

ASSESSMENT OF REAGENT AND REGRINDING IN A FLOTATION CIRCUIT

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ABSTRACT

Laboratory flotation tests using a bottom driven cell are reproduced with a high level of confidence. These types of laboratory data are used to investigate the effect of reagent and regrinding of coarse particles in an industrial flotation circuit. The addition of collector (BX) has a significant effect on the flotation response of chalcopyrite in the scavenger bank. The reconstructed recovery-time curve (combine products) is greater than that of the rougher tailings (scavenger feed) prior to reagent addition. By adding collector (BX) in the scavenger feed, the ultimate recovery of chalcopyrite increases 20% which means an increase of 1.7% of chalcopyrite recovery in the scavenger feed.

Meanwhile, the regrinding of coarse particles shows a detrimental effect on the collectorless flotation of an initially hydrophobic chalcopyrite sample. Cyclone underflow, 80% recovery at pH 7.7, was decreased to 40% after regrinding at the same range of pH. The chalcopyrite flotation response immediately after regrinding is severely retarded. It is assumed that the centrifugal action of the cyclone is another important factor restoring the chalcopyrite hydrophobic flotation due to the oxygenation of the slurry. Therefore, additional pre-conditioning time after a regrinding stage should have a positive change in the recovery of chalcopyrite.

The overall flotation response before and after the regrinding stage showed that the cyclone underflow response is slightly slower compared with the combine feed in the first four minutes of flotation. This behavior is related to changes on surface chemistry because of the regrinding of coarse particles.

INTRODUCTION

Evaluation and optimization of flotation circuits has been the focus on most metallurgists since the first plant started hundreds of years ago. In the late 60's, computer based techniques were developed to evaluate flotation process performance and to develop mathematics model which describe behavior of minerals across a flotation cell/bank or circuit. Such mathematical

models were developed to simulate flotation circuit behavior through laboratory batch flotation tests (Garcia Zuñiga, 1935). Since the development of a standard batch flotation tests; laboratory tests have been used to investigate the kinetics of flotation (Meloy *et al.*, 1998; Brown and Hall, 1999; Bloom and Heindel, 2003) as well as the reproducibility, reliability and performance index in a semi-batch flotation tests (Bazin *et al.*, 1996; Apling and Ersayin, 1986; Petho and Tarshan, 2000). Applications of kinetics and liberation data to analyze industrial flotation process were published in the 70's and 80's (Cameron *et al.*, 1971; Lynch *et al.*, 1981; Frew, 1982).

These types of research are very useful to describe the behavior of mineral in the entire flotation process or individual flotation cells. However, the most interesting approach for evaluation of flotation processes is that in which the analysis can be used to quantify the effect of reagent and regrinding to improve the recovery-grade relationship (Klimpel, 1984; 1995; 1996).

A new methodology to investigate the effect of reagent and regrinding on industrial flotation circuits is presented in this paper. This methodology uses laboratory batch flotation tests performed on plant streams across a flotation circuit under standard procedure and a bottom driven cell.

EXPERIMENTAL

Sampling

Research work was carried out at the Mt Isa Copper Concentrator in June and August 2000. Approximately between 2 or 4 liters of slurry were taken from several streams around the copper flotation circuit to ensure a feed sample to make up to 4.4 liters approximately at 23 % solids for each laboratory flotation test. All samples were weighed to calculate percent of solids before the flotation test. Feed samples were analyzed for lead, zinc, iron and silica at the Mt Isa laboratory.

Batch Flotation Tests

Figure 1 shows the bottom driven flotation cell used in the laboratory tests. Batch flotation tests were conducted in conjunction with each plant survey to determine the floatability parameters more accurately. Mill water, dosed with drops of *methyl-isobutylcarbinol* (MIBC), was used to make up the volume of the laboratory flotation cell to 4.4 liters.

