PHARMACEUTICAL ENGINEERING

UNIT 1 NOTES

FLOW OF FLUIDS

- TYPES OF MANOMETERS
- REYNOLDS NUMBER
- BERNOULLI'S THEOREM

SIZE REDUCTION

- OBJECTIVES
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- FACTORS AFFECTING SIZE REDUCTION
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FLOW OF FLUIDS

- Any substance that having property of Flow and being capable of changing its shape continuously is known as **Fluid**.
- Fluid is basically refers to Liquids and Gases.
- The subject of Fluid Flow can be divided into two parts :

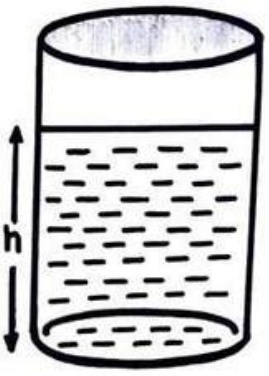
① Fluid Statics
② Fluid Dynamics

APPLICATION OF FLUID FLOW

- Manufacturing of Dosage Forms.
- Mixing of Solid & Liquid to form Suspensions.
- Handling & Packaging of Drugs.
- For Measuring rate of flow of Fluids.

FLUID : PRESSURE

- Lets consider a cylinder containing liquid upto height 'h', Now Pressure due to this liquid at the bottom of the cylinder can be calculated as :



- $P = F/A$ & here $F = mg$ & $m = \rho \times V$ & $V = A \times h$, so $P = \rho A h g / A$
- So, Finally we get

$$P = \rho g h$$

- where, P = Pressure, ρ = Density, h = height, g = Acceleration due to gravity

MANOMETER

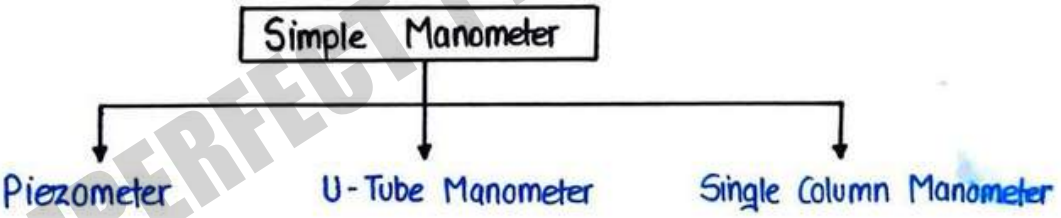
- Manometers are the devices that are used to measure pressure of a single fluid or pressure difference between two different types of Fluid.
- Manometers are of mainly two types :

① Simple Manometer

② Differential Manometer

① SIMPLE MANOMETER

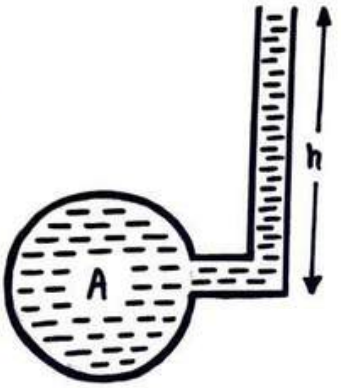
- Simple Manometers are those that measures the pressure at a point in a fluid contained in a pipe or vessel.
- It can be further divided into following types :



Piezometer

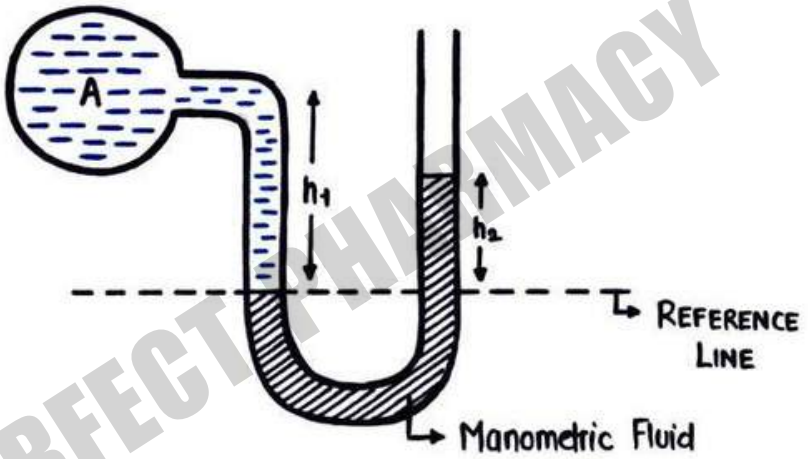
- It is the simplest type of Manometer.
- It can be used to measure low to moderate pressures.
- It consist of a glass tube that is connected with the vessel / pipe containing liquid.
- The pressure at point A is given by :

