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Modelling flotation per size liberation class – Part 2 – Evaluating flotation per class

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ABSTRACT

Several studies have been developed to better understand the impact of froth on flotation recoveries. It has been shown that particle size and hydrophobicity affect froth stability. There are indications of selective attachment or detachment of particles depending on their characteristics.

To evaluate the effect of froth height and recovery in a rougher stage, three continuous pilot flotation tests were performed with a chalcopyrite ore, each one with a specific froth height in the first rougher cell. Results were evaluated by global flows, by size fraction and by size-liberation classes. Liberation data were stereologically corrected and reconciled with process mass balance data using the beta adjustment method as described in the first paper of this series.

In this second paper, different ways of expressing and analysing the recoveries per liberation classes provided an overview of the behaviour of particles in the process. Results show the trends presented by size liberation classes when the froth height increases and the recovery decreases. An empirical mathematical model was proposed to represent the recovery of liberation classes in size fractions.

1. Introduction

Particle size and liberation are the ore characteristics that have the greatest impact on flotation performance. Innumerable studies have evaluated the impact of particle size in flotation. There were studies about the effect of particle size on flotation as a whole (Rahman et al., 2012; Falutsu and Dobby, 1989; Trahar, 1981), in attachment in pulp (Feng and Aldrich, 1999; Albijanic et al., 2015), in froth recovery (Ata & Jameson, 2005), in froth stability (Aktas et al., 2008; Dippenaar, 1982).

It is well known that flotation is most efficient in a range of particle sizes that varies according to the floated mineral but that is typically in the range of 10–100 µm. Finer and coarser material will present lower recoveries.

Low recovery of coarse particles has been attributed mainly to detachment, which may occur in froth phase or in the interface pulp-froth (Ata, 2012; Seaman et al., 2006). Therefore, the higher the froth, the lower the recovery of coarse particles.

Due to their lower mass, fine particles tend to follow water streamlines, what reduces collision probability and, consequently, reduces recovery (Klassen and Moukrosov, 1963). Furthermore, in the froth, fine particles can detach due to bubble collapse or bursting, and tend to be drained back to the pulp in deeper froths.

However, this effect of particle size is conditioned by the degree of hydrophobicity which mainly depends on liberation, mineral texture and reagent adsorption. The role of liberation has also been recognized for many years (Klassen and Moukrosov, 1963; Sutherland, 1989; Barbery, 1991), but only in the last two decades, with the advance of automated mineralogical techniques, have detailed studies been developed to further clarify this aspect (Muganda et al., 2011; Albijanic et al., 2015; Welsby et al., 2010; Farrokhpay and Fornasiero, 2017). Particularly, there has been more focus on the effect of particle size and liberation in the froth.

There is evidence that froth recovery is selective based on the particle size, density and hydrophobicity which includes liberation as well as chemical environment. Attachment, detachment, drainage and re-attachment are the main sub-process that may be responsible for this selectivity (Seaman et al., 2006). Several studies have aimed at increasing coarse and fine recoveries.

However, it is still necessary to investigate how liberation and size, in conjunction, affect flotation performance, using a real ore in a continuous circuit, under conditions close to the industrial ones and after correction of liberation data. This is the main objective of this series of papers.

In this second study, the behaviour of size liberation classes is

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Fig. 1. Sequence of cells in the flotation mini pilot plant.

evaluated in the first rougher cell, with three different froth heights. Results show how size and liberation distributions affect the flotation performance in this first rougher according to the froth height. An empirical mathematical model was developed to represent flotation recovery of liberation classes per particle size fraction as a function of the mineral grade of liberation classes.

The third paper (Santos, 2017, 2018), based on the same tests, details and models the effect of liberation on flotation for the first rougher considering the mineral surface area in the particles.

The whole circuit as well as more detailed results on the kinetics of liberation classes will be the subject of future studies.

2. Method

Conditions of tests, sampling scheme, stereological correction and mass balance reconciliation methods were detailed in the first paper of this series (Santos and Galery, 2017, 2018). This section presents only an overview of the method.

