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Experimental Studies on Column Flotation Cell

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Abstract: Column flotation is an emerging technology, which finds its applications in many industries like coal beneficiation, iron ore, deinking pulp and various mineral processing industries. The objective of this study is to study the effect of operating parameters namely air flow rate, water flow rate, pH and frother concentration on the amount of froth formed. An experimental column flotation cell was designed and fabricated in the laboratory and experiments were carried out by varying the operational parameters. Based on the experiments, the optimum values of these parameters were found to be 0.15 m^3/hr of water flow rate, 1.5 m^3/hr of air flow rate, pH of 8.91 and a frother concentration of 0.175 ml/lit.
Keywords: Column flotation, frothers, flotation cell, continuous flotation.

1. Introduction

Froth flotation is a surface chemistry based process of separation of fine solids that take advantage of the differences in wettability at the solid particle surfaces. Solid surfaces are often naturally wettable by water and are termed hydrophilic. A surface that is non- wettable is called water repelling and termed aerophilic and is strongly attached to air interface, which readily displaces water at the solid interface. In froth flotation, separation of a binary solids mixture may be accomplished by the selective attachment of hydrophobic solid particle to the gas bubbles. The other solids remain in the liquid. The difference in density between the air bubbles and water provides buoyancy that preferentially lifts the hydrophobic solid particles to the surface where they remain entrained in the froth which can be drained off or mechanically skimmed away thereby effecting separation. Froth flotation is often used to separate solids of similar densities and sizes, particles of size less than 150 mesh which are typically difficult to separate using other mechanical separation techniques. Froth flotation is widely used in the mineral processing industries like coal, iron ore etc [1, 2, 3] and also has found applications in non mineral industries like sewage treatment, water purification, paper de inking [4] and plastic and food processing.

Unlike conventional mechanically agitated flotation cells which tend to use shallow rectangular tanks, column flotation uses tall vessels and for an equivalent volumetric capacity, the surface area of the column is much smaller than the conventional cell. This reduced area is beneficial for promoting froth stability and allowing very deep froth beds to be formed. In a column flotation cell, the solids and the air bubbles flow countercurrent to each other. The attachment of hydrophobic mineral particles to the air bubbles take place in the lower enrichment section of the column between the feed point and air inlet and are known as the flotation zone. The froth from the flotation zone moves to the cleaning zone that is washed with water at the top of the column to remove the entrained particles from the froth. To efficiently operate the froth flotation column, flotation aiding reagents known as collectors, frothers and modifiers are added to the solution. Collectors enhance the hydrophobicity of one of the solid compounds that is otherwise hydrophilic or weakly hydrophobic. Typically hetero polar substances are used as collectors and the commonly used collectors are sodium oleate, xanthanates, dithiophosphates and alkyl sulphuric salts. Frothers are added to promote the formation of stable air bubbles under aeration that are capable of carrying the mineral to the wash section of the cell. Frothers, like collectors are made of both polar and non polar ends. The non polar hydrophobic end orients themselves into the air phase. Bubble wall strength is enhanced by simultaneous strong polar group – water dipole reaction at the air – liquid interface, resulting in greater bubble stability due to localized increase in surface tension. The common group of chemicals that act as frothers are hydroxyl (-OH), carboxyl (-COOH), carbonyl (=C=O), amino ($-NH_3$) and sulfo ($-SO_2OH$) groups. Modifiers include activators, pH regulators, depressants, dispersants and flocculators.

The open literature on the frothing capacity of column flotation column is limited. A review of the flotation column scaleup, circuit and bubble genearation has been carried out by Dobby and Finch [5]. Finch [6] also has reviewed about the various types of flotation columns. The most important parameter that determines the efficiency of operation of the column flotation cell is the froth formation. Yianatos [7] has reported that the separation efficiency of the column flotation to depend on the froth depth. The froth formation is affected by a variety of operational parameters. Tao et al [8] has reported that the froth stability is controlled by the gas flow rate, wash water flow rate, froth height, wash water addition point and the feed solids concentration. Falutsu and Dobby [9] investigated the performance of froth for the operating parameters like gas rate and wash water pipe location. Hasan and Hale [10] compared the performance of column and mechanical flotation cells for coal cleaning and analyzed the effect of frother concentration, collector dosage, froth thickness, wash water flow, air flow rate and feeding rate. The comparison showed the column flotation to be more efficient than their mechanical counterpart. Tavera et al [11] has reported the effect of gas hold up on the column flotation performance. These studies have reported the significance of froth formation on the performance of the column flotation cell. This study was carried out to analyze the effect of various operating conditions on the froth forming capacity of the experimental column flotation cell in our laboratory.