$$P_A = \rho g h$$



U- Tube Manometer

- It consist of a glass tube folded like the letter 'U'.
- In this Manometer One end of the U- Tube is connected with the Fluid whose pressure is to be measured while the other end is open to the Atmosphere.
- It consist of a Manometric Fluid (generally Mercury) whose density must be higher than the Fluid whose pressure has to be measured.
- It is used to measure Moderate to High Pressures.



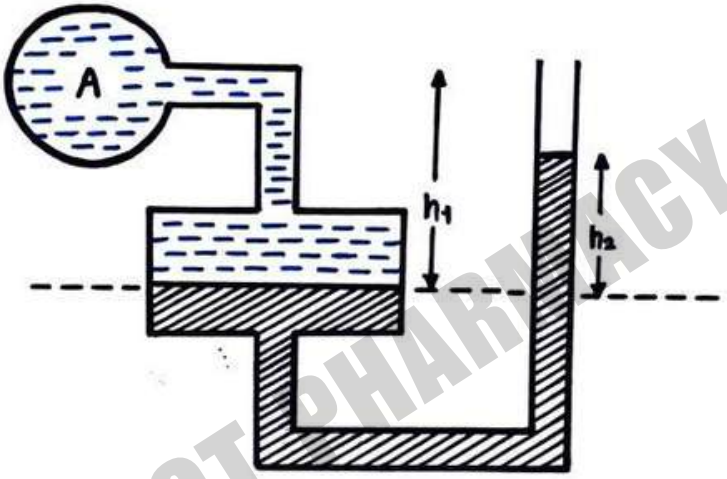
Pressure at Point A is given by :

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

Here,
- P_A = Pressure at Point A
- ρ_2 = density of heavy (Monometric) Fluid
- h_2 = height of liquid above reference line
- g = Acceleration due to gravity
- ρ_1 = density of lighter liquid (A)
- h_1 = height above reference line

Single Column Manometer

- It is a modified form of U- Tube Manometer in which a Reservior, having a large cross- sectional area is connected with one of the Manometer's limb.
- This manometer can be either Vertical Single Column Manometer or Inclined Single Column Manometer.

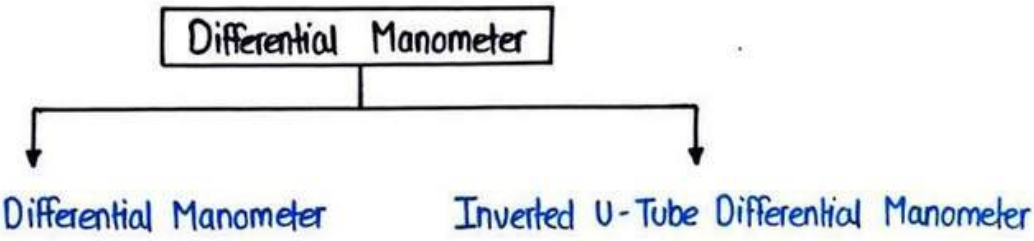


- The pressure at point A can be given by

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

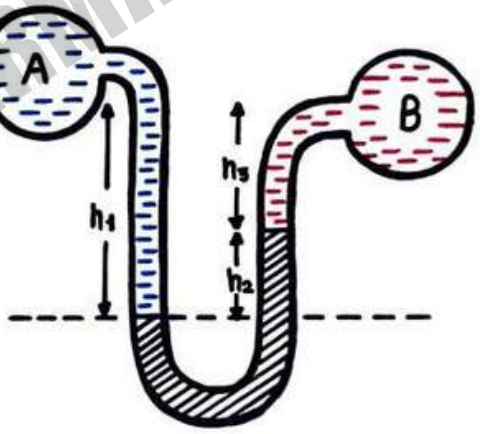
② DIFFERENTIAL MANOMETER

- Differential Manometers are the manometers that are used to Measure the pressure difference between two different liquids.
- Differential Manometers are of following types :



