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Effects of gas distribution profile on flotation cell performance: An experimental investigation

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ABSTRACT

A flotation cell that enables the study of the effects of different air distribution profiles on flotation performance has been designed. Three distinct gas fluxes viz. high gas flux at the back of the flotation cell (impeller and gas distribution mechanism at the back), high gas flux at the centre (impeller and gas distribution mechanism at the centre) and high gas flux close to the concentrate weir (impeller and gas distribution mechanism close to concentrate weir). Pseudo-steady state experiments using an artificial ore comprising of 80% silica as gangue and 20% limestone as floatable component were done. Results indicated that high gas rate at the back of the flotation cell resulted in higher limestone recovery when compared to the other gas distribution profiles investigated while high gas flux close to the concentrate weir resulted in high limestone grade. The differences in recovery ranged between 5 and 10% while the grade differences ranged between 0.5 and 5% with high gas flux at the centre produced lower values for all froth depths and gas rates. The effect of gas distribution profile on limestone grade was found to dwindle as froth height was increased; changes in limestone grade ranged between 0.47 and 2% for a froth depth of 10.1 cm while those for a froth height of 6.3 cm ranged between 1.40 and 5%.

1. Introduction

Gas dispersion properties (bubble size, superficial gas velocity, gas hold up and bubble surface area flux) have significant impact on flotation cell performance. A significant amount of research effort has been expended on this area. Ahmed and Jameson (1985) found that the flotation rate was very strongly affected by bubble size; they reported an increase of up to one hundred-fold when the bubble size was reduced from 655 μm to 75 μm. Gorain et al. (1998) found that none of the three gas dispersion factors (bubble size, gas holdup and superficial gas velocity) could be satisfactorily related to flotation rate individually; but when they are lumped together into a bubble surface area flux they related to flotation rate extremely well.

Their work showed a linear correlation between the collection rate constant and the bubble surface area flux. The research on gas dispersion properties discussed in flotation literature and summarised above assumes an average superficial gas velocity which is then taken to be uniform across the flotation cell. It does not take into account the effects of air distribution across the pulp–froth interface and how that distribution impacts flotation performance. It is our belief that the way in which gas is distributed across the pulp–froth interface has a significant impact on flotation since it will affect the distribution of particle residence times in the froth. Froth residence time by definition is inversely proportional to superficial gas velocity such that for a given froth depth, the distribution of gas across the pulp–froth interface strongly influences the distribution of residence times in the froth. Thus, how gas is distributed across the pulp–froth interface offers an opportunity for optimising froth residence time distribution and consequently flotation performance. Moys (1979) recognised the influence of air flux distribution across the pulp–froth interface in simulating his two dimensional model for the froth phase. He suggested several gas distribution profiles across the pulp–froth interface including the distribution profile given by $g(x) = g_o \sin(\pi x/L)$, where $g(x)$ is superficial gas velocity at a distance x from the back plate of a cell of length (L) and g_o represents air flux at the centre of the cell. Ross and Van Deventer (1988) after taking measurements in industrial flotation cells supported this proposal. Moys op cit. simulations revealed that the sinusoidal form of the gas distribution profile which is normally found in mechanically agitated vessels with impeller at the centre of the cell and concentrate launder on one side results in negative velocity profiles at the back of the cell which reduces the effective froth volume. Thus though the importance of air distribution profile to froth performance has been recognised, experimental work to characterise the best air distribution profiles in a single flotation cell seems absent in the flotation literature.

In view of the above, this work strives to answer whether or not profiling gas flux in a single flotation cell can optimise cell performance. Simulations by Moys (op cit) suggest that there is merit for further investigations. If indeed air profiling within individual flotation cells can be an additional manipulated gas dispersion property, then the effect of this on flotation cell design may be significant. A distribution profile that reduces dead zones and optimises froth residence times in a

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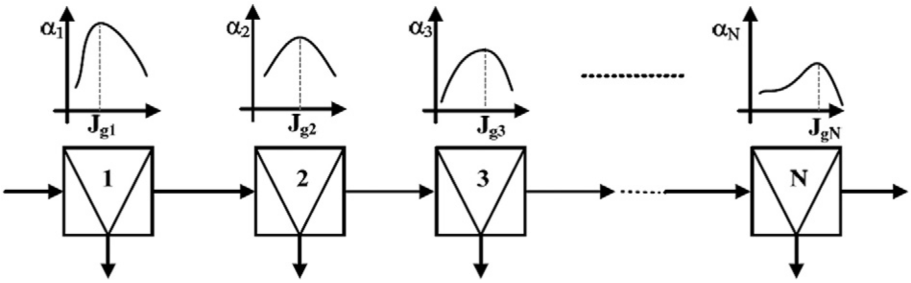

Fig. 1. Peak air recovery profiling for a typical flotation bank (after Maldonado et al., 2011).

flotation cell will increase the separation efficiency of each flotation cell and if it is coupled with an optimum air distribution profile on a flotation bank, it will increase flotation circuit performance.

