

Abstract

The performance of the froth phase, usually evaluated as froth recovery determines overall flotation performance. In most flotation operations, recovery across the froth is rate controlling; consequently understanding the froth phase is very critical. Although much research effort to understand the physics of the froth has been expended, not many techniques to optimise froth recovery have been implemented industrially. This is partly due to the complexity of the froth, brought about by the large number of variables involved and the lack of measurement techniques that can provide data to validate our current understanding of this phase. The work covered in this thesis both addresses the lack of measurement techniques and explores possible non-conventional ways in which froth phase sub-processes can be altered with the sole intention of optimising froth performance.

In response to the known lack of techniques to quantify froth phase sub-processes, an electro-resistivity technique was developed and tested to estimate froth phase bubble sizes in non-transparent flotation cells as a function of height above the pulp froth interface. Comparison of the froth bubble size estimates obtained from this new technique with the Sauter-mean diameter obtained using the photographic method established a linear correlation. The effect of pulp chemistry and solids content on the applicability of the estimation technique was also tested and it was concluded that a signal amenable to froth bubble size estimation can be obtained irrespective of the pulp chemistry. The applicability of the technique was further tested by investigating the effect of froth depth and gas rate on froth phase bubbles sizes. Results indicated that as superficial gas velocity was increased, bubble size estimates decreased. Increasing froth height at fixed gas rate resulted in an increase in froth phase bubble size estimates especially close to the froth surface.

In a quest to develop novel ways of optimising recovery across the froth phase, a cell was designed that enabled the study of the effects of different air distribution profiles across the pulp-froth interface on flotation performance. Three distinct gas fluxes viz. high gas flux at the back of the flotation cell (impeller at the back), uniform gas distribution (impeller at the centre) and high gas flux close to the concentrate weir

(impeller in front) were investigated using an artificial ore comprised of 80% silica as gangue and 20 % limestone as floatable component. Results indicated that high gas flux at the back of the flotation cell resulted in higher recovery of limestone when compared to the other two gas flux distributions while producing grade values similar to those obtained when high gas flux was supplied close to the concentrate weir. The effect of gas flux distribution profile on limestone grade was found to dwindle as froth height was increased. Froth surface velocities were then used to explain the flotation performance changes as a result of gas flux distribution changes but were found to be inadequate. This led to the use of numerical models to aid understanding. The 2D stream function equation was chosen as the primary model since it has been previously found to adequately describe the flow of froth by a number of workers e.g. Moys (1979), Murphy et al. (1996). A semi-analytical method called the method of false transients was used to obtain a solution to the stream function equation subject to boundary conditions defined according to the gas distribution fluxes obtained experimentally. Results from the endeavour confirmed changes in bubble and particle residence time distribution which were suspected to be partly responsible for the observed flotation performance changes.

In another endeavour to develop ways of manipulating froth phase sub-processes, the use of a froth baffle previously suggested by Moys (1979) was tested in a laboratory mechanical flotation cell. Results indicated that a froth baffle has a profound effect on both recovery and grade. The presence of a froth baffle resulted in increased grade at the expense of recovery when compared to an un-baffled froth. The stream function equation was also solved subject to boundary conditions that represent the presence of baffles. A solution was developed using finite difference methods on a rectangular map obtained by using Schwarz-Christoffel (SC) mapping. Results from the simulations indicated a change in particle residence time distribution in a manner that reduces spread. The change in residence time distribution helped in developing an explanation of the experimental data.

Thus results in this thesis clearly show that froth bubble sizes can be estimated in a non-transparent flotation cell and also that gas flux profiling in a single flotation cell changes flotation performance. The use of froth baffles as originally coined by Moys (1979) has also been shown to impact on flotation performance.