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Study of froth behaviour in a controlled plant environment – Part 2: Effect of collector and frother concentration

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ABSTRACT

An investigation into froth zone recovery in a controlled plant environment is presented. The effect of operating conditions on the froth performance is given in our previous work (Rahman et al., 2015). This paper is primarily concerned with the influence of chemical properties such as frother and collector concentration on the froth behaviour. The results suggested that increasing the collector concentration gave expected results in the collection (pulp) zone, with a significant increase in coarse particle recovery. However, at high collector concentrations, it was observed that there was an increase in bubble coalescence and froth instability as well as a slight decrease in froth recovery. Increasing frother concentration gave a significant improvement in froth recovery and a slight increase in the collection zone recovery was also found. This was attributed to the formation of finer, more stable, bubbles and a corresponding increase in froth stability. Size and grade analysis of the samples suggested that the dropback particles were mainly composite or middling fractions. It appeared that particles whose grade was higher than the feed may be collected into the froth zone, but some particles with grades lower than the concentrate may detach from the froth.

1. Introduction

An investigation into froth zone recovery using a unique device is presented. The device has ability to collect the froth dropback particles and allow independent measurement of both froth and pulp phase recoveries. The effect of operating conditions (froth depth and air flow rate) on the froth performance was recently reported by the authors (Rahman et al., 2015). The work was carried out at the Northparkes concentrator (NSW, Australia) using a feed taken directly from the head of the cleaner scavenger bank.

This paper presents the results of a parallel investigation into the effect of the chemical parameters on the froth behaviour where the influence of collector and frother concentration on froth recovery was studied.

2. Experiments

The design of the froth dropback (FDB) device, a schematic diagram of the rig and the experimental procedure are given in Rahman et al. (2015). Feed to the cell was taken from the head of the cleaner–scavenger of Module 1 of Northparkes copper concentrator. The procedure followed for the treatment of raw data may also be found in the previous paper.

In Module 1 reagents were added at different stages of the flotation circuit. The cleaner–scavenger feed contained approximately PAX – 5 g/ton and Interfroth 6801 – 4 ppm. These dosages were used as the base. Frother and collector were added on top of these values in order to investigate their effect on froth performance in the dropback cell. Chemical upstream additions at the flash flotation and scavenger stages are not considered here. Experiments were performed at collector concentration of 5, 10, 15 and 22 g/ton and frother concentration of 4, 9,14 and 18 ppm. Each test was repeated twice.

3. Results and discussion

3.1. Effect of collector concentration

3.1.1. Effect of collector concentration: overall recovery

Two consecutive runs, donated as Runs 5 and 6, were completed at four different collector concentrations of 5 g/ton, 10 g/ton, 15 g/ton and 22 g/ton. The superficial air velocity (J_g) and froth

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depth were maintained at 1 cm/s and 240 mm, respectively. Collector (PAX) was added to the feed sump.

The average froth recovery R_f, collection zone recovery R_c and overall recovery R, at different collector concentrations are presented in Table 1. The table shows that the collector concentration has a distinct impact on collection zone recovery. In general, recovery in the pulp phase increases with increasing PAX concentration, confirming that more of the ore is being floated. This is expected as flotation is a surface phenomenon and the availability of more collector molecules in the cell enhances particle hydrophobicity, assisting in stronger bubble–particle attachments and eventual improvement in collection zone recovery. On the other hand, the froth zone recovery does not show any significant change with variations in collector concentration. It is evident from Table 1 that a slight decrease in froth recovery occurs at the highest collector concentration of 22 g/ton, suggesting that the froth may become unstable at very high collector concentrations. Overall flotation recovery at the lowest collector concentration of 5 g/ton is 36%, and it reaches 46% at the highest collector concentration, which is believed to be the result of significant improvements in particle collection in the pulp zone.

3.1.2. Effect of collector concentration: recovery and particle size

Froth recovery as a function of particle size at different collector concentrations is presented in Fig. 1. Froth recovery results are high for fine particles and decrease with increased particle size. It seems that there is a decrease in the froth recovery of relatively coarser particles from 90 to 150 μm, at the highest collector concentration 22 g/ton that could be attributed to the instability of the froth structure at very high collector concentrations. There is an apparent discrepancy between the overall recoveries shown in Table 1, and the size-by-size recoveries shown in Fig. 1, in that the results in Table 1 suggest that froth recovery is relatively insensitive to the collector concentration, while Fig. 1 shows significant differences, especially for the larger particles. The reason for the discrepancy is that the mass fraction of the coarse particles in the froth is much smaller than the mass fraction of the fines, which tend to dominate the results, and which are relatively insensitive to collector concentration as shown in Fig. 1. It is worthwhile to mention that the mass fraction of the particles less than 90 μm in the feed stream is 72% while that of the 90–150 μm particles is 28%. It can also be found from Fig. 1 that the froth recovery of coarse particles decreases significantly at higher collector concentration. In this case, the mass fraction of coarse particles is much greater than fines; as a result, the overall froth recovery also decreases at higher collector concentration.