U-Tube Differential Manometer

- Constructionwise, it is same as U-Tube Manometer whose both ends are connected with two different vessels containing Liquids A & B.
- The Pressure difference b/w A & B is given by :



$$P_A - P_B = \rho_2 g h_2 + \rho_3 g h_3 - \rho_1 g h_1$$

Here,
- $P_A - P_B$ = Pressure difference b/w A & B
- ρ_1 = Density of Liquid A
- ρ_2 = Density of Manometric Liquid
- ρ_3 = Density of Liquid B

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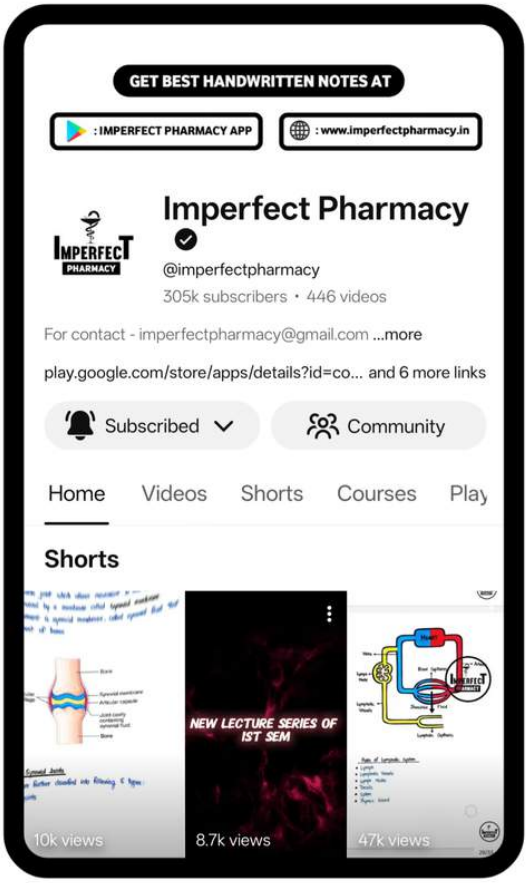

