Unit-1

Pharmaceutical Engineering

UNIT-I

- **Flow of fluids:** Types of manometers, Reynolds number and its significance, Bernoulli's theorem and its applications, Energy losses, Orifice meter, Venturimeter, Pitot tube and Rotometer.
- **Size Reduction:** Objectives, Mechanisms & Laws governing size reduction, factors affecting size reduction, principles, construction, working, uses, merits and demerits of Hammer mill, ball mill, fluid energy mill, Edge runner mill & end runner mill.
- **Size Separation:** Objectives, applications & mechanism of size separation, official standards of powders, sieves, size separation Principles, construction, working, uses, merits and demerits of Sieve shaker, cyclone separator, Airseparator, Bag filter & elutriation tank.

Flow of fluids: Types of manometers, Reynolds number and its significance, Bernoulli's theorem and its applications, Energy losses, Orifice meter, Venturimeter, Pitot tube and Rotometer.

Flow of fluids:

- The flow of substances that do not resist distortion permanently is termed fluid flow or flow of fluids. Characteristic property of fluids is that they deform or flow continuously under an applied shear stress.
- Fluids denote the phases of matter like gases, liquids, plasma, and to some extent plastic solids.
- The distinction between solids and fluids is made by evaluating the viscosity of the substance.

For example:

- If you are pouring water from a mug, the velocity of water is very high over the lip, moderately high approaching the lip, and very low at the bottom of the mug.
- The unbalanced force is gravity, and the flow continues as long as the water is available and the mug is tilted.

Fluid pressure –

- The pressure which is applies by the fluid.
- Also known as hydrostatic pressure

Pressure:

$$\text{Pressure}\frac{\text{Force}}{Area} = \frac{\text{f}}{a} = \frac{\text{Mg}}{A}$$

$$P = \frac{\text{Force}}{A} = \frac{\text{Mg}}{A}$$

$$\text{P} = \rho\text{hg}$$

Application of Flow of Fluids:

- To transfer air and nutrient broth into the fermenter,
- For passing of reactant (liquid or gases) into the reaction apparatus,
- During packaging and bottling of medicament (mainly liquid and semisolid dosage form),
- For mixing of solids and liquids to form a suspension, and
- To transfer sterile air and water while preparing parenteral.

Fluid flow can be studied under the following two headings:

1) **Fluid Statics:** It is the study of fluids at rest in equilibrium stage.
2) **Fluid Dynamics:** It is the study of fluids in motion.

Manometer:

It is a devices which is used to measure pressure difference.

Type of Manometer:

1. Simple manometer
2. Differential Manometer

1. Simple manometer-
   - These are those manometers which measure the pressure at any point is a tube etc.
   - Simple Manometers: These manometers are made up of glass tubes. One end of these remains open to the atmosphere and the other end are connected to a point where pressure is to be measured.
     Ex. U-tube manometer

U-tube manometer:

- A U-tube manometer is a simple device used to measure pressure. It consists of a U-shaped glass tube filled with a liquid, typically mercury.
- One leg of the tube is connected to the system whose pressure is to be measured, while the other leg is open to the atmosphere. When there is no pressure difference between the two legs, the liquid levels in the two legs will be equal.
-

The pressure at point B is given by:

$$P = \rho_2 g h_2 - \rho_1 g h_1$$

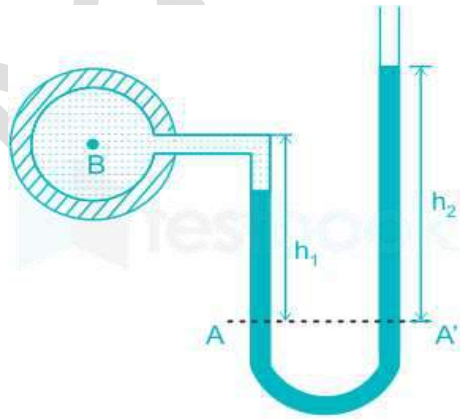
Where

ρ_1 = density of light liquid

h_1 = height of light liquid above reference line.

ρ_2 = density of heavy liquid

h_2 = height of heavy liquid above reference line



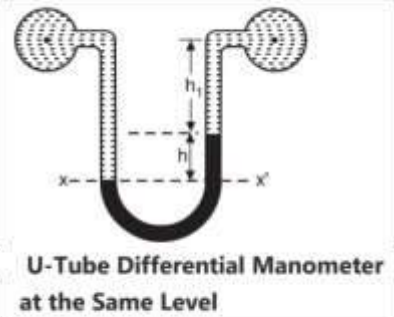
2. Differential Manometer

- A differential manometer is a device that measures the difference in pressure between two places.
- They can range from simple to complex digital equipment.
- Standard manometers are used to measure the pressure in a container by comparing it to normal atmospheric pressure.
- Differential manometers are also used to compare the pressure of two different containers

Example: U-tube differential manometer

U-tube differential manometer:

- As shown in the picture, the point of measurement is attached to one end of a glass tube curved into a V while the other end is exposed to the atmosphere.



U-Tube Differential Manometer at the Same Level

U-Tube Differential Manometer at the Different Level

- The two ends are linked to the two spots in the pipe where a pressure differential is necessary. Allow pressure at point A to be greater than pressure at point B.
- The higher pressure at A will then cause the heavier liquid in the U-tube to travel downward. Due to this effect, the heavy liquid in the right limb will ascend, causing the heavy liquid in the left limb to descend

Reynolds number:

- The Reynolds number is a dimensionless quantity that is used to determine the type of flow pattern as laminar or turbulent while flowing through a pipe.
- It is defined by the ratio of inertial forces to that of viscous forces.
- The Reynolds number (Re) is given by the following formula:

$$Re = \frac{\rho VD}{\mu}$$

Where:

- ρ is the density of the fluid
- V is the velocity of the fluid
- D is the characteristic length of the flow (e.g., the diameter of a pipe)
- μ is the viscosity of the fluid

- It gives that flow is steady or tubulent
- It Re <1000 then flow is steady.
- It Re>2000 aprox then it is turbulent.