2. Experimental Set up

A laboratory scale column flotation cell was designed and fabricated in the laboratory. The schematic diagram of the experimental setup is given in Fig 1. The column is fabricated of Perspex glass. The column has a internal diameter of 10 cm and is 120 cm long. The top 5 cm of this column protrudes into the froth recovery section which had a diameter of 20 cm and height of 15 cm. an air sparger is placed at the bottom of this section which had a distributor plate having 91 holes of 2 mm each diameter. A conical section is attached to the bottom of the column for tailings recovery. A preconditioning tank is available upstream for mixing of the reagents with the liquid inlet. In the preconditioning tank, sodium carbonate and sodium meta silicate were added as pH regulators and pine oil is added as the frothing agent.

To carry out the experiments, the operational parameters chosen were the water flow rate, air flow rate, pH and frother concentration. The effects of these parameters are analyzed on the froth formation capacity. In the experiment, sodium carbonate and sodium meta silicate are added in the pre conditioner which is constantly agitated. This solution is then send to the feed tank in which pine oil is added and the mixture is mixed thoroughly before feeding into the column at the top. The air flow rate to the distributor is adjusted through a rotameter which controls the rate of aeration. The height of froth formation is noted using the naked eye for the various operating parameters.

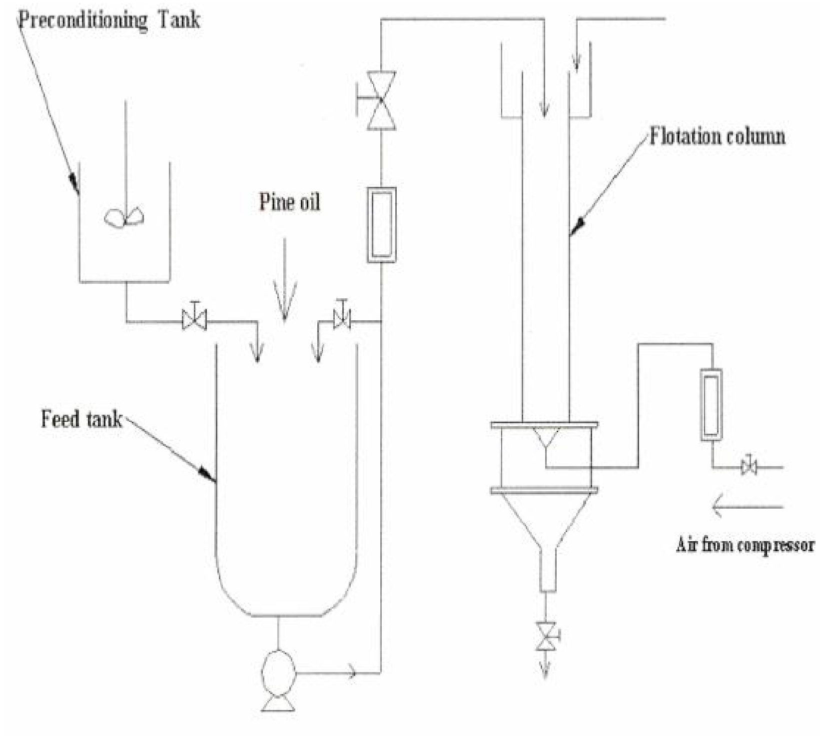

Fig 1 Schematic of the Column Flotation Cell Experimental set up

3. Results and Discussion

The experiments were carried out in the column to analyze the effect of water flow rate, air flow rate, pH and frother concentration on the froth forming capacity inside the flotation cell.

3.1 Effect of water flow rate on froth formation

The experiment was carried out at a constant air flow rate of 1.5 m^3/hr, pH of 8.91 and frother concentration of 0.175 ml/lit. The water flow rate is varied and the height of froth formed was noted down. The variation of froth height with varying water flow rate is given in Fig. 2. The height of froth formation increased with the increase in water flow rate till a flow rate of 0.15 m^3/hr and then decreases with increase in water flow rate. This may be due to the increase in liquid loading leading to breakage of bubbles that are formed. It is found that the optimum liquid flow rate for this column was reached at 0.15 m^3/hr.