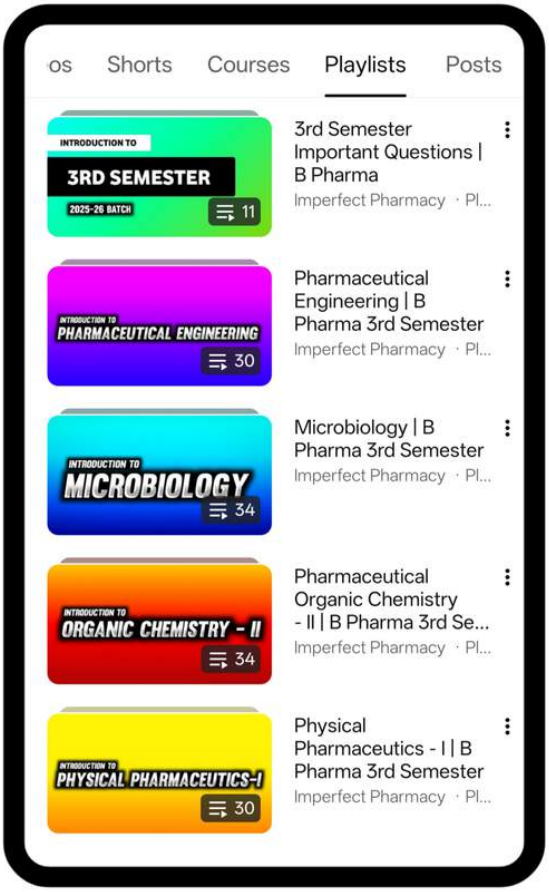

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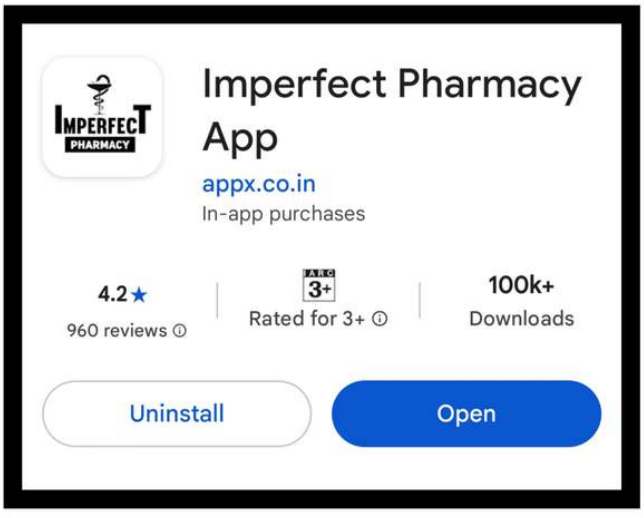
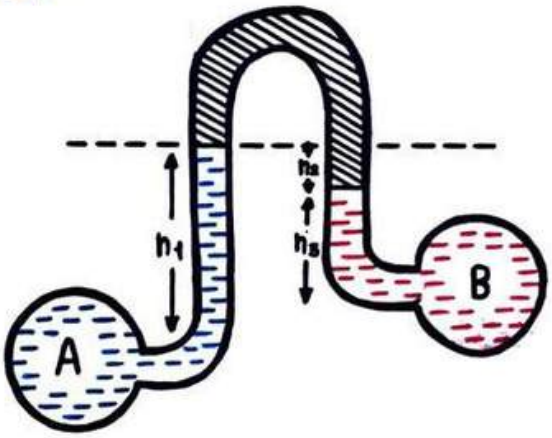


Inverted U- Tube Differential Manometer

- It consist of a inverted U- tube, both ends connected with two different liquids A & B.
- It is used to measure low to moderate pressure difference.
- The Pressure difference b/w A & B is given by :



$$P_A - P_B = \rho_1 g h_1 - \rho_2 g h_2 - \rho_3 g h_3$$

Here,
- ρ_1 = Density of Liquid A
- ρ_2 = Density of Monometric Liquid
- ρ_3 = Density of Liquid B

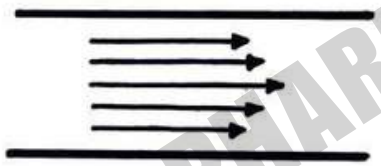
TYPES OF FLOW

There are generally 3 types of Fluid Flow seen in Pipes.

① Laminar Flow
② Turbulent Flow
③ Transition Flow

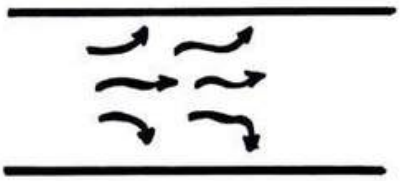
LAMINAR FLOW

- It is a type of flow in which fluid particles moves in a straight Layers or in Laminar with one layer sliding with other layer.
- It is also known as Viscous or Stream Line Flow.



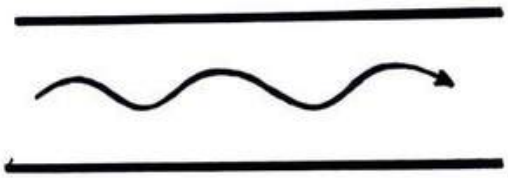
TURBULENT FLOW

- In Turbulent Flow, fluid particles moves in a random manner due to the increased velocity.
- Under this velocity, all the Fluid particles get disturbed and mixed with each other.