The following conditions were used in the tests:

- Tests were conducted in a bottom driven flotation cell;
- Both air rate and impeller speed were fixed for each test (13 liters/min and 1000 rpm);
- Six concentrates were collected over the following times:
 - Con 1 - 20 seconds
 - Con 2 - 20 seconds
 - Con 3 - 20 seconds

- Con 4 - 1 minute
- Con 5 - 2 minutes
- Con 6 - 4 minutes
- Throughout each test, froth depth was maintained at constant level of 1 cm. The shallow froth depth was used to ensure the froth recovery was near 100%;
- No collector, frother, activator, pH modifier, or depressant was added in any test;
- The froth pull rate from the cell was constant at 6 scrapes per minute;
- Other measurements included:
 - Wet weights of each product;
 - Impeller speed;
 - pH and Eh at the beginning and end of each test using Corning pH/Eh meters (model 240). All potential measurements were against Ag/AgCl reference electrode; and
 - Air pressure.

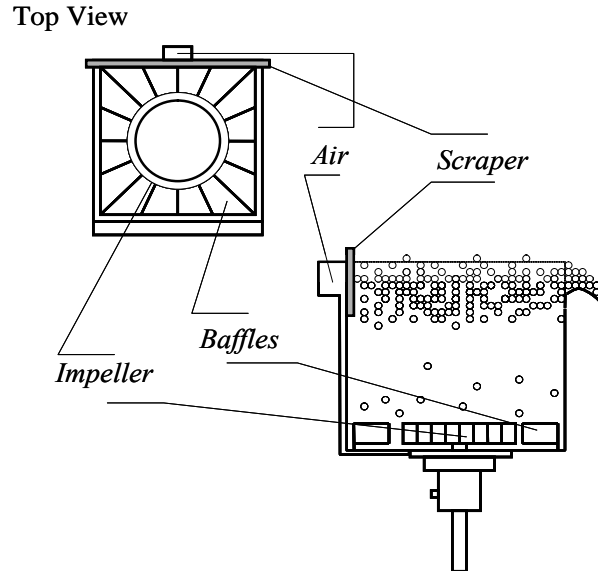


Figure 1.- Schematic representation of the bottom driven flotation cell.

All samples were weighed, filtered and weighed again to calculate the percent of solids. Then, dried samples were assayed by lead, zinc iron and silica at the Mt Isa laboratory to construct the recovery-time curves of each stream.

RESULTS AND DISCUSSIONS

Reproducibility of Batch Flotation Tests

Laboratory batch flotation tests are useful in the determination of the ore floatability parameters, such as the kinetics (k) and the fraction (m) of that particular floatability class in

the feed stream. Replicate laboratory batch flotation experiments were conducted in the retreatment tailings during the first survey with the regrinding in operation. Figure 2 shows the recovery-time and grade-time curves for chalcopyrite of two laboratory tests. As shown in these curves, a good level of reproducibility is observed.

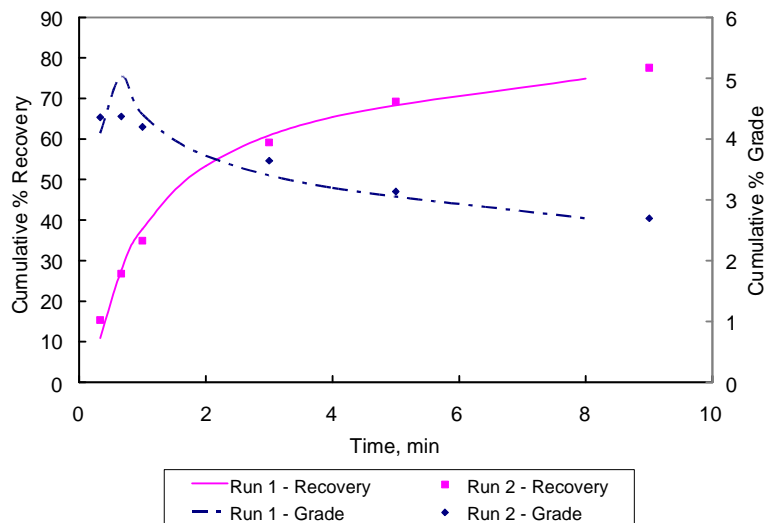


Figure 2.- Reproducibility of batch flotation test performed in the retreatment tailings.

