MINERAL PRODUCERS IMPROVE PLANT PERFORMANCE USING COLUMN FLOTATION TECHNOLOGY

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INTRODUCTION

Column flotation cells were introduced to the market place about thirty ago years as devices capable of producing concentrates that were lower in impurities than those produced by other types of flotation machines. The ability to operate columns with deep froth beds and to wash the froth was the main reasons cited for the improved metallurgical performance. In recent years, many phosphate producers have installed column flotation systems as a means of boosting production whilst reducing operating costs.

HISTORY

G.M. Callow patented the first pneumatic flotation cell, which used air sparging through a porous bottom and horizontal slurry flow, in 1914. The first countercurrent column flotation device was designed and tested by Town and Flynn in 1919. Cross-current pneumatic flotation machines were widely used in industry in 1920's and 1930's, but were later replaced by the impeller-type flotation devices in mineral processing plants. Dissolved-air flotation became the main type of flotation for water treatment applications. These substitutions were the result of the absence of effective and reliable air spargers for fine bubble generation and by the lack of automatic control systems on the early columns. During this period, both the poor flotation selectivity and entrainment of slimes characteristic of impeller-type cells was offset by the use of complex flowsheets using large numbers of cleaner stages and recycle lines. Column flotation devices were re-introduced for mineral processing in the late-1960's in Canada by Boutin and Wheeler (1967) at which time wash water addition to the froth was used to eliminate entrainment of hydrophilic materials to the float product. By the late-1980's column flotation had became a proven industrial technology in the mineral industry. These separators are routinely used on their own or in conjunction with other types of devices within separation circuits.

DESCRIPTION

Column cells (Figure 1) are flotation devices that also act as three phase settlers where particles move downwards in a hindered settling environment countercurrent to a swarm of rising air bubbles that are generated by spargers located at the bottom of the cell. Within the vessel there is a distribution of particle residence times dependent on settling velocity that may impact on the flotation of large particles. Impeller devices do not suffer from this effect to the same degree but do require higher energy input to suspend larger particles.

Mechanism of particle/bubble collision in columns is different from intensive mixing devices such as impeller cells. Under the low-intensity mixing caused only by a rising bubble swarm, particle drift from the liquid streamlines is caused mainly by gravity and inertial forces and also by interception, while in mechanical cells, according to many researchers, bubble-particle collision occurs at their relative movement

FIGURE 1
Typical industrial column flotation cell

FIGURE 2
The use of wash water improves concentrate quality

FIGURE 3
Column flotation plants are inexpensive and compact

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within turbulent vortex or at adjacent vortices. Also, as velocities of both bubble and particle during the attachment are slower under quiescent conditions in a column, the contact time is generally higher. Therefore, probabilities of both collision and adhesion (components of attachment probability) are different than that in mechanical flotation process.

A column can support a deep froth bed and may use wash water (Figure 2) to maintain a downward flow of water in all parts of the vessel. This essentially eliminates the entrainment of hydrophilic particles in the float product when the vessel is used for solid/solid separation. This property, along with the absence of stray flows of feed material to the float product from turbulence, means that column devices are normally superior to impeller type machines for the selective separation of fine particles.

The bubbles used in a column are usually generated within the size range that maximizes interfacial surface flux and collection intensity through the vessel. In mechanical cells bubbles are usually generated by shear action of the impeller; thus, bubble size is dependent on both airflow rate and impeller rotation speed. As such, bubble size cannot be controlled independently of cell turbulence.

The height to diameter ratio of a column is significantly higher than the impeller - type machines. As a result control and consistency of flow is more critical. The column requires much less floor space to operate.

Nowadays, the mineral processing engineer has a wide selection of processes and equipment to choose from when designing a new concentrator. For the flotation section there are many different types of machines available including, self-aspirating or forced air impeller-type cells, column cells, pneumatic cells and a variety of specialty or hybrid designs. In many instances, characteristics of the ore will dictate whether or not certain methods can be applied. In other cases, economic considerations and personal preferences of the operators will prevail.

Metallurgical benefits can be derived in a number of ways. In some cases the metallurgical benefits may be obvious. Improved concentrate grades, improved recoveries and reduced reagent consumption are some of the benefits attributed to column cells. In other cases the benefits may be less clear. With some ores, for example, it is possible to recover a portion of the valuable mineral into a high grade concentrate directly at the rougher stage, thereby reducing the size of the subsequent treatment stages.

For new installations, capital equipment and installation costs can be significantly less that for agitated flotation machines. Table 1 compares the costs for an iron ore flotation project utilizing two different types of equipment: mechanically agitated cells and column cells.

Description		Mechanical Cells		Column Cells	
		Qty	Cost ($US)	Qty	Cost ($US)
Equipment	Flotation Cells	44	$1,760,000	4	$380,000
	Compressor	-	-	3	$240,000
Metal Structure (Fabrication and Erection)		200t	$500,000	65t	$162,000
Civil Works	Concrete	416 m^3	$232,000	240 m^3	$133,000
	Foundations	144t		83t	
Total			$2,492,000		$915,000

Table 1
Investment Requirements: Mechanical Cells vs. Column Cells (Salim, 1996)

Operating cost savings can be realized from reduced power requirements, reduced maintenance costs and in some cases reduced reagent consumption.

• Power costs can be 40 - 50% lower than an equivalent mechanical flotation circuit. Using column flotation it is possible to simplify the process by replacing two to three cleaner stages and associated transfer pumps with a single column producing final concentrate.

• Column cells have very low maintenance requirements and low inventory requirements.

• Reagent savings depend on the nature of the ore being treated and the reagent scheme being utilized. The most significant reductions usually occur with depressants, where it is possible to use wash water to lower impurity levels.

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