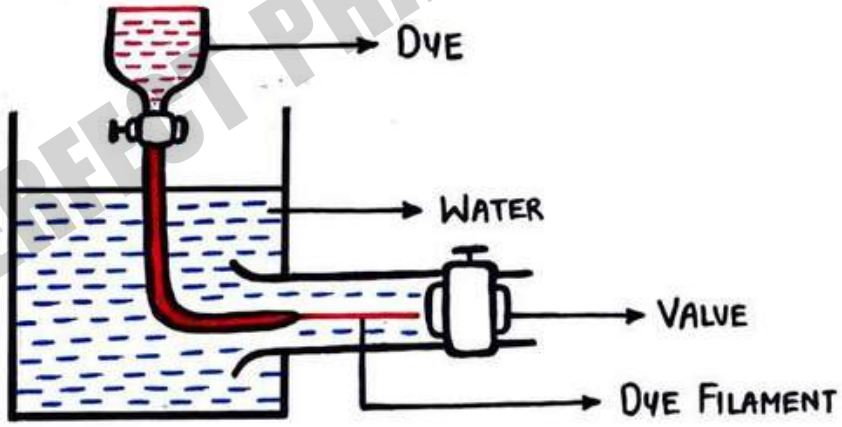
TRANSITION FLOW

- Transition Flow can be defined as a state between Laminar and Turbulent Flow.
- It is a mixture of both Laminar & Turbulent.



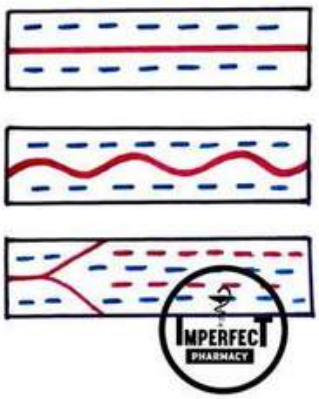
REYNOLD'S EXPERIMENT

In 1883, Sir Osborne Reynolds performed an experiment to know about the nature of Fluid Flow as follows:



Observations

- When the velocity of the fluid is low, Dye Filament is in straight line and flow is **Laminar**.
- When velocity of the flow is medium, Dye Filament shows zigzag motion & flow is **Transition**.
- When velocity of the flow is High, Dye Filament mixed with water & flow is **Turbulent**.



REYNOLDS NUMBER

- Reynold's Number is nothing but the summarised form of Reynolds Experiment .
- In Reynolds Experiment , the flow conditions are mainly affected by following four factors.

① Diameter of the Pipe (D)
② Average Velocity of Flow (u)
③ Density of Liquid (ρ)
④ Viscosity of Fluid (η)

- After combining the above 4 factors , we get Reynolds Number as :

$$Re = \frac{Du\rho}{\eta}$$

- In other words it can also be defined as ratio of Inertial Forces to Viscous Forces.

$$Re = \frac{\text{INERTIAL FORCES}}{\text{VISCOUS FORCES}}$$

Now, If

- $Re < 2000$: Flow will be Laminar
- $Re > 4000$: Flow will be Turbulent
- $2000 < Re < 4000$: Flow will be Transition

Significance Of Reynolds Number

- To Predict the nature of Flow.
- To study the flow of incompressible Fluids in closed pipes.
- The Stock law equation is modified to include the Reynolds Number to study the sedimentation rate in suspensions.
- Heat Transfer in liquids also depends on flow.

ENERGY LOSSES

- When a Fluid flows through a pipe, the fluid experiences some resistance due to which part of the energy lost.
- This loss of energy is classified as follows :

① Friction Losses
② Losses in Fittings
③ Enlargement Losses
④ Contraction Losses

FRICTION LOSSES

- Friction Loss refers to resistance caused by Fluid flowing through pumps, pipes and fittings.
- The resistance results in decreased pumping pressure and decreased velocity. Friction loss can be calculated by following formula :

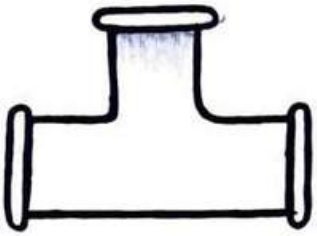
$$\Delta P_f = \frac{fLv^2}{2gD}$$

Where,
- ΔP_f = Loss in Pressure due to Friction
- f = Friction Factor
- L = Length of Pipe
- v = Velocity of Fluid
- g = Acceleration Due to Gravity
- D = Diameter of Pipe

LOSSES IN FITTINGS

- Various types of fittings in a straight Pipe, cause disturbances in the flow, which results in loss of energy.
- Losses in fittings may be due to change in direction or change in type of the fittings such as Elbow fittings, T fittings etc.