Significance:

- The Reynolds number is that it can be used to predict the type of flow that will occur in a given situation.
- This information can be used to design and optimize fluid systems to ensure that they operate efficiently and safely.
- It also used to study the sedimentation rate

Bernoulli's theorem:

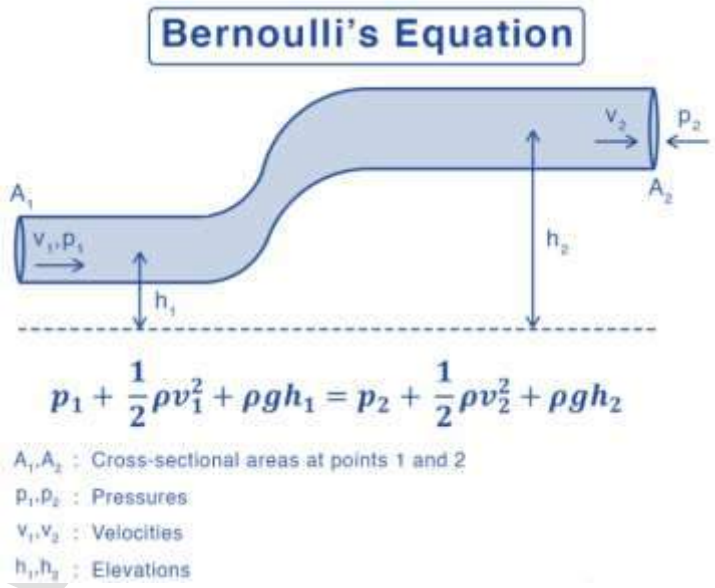
- Bernoulli's equation allows us to estimate the flow rate of fluid through a pipe.
- Bernoulli's theorem is a principle in fluid dynamics that states that the total energy of an ideal fluid in a steady-state flow remains constant. This means that the sum of the fluid's pressure energy, kinetic energy, and potential energy per unit mass is constant at all points in the flow.
- The theorem was first proposed by Daniel Bernoulli in 1738.

The formula for Bernoulli's theorem is:

$$P + 1/2\ \rho v^2 + \rho gh = \text{constant}$$

Where:

- P is the pressure of the fluid
- ρ is the density of the fluid
- v is the speed of the fluid
- g is the acceleration due to gravity
- h is the height of the fluid



The constant on the right-hand side of the equation represents the total energy of the fluid, which is conserved as the fluid flows.

Applications:

- It can be used to calculate the lift force on an airfoil, if the behaviour of the fluid flow in the vicinity of the foil is known.

Energy losses:

The change in velocity of the fluid in a flow (either in magnitude or direction) induces large scale turbulence due to formation of eddies.

1. Friction losses
2. Loss in fitting
3. Enlargement losses
4. Contraction losses

1. Friction losses:

During of fluids in pipe some friction apply on fluid by the walls of pipe and it oppose the flow and during this some energy loss.

Hagen poiseuille equation:

$$\Delta Pf = \frac{32\mathrm{L}\mu u}{D^2}$$

Where:

ΔPf: friction loss

L: Length of pipe

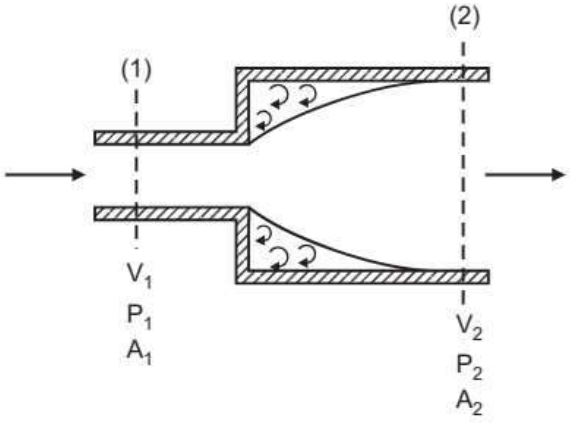
μ: velocity of fluid

u: viscosity of fluid

D: Diameter

2. Enlargement losses:

When we increases the pipe size then there are changes of some velocity due to this energy loss occurs.



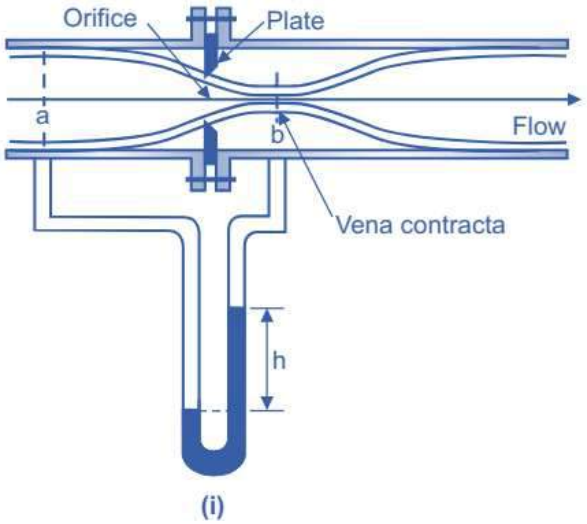
$$\Delta He = \frac{(V_{1-}V_2)}{2_g}$$

Rate of Flow of fluids:

- Orifice meter,
- Ventury meter,
- Pitot tube
- Rotometer.

Orifice meter:

The orifice meter is made-up of stainless steel, phosper bronze, nickel and monel. An orifice meter provides a simpler and cheaper arrangement for the measurement of flow through a pipe.



Formula:

$$\mu_0 = \mathrm{Co}\sqrt{2_g \Delta H}$$

Where:

μ0= Velocity of fluid

Co= Constant

2g= gravitation force

ΔH= Pressure difference

So we can find ΔH= Pressure difference through the manometer which we attached on pipe

Put the value of pressure difference on oritic meter formula we find out the velocity of fluid easily.

Uses:

- The concentric orifice plate is used to measure flow rates of pure fluids.
- The eccentric and segmental orifice plates are used to measure flow rates of fluids containing suspended materials such as solids, oil mixed with water and wet steam.

Advantages:

- It is very cheap and easy method.
- It has predictable characteristics and requires less space.
- It can be used to measure flow rates in large pipes.

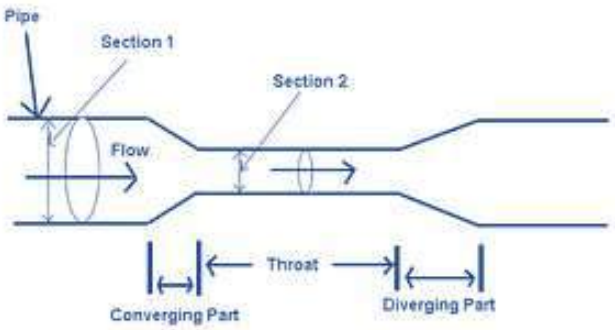
Disadvantages:

- Maintenance problem
- Poor accuracy

Venturimeter:

- Venturi meter is a flow measurement instrument or device used to measure discharge through a pipe.
- It is based on Bernoulli's principle.