Nodal Analysis

The nodal analysis technique evaluates the ore floatability behavior around a single separator or mixer in a flotation process using the mineral recovery-time curves (Runge *et al.*, 1997; Reyes Bahena, 2000; Runge and Reyes Bahena, 2004). This technique is a back calculation of procedure in which the flotation responses of separator products are combined and compared with that of the feed (Figure 3a). In the case of a mixer (Figure 3b), the flotation responses of the various feed streams are combined and compared with that of the product stream.

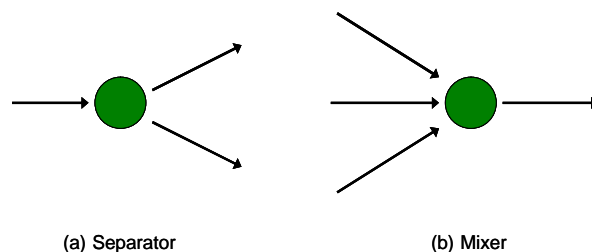


Figure 3: Typical separator and mixer in a flotation circuit: (a) combined stream separated into two streams; (b) a number of feed streams produce one combine stream.

Evaluating Reagent Addition

Visual inspection of the flotation response of the scavenger bank is shown in Figure 4 and Figure 5. The flotation response was obtained from samples taken from feed, concentrate and

tailings of the scavenger bank as shown in Figure 4. It is important to note that the feed of the scavenger bank is the rougher tailing which was taken before the collector *sodium butyl xanthate* (BX) and the frother (MIBC) were added.

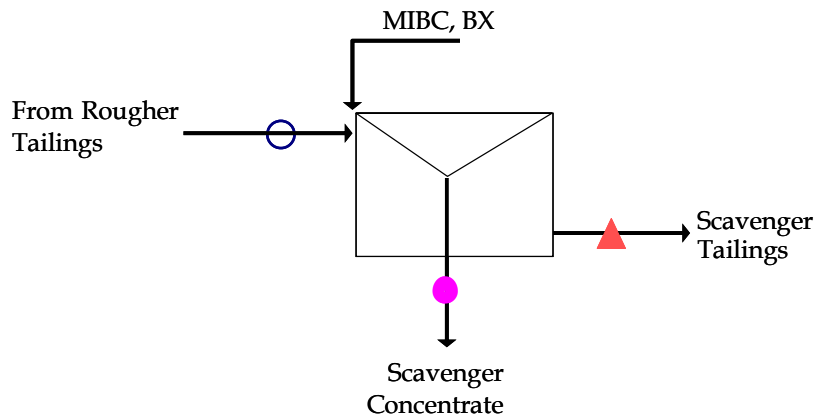


Figure 4.- Sampling points for batch flotation tests around the scavenger bank. The symbols are associated with the recovery-time curves in Figure 5.

Figure 5 shows the chalcopyrite recovery-time curves around the scavenger bank (Figure 4). The concentrate stream shows a very fast flotation response in which 84% is recovered in the first 2 minutes of flotation. Meanwhile, the chalcopyrite response in the tailings is slow, may be due to the coarse particles or poor liberation.

