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Experimental studies and numerical model validation of overflowing 2D foam to test flotation cell crowder designs

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ABSTRACT

A computational fluid dynamics model of froth motion has been developed to assess different flotation cell designs. This work presents an implementation of the model in a 2D case, to compare the simulated bubble velocity distribution and streamlines to an experimental foaming system. The model uses finite elements to solve Laplace's equation for a potential function from which the foam velocity can be obtained. It requires the air recovery, or the amount of air that overflows a flotation cell as unburst bubbles, as an input parameter to calculate the foam velocity distribution and bubble streamlines. The air recovery was obtained by image analysis from a vertical, overflowing monolayer of foam (2D) created in a Hele-Shaw column, which mimicked important flowing properties of flotation froths such as coalescence. Inserts were included in the foam column to represent potential crowder designs for industrial flotation cells. Three different designs were chosen to compare the effect of insert depth and shape, including rectangles and a triangle. The effect of the insert design on the overflowing foam is obvious from visual assessment of the bubble streamlines and velocity distribution, which were closely agreed by both the experiment and model.

Keywords: Froth flotation; Flotation bubbles; Image analysis; Computational fluid dynamics; Process optimisation

1. Introduction

Flotation machine design is constantly evolving to meet specific requirements of a particular industrial plant. The recent trend has been to increase the size of the flotation cell, which increases the froth volume. If this froth can only overflow at the vessel lip, the centre of the vessel becomes a large stagnant zone of froth which does not report to the concentrate (Zheng et al., 2004; Zheng and Knopjes, 2004). Therefore two different types of devices have been placed in the froth zone to improve mineral recovery: launders to increase the surface area for overflowing froth, and crowders to direct the froth flow. In this work, a model of foam flow has been developed that can predict the effect of insert design on overflowing foam, to give insight into the effect of crowder design on flotation performance.

The function of a crowder is to decrease the cross sectional area at the top of the froth to improve the froth removal dynamics in the flotation cell. The walls of a crowder provide a surface to direct froth toward the overflow launder. They reduce the amount of air required for operation, or alternatively increase the volume of overflowing froth for a particular air rate. Crowders usually extend from the impeller outwards and from the outer wall inwards, although they can be placed mid-cell directing towards the weir. A crowder design from a flotation cell at Rio Tinto's Northparkes mine is shown in Fig. 1, where the angled surface of the crowder directs the froth to overflow the weir on the right side of the image. Degner (1997) patented a crowder device designed to improve the removal of froth, reducing the amount of air needed to produce froth and thus the energy needed to power the cell rotor. Fuerstenau et al. (2007) described the effect of adding a conical crowder above the impeller hood to a Wemco 1 + 1 flotation machine, which increased the copper recovery by 18%. For a reasonably straight forward engineering solution, crowders can have a significant effect on flotation efficiency.

Computational fluid dynamics (CFD) is a powerful tool that can be exploited to optimise the performance of existing

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