Construction:



Venturimeter

- It consist of two tapered section inserted in a pipeline with constriction at meter's centre.
- The upstream cone is normally shorter than the downstream.
- The tapers are smooth and gradual.
- A monometer is connected at point A and B to measure the pressure difference.

Applications:

- Venturimeter can be used for the measurement of flow of water, liquids, gases, dirty liquids etc.
- They are commonly used in water supply industry.

Advantages:

- It has low head loss of about 10% of differential pressure head.
- It can measure higher flow rates in pipes having few meters of diameters due to high coefficient of discharge owing to lower loss.
- It is suitable for use in any position, for example, horizontal, vertical or inclined.
- Higher sensitivities can be achieved due to smaller size throat which leads to higher pressure differential.

Disadvantages:

- It has space limitations due to larger size.
- Due to large size, the cost of venturimeter is higher

Pitot tube:

- The principle of flow measurement by Pitot tube was first used for measuring velocities of water in the river.
- A right angled large glass tube was used for the purpose.
- One end of the tube faces the fluid flow while the other end remains open to the atmosphere,

Applications:

- It is widely used to measure the airspeed of aircrafts, speedboat speed and for fluid flow measurement in industrial application.
- Pitot tubes are mainly used for gas lines.
- These may be employed where the flowing fluid is not enclosed in a pipe or duct. For example, for measuring the flow of river water, or for measuring air flow in aero plane.

Advantages:

- Pitot tube is small and do not contain any moving parts.
- Low permanent pressure loss.
- Loss of head is negligible by insertion of Pitot tube.
- It is very cheap as compared to venturi meter, orifice plate and flow nozzle.
- Ease of installation into an existing system.

Disadvantages:

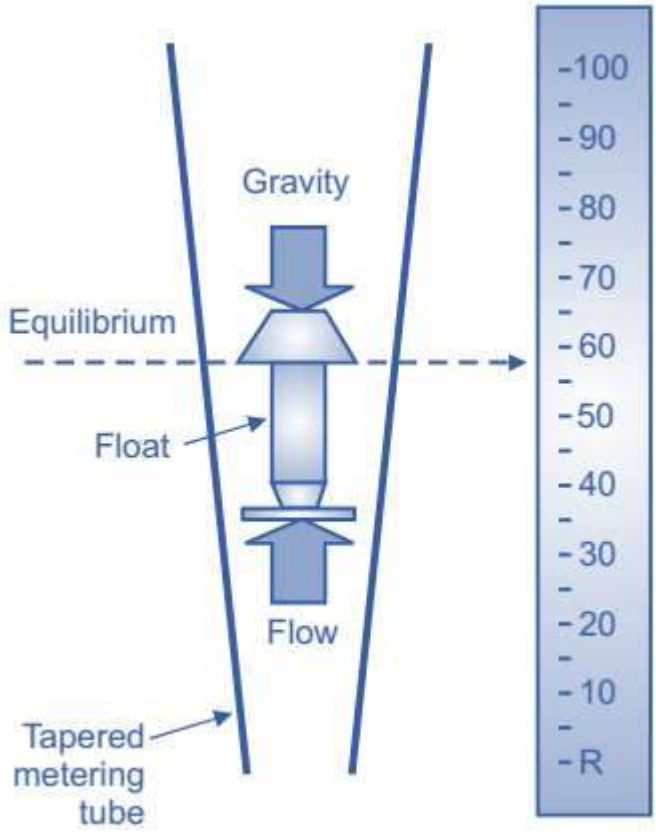
- The differential pressures produced are usually low, say of the order of 250 Pa, and so their sensitivity is low.
- Pitot tube requires higher flow velocity in order to produce measurable heads.

Rotometer

- A rotameter is a device that measures the volumetric flow rate of fluid in a closed tube.
- It measures flow rate by allowing the cross-sectional area the fluid travels through to vary, causing a measurable effect.

Construction:

- It consists of vertical tapered tube which is mounted with a narrow end down.
- The tube is usually made of glass on which a linear scale is etched.
- A solid plummet is placed in the tube (diameter smaller than narrow end of tube)
- Plummet/ float may be made of lead, aluminum, glass and plastic.



Applications:

- The rotameter is used in process industries to measure fluid flow rates.
- It is used for monitoring gas and water flow in plants or labs.
- It is used for monitoring filtration loading.

Advantages:

- It has good accuracy for low and medium flow rates.
- The pressure loss is nearly constant and small.
- It can be used for corrosive fluids.

Disadvantages:

- It is not suitable for opaque fluids as float may not be visible through them.
- Glass tube may be subjected to breakage.

Size Reduction: Objectives, Mechanisms & Laws governing size reduction, factors affecting size reduction, principles, construction, working, uses, merits and demerits of Hammer mill, ball mill, fluid energy mill, Edge runner mill & end runner mill.

Size Reduction:

- It is the process of reducing drugs size in smaller particles, or fine powder.
- The term size reduction is applied to ways in which particles of solids are cut or broken into smaller pieces.
- Size reduction is necessary if the starting material is too coarse, and final product needs to be a fine powder.

Objectives:

- To improve the stability of certain pharmaceutical dosage forms such as suspension the rate of sedimentation decrease to a large extent by reducing the particle size of the drug.
- To help in the process of separation of the solid from liquids by filtration by the rate of filtration depend upon the particle size.
- To increase the rate of absorption of a drugs the smaller particle size the greater is the rate of absorption.
- To increase the rate of solution is case of chemical substance become reduction of the particle size increases the surface area for the action of solvent.
- Due to size reduction, we are design the different type of drug dosages form (tablets, capsules, suspension and emulsion etc).

Mechanisms of Size Reduction.

- Cutting
- Compression
- Impact
- Attrition

1. **Cutting.** - The material is cut on a small scale by means of a sharp blade knife, root cutter or other any sharp instruments on a large scale a cutter mill is used cutting of the drug is usually done to hasten the drying of drugs.
   Example: Cutter Mill ,

2. **Compression.** In this method the material is crushed by the application of pressure on a small scale using mortar and pestle where as on a large scale roller mill is used.
   Example: Roller mill,

3. **Impact.** This involves hitting the material with a hammer or other object at high speed. This causes the material to shatter into smaller pieces.

Example: Hammer Mill, Ball Mill

4. **Attrition.** This involves rubbing the material against a hard surface. This causes the material to grind down into smaller pieces. This is a good mechanism for reducing the size of tough materials, such as metals.