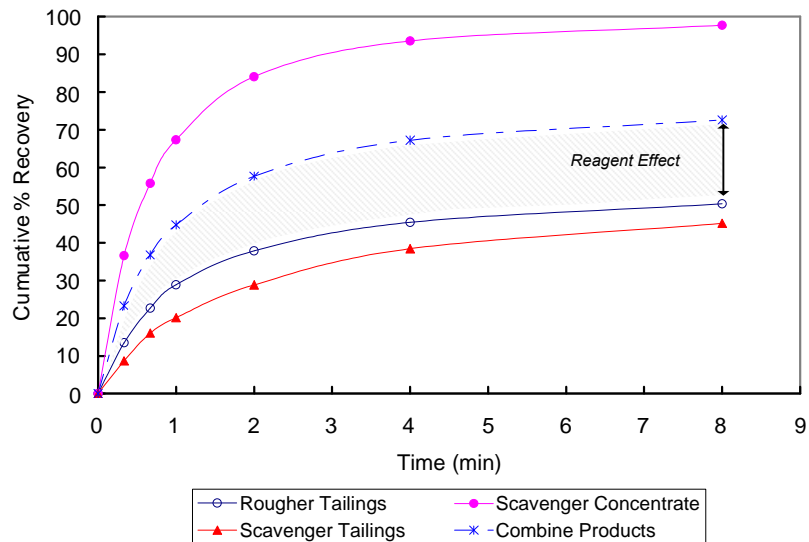


Figure 5.- Chalcopyrite recovery-time curves around the scavenger bank. Combined product is calculated using the scavenger concentration and tailings.

The most important aspect of Figure 5 is that the reconstructed recovery-time curve (combine products) is greater than that of the rougher tailings (scavenger feed) prior to reagent addition. By adding more collector (BX) in the scavenger feed, the ultimate recovery of chalcopyrite

increases 20% which means an increase of 1.7% of chalcopyrite recovery in the scavenger feed.

When no collector is added across a separator or mixer in a flotation process, the ore floatability must be conserved as in the case of the cleaner bank (Figure 6 and 7). The combine feeds is calculated based on the rougher concentrate, column tailings, retreatment concentrate and recleaner tailings and the combine products is calculated based on the cleaner concentrate and tailings.

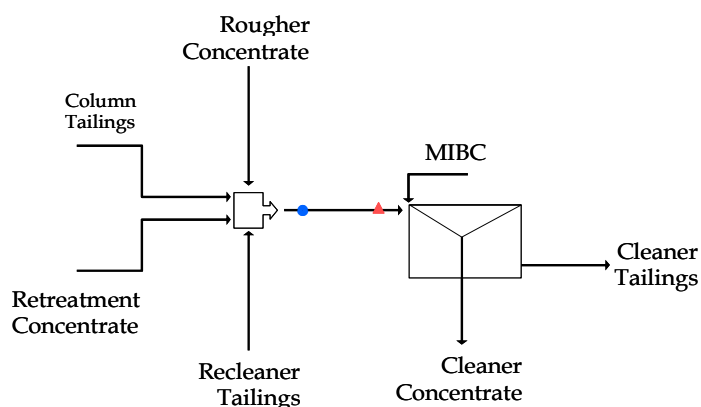


Figure 6.- Sampling points for batch flotation tests around the cleaner bank. The symbols are associated with the recovery-time curves in Figure 7.

Figure 7 shows the chalcopyrite recovery-time curves of the combine feeds and combine products (Figure 6). As shown in Figure 7, both recovery-time curves are very similar. It is an indication that the ore floatability is conserved when no collector or changes on the physical properties of minerals occurs.

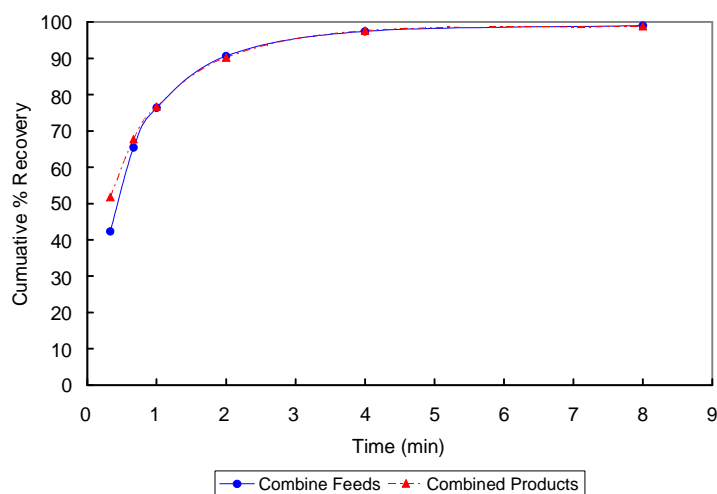


Figure 7.- Chalcopyrite recovery-time curves around the cleaner bank. Combine product is calculated using the cleaner concentrate and tailings.

