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Evaluation of Factors Affecting Carrying Capacity of Laboratory Flotation Column Treating Copper Sulfides

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ABSTRACT: One of the necessary parameters in designing and scaling up flotation columns is carrying capacity (C_a) which can be determined in terms of mass of solids per unit time per unit column cross-sectional area. The prediction of C_a for a given flotation technology has been commonly achieved using a simplified expression based on a representative particle size and density of the floatable material, regarding several assumptions in limited data ranges. In determining the C_a, the effect of operational parameters, such as particle size, pulp solids rate, bubble diameter, air flow rate, pulp solid content, frother dosage and froth height should be considered. In this study, the effect of these parameters on the C_a was investigated in column flotation. The studied sample was obtained from rougher circuit concentrate of Sungun copper complex flotation plant. It was found that when the pulp solid rate increased up to 1.4 cm/s, more surface of bubbles is covered by entering more solid particles to the column and C_a increased, but it decreased in higher rates. In lower speed of input pulp, the increase of frother dosage led to higher C_a, but in pulp rate higher than 1.2 cm/s, the maximum C_a was obtained in frother dosage of 45 ppm. By decreasing the froth height and increasing the solid percent up to 30%, C_a increased. Likewise, the results of the experiments with particles of different size distribution showed that the input pulp with size 44-63 µm had the maximum C_a.

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1- Introduction

Maximum carrying capacity (C_{amax}) is an important index to be considered at the design of flotation column and in the diagnosis of flotation operation. The maximum solids concentrate rate is referred to as the carrying capacity and is expressed as mass of solids to overflow per unit time per unit of column cross sectional area, C_a (e.g. g/min.cm^2) [1-3].

The aim of this study is to evaluate the effect of significant common flotation variables, such as: feed solid content, feed solid rate, frother dosage, air flowrate, froth height and feed particle size on copper carrying capacity in the cleaner column flotation circuit.

2- Experimental

The copper ore sample employed in this study was obtained from the rougher circuit concentrate of the Sungun copper concentrator plant.

Results displayed that ore samples mainly consisted of $CuFeS_2$ and Cu_2S as valuable sulphide minerals and SiO_2 and FeS_2 as grange minerals. The size analysis of the samples, showed that the rougher concentrate had a top size of 250 µm and 80% finer than 100 µm. The chemical analysis illustrated that Cu grade in studied sample was equal to 4.83%.

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The experiments were carried out in a 90 cm high Plexiglas column with cross sectional areas of 26.28 cm^2. To obtain the effect of the each parameter on C_a, the concentrates in a period of time were collected after the system reached a steady state.

The most significant variables including frother dosage, gas flowrate, froth height, feed solid concentration, feed flowrate and particle size on the bubbles carrying capacity were investigated.

The column flotation operation conditions employed for all tests in this study were shown in Table 1. In all experiments, one or two variables were changed and other parameters were kept.

To investigate the effect of feed size distribution on C_a, the samples were prepared to obtain seven size ranges: >150, 105-150, 88 -105, 63-88, 44-63, 20-44 and <20 µm, so that each range had the same weight.

In this study for investigation of the effect of air flowrate and frother concentration on the bubbles carrying capacity, the effect of bubble size for a two phase systems was directly studied. Hence, an important part of the experimental set-up was the image acquisition system for photographic purposes.

3- Results and Discussion

It can be observed from Figure 1 that the C_a increased with increasing solid concentration until it reached a constant value and finally decreased. By increasing the solid percent, the amount of particles that attached to bubbles increased, thus at first the C_a increased. Due to the saturation of the bubbles with particles, C_a for pulp with solid of 30% had a little increase, in comparison with solid of 25%. In solids contents over 30%, collector insufficiency for the full surface coverage of pulp particles could lead to the reduction of C_a.

Table 1. Operating conditions in flotation tests

Variables	Values
pH	11.7
Collector dosage, R407, Z11, 1:1 (ppm)	40
Frother dosage, MIBC (ppm)	30
Froth depth (cm)	20
Solid (%)	20
Air flowrate (cm/s)	1.6
Feed flowrate (cm/s)	1.4
Wash water flowrate (cm/s)	0.5
d80 (μm)	100
Feed specific gravity (gr/cm^3)	3.1

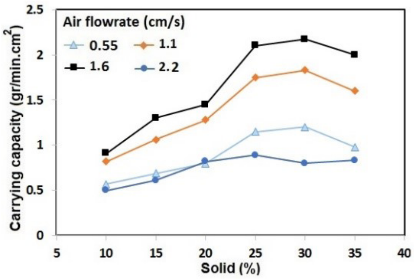

Figure 1. Effect of the feed solid content on the C_a at four different air superficial velocities

When the air flowrate increased, the C_a increased firstly and then dramatically decreased. Totally, when gas velocities were within the range in which an increase in gas rate results in an approximate proportional increase of bubble surface area flux, higher values of C_a were achieved for higher gas velocities.

Regarding C_a results, feed flow rate behavior was similar to feed solid percent. By rising pulp velocity to 1.4 cm/s, C_a first increased and then decreased. Carrying capacity reduction in the feed rate equal to 1.6 cm/s can be justified by decreasing the bubbles rising velocity.

An increase in C_a can be seen with increase in frother concentration. This was due to reduction in bubble size in presence of frother.

When overloading of bubbles takes place (e.g., high slurry densities and feed flowrates), a decrease in bubble size made by high frother concentration (e.g., 70 ppm), has a detrimental effect on solid recovery. In the absence of overloading phenomenon, a decrease in bubble size favoured the recovery.

It can be seen that C_a decreased with increasing froth depth. This issue can be justified by increasing the effect of washing water because of the froth depth increase and also increment the particles residence time in froth phase.

The results of the experiments (Figure 2) at various feed sizes illustrated that the overall fine particles C_a was much higher than that of coarser particles so that particles with size 44-63 μm had the maximum carrying capacity (C_a: 4.4 g/min.cm^2). Both very fine (-20 μm) and coarse (+105 μm) particles were float with difficult, In the latter case, no flotation actually occurred above a limiting size that is in agreement with the previous studies [4]. It should be stated at this point that while fine particles may be known to increase froth stability, extremely fine particles (<20 μm) were found to have a destabilising effect on froth which has a detrimental effect on solids recovery. This drop in mass recovery with size has been observed by Awatey et al. [5].

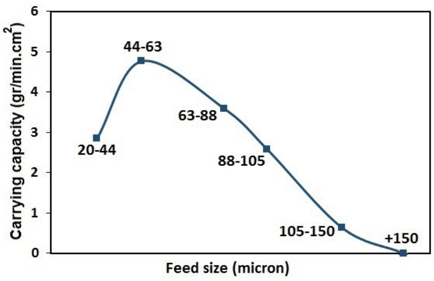

Figure 2. Relationship between particle size and C_a

4- Conclusion

The major conclusions achieved from this work are as follows:

- It was found that when the feed solid rate increased, the concentrate solid rate increased to a certain point whereafter it started to decrease.
- When the air flowrate increased, at first, the C_a increased and then dramatically decreased.
- In low feed flowrates, the increase of frother rate resulted in the higher carrying capacity whereas in feed flowrates over 1.2 cm/s, the C_a in frother rate of 45 ppm was more than 75 ppm.
- By decreasing the froth height and increasing the solid percentage (up to 30%), C_a increased.
- The particles with size 45-63 μm had the maximum C_a.

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