Laws governing size reduction:

The energy needed to produce a slight change in the size of the material's unit mass can be expressed as a power function of the size of the material, i.e.

$$\frac{dE}{dx} = -\frac{K}{x^n}$$

Where,
dE = Change in energy
dx = Change in size
K = Constant
x = Particle size

Equation (1) is known as the general law of comminution. This equation is useful for many workers to derive other specific and more appropriate laws depending on the application.

Kick's law:

According to this law, energy required to reduce size of particle is proportional to ratio of initial size of a typical dimension to the final size of that dimension

$$E = K_K In\left(\frac{d_1}{d_2}\right)$$

Where
E-energy required per mass of feed
K_k - Kick's constant
d_1 = average initial size of pieces (m) d-average size of ground particles (m)
d_1/d_2 = is size reduction ratio (RR), and it is used to evaluate relative performance of different type of equipments. Coarse grinding has RR value below 8:1 while in fine grinding ratio can exceed 100:1.

Application: Kick's law gives reasonably good results for coarse grinding where there is a relatively small increase in surface area per unit mass.

Rittinger's law:

This law states that the energy required for the size reduction of unit mass is proportional to the new surface area produced.

$$E = K_R \left(\frac{d_1}{d_2}\right)$$

Where
E-energy required per mass of feed
K_R-Rittinger's constant
d_1-average initial size of pieces (m)
d_2-average size of ground particles (m)
1d=s (surface area)
So equation will become

E-K_R (Sn-Si)

S is initial specific surface area
S, is new surface area

Application:
Rittinger's law gives better results with fine grinding where there is a much greater increase in surface area.

Bond's Law

This law states that energy used for size reduction is proportional to new crack length.

$$\frac{E}{W} = \sqrt{\frac{100}{d_2}} - \sqrt{\frac{100}{d_1}}$$

Where
E = energy required per mass of feed
W = Bond Work Index work required to reduce a unit weight
d_1 = diameter of sieve aperture that allows 80% of mass of feed to pass (in meters)
d_2 = diameter of sieve aperture that allows 80% of mass of ground material to pass (in meters).

Factor affecting size reduction

1. Hardness:- The hardness of the material affect the process of production it is easier brakes soft material to a small size then hard material. Due to the hardness of any material it affects the drug solubility and modification of any drug dosages form.

2. Toughness:-The crude drugs of fibrous nature, it is not easily break down in smaller particle and shows the tough nature. In the toughness, materials fibrous are attached to each other in the layering form and affect the solubility of materials.

3. Material structure:- Material structure is one of the major problem during the size reduction because special size and shape materials are easily break down by special machine or by special method.

4. Moisture content: - The presence of moisture in the material influences a number of its

properties such as hardness stickiness which in its turn effect the particle size reduction.

5. The material having 5% moisture in case of drying grinding and 50% moisture in wet grinding does not create the problem.

6. Stickiness:- Stickiness cause a lot of difficulty in size reduction this is due to the fact the material adhere to the grinding surface or sieve surface of the mill. Due to stickiness of material it affects the material weighing accuracy.

7. Softening temperature:- Waxy substance (Stearic Acid, or drugs containing oil or fat) because softened during the size reduction process if a heat generated then the material not easily breakdown and sticks on the mill. If more the temperature generate in the machine, it affects the material stability and change their activity.

8. Purity required:- Various mill are used for size reduction often cause the grinding surface to wear off and thus impurities come in the power if a high degree purity is required such mill must be avoided.

9. Physiological effect:- Some drugs are very patent during their particle size reduction in a mill dust is produced which may have an effect on their operator in such cases the enclosed mill may be used avoid dust.

10. Bulk density:- The output of the size reduction of material in a machine depends upon the bulk density of the substance.

11. Ratio of feed size to product size:-To get a fine powder in a mill. It is required to fairly small feed size should be used hence it is necessary to carry out the size reduction process is several stage using different equipment.

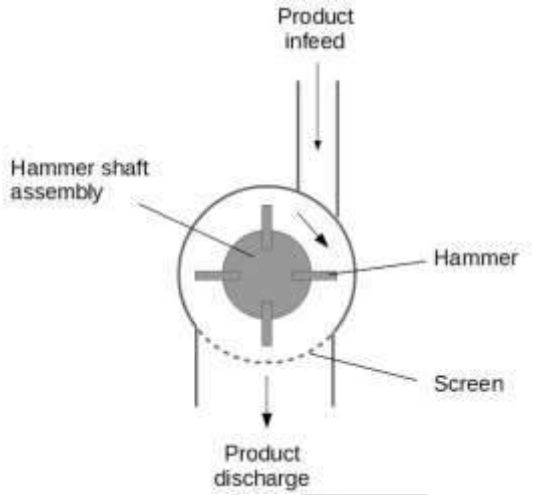
- Example:- Preliminary crushing following by coarse powder and then fine grinding.

Hammer Mill

Principal:- It work on the principle of impact.

Construction:- It consists of metal causing inclosing a control shaft to which four or more swinging hammer are attached the lower part of the mill, consists of a screen through which material can pass in a suitable receiver when the discrete of size reduction is reached.

Diagram:



Working:

- The material to be milled is fed into the feed hopper.
- The rotating drum carries the hammers or blades around the inside of the drum.
- The hammers or blades impact the material, breaking it into smaller pieces.
- The smaller pieces are then further broken down by attrition, as they rub against each other and the walls of the drum.
- The ground material exits the mill through a discharge port at the bottom of the drum.

Uses:

- Hammer mills are used to grind a variety of materials, including food, wood, plastics, and minerals.
- They are often used to produce a coarse grind, but they can also be used to produce a fine grind.

Merits:

- Hammer mills are relatively inexpensive to purchase and operate.
- They are easy to maintain and clean.
- They can be used to grind a variety of materials.
- They can produce a coarse or fine grind.

Demerits:

- Hammer mills produce a lot of noise.
- They can be dusty.
- They can produce heat, which can damage the material being milled.
- They are not as efficient as some other types of mills, such as ball mills.

