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Study of froth behaviour in a controlled plant environment – Part 1: Effect of air flow rate and froth depth

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ABSTRACT

This paper presents the results of a thorough investigation into the froth recovery measurements in a controlled plant environment using a device that allows direct collection of dropback particles from the froth phase.

Experiments were performed at the Northparkes concentrator (NSW, Australia), using a feed taken from the head of the cleaner scavenger bank. The feed slurry had a relatively higher copper grade varying from 5.2% to 6.8%. Experiments were performed to investigate the effect of important flotation parameters such as air flow rate and froth depth, on the froth performance. The size of the particles in the relevant streams was analysed to acquire in-depth knowledge about the froth dropback mechanism. The results suggested that the froth recovery could be as low as 70%, although it was relatively easy to achieve the values in the range 75–85% by the correct choice of operating variables. It was found that the air flow rate has a positive impact on both collection (pulp) and froth zone recoveries. However, the effect was more prominent in the froth zone. It appeared that the froth recovery is a strong function of particle size.

1. Introduction

Froth flotation is an important mineral concentration process that exploits the physicochemical surface properties of mineral particles to separate the valuable minerals from the waste rock. Two distinct zones are evident in a flotation cell: the pulp zone and the froth zone. The pulp zone provides a platform for an efficient bubble–particle-attachment while the froth zone plays an important role in upgrading the final concentrate.

The efficiency of froth phase is often defined by the term froth recovery. A number of techniques have been developed over the past few decades to determine froth recovery. These techniques can be broadly divided into two categories: Indirect methods that include model fitting; correlation of froth recovery with flotation rate constant and froth retention time; mass balancing across the flotation cell (Alexander et al., 2003; Savassi et al., 1997; Vera et al., 1999; Yianatos et al., 2008; Neethling, 2008) and direct methods. Two types of direct froth recovery measurement methods currently present in the mineral industry are bubble load and modified column or froth dropback methods (Falutsu and Dobby, 1989; Seaman et al., 2004).

Recently, we have developed a laboratory-scale device to measure froth performance (Rahman et al., 2012). The device permits independent measurement of froth recovery by collecting the particles dropping out of the froth zone. Flotation feeds were prepared as mixtures of silica (quartz) particles of two size ranges: 60G ('fine' particles, $d_{80} = 72\ \mu m$) and 50N silica ('coarse' particles, $d_{80} = 299\ \mu m$), in varying proportions, at a constant total solids concentration of 20% w/w. The fraction of fines in the feeds was varied from 40% to 95%. The silica used in the study was fully liberated. As a result, no composites were present, and the effect of various variables on the froth behaviour were investigated. Following on from this work, similar experiments were attempted in a laboratory cell using raw samples received from the Northparkes mine (NSW, Australia). The ore was first ground, treated with reagents and then fed continuously into the laboratory cell. However, the grade of the feed samples was low, and the number of tests required to capture sufficient concentrate solids for meaningful analysis was found to be extremely time-consuming. It was, therefore, decided to move the laboratory rig to the Northparkes concentrator, and to conduct experiments using the feed from the cleaner/scavenger, which had a grade in the order of around 7% copper, that would generate a concentrate flowrate sufficient enough for subsequent analysis. The influence of air flow rate, froth depth, collector concentration, and frother

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concentration on the froth performance was investigated. The variation of froth recovery as a function of particle size and a comparison of the copper grade of feed, tailings, dropback and concentrate samples were also provided in order to acquire an in-depth knowledge of froth behaviour. This paper presents the results of the influence of operating parameters (air flow rate and froth depth) on the froth recovery while the effect of frother and collector concentration on the froth recovery will be given in a following study.

2. Experimental

2.1. Flotation feed ore

To perform independent flotation experiments in a controlled environment, feed slurry samples were collected from the cleaner-scavenger feed stream of Module 1 of the Northparkes flotation circuit. The slurry collection point in the Module 1 flotation circuit is shown in Fig. 1. The feed contains primarily chalcopyrite ($CuFeS_2$) and bornite (Cu_5FeS_4) with small amounts of chalcocite and covellite. The feed at the time of testing had a relatively high copper grade that varied from 5.20% to 6.76%, and a particle size P_{80} of approximately 130 μm.

2.2. Chemical reagents

A sample of the feed stream was collected from Module 1 and was already conditioned with chemical reagents in the flotation circuit. PAX was used as collector, and reagents designated DSP110, Interfroth 6801 and NaHS were used as promoter, frother and sulphidiser, respectively. In Module 1 reagents were added at different stages of the flotation circuit such as flash flotation, conditioning tank and scavenger stage. The cleaner-scavenger feed contained approximately PAX – 5 g/ton and Interfroth 6801 – 4 ppm.