Evaluating Regrinding

Regrinding composite particles is expected to decrease the rate of flotation due to a decrease in the particle size and the need for additional collector on the new surface available. In this section, comparing the recovery-time curves before and after regrinding assesses the regrinding on chalcopyrite. Figure 8 shows the sampling points around the regrinding circuit.

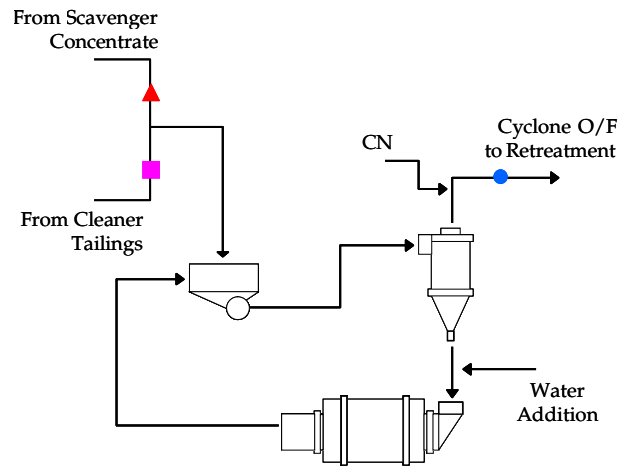


Figure 8.- Sampling points for batch flotation tests around regrinding. The symbols are associated with the recovery-time curves in Figure 9.

The combine feed involves the scavenger concentrate and cleaner tailings. Thus, a comparison between the recovery-time curves of both the combine feed and the cyclone overflow is investigated (Figure 9). It is important to note that only *cyanide* (CN) is added in the cyclone overflow.

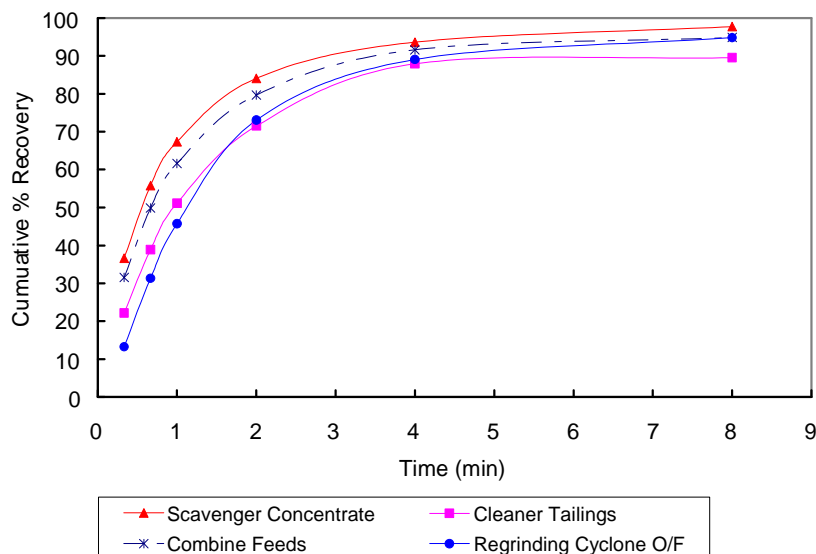


Figure 9.- Chalcopyrite recovery-time curves around regrinding. Combine feed is calculated using the scavenger concentrate and cleaner tailings.

Figure 9 shows that the cyclone underflow response is slightly slower compared with the combine feeds in the first four minutes of flotation. This behavior is due to changes on surface chemistry because of the regrinding of coarse particles as observed in Figure 10.