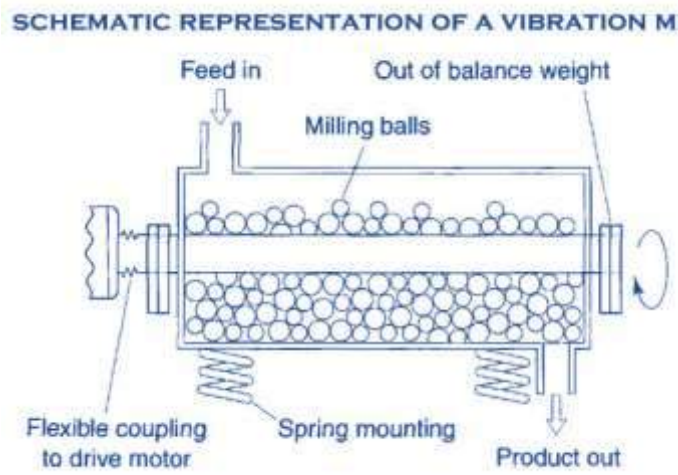
Ball Mill

Principle: It work on the principle impact and attrition.

Construction:

- A ball mill consists of a rotating cylinder, steel balls, and a feed hopper. The cylinder is made of steel and is lined with wear-resistant material.
- The steel balls are made of steel or tungsten carbide. The feed hopper is located at the top of the cylinder and is used to feed the material into the mill.

Diagram:



Working:

- The material to be milled is fed into the feed hopper.
- The rotating cylinder carries the steel balls around the inside of the cylinder.
- The steel balls impact the material, breaking it into smaller pieces.
- The smaller pieces are then further broken down by attrition, as they rub against each other and the walls of the cylinder.
- The ground material exits the mill through a discharge port at the bottom of the cylinder.

Uses:

- Ball mills are used to grind a variety of materials, including food, minerals, and chemicals.
- They are often used to produce a fine grind.

Merits:

- It can product very fine powder.
- It can be used for continues operation.
- If sieve are classified classifier to attach to the balls.
- The suitable for both weight and drug grinding process.

Demerits:

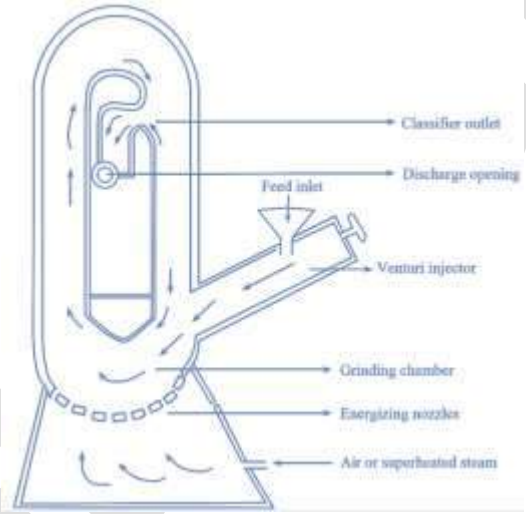
- Ball mills are more expensive to purchase and operate than hammer mills.
- The ball mill is a very noise.
- Wear occurs from the ball as well as from the cassing which may result contamination.

Fluid energy mill

Principle: The fluid energy mill uses the principle of impaction and attrition to reduce the size of particles.

Construction:

- A fluid energy mill typically consists of a chamber, a high-pressure air or gas supply, and a classifier. The chamber is made of a durable material such as steel or concrete.
- The air or gas supply is connected to the chamber through a nozzle. The classifier is used to separate the small particles from the large particles.



Working:

- The material to be milled is fed into the chamber through a hopper.
- The high-pressure air or gas is then turned on. The air or gas particles impact the material, causing it to break down into smaller particles.
- The attrition process also occurs as the particles rub against each other. The small particles are then exhausted from the chamber through the classifier.

Uses:

- Fluid energy mills are used to grind a variety of materials, including spices, herbs, minerals, and pharmaceuticals.
- They are also used to prepare slurries for further processing.

Merits:

- Fluid energy mills are relatively fast and efficient at grinding materials.
- They are also easy to operate and maintain.

Demerits:

- Fluid energy mills can be noisy and produce dust.
- They are also not suitable for grinding fibrous materials.

Edge runner mill

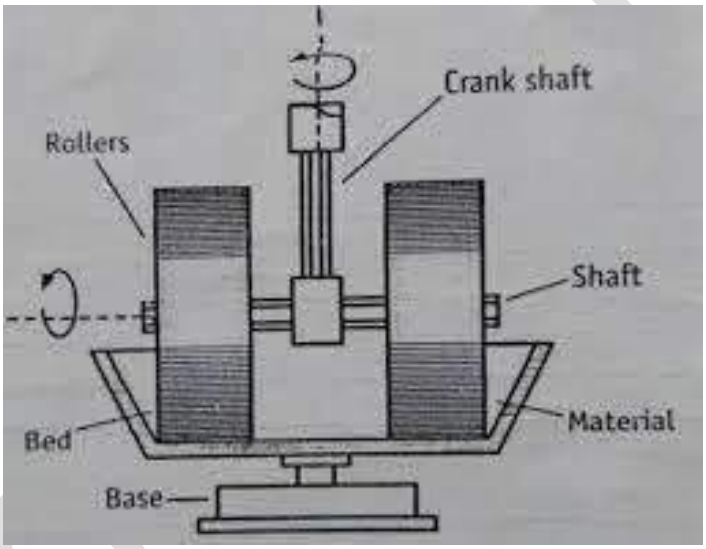
Principle:

- The edge runner mill uses the principle of attrition to reduce the size of particles.

Construction:

- An edge runner mill typically consists of two rollers, a frame, and a motor. The rollers are mounted on a frame that is supported by a motor. The motor turns the rollers at a high speed.

Diagram:



Working:

- The material to be milled is placed between the rollers.
- The motor is turned on, which causes the rollers to rotate at a high speed.
- The friction between the rollers and the material causes the material to break down into smaller particles.
- The small particles are then discharged from the mill.

Uses:

- Edge runner mills are used to grind a variety of materials, including spices, herbs, minerals, and pharmaceuticals.
- They are also used to prepare pastes and ointments.

Merits:

- Edge runner mills are relatively simple to operate and maintain.
- They are also relatively inexpensive.

Demerits:

- Edge runner mills can be noisy and produce dust.
- They are also not suitable for grinding fibrous materials.

