Density

Density is important next to the size of the particle. Density of the particle is defined as the mass of the particle per unit volume. The ratio of the density of the particle to the density of water is defined as specific gravity.
In all beneficiation operations, particularly in Gravity Concentration operations, density, together with the size and the shape of the particles, has an important role.
As the ore contains different minerals, the density of an ore varies depending on the minerals it contains. Before the ore is to be beneficiated, the density of the ore and the density of the different minerals present in the ore are to be determined.

A bulk solid (bulk material) is a combination of particles and space. For a bulk material, the average particle density can be determined by dividing the mass of the material (solids) by the true volume occupied by the particles (not including the voids). This can be determined by using a density bottle.
The stepwise procedure for determination of density of an ore is as follows:

1. Wash, dry and weigh the density bottle with stopper. Let this weight be w_1.
2. Thoroughly dry the ore sample.
3. Add 5–10 grams of ore sample to the bottle and reweigh. Let this weight be w_2.
4. Now fill the bottle with a liquid of known density. The liquid used should not react with the ore.
5. Insert the stopper, allow the liquid to fall out of the bottle, wipe off excess liquid and weigh the bottle. Let this weight be w_3.
6. Remove ore and liquid from the bottle and fill the bottle with liquid alone and repeat step 5. Let this weight be w_4.

$w_2 - w_1$ is the weight of the ore sample.
$w_4 - w_1$ is the weight of the liquid occupying whole volume of the bottle.
$w_3 - w_2$ is the weight of the liquid having the volume equal to the volume of density bottle less volume of ore sample taken.
$(w_4 - w_1) - (w_3 - w_2)$ is the weight of the liquid of volume equal to that of the ore sample.

If ρ_l is the density of the liquid:

$$\text{Density of the ore sample} = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)} \times \rho_l \qquad 11.1$$

Most of the mineral beneficiation operations are wet. Water is added to the ore particles to aid beneficiation. The mixture of water and solid particles is known as **Pulp**.
Other terms commonly used are:
Suspensionعالق: When the solid particles are held up in the water, the pulp is called suspension.
In other words, in suspension, the solid particles are well dispersed throughout.
Slurryوحل: A mixture of fine solids (slimes) and water.
Sludgeحمأ: Thick pulp i.e., pulp with less quantity of water.

Pulp or slurry density is most easily measured in terms of the weight of the slurry per unit volume (gm/cm3 or kg/m3). A sample of slurry taken in container of known volume is weighed to give slurry density directly. Marcy Scale available in the market gives direct reading for the density of the slurry and % solids in the slurry.
The composition of a slurry is often represented as the fraction (or percent) of solids by weight. It is determined by sampling the slurry, weighing, drying and reweighing.

One of the most effective techniques used for the separation of fine solid particles is sedimentation. Sedimentation is the act of the settling of solid particles in a fluid medium under the force of gravity. A few observations in everyday life indicate that there are natural forces which can, under control, be used in the mineral beneficiation field to separate one mineral from another or to separate a solid from a fluid. The following are some examples:

1- If a stone and a feather are dropped from the same height in air, the stone lands first – due to the difference in shape causing different resistances.

2- Sawdust floats and sand sinks in a pail of water – due to the difference in the specific gravities of the three materials.

3- The texture of a river bottom becomes finer as one approaches the river mouth.

All the above examples are uncontrolled manifestations of forces of gravity and fluid resistance. If controlled, these forces can be used in mineral beneficiation to effect the required separation.

جم

12.1.1 Free settling

In a large volume of fluid, the particle settles by its own specific gravity, size and shape and uninfluenced by the surrounding particles as the particles are not crowded. Such a settling process is called **Free settling**. Free settling predominates in well dispersed pulp where the percent of solids by weight is less than 10. Figure 12.1 (a) shows how the particles of different sizes and two specific gravities settle under free settling conditions.

Figure 12.1 (a) Free settling; (b) Hindered settling.

12.1.2 Hindered settling

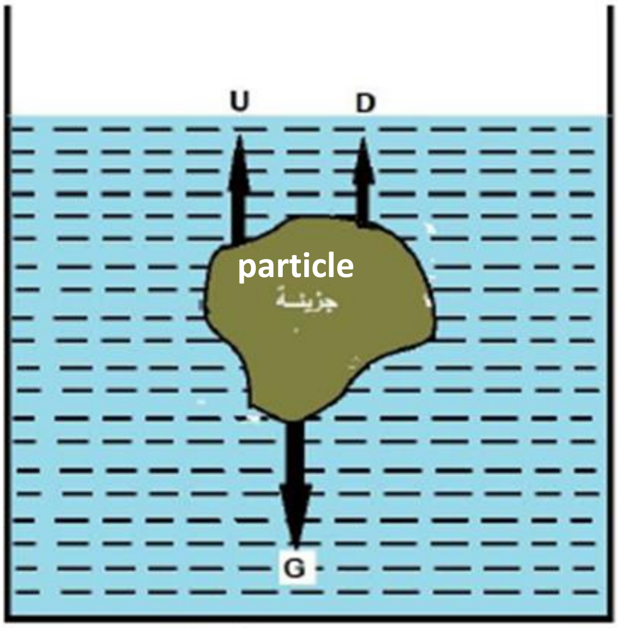
When the particles settle in a relatively small volume of fluid, they are crowded in the pulp and are very close to each other. As a result, the settling of a particle is influenced by surrounding particles. Such a settling process is called **Hindered settling**.

In this type of settling, particles collide with each other during their settling and this collision affects their settling velocities. Thus lower settling velocities are encountered.