2. Air distribution profiling in flotation systems

2.1. Air rate profiling

Air profiling in flotation has been used as a means to optimise the performance of a flotation bank (Maldonado et al., 2011). Cooper et al. (2004) studied three air distribution profiles on a Zinc cleaner bank viz. increasing, balanced and decreasing air profiles. The increasing air rate profile involved setting the bank air flowrate in such a way that low gas rate is set in first flotation cell, and is then increased down the flotation bank. They found that the increasing air profile performed better as it gave minimum difference between its worst and best performance in flotation grade at a given target recovery. This observation was explained by realising that a low air profile in the first cell increases selectivity while increasing air rate down the bank ensures that the flotation bank's air requirements to achieve the bank target recovery are met.

2.2. Peak air recovery (PAR)

Air recovery (α) is defined as the fraction of air supplied to the flotation cell that is recovered to the concentrate as unburst bubbles. Moys (1979) and later Woodburn et al. (1994) introduced/used this concept as a measure of froth stability. Hadler et al. (2010) found that there is an air rate at which a flotation cell can be operated where air recovery is at its peak called the peak air recovery (PAR). Operating the flotation cell at this peak air recovery improves flotation performance especially recovery. Maximum flotation recovery is obtained when a flotation cell is operating at the PAR point because operating below it results in highly loaded bubbles which have low mobility while operating beyond the PAR would reduce the loading on bubbles resulting in an unstable froth. Profiling of a flotation bank involves operating each flotation cell at its PAR point. Fig. 1 is a schematic representation of an air profile in a typical flotation bank with (N) flotation cells. As depicted each

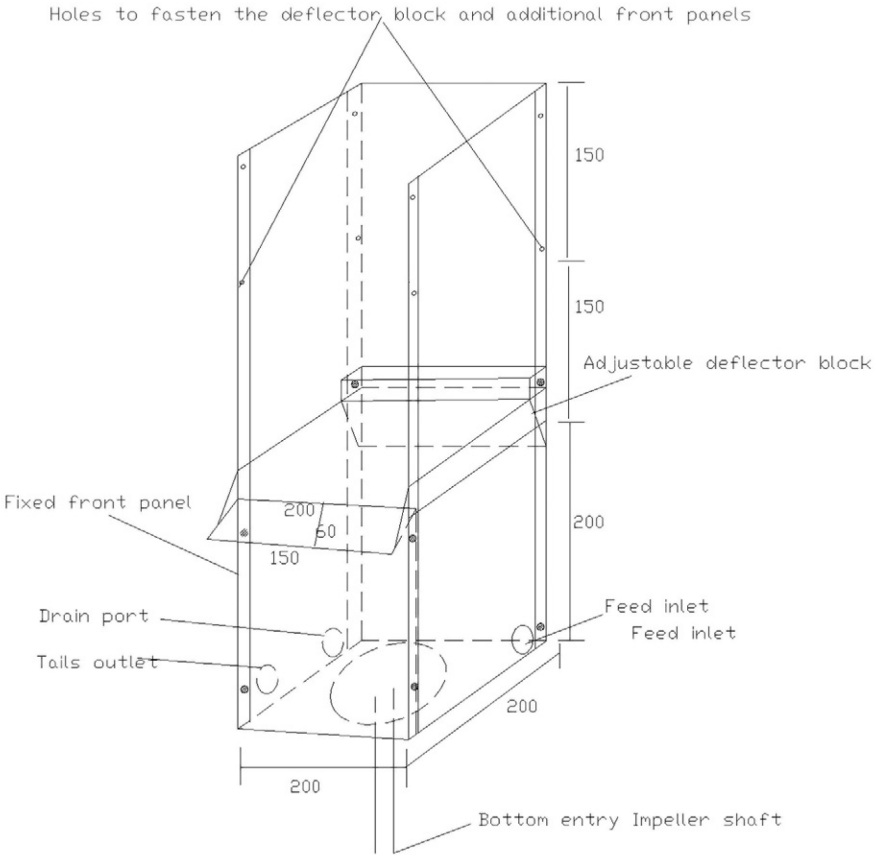

Fig. 2. Variable-depth variable-rotor position flotation cell used for both batch and continuous experiments (dimensions in millimetres).