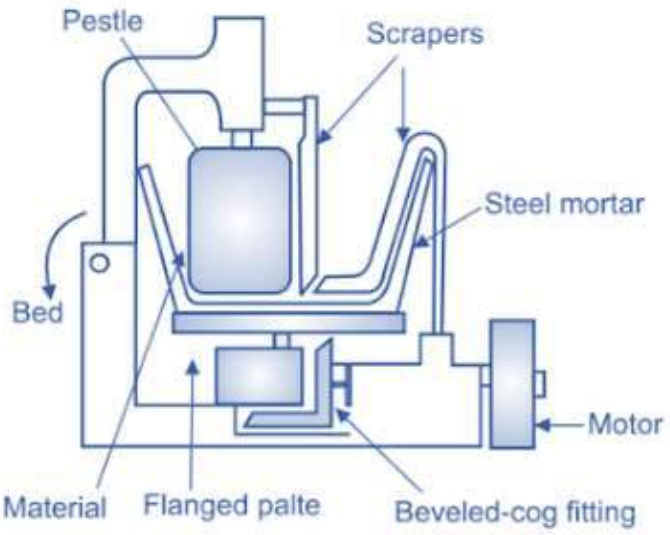
End runner mill

Principle:

- The end runner mill uses the principle of attrition to reduce the size of particles.

Construction:

- An end runner mill typically consists of a roller, a plate, a frame, and a motor.
- The roller is mounted on a frame that is supported by a motor.
- The plate is mounted on the frame opposite the roller.
- The motor turns the roller at a high speed.



Working:

- The material to be milled is placed between the roller and the plate.
- The motor is turned on, which causes the roller to rotate at a high speed.
- The friction between the roller and the plate causes the material to break down into smaller particles.
- The small particles are then discharged from the mill.

Uses:

- End runner mills are used to grind a variety of materials, including spices, herbs, minerals, and pharmaceuticals. They are also used to prepare pastes and ointments.

Merits:

- End runner mills are relatively simple to operate and maintain. They are also relatively inexpensive.

Demerits:

- End runner mills can be noisy and produce dust. They are also not suitable for grinding fibrous materials.

Size Separation: Objectives, applications & mechanism of size separation, official standards of powders, sieves, size separation Principles, construction, working, uses, merits and demerits of Sieve shaker, cyclone separator, Airseparator, Bag filter & elutriation tank.

Size Separation:

- Size Separation is a unit process that involved the separation of a mixture of various size particles into two or more portion by means of screening surface or by shifting. it is also known as sieving, sifting, and screening.
- Size separation technique is based on different physical properties of the separating mixture or substance like size, shape and density.

Objectives:-

- To improve the flowability of powders.
- To increase the surface area of particles, which can improve their reactivity.
- To separate different components of a mixture, such as solids from liquids or different sizes of particles from each other.
- To meet the specifications of a particular application, such as the production of tablets or capsules.

Applications:-

- Size separation technique determines the particle size for the production of tablets capsules, suspension and emulsion etc.
- Due to separation, we obtain the desired granules or particles and ensure their flow ability and uniformity.
- Undesirable substances are removed by the size separation technique.
- By obtaining the desired size particles we improve the mixing properties of the powders.
- To improve the solubility and stability of particles during production.
- Size separation technique optimize feed rate, agitation, screening during production.
- Quality control of raw materials.

Mechanism of size separation

➢ Agitation.
➢ Brushing.
➢ Centrifugal.

Agitation methods- Sieves may be agitated in a number of different ways, such as:
Oscillation:
This sieve is mounted in a frame that oscillates back and forth. It is a simple method but the material may roll on the surface of the sieve.

- Vibration: The sieve is vibrated at high speed by means of an electric device. The rapid vibration is imparted to the particles on the sieve which helps to pass the powdered material through it.

- Gyration: In this method, a system is made so that sieve is on rubber mounting and connected to an eccentric flywheel. This gives a rotary movement of small amplitude to sieve which turn gives spinning motion to the particles that helps to pass them through a sieve.

➢Agitation methods are not continuous methods but can be made so by inclination of the sieve and the provision of separate outlets for undersize and oversize particles.

Brushing methods-

- In this case, a brush is used to move the particles on the surface of the sieve and to keep the meshes clear.
- The brush is rotated in the middle in the case of a circular sieve but spiral brush is rotated on the longitudinal axis in case of a horizontal cylindrical sieve.

Centrifugal methods-

- In this method, a high speed rotor is fixed inside the vertical cylindrical sieve, so that on rotation of rotor the particles are thrown outwards by centrifugal force.
- The current of air which is produced due to high speed of rotor helps in sieving the powder.

Official standards of powders: (Official Grade of powder as per Indian Pharmacopoeia/IP)

S. No.	Grade of powder	All particles must pass through Sieve No. /Nominal mesh aperture	Sieve through which 40% of the particles pass/ Nominal mesh aperture
1	Coarse powder	10 /(1700 µm)	44 /(355 µm)
2	Moderately coarse powder	22 /(710 µm)	60/ (250 µm)
3	Moderately fine powder	44/(355 µm)	85/(180 **µm**)
4	Fine powder	85/(180 µm)	Not specified
5	Very fine powder	120/(125 µm)	Not specified

A) Coarse Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 1.70 mm/1700 µm (**Sieve No. 10**) and not more than 40% pass through nominal mesh aperture of 355 µm (**Sieve No. 44**) is called a **Coarse Powder**.

B) Moderately Coarse Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 710 µm (**Sieve No. 22**) and not more than 40% pass through nominal mesh aperture of 250 µm (**Sieve No. 60**) is called a **Moderately Coarse Powder.**

C) Moderately Fine Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 355 µm (**Sieve No. 44**) and not more than 40% pass through nominal mesh aperture of 180 µm (**Sieve No. 85**) is called a **Moderately Fine Powder.**

D) Fine Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 180 µm (**Sieve No. 85**) is called a **Fine Powder.**

E) Very Fine Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 125 µm (**Sieve No. 120**) is called a **Fine Powder.**

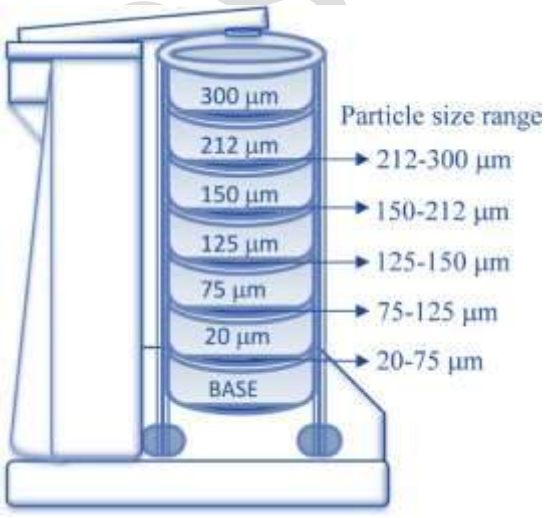
Sieve Shaker

Principle

- The principle of sieve shaker is based upon vibration, agitation or gyration.

