

VI. GRAVITY CONCENTRATION

Gravity concentration process that exploits the differences in densities of minerals to bring about a separation is the oldest beneficiation method known to mankind. Although with the advent of froth flotation, the relative importance of gravity concentration has declined in twentieth century, on an average higher tonnage of material is still treated by gravity concentration than flotation. It finds diverse applications in the treatment of coal, beach sands, iron, gold, diamonds platinum, barite, fluorspar, tin, tungsten ores etc. The gravity separation processes are comparatively cheaper and environment friendly.

Gravity separation of two minerals with different specific gravity is carried out by the relative movement in response to force of gravity and one or more other forces. Normally one of the forces is resistance to motion by a fluid, usually water. Besides the specific gravity, the factors such as size, shape and weight of the particle also affect the relative movement and hence, the separation. The ease or difficulty of separation depends upon the relative differences in these factors.

The Concentration Criteria (CC) which gives an idea of the amenability of separation of two minerals, can be expressed by

$$CC = \frac{(d_H - d_F)}{(d_L - d_F)} \dots\dots\dots(11)$$

where, d_H = Sp. gr. of the heavy mineral
 d_F = Sp. gr. of the fluid, and
 d_L = Sp. gr. of the light mineral.

Generally, when the quotient is greater than 2.5 (whether positive or negative) then gravity separation is relatively easy. With a decrease in the value of the quotient the efficiency of the separation decreases and below 1.25 generally, gravity concentration is not feasible.

As mentioned above, besides the specific gravity, the motion of a particle in fluid also depends on its size. The efficiency of gravity concentration increases with an increase in particle size. The particle movement should be governed by the Newton's Law, Eq. 12

$$v = \left[3gd \frac{(D_s - D_f)}{D_f} \right]^{1/2} \dots\dots\dots(12)$$

where, v = terminal velocity of the particle, D_s = density of the solid, D_f = density of the fluid, and d = diameter of the particle.

For small particle, the movement is dominated mainly by surface friction and these respond poorly to commercial, high capacity gravity separators. To reduce the size effect and for making the relative motion of the particles specific gravity dependent, a closely sized feed is desirable.

There is no single mechanism for the operation of a particular gravity separator. Generally a combination of two or more mechanisms is helpful in explaining the behavior of any separator. The various mechanisms proposed are briefly described below.

Density

The methodology employs a fluid with the apparent density in between those of the minerals to be separated. Hence due to difference in the buoyancy, one mineral floats while the other sinks. The most common example is the heavy medium separation.

Stratification

In this case the minerals are stratified by an intermittent fluidization caused by the pulsation of the fluid in a vertical plane. Examples are various types of jigs used for concentration including Baum and relatively more recent Batac jigs.

Flowing Film

The minerals are separated by the relative movement through a stream of slurry which is flowing down a plane by the action of gravity. Examples are sluice, Richert Cone etc.

In another type of flowing film concentrators, the various constituents are separated by the superposition of a horizontal shear force on the flowing film. Examples are Shaking table, Bartles-Mozley Separator and Cross Belt Concentrator.

Range of the Available Gravity Concentrators

A wide range of gravity separators is available for concentration of various types of ores with feed varying particle size distribution. Besides the cost involved, the important factors in equipment selection are the particle size distribution of the feed, specific duty required, throughput and efficiency of the separation desired.

Recent Developments in Fine Gravity Concentration

As mentioned in the previous section, gravity concentration processes suffer from serious limitations in treating fine particles (typically below 50 micron) efficiently. The factors such as small mass, low momentum, colloidal coating, hetero-aggregation, high surface area, increased surface energy and viscosity cause loss in selectivity of separation. But considering the high loss of values in fines and slimes coupled with the environmental pollution problems, there have been considerable efforts to develop an efficient gravity separator for fines. The various early fine gravity concentrator like Buddles, Stakes, Vanners, Round tables and Round frames were relied upon the principle of thin film concentration and suffer from very low capacity per unit area and the low ratio of enrichment.

In recent times because of their simple design and less maintenance problems, water only cyclones are gaining popularity. The equipment is similar to conventional cyclone except that it has got a large angle lower conical section. This helps in suppressing the classification and leads to separation based on the difference in the specific gravity of the suspended particles. The equipment has been

used for coal preparation but there exists scope for extending its application to lead-zinc, cassiterite, placer deposits of gold etc.

The application of centrifugal forces to heavy media separation, in the D.M.S. Cyclone, Dynawhirpool and the Triflow separator, has increased the range of particle sizes that can be treated down to 200 microns. The recent fine gravity centrifugal separators like Knelson concentrator, Kelsey jig and Multi-Gravity separator (MGS) can treat particles further in the finer size range.