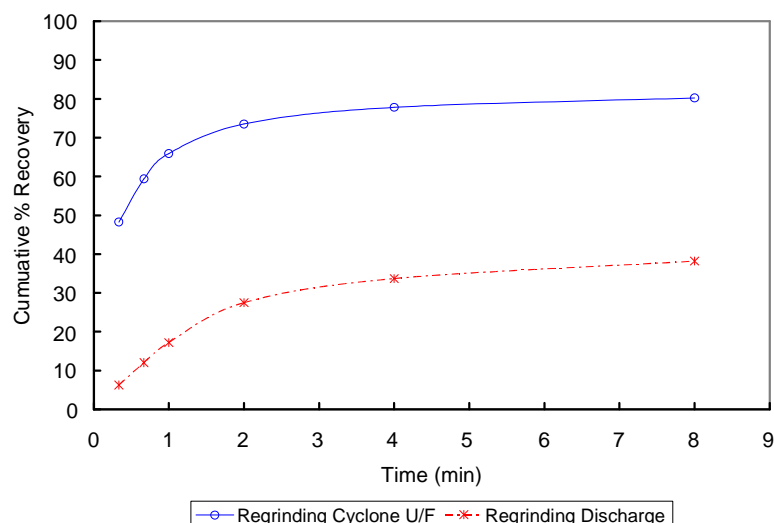


Figure 10.- Chalcopyrite recovery-time curves before and after regrinding.

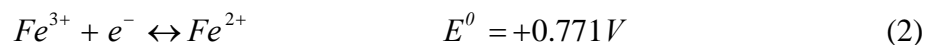
This figure shows that the collectorless flotation of an initially hydrophobic chalcopyrite sample, cyclone underflow (80% recovery at pH 7.7), was decreased to 40% after regrinding at the same range of pH (see Table I). The chalcopyrite flotation response immediately after regrinding is severely retarded. However, more investigation is required to determine which of these two mechanisms are taking place on the chalcopyrite surface:

- Adsorption or precipitation of iron oxyhydroxide species as an overlayer on the iron-deficient chalcopyrite;
- Ferric iron oxidative leaching of the chalcopyrite surface.

Table I.- Chemistry conditions of laboratory batch flotation tests.

Stream	pH		Eh (SHE), mV		Temp (°C)	
	Start	End	Start	End	Start	End
Regrinding Cyclone U/F	7.55	7.85	17	51	25	26
Ball Mill Discharge	7.50	7.70	-132	37	25	25

It should be noted that some oxidation products such as ferric or ferrous ionic species originating from pyrite and/or pyrrhotite particles may exist in the pulp and produce an acidic oxidation environment. Researchers (Subrahmanyam and Forssberg, 1993; Trahar *et al.*, 1994) have published that the following equation has a dominant role in determining the pulp potential level in flotation:



Consequently, the pulp potential becomes lower according to Equation 3. This could be the reason why regrinding leads to more negative pulp potential as reported in Table .

$$E = 0.771 - 0.05916 \log \left[\frac{Fe^{2+}}{Fe^{3+}} \right] \quad (3)$$

However, the retardation effect showed in Figure 10 is restored once the ball mill discharge is mixed with the scavenger concentrate and cleaner tailings which passing through the cyclone unit. It is assumed that the centrifugal action of the cyclone is another important factor restoring the chalcopyrite hydrophobic flotation due to the oxygenation of the slurry. Therefore, additional pre-conditioning time after a regrinding stage should have a positive change in the recovery of chalcopyrite.

CONCLUSIONS

Laboratory flotation tests using a bottom driven cell are reproduced with a high level of confidence. The addition of collector (BX) has a significant effect on the flotation response of chalcopyrite in the scavenger bank. The reconstructed recovery-time curve (combine products) is greater than that of the rougher tailings (scavenger feed) prior to reagent addition. By adding more collector (BX) in the scavenger feed, the ultimate recovery of chalcopyrite increases 20% which means an increase of 1.7% of chalcopyrite recovery in the scavenger feed.

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