Construction

- The sieve shaker consists basically of a cradle for holding the sieves, a power unit and a base.
- The cradle consists of a platform fastened to the lower ends of two vertical support rods, The upper ends of which are shock mounted to a horizontal support that is free to pivot about its mounting.
- A sieve holder, a retaining ring and nuts on the vertical support rods hold the top bar firmly against the nest of sieves. The standard sieves of different sieve numbers are used.



Working

1. The sieve stack is assembled with the sieves in decreasing order of mesh size.
2. The sample is placed on the top sieve.
3. The sieve shaker is turned on and the sieving time is set.
4. The sieve shaker is allowed to run for the specified time.
5. The sieve stack is removed from the sieve shaker and the particles are collected from the collection pan.

Uses

- Particle size analysis
- Quality control
- Research
- Education

Merits

- They are relatively inexpensive.
- They are easy to use.
- They are accurate.
- They can be used to analyze a wide range of particle sizes.

Demerits

- They can be time-consuming to use for large samples.
- They can be noisy.
- They can be messy.

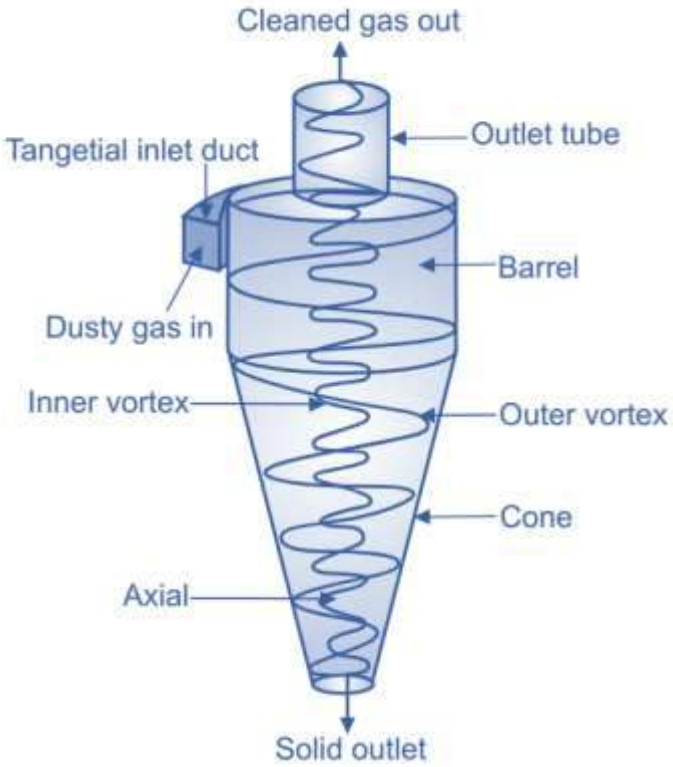
Cyclone Separator:

Principle: -

In cyclone separator, the centrifugal force is used to separate solids from fluids.

Construction: -

- It consists of a cylindrical vessel referred to as the barrel with the conical base,
- The upper part of the vessel is fitted with a tangential inlet and a fluid outlet and at the base it is fitted with the solid outlet.
- Cyclones have no moving parts and are available in many shapes and sizes.



Working:-

- The suspension of a solid in gas (usually air) is introduced tangentially at a very high velocity, so that rotary movement takes place within the vessel.
- The fluid is removed from a central outlet at the top.
- The rotatory flows within the cyclone separator generate the centrifugal force on the particle.
- The solids are thrown out to the walls; thereafter it falls to the conical base and discharged out through solids outlet.

Uses:-

- Cyclone separators are used to separate the suspension of a solid in a gas (air). It can be used with liquid suspensions of solids.

Merits:

- Cyclone separator requires low capital investment.
- It has high efficiency for 5 - 200 µm particles.
- It produces high volume flow rate.
- A lack of moving parts reduces wear and tear.
- It can be operated on continuous or batch process.
- It requires virtually no downtime for maintenance or recovery.

Demerits:-

- It shows reduced efficiency when overloaded than its capacity.
- It cannot handle viscous flow.
- The extremely high velocities cause abrasive wear.
- Clogging of the dust outlet is common in reverse flow cyclones

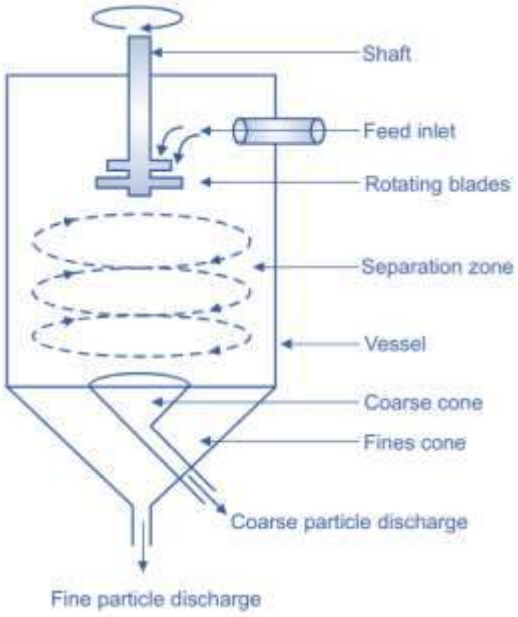
Air separator:

Principles:

- Air separators work on the principle of centrifugal force.

Construction:-

- It consists of vertical metal cylindrical vessel with conical base at the bottom.
- The feed inlet is fitted tangentially at the upper part of vessel.
- The outlet for collected solids is at the base of conical portion where as fluid outlet is at the centre of the top portion.
- The fluid outlet pipe extends down below inlet section to avoid air short-circuiting directly from the inlet into the outlet.
- The rotating disc and rotating blades are fitted on shaft is placed at the center of the vessel.
- It has two separate outlets at bottom for finer and coarser/heavy particles.



Working:

- The feed enters through the inlet tangentially in the upper part of vessel. Feed falls on the rotating blades.
- The rotating blades produce an air jet.
- He fine particles are blown away on the walls by centrifugal force generated with the air jet and are collected at the bottom.
- The coarser particles due to their large mass travel less distance from the centre of the separator and falls in the coarse particle collection zone which is collected at its discharge.

Uses:

- It is used as dust collectors in many processes to either recover valuable granular solid or powder from process streams.
- It can be used to separate sub micron size particles those cannot be handled by sieving.

Merits:

- The rotor speed as well as air flow is adjustable.

- It has high product output.
- It is easy to clean and maintain.

