# V. CLASSIFICATION

Classification is a method of separating of minerals into two or more products on the basis of size. In coarse size range this may be achieved under dry conditions. However, starting from grinding most operations are generally performed under wet conditions in mineral processing. When a solid particle falls in fluid (water) medium there is resistance to this movement and the value increases with velocity. When equilibrium is attained between the gravitational and fluid resistances forces, the body reaches its terminal velocity and thereafter falls at a uniform rate. This terminal velocity is function of the particle size and density.

Classifiers consist essentially of sorting column in which a fluid is rising at a uniform rate. Particles introduced into the sorting column either sink or rise according to whether their terminal velocities are greater or less than the upward velocity of the fluid. The sorting column therefore separates the feed into two products - an overflow consisting of particles with terminal velocities less than the velocity of the fluid and an underflow of particles with terminal velocities greater than the rising velocity.

Classifiers are divided mainly into two broad classes depending on the direction of flow of the carrying current. Horizontal current classifiers such as mechanical classifiers, spiral classifiers, rake classifiers are essentially of the free settling type. Vertical current or hydraulic classifiers such as elutriators, hydrocyclones, hydrosizers are usually of hindered settling types. Sieve bends are also commonly used for classification.

## Hydrocyclone

Hydrocyclones (Figure-5) are continuously operating classifying devices that utilise centrifugal forces to accelerate the settling rate of particles. It is one of the most important devices used in the mineral

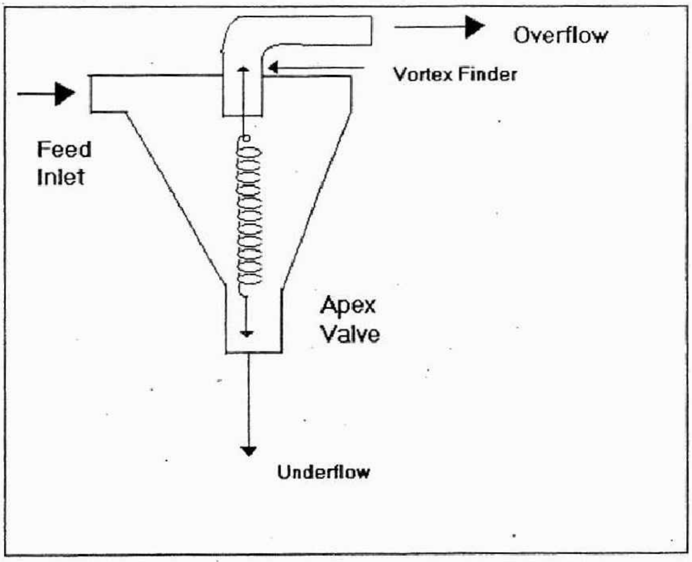


**Fig. 5 :** Schematic of a hydrocyclone classifier

industry. Hydrocyclones operate under pressure. The feed, a mixture of water and solids, enters the hydrocyclone tangentially through the inlet, which forces the mixture to spin inside the cyclone. This spinning motion generates centrifugal forces, which cause the air to disengage quickly and exit through the vortex finder.

The liquid passes down into the conical section where the reduction in diameter accelerates the fluid thus generating centrifugal forces strong enough to cause the solids to separate from the liquid. The larger particles are forced towards the wall because of greater mass and then travel down the length of the conical section of the hydrocyclone in a spiral pattern towards the solids outlet, termed the underflow. The liquids migrate towards the center of the hydrocyclone where the flow reverses and moves upwards towards the overflow through the vortex finder. The finer particles do not get centriguged towards the peripheri due to their smaller mass and hence accompany the liquid to the overflow. Thus a separation of larger size particles from smaller size ones are achieved.

