentrate and tailings grade are monitored while pulp level and frother dosage are manipulated variables. On the other hand air aspiration valves are kept fully open, so that the maximum air rate available by self-aspiration is typically used.

2. Experimental

2.1. Mass balance

An overall mass balance was developed on the circuit by sampling eleven streams of the plant, see Fig. 1. The selected stream points include the plant feed, the final collective concentrate and the combined final tail, which allows for the calculation of the global mass balance as well as the rougher, cleaners and scavenger stage balances. At each point, samples were taken for a period of 7 h, and a composite of 17 samples of about 10 L of pulp was obtained. Mass balance adjustment was developed using the Bilmat version 8.0 commercial software (Algosys Inc, 2004).

The mass balance results are shown in Table 1.

2.2. Flotation cells performance

In order to evaluate the flotation cells performance in the rougher bank, sampling from each cell was developed. Thus, the kinetic of the flotation bank was determined and the individual contribution of each cell was identified.

2.2.1. Concentrate sampling

The concentrate samples were taken directly from the cell lip using a modified standard sampler of 20 cm long. The modification consisted of a 7.5 cm extension, in order

Table 1
Results of the mass balance adjustment

No.	Name	Adjusted grades [%]			
		Total copper	Soluble copper	Total iron	Non-soluble Gangue
1	Rougher feed	1.27	0.07	2.21	87.43
2	Rougher concentrate	5.04	0.18	4.67	77.09
3	Rougher tail	0.26	0.04	1.55	90.19
4	First cleaner concentrate	14.53	0.50	11.68	50.36
5	First cleaner tail	0.40	0.11	3.03	86.23
6	Scavenger concentrate	2.39	0.25	5.43	78.20
7	Scavenger tail	0.18	0.10	2.77	87.12
8	Final concentrate	36.24	0.75	16.91	12.70
9	Second cleaner tail	6.51	0.40	9.75	64.26
10	Final tail	0.25	0.05	1.78	89.61
11	First cleaner feed	5.23	0.24	5.99	73.96