Demerits:

- If particles are too fine (<5 µm) its efficiency decreases.
- It is not suitable for wet and sticky materials.

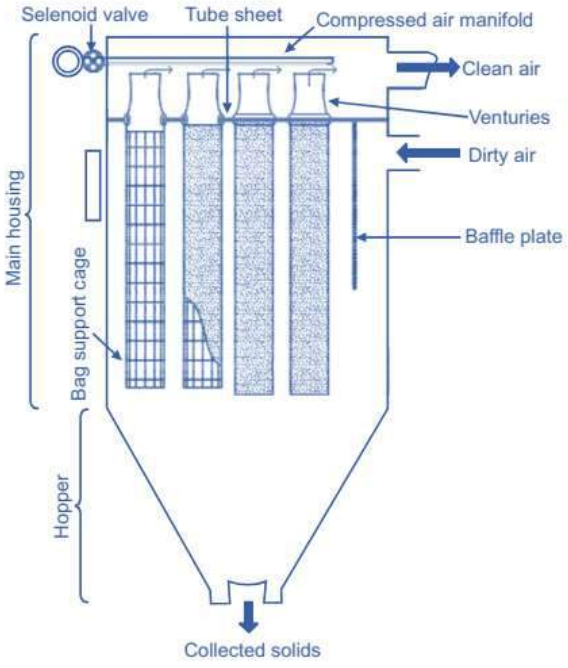
Bag Filter:

Principles:

- The purpose of filter bag to collect dust is based upon the principle of filtration.

Construction:-

- This equipment consists of a big metal vessel (bag house) with series of fabric bags in compartments.
- The bags are made-up of woven cotton, wool, membranes, sintered metal fibers or ceramic cartridges.
- The selection is based upon the operating temperature and pressure and stability of filter medium to these conditions.
- Filter bags are suspended in invert position in the vessel. The length of bags varies from 2 to 10 m with a diameter up to 40 cm. The open ends of the bags are attached to the manifold.
- The number of bags in a vessel varies from 100 to 1000 or more depending on bag house. In the bottom portion hopper is provided to collect dust held by the filter.



Working

Filtering period:

- During this period the gas containing dust enters through the hopper. Then it is passed inside the bags and at the top of the apparatus. The vacuum fan produces pressure below the atmospheric pressure inside the apparatus. As a result, the particles get trapped within the bags.

Shaking period:

- During this period, the bell-crank lever rotates and changes the position of the damper. The outside air enters through the top in the metal casing and therefore the vacuum is broken. At the same time, it causes violent shaking or jerking action to the bags. Dust or fine particles are displaced from the bags. The maximum portion of dust falls into the hopper which is withdrawn further from the conical base.

Uses:

- Bag filters are used in industries to separate dust particles from the air.
- These are used to clean the air in working areas.
- It is most commonly used in fluidized bed dryer

Merits

- Filter bag is best method amongst all for removing fines from the air.
- Electricity consumption is low.
- It help to maintain and protect healthy environment.
- They are simple in construction and operation.
- It has versatility and effective design.

Demerits

- The maintenance cost is high as fabric used is costly.
- The characteristics of fabric change with operating parameters.
- Comparatively it is large in size.

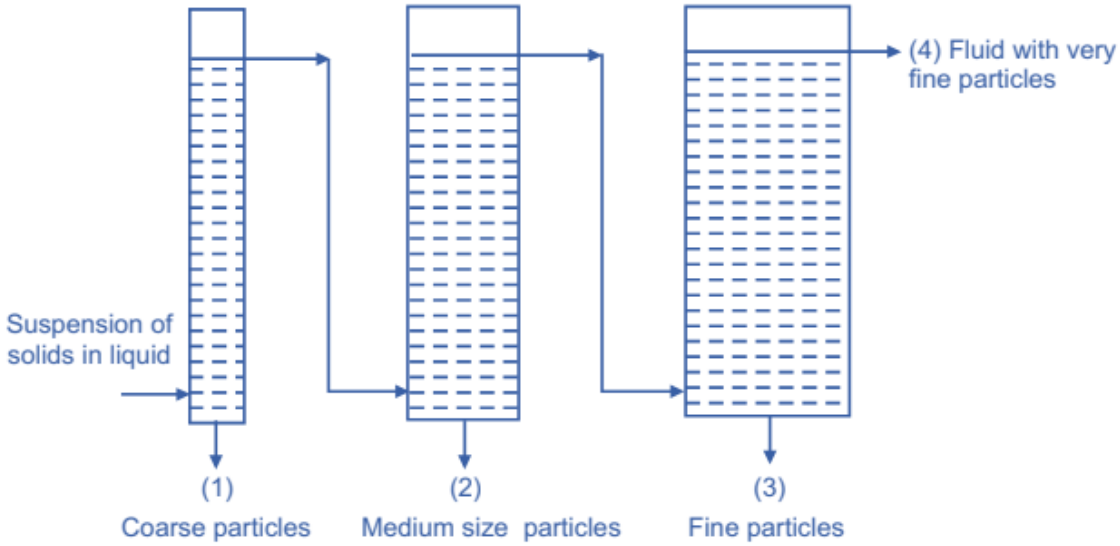
Elutriation tank

Principles

- It work on the principle of sedimentation

Construction

- The gravitational system, the apparatus consists simply of a vertical column with an inlet near the bottom for the suspension, an outlet at the base for coarse particles, and an overflow near the top for fluid
- One column will give a single separation into two fractions, but it must be remembered that this will not give a clear cut separation, since there is a velocity gradient across the tube, resulting in the separation of particles of different sizes according to the distance from the wall.



Working:

- The material whose particles are to be separated is first levigated and the paste is transferred to elutriation tank.
- A large amount of water is added to tank so as to make independent particle settling. The contents in the tank are stirred to obtain uniform particle distribution.
- If left aside undisturbed coarse particles settle at the bottom where as small size particles remain suspended in liquid.
- These fines can be transferred to next elutriator in connection wherein similar process of separation takes place to obtain further fractions of fines.

Uses:-

- They are used for size reduction process, with the object of separating oversize particles, which may be returned for further grinding, used for other purposes, or

discarded according to the circumstances.

Merits:-

- The process is continuous.
- The separation is quicker than with sedimentation.
- It has feasibility to add many columns based upon fractions required.
- It needs no skilled operators.
- It is a fast process than sedimentation

Demerits:-

- The suspension has to be dilute; which may sometimes be undesirable.
- It cannot separate different types of particles which have similar sedimentation properties.