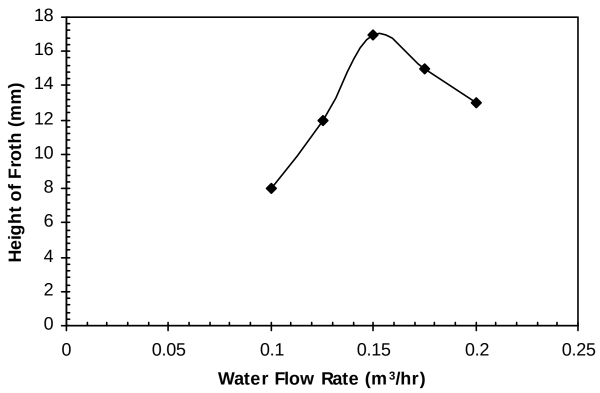

Fig 2 Effect of water flow rate on froth formation at air flow rate of 1.5m^3/hr, pH of 8.91 and frother concentration of 0.175 ml/lit

3.2 Effect of air flow rate on froth formation

Since the optimum water flow rate is obtained at 0.15 m^3/hr, further experiments were carried out with a liquid loading at that value. To study the effect of air flow rate, the liquid flow rate, pH and frother concentration were maintained constant and the air flow rate was increased. The observations of this are depicted in Fig 3. The plot shows that the height of froth increase with increase in flow rate of air. But it was observed that at air flow rates higher than 1.5 m^3/hr, though the formation of froth was more, when the air supply is cut off, the froth vanished suggesting that the bubbles were unstable. In view of the observation it is felt that the optimum air flow rate is 1.5 m^3/hr.

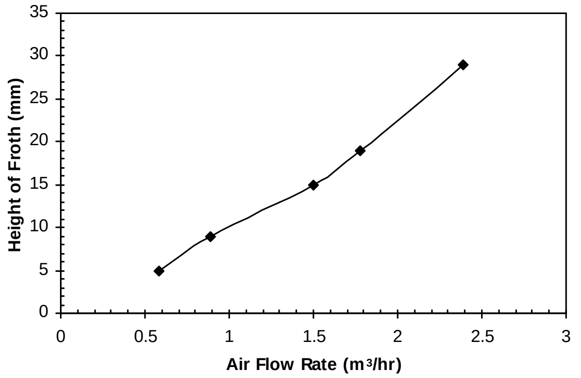

Fig 3 Effect of air flow rate on froth formation at water flow rate of 0.15 m^3/hr, pH of 8.91 and frother concentration of 0.175 ml/lit

3.3 Effect of pH on froth formation

The pH of the solution is varied by varying the quantity of the sodium carbonate and sodium meta silicate and keeping the water and air flow rates constant along with constant frother concentration. The results obtained are plotted in Fig 4. It can be seen that the pH plays a very important role in the formation of froth. With ordinary water even with frothers, there is no froth formation and only on increase in pH does the formation of froth increase. The froth formation increases and then peaks at a pH of 8.91. after this pH, the froth formation drops suggesting that the froth formation is good at a pH of 8.91.

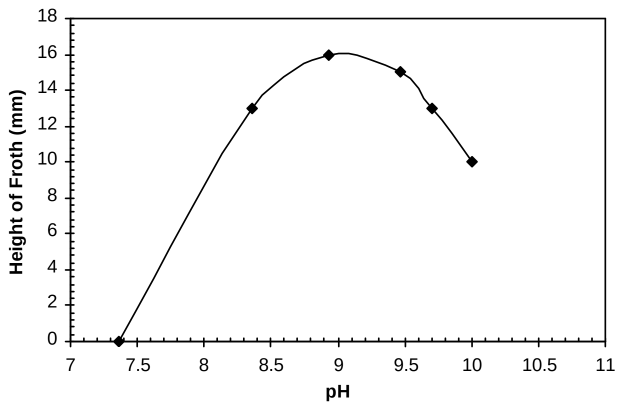

Fig 4 Effect of pH on froth formation at water flow rate of 0.15m^3/hr, air flow rate of 1.5 m^3/hr and frother concentration of 0.175 ml/lit

3.4 Effect of frother concentration on froth formation

The varying quantities of pine oil addition changes the frother concentration of the liquid fed into the flotation column. To study the influence of frother concentration on the froth formation inside the column, the frother concentration is varied in the feed liquid by keeping the water flow rate, air flow rate and the pH of the liquid constant. As seen from the Fig 5, the height of the froth increases with increase in frother concentration till a value of 0.175 ml/lit and then it started decreasing. It can be observed that the decrease in height of froth is very little.

3.5 Effect of frother on gas holdup

To study the effect of gas holdup due to frother addition, the experiments were continued with constant water flow rate, pH and frother concentration/ without frother at varying air flow rates. The results obtained were plotted in Fig 6. It is found from the graph that the gas holdup is more in the case of liquid with frothers than the one without frothers. This shows the positive effect of addition of frothers in the froth flotation column.