The reduction in recovery of coarse large particles may be a consequence of their effect on the stability of the froth, which is also a function of their hydrophobicity as influenced by the collector concentration. Instability of froth at high collector concentrations has been observed by other researchers (Dippenaar, 1982; Pugh, 1996). Strongly hydrophobic particles can lead to faster drainage of liquid at the thin film and cause immediate film rupture and froth instability.

The average collection zone recovery at different collector concentrations is presented in Fig. 2, as a function of particle size. It appears that for all particle sizes, but more particularly for coarse particles, the collection zone recovery increases with increases in collector concentration. At 5 g/ton collector concentration, particles of 128 μm have a collection zone recovery of less than 20%, while it improves to around 37% at the highest collector concentration of 22 g/ton.

Table 1
Overall froth recovery, R_f (%), collection zone recovery, R_c (%) and flotation recovery, R (%) as a function of collector concentration (averages of data for Runs 5 and 6).

Collector concentration (g/ton)	R_f (%)	R_c (%)	R (%)
5	77	47	36
10	79	52	41
15	78	55	44
22	76	60	46

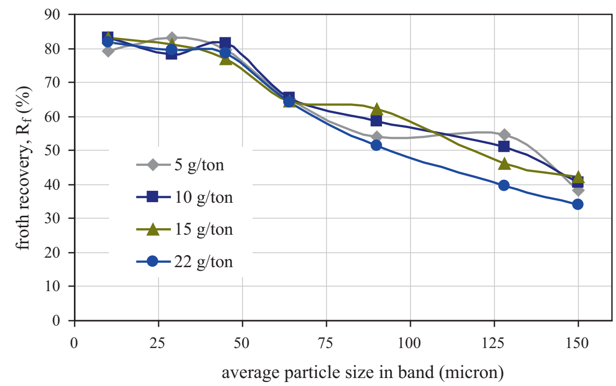

Fig. 1. Froth recovery as a function of particle size at different collector concentrations (average of two runs, Runs 5 and 6).

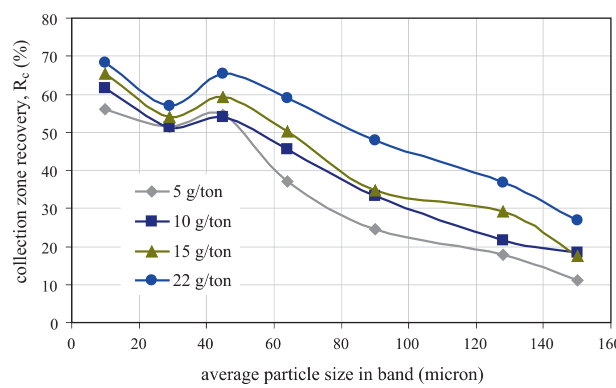

Fig. 2. Collection zone recovery as a function of particle size at different collector concentrations (average of Runs 5 and 6).

3.1.3. Effect of collector concentration: comparison of copper grade of flotation samples

The grades of concentrate, feed, tailings and dropback samples, at various collector concentrations, are presented in Fig. 3. The bars denote the copper grade of the concentrate, shown in the primary *y*-axis. The lines in the figure show the overall copper grade of the feed, tailings, and dropback samples; their copper grades are given on the secondary *y*-axis. It is seen that the grade of the concentrate decreases with increases in collector concentration for Runs 5 and 6. This indicates that greater masses of composites and relatively larger particles are floated as the collector concentration is increased. For the same reason, the grade of the tailings also decreases with increasing collector concentrations, as only the poorly liberated or gangue particles are left in the pulp at high collector concentrations. In Fig. 1 the detachment of coarser valuable particles in the froth zone increases at high collector concentrations, but in Fig. 3 it appears that with increases in collector concentration the dropback grade decreases, which is unexpected. The most probable reason behind this observation is that increases in collector concentration result in higher masses of composite mineral particles entering from the collection zone into the froth phase. At the same time, the higher collector concentrations also lead to an increase in highly hydrophobic particles which cause