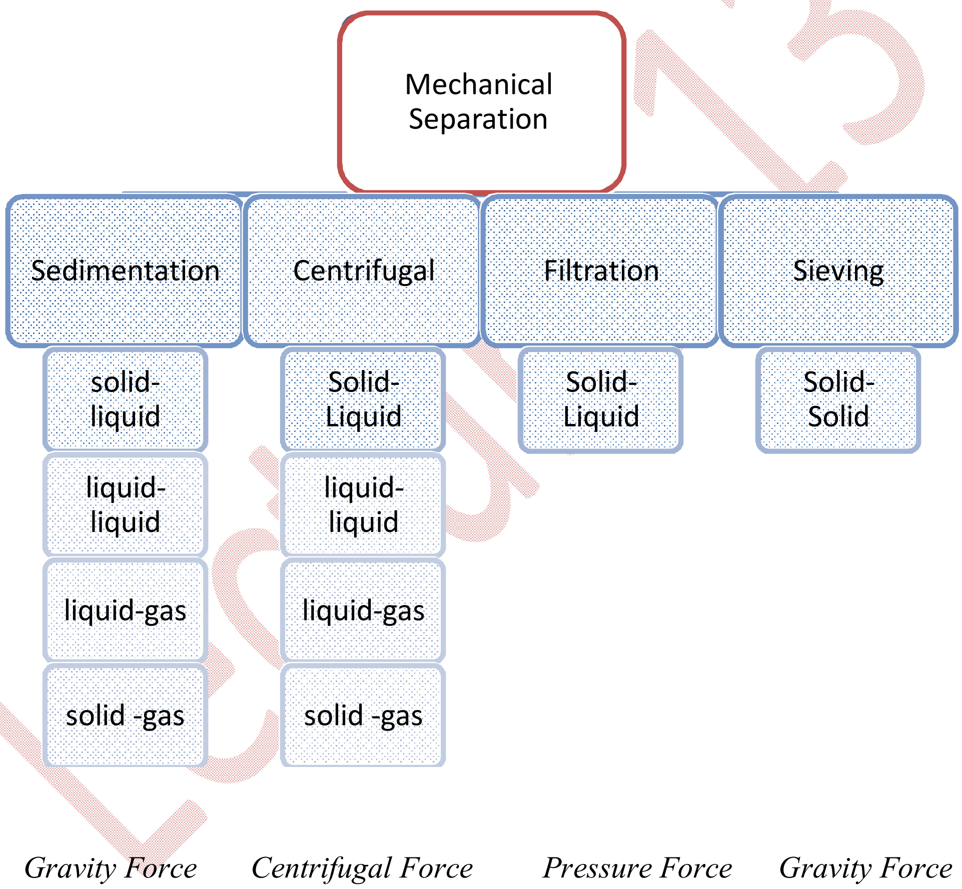
MECHANICAL SEPARATIONS

Mechanical separation of particles from a fluid uses forces acting on these particles. So the separating action depends on the character of the particle being separated and the forces on the particle which cause the separation. Mechanical separations can be divided into four groups;



Sedimentation

Introduction

In setting and sedimentation the particle are separated from the fluid by gravitational forces acting on the particles .

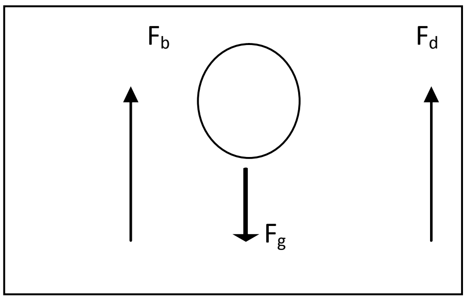
Free setting : when a particles is at a sufficient distance from the walls of the container and from other particles so that its fall is not affected by then .(The ratio of the particle dia. to the container dia. is less than 1/200 or if the particle cen. is less than 0.2vol % in the solid) .

Hindered setting : when the particles are crowded , the settle alower rate . The separation of a dilute slurry or suspension by gravity setting in a clear fluid and a slurry of higher solids content is called sedimentation .

Gravitational sedimentation

Reminal falling (setting) velocity of a particle

Forces Balance :



gravitation Force = Bouyancy force + Dray force

$$F_g = F_b + F_d$$

$$V_S \rho_s g = V_S \rho g + C_D A_{Proj} . \frac{\rho U_t^2}{2}$$

$$V_s g(\rho_s - \rho) = C_D A_{Proj} . \frac{\rho U_t^2}{2}$$

For spherical particle

$$Vs = \frac{\pi}{6} d_s^3$$

$$A_{proj} = \frac{\pi}{4} d_s^2$$

$$\frac{\pi}{6} d_s^3 \, g \, (\rho_s - \rho) = \frac{\pi}{4} d_s^2 \, C_D \, . \frac{\rho U_t^2}{2}$$

$$U_t = \sqrt{\frac{4 d_s (\rho_s - \rho) g}{3 C_D \, \rho}}$$

terminal falling (setting)

velocity of spherical particle

where :

U_t : terminal falling velocity (m/s)

D_s : dia. of solid particle

A_{proj} : projected area of solid particle (m^2)

ρ_s : density of solid (kg / m^3)

ρ : density of fluid (kg / m^3)

C_D : dreg coeff.

g : gravitational acc. (m/ s^2)

In the deriving the terminal falling velocity eq. it has been ass.

a) That the setting is not affected by the presence of other particles in the fluid (i.e. free setting) .
b) The walls of the container a enatexert an appreciable retarding effect .
c) The fluid can be considered as a continuous modia .

C_D is a function of Reynolds num. of particle $(Re)_p$ where :

$(Re)_p = (\rho \; U_t \, d_s / \mu)$

For a flow of $(Re)_p < 0.2$ around a spherical particle stokes obtained the following formula from theoretical consideration

$$F_d = 3\pi \, d_s \, \mu \, U \qquad \text{stokes law}$$

Where :

$$C_D A_{Proj} . \frac{\rho U_t^2}{2} = 3\pi \, d_s \, \mu U_t$$

$$C_D . \frac{\pi}{4} d_s^2 . \frac{\rho U_t^2}{2} = 3\pi \, d_s \, \mu U_t$$

$$C_D = \frac{24 \, \mu}{\rho U_t d_s} \rightarrow C_D = \frac{24}{(Re)_p} \qquad \text{for } (Re)_p < 0.2$$

Sub. Interminal velocity eq. gives

$$U_t = \frac{d_s^2 (\rho_s - \rho) g}{18 \, \mu}$$

(stokes eq. for steady streamline flow past a sphere $(Re)_p < 0.2$)

For non – spherical particle , the terminal falling velocity eq. can be written in the modified formas

$$U_t = \sqrt{\frac{4\varphi d_s(\rho_s - \rho)g}{3C_D\,\rho}} \qquad \text{(for non-spherical particle)}$$

φ : sphericity