IX. FROTH FLOTATION

Froth flotation is a process used to separate minerals, suspended in liquids, by selectively attaching them to gas bubbles. Hence, in flotation we have a three-phase system. The separation principle is based on the lack of affinity of the mineral surface towards water, a property denoted by hydrophobicity. Flotation is undoubtedly the most important and versatile mineral processing technique and applications are being expanded to treat greater tonnages and to cover new areas. It is a selective process and can be used to achieve separation from complex ores such as lead-zinc, copper- zinc etc.

Principles of flotation:

Froth flotation utilises the differences in physico-chemical surface properties of various minerals. After treatment with reagents, such differences in surface properties between the minerals within the flotation pulp become apparent. For flotation to take place, an air bubble must be able to attach itself to a particle and lift it to the water surface. The process can be applied to relatively fine particles. In flotation concentration, the mineral is usually transferred to the froth leaving the gangue in the tailing in direct flotation and in the reverse flotation the gangue is separated into the float fraction leaving the concentrate in the pulp.

In flotation, the minerals can be classified as hydrophobic, i.e., having no affinity towards water and hydrophilic, i.e., having strong affinity towards water. Very few minerals are naturally hydrophobic and the hydrophobic conditions could be achieved by using chemical reagents. Diamonds are naturally hydrophobic and this property is made use of in grease tabling to recover diamonds.

The tensile forces acting on the surface of the particles are responsible for the development of an angle between the mineral surface and bubble surface and this angle is known as contact angle. The flotability of mineral increases with the contact angle. Surfaces with greater contact angles are said to be hydrophobic or aerophilic. Most of the minerals are not water repellent in their natural state and flotation reagents must be added to the pulp to attain selective hydrophobicity of the surfaces. The most important reagents in this regard are collectors. Various other reagents are also used in flotation and are briefly discussed below.

Reagents for flotation process

The reagents employed in flotation are generally interfacial surface tension modifiers, surface chemistry modifiers, and/or flocculants. Usually these are classified as collectors, frothers and modulating agents.

Collectors are reagents that are absorbed on the mineral surfaces to render water repellent property of the surface. The collectors are mainly classified as ionising and non-ionising. The ionising collectors

may be divided into anionic and cationic types. Anionic collectors are characterised by an organic-acid group and are the most important type. The cationic collectors are characterised by the cation. Usually, very small quantities of collectors are used in flotation ranging from 0.2 to about 1.0 kg per ton of material processed.

Frothers are another group of reagents used to obtain the stability of the froth. Frothers are similar to ioninc collectors. Generally, they are heteropolar, surface-active organic reagents capable of being adsorbed on the air-water interface and reduce the surface tension to form a stable air-bubble. Chemically, the frothers may contain any of the groups such as hydroxyl, carboxyl, carbonyl, amino group and sulpho group. The alcohols containing hydroxyl group are most common. Pine oil, cresylic acid, MIBC are widely used frothers.

Modulating agents are chemical additives that modify the environment of the flotation and may be classified into activators, depressants, pH regulators and flocculants.

Activators are chemical compounds, which interact at the mineral surface thus altering its chemical nature to promote its interaction with the collector.

Depressants are chemical compounds, which again alter the mineral surface to prevent or hinder the action of collectors. They are required to depress certain minerals to promote the selective flotation of desired minerals.

pH regulators are used to control the selective separation of the minerals and can be achieved by using a variety of bases and acids.

Flocculants are another class of reagents that may effectively control flotation in certain cases. They are essentially surfactants like collectors but having different effect and hence different application. Their principal characteristic is a polymeric hydrocarbon chain, which bridges together large number of fine particles producing an aggregate of them called flocs. Unlike a single fine particle, a floc may have enough mass for effective flotation and help in recovery of fines through the flotation route.

Flotation Mechanism:

The process of flotation is a sequence of several operations, some of which are done in the preparatory stage and some in the flotation cell itself. The sequences are:

1) Liberation of desired material

2) Absorption of reagents on particle surfaces through conditioning

3) Generation of air bubbles

4) Collision of particles with bubbles and their adsorption

5) Generation of air-water mineral complex in the presence of reagents and

6) Transport of air-water-mineral aggregate to the surface.

Flotation Machines:

Preliminary laboratory test work on few grams could be conducted in Hallimond tube. In this tube the mineral particles are held on a support of sintered glass inside it containing the distilled water and the collector under test. Air bubbles are introduced through the sinter and hydrophobic mineral particles are lifted by the bubbles. The bubbles burst at the water surface allowing the particles to fall into the collecting tube. Commercial flotation machines may be divided in to mechanical cell, pneumatic cell and cyclone cell.

A mechanical cell equipped with a stator and a rotor to keep the mineral particles in suspension and to disperse air supplied (partly by suction and partly by compression) through a central pipe around the shaft for the rotor. The stator may be attached to the air pipe or to the cell walls. Manufacturers of mechanical flotation cells in the industry include Denver equipment, Galigher, Wemco, Outokumpu and Sala. Denver type flotation machines are also being manufactured indigenously in India.

In a pneumatic cell, suspension of solid particles in water is achieved by the compressed air being suitably dispersed throughout the volume of the cell. It employs a perforated grid (or pipes) arranged in an appropriate position near the top of the cell. This arrangement allows a thick bed of froth to be formed. The flotation pulp, appropriately prepared and ready for separation, is fed with a minimum of agitation on top of this bed of froth.

A cyclone cell, into which the feed is delivered (together with air) through a cyclone feeder, under pressure. These are known as air-sparged hydrocyclones. Very few of this type are presently in use.

Operating guidelines in flotation machine

1. Peripheral speed affecting amount of air drawn.
2. Pulp density affecting volume of air and power consumption.
3. Pulp feed point below impeller may create choking.
4. Pulp level affects turbulence and aeration.
5. Frother quantity may affect bubble size and air intake.
6. Impeller and stator position affects air intake and specific power consumption.
7. Mechanism of removal of froth affects the quality of froth.
8. Improper removal of chamber product affects efficiency and quality.

Oleo flotation and oil agglomeration are also prevalent in coal industry. Electro-flotation is a recent development in the recovery of ultra fines. Scope of electro-flotation has also been extended to the field of effluent treatment.