2.3. Experimental set up

The schematic diagram of the complete experimental arrangement is shown in Fig. 2(c), while Fig. 2(a) and (b) present the picture of the bottom section where bubble particle interaction takes place and the cell with the froth dropback (FDB) attached to the top. FDB consists of two concentric cylindrical tubes with the inner tube denoted the dropback collection chamber. Particle-laden bubbles pass through the annular gap between the two concentric tubes and a stable froth is formed at the

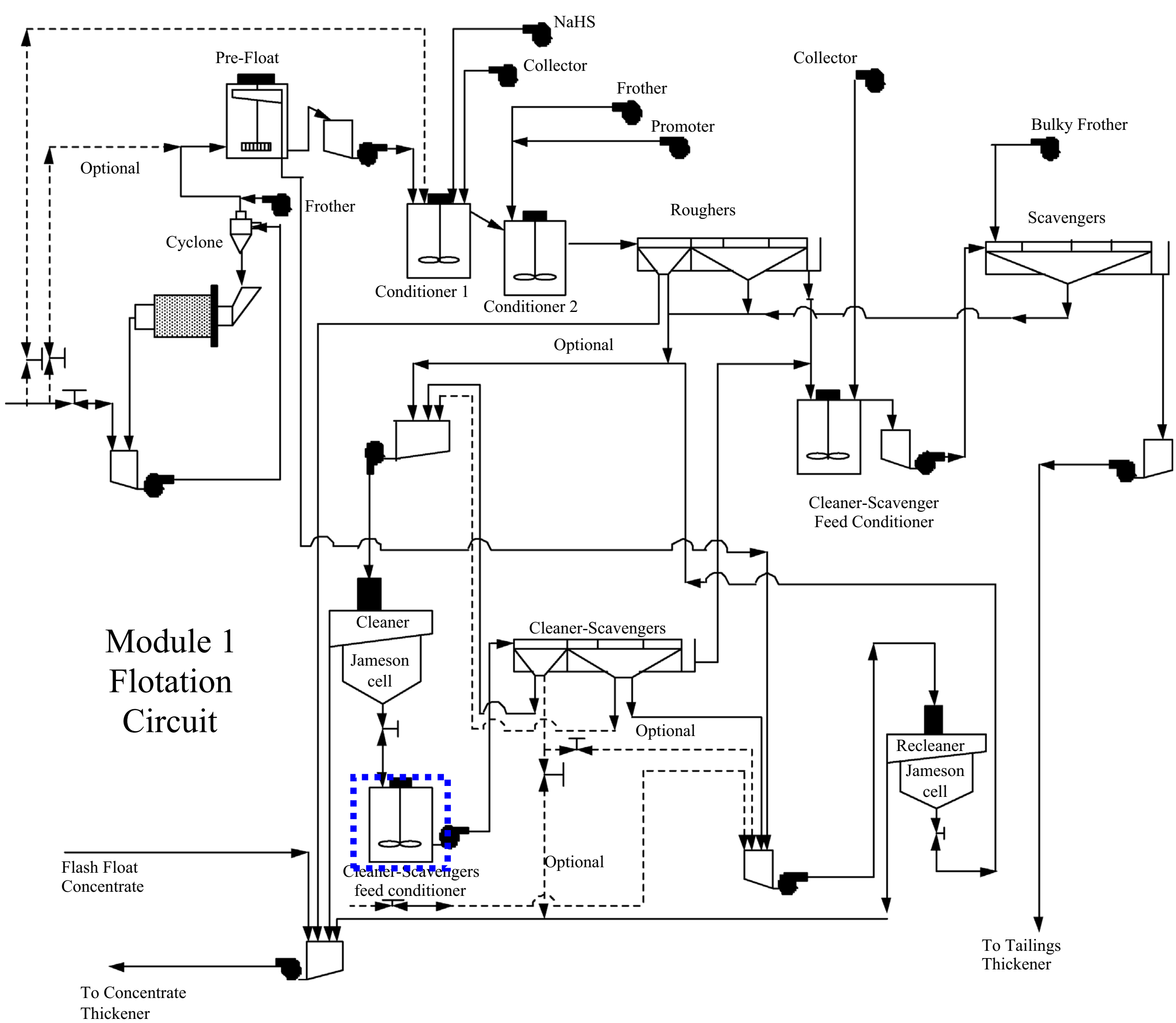

Fig. 1. Conventional flotation circuit of Module 1 at Northparkes concentrator showing the feed slurry collection point.