Three continuous pilot tests were conducted in a flotation mini pilot plant (MPP) using a chalcopyrite ore from an operating industrial plant in the north of Brazil. The MPP is a continuous flotation equipment that comprises 12 cells of 1.7 L, similar to Denver laboratory cells, whose flows are interconnected by peristaltic pumps, as shown in Fig. 1.

Each test had a specific froth height in the first rougher cell, to allow an evaluation of froth recovery. Tests were called Cal 01, Cal 02, and Cal 03 and were performed with low, intermediate, and high froth height in the first rougher, respectively.

The circuit included rougher, scavenger and cleaner. Fig. 2 shows the flowsheet.

Each square corresponds to a 1.7-L cell with a froth crowder as shown in Fig. 3.

Fig. 4 illustrates the sampling points and analysis performed in each flow.

These products were screened at 210 μm, 150 μm, 74 μm, and 44 μm and the fraction below 44 μm was analysed in a cyclosizer. Chemical analyses of Cu, Fe, Si, and S were performed for the overall sample and the size fractions.

The mineralogical analysis was conducted in QEMScan for size fractions of −210 μm +150 μm, −150 μm +74 μm, −74 μm +44 μm and −44 μm +20 μm, for the feed and the rougher 1 concentrate, rougher 2 tailings, scavenger concentrate, cleaner concentrate and cleaner tailings. The liberation distribution in other fractions was obtained through QEMScan estimates and the distribution in other streams, through mass balance reconciliation.

Stereological correction and an appropriate mass balance reconciliation procedure are essential in any quantitative evaluation of liberation data in a process. More information on the method used in this study, including comments on sampling accuracy, circuit configuration, stereological correction and mass balance reconciliation can be seen in Santos and Galery (2018).

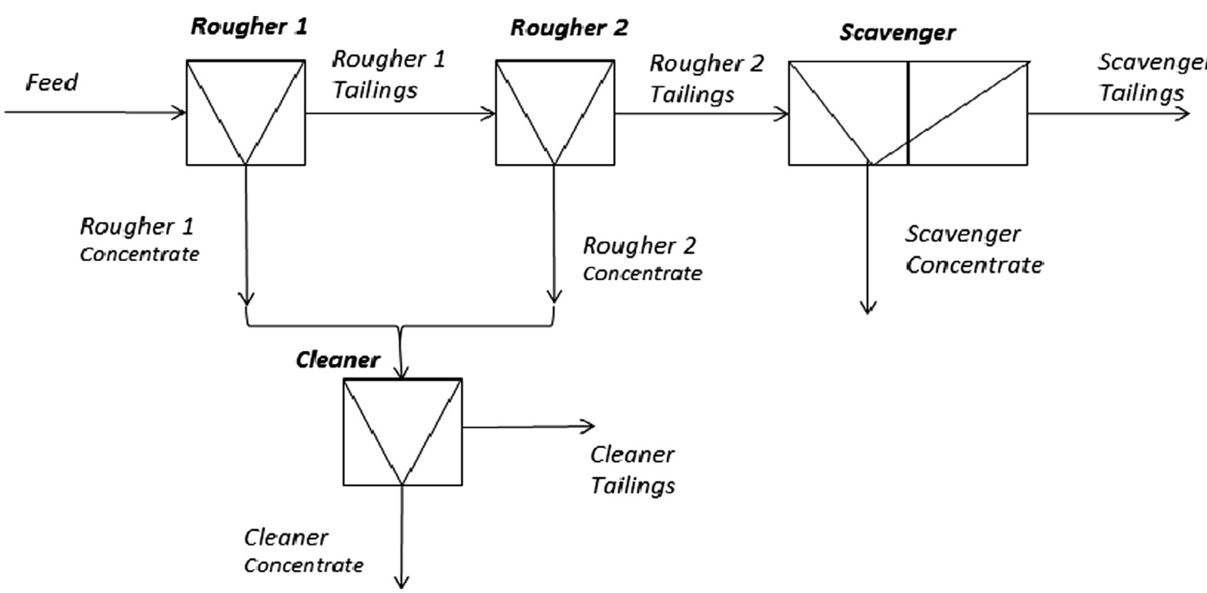

Fig. 2. Flotation circuit.

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