The commonest method of representing cyclone efficiency is by a performance curve or partition curve as shown in the Figure-6. This relates the weight fraction or percentage of material in each size in the feed that reports to the apex or underflow to the particle size. The cut point or separation size of the cyclone is often defined as that point on the partition curve for which 50% of particles in the feed of that size reports to the underflow. Particles of this size have an equal chance of going either with the overflow or underflow. This point is usually referred as the $d_{50}$. The sharpness of the cut depends on the slope of the central section of the partition curve; the closer to vertical is the slope, the higher is the efficiency. The slope of the curve can be expressed by taking the points at which 75% and 25% of the feed particles report to the underflow. These are the $d_{75}$ and $d_{25}$ sizes, respectively. The efficiency of separation or the so called imperfection I, is then given by

$$I = (d_{75} - d_{25}) / 2d_{50} \qquad \text{.......................(9)}$$

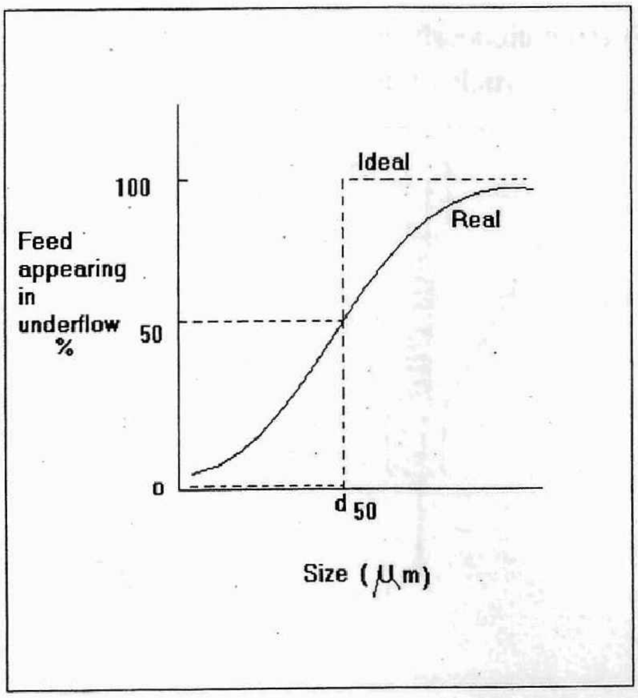


**Fig. 6 :** Partition curve of a hydrocyclone

Several factors affect the performance of a hydrocyclone. The effects of changing operating and design parameters are given below in the Table-3.

**Table 3 :** Factors affecting hydrocyclone performance

| Parameter | Change | Effect | Reason |
|---|---|---|---|
| Vortex Finder diameter | Increase | Decrease Efficiency | More likely to suck particles up |
| Pressure Drop | Increase | Increase Efficiency | Flow rate increases, Increase in G forces |
| Apex diameter | Increase | Prevents Overload, And in the extreme case decreases efficiency | Causes flushing of particles and fluid |
| Feed Flow Rate | Increase | Increase Efficiency | Increase G forces |
| Vortex Finder length | Increase | Decrease Efficiency | More likely to suck particles up |
| Cyclone dia. | Increase | Decrease Efficiency | Decrease G forces |
| Cyclone Length | Increase | Increase Efficiency | Residence time increases |
| Particle size | Increase | Increase Efficiency | More likely for particle to migrate to exterior wall |

There are a number of empirical relationships that are used by designers in predicting performance and designing cyclones. There are different equations to calculate the cut-point $d_{50}$. Plitt's equation is one of the most important of them:

$$d_{50} = \left[14.8 D_c^{0.46} D_i^{0.6} D_o^{1.21} \exp(0.063V)\right] / \left[D_u^{0.71} h^{0.38} Q^{0.45} (S-L)^{0.5}\right] \qquad \text{.........................} (10)$$

Where, $d_{50}$ is the cut point (μm), $D_c$ is the cyclone diameter, $D_o$ is overflow diameter, $D_i$ is inlet diameter, V is the volumetric percentage of solids in feed, $D_u$ is the underflow opening diameter, h is the effective cyclone length, Q is total volume flow rate, S and L are specific gravity of solids and liquid respectively.