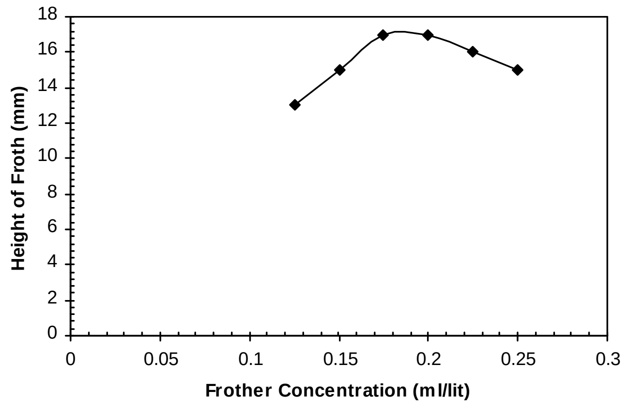

Fig 5 Effect of frother concentration on froth formation at water flow rate of 0.15m^3/hr, air flow rate of 1.5 m^3/hr and pH of 8.91

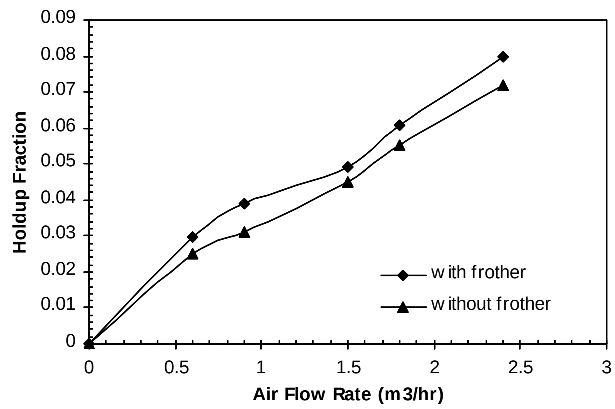

Fig 6 Gas holdup with and without frothers

Thus the water flow rate, air flow rate, pH and frother concentration were found to have a greater influence in determining the successful operation of a column flotation cell. The quantity of froth formation is used as an indicator to optimize the operational parameters for the operation of the column flotation cell.

4 Conclusions

Column flotation cell is a continuous and improved version of the conventional flotation cell and has the advantages of higher grade separation, low operating cost, improved operating stability, reduced maintenance and increased suitability for automatic control. In this study a column flotation cell was designed and fabricated in the laboratory to analyze the influence of operational parameters like water flow rate, air flow rate, pH and frother concentration on froth formation. For the designed column, the froth formation was maximum at water flow rate of 0.15 m^3/hr and air flow rate of 1.5 m^3/hr. The influence of pH on froth formation was analyzed and the frothing peaked at a pH of 8.9. The frother concentration corresponding to maximum froth formation was found to be 0.175 ml/lit. Moreover it was observed that with increase in frother concentration, the gas hold up in the column increased. Thus the effect of the various operating parameters on the froth formation and stability in a continuous column flotation cell were analyzed and the results have been reported.

References

[1] Gursu B., C. Hicyılmaz and S.Bilgen, Beneficiation of fine Bituminous Coal by Column Flotation, Developments in Mineral Processing, 2000, 13, 29 -35.
[2] Flint I.M., H.E. Wyslouzil, V.L. de Lima Andrade and D.J. Murdock, Column Flotation of Iron Ore, Minerals Engineering, 1992, 5(10–12), 1185-1194.
[3] Prabhakar S., G. Bhaskar Raju and S. Subba Rao, Beneficiation of sillimanite by column flotation—a pilot scale study, International Journal of Mineral Processing, 2006, 81, 159–165
[4] Subhashini Vashisth, Chad P.J. Bennington, John R. Grace and Richard J. Kerekes,Column Flotation Deinking: State of the art and Opportunities, Resources, Conservation and Recycling, 201, 55 (12), 1154-1177.
[5] Dobby G. S and J.A. Finch, Column Flotation: A selected Review Part II, Minerals Engineering, 1991, 4 (7-11), 911-923.
[6] Finch J.A., Column Flotation: A Selected Review Part IV – Novel Flotation Devices, Minerals Engineering, 1995, 8 (6), 587-602.
[7] Yianatos J.B., J.A. Finch and A.R Laplante, Selectivity in Column Flotation Froths, International Journal of Mineral Processing, 1988, 23, 279–292.
[8] Tao D., G.H. Luttrell and R.H. Yoon, A parametric study of froth stability and its effect on column flotation of fine particles, International Journal of Mineral Processing, 2000, 59, 25–43.
[9] Falutsu M. and G.S. Dobby, Froth Performance in Commercial Sized Flotation Columns, Minerals Enginering, 1992,5(10-12), 1207-1223.
[10]Hasan Hacifazlioglu and Hale Sutcu, Optimization of some parameters in column flotation and a comparison of conventional cell and column cell in terms of flotation performance, Journal of Chinese Institute of Chemical Engineers, 2007, 38, 287–293.
[11]Tavera F.J., R. Escudero and J.A. Finch, Gas holdup in flotation columns: laboratory measurements, International Journal of Mineral Processing, 2001, 61, 23–40.

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