Hindered settling predominates when the percent of solids by weight is more than 15. Figure 12.1 (b) shows how the same particles, as considered in free settling, settle under hindered settling conditions. By comparing (a) and (b) in Figure 12.1, it
is evident that the heavier (or lighter) particles can be separated when they settle by hindered settling. This is possible because hindered settling reduces the effect of size and increases the effect of specific gravity.

12.1.3 Equal settling particles

Particles are said to be equal settling if they have the same terminal velocities in the same fluid and in the same field of force.



When movement of particle Increase the viscosity force (D) increase toward top and when velocity be zero D= G-U return to same movement and continue fall in staff velocity until stay in the bottomless. This call terminal velocity it is depended on weight of particles minerals (size and shape), while particles have different shape and size (between 10-300 micron) so it is impossible to be stable inside liquid, when the size of particle is large the terminal velocity is large and the velocity of fall down is large too.

From the previous law we conclude:

1-when density of mineral particles equal the large size particle deposits More velocity than the smaller.
2- when diameter of mineral particles equal the high density particle fall down more velocity than the smaller.
3- when density and size of mineral particles equal the regular particle fall down more velocity than the irregular.

13.1 CLASSIFIERS

The units in which the separation of solids in fluid medium is carried out are known as classifiers. These classifiers may be grouped into three broad classes as:
1 Sizing classifiers.
2 Sorting classifiers.
3 Centrifugal classifiers.

13.1.1 Sizing classifiers

A typical sizing classifier consists of a sloping rectangular trough. Feed slurry is introduced at point 1 as shown in Figure 13.2 fines overflow at point 2. The rate of feed and distance between point 1 and point 2 is selected in such a way that the rate of travel of required fine particles must be more than the rate of their settling so that all the required fine particles overflow at point 2.

The coarse particles settle to the bottom.To remove these coarse particles, a mechanical means such as spiral or rake is placed at the bottom of the trough. Figure 13.3 shows how the particles are separated in Spiral and Rake classifiers.

Sizing classifiers are the mechanical classifiers. Since the stream of slurry consists of fines flow horizontally from the feed inlet to the overflow weir, these are also called as horizontal current classifiers.

They are also called pool classifiers as the classification takes place in the pool. These classifiers are extensively used in closed circuit grinding operation with a ball mill where underflow coarse product is directly fed to the inlet of the ball mill. Another type of classifier is of tank type such as Dorr Bowl.

These classifiers are:

- Free settling classifiers.
- Uses relatively dilute aqueous suspension.
- Perform mostly sizing.
- Percent solids are usually 5–10%.
- Yields only two products.

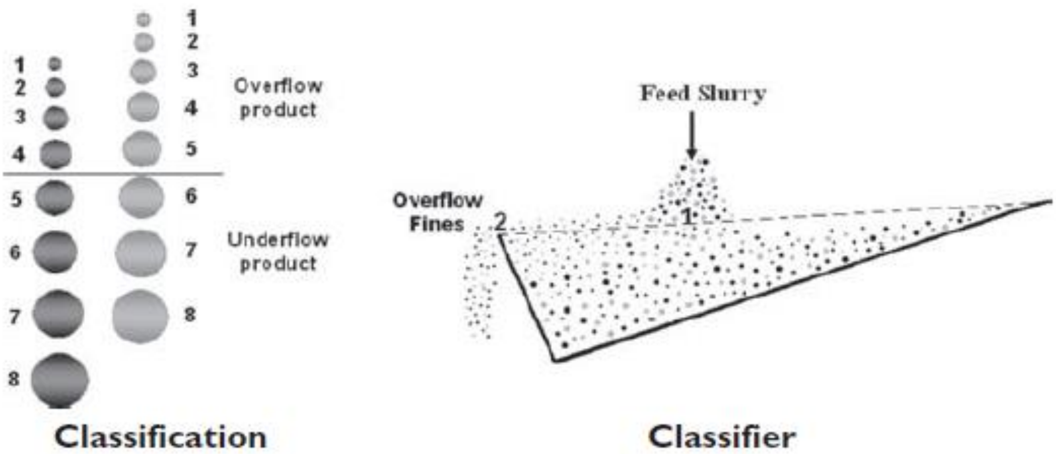


Figure 13.2 Principle of a mechanical classifier.

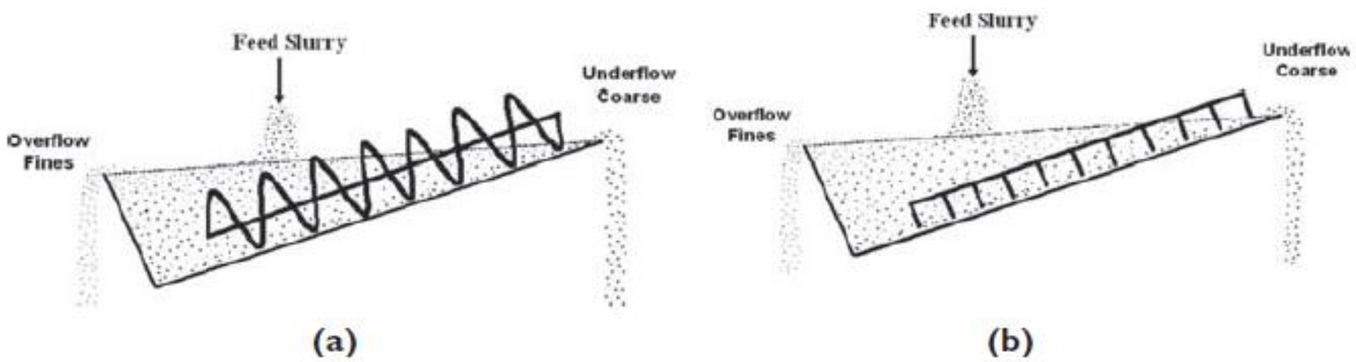


Figure 13.3 (a) Spiral classifier; (b) Rake classifier.