ELBOW FITTINGS



T- FITTINGS

- Pressure loss due to Fittings can be calculated by :

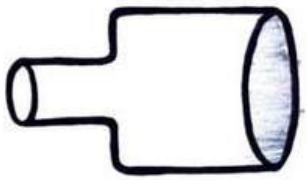
$$\Delta H_L = \frac{kV^2}{2g}$$

Here,
- ΔH_L = Pressure Head Loss
- k = Resistance Coefficient due to Fittings
- V = Velocity of Fluid
- g = Acceleration due to gravity

Enlargement Loss

- If there is a sudden enlargement in pipe cross section, then it results into loss of Pressure head across the fittings.
- For suddent enlargement, loss is given by :

$$\Delta He = \frac{(u_1 - u_2)^2}{2g}$$

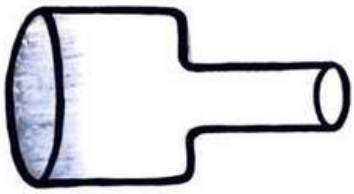


Here,
- ΔHe = Loss in Pressure head due to Enlargement
- u_1 = Velocity of smaller cross section
- u_2 = Velocity of Larger cross-section
- g = Acceleration due to gravity

Contraction Loss

- When cross section of the pipe reduced suddenly, energy is lost because flow of fluid get disturbed.
- For sudden contraction, loss is given by :

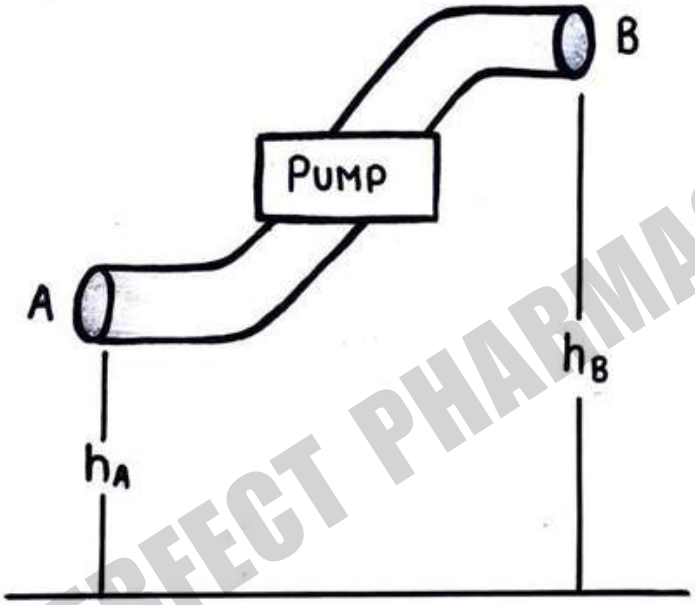
$$\Delta Hc = \frac{k u_2^2}{2g}$$



Here
- ΔHc = Loss due to Contraction
- k = constant
- u_2 = Velocity of smaller cross section
- g = Acceleration due to gravity

BERNOULLI'S THEOREM

- Bernoulli's Theorem is based on law of conservation of energy.
- Bernoull's theorem states that the sum of Total Energy (includes Pressure Energy , kinetic Energy and Potential Energy) per unit volume remains constant at any cross-section of the pipe throughout the Fluid Flow.



TOTAL ENERGY PER UNIT VOLUME AT POINT 'A'

- Potential Energy Per Unit Volume at A = $\frac{mgh}{V} = \rho g h_A$
- Pressure Energy Per Unit Volume at A = $\frac{P_A V}{V} = P_A$
- kinetic Energy Per Unit volume at A = $\frac{1}{2}\frac{mV^2}{V} = \frac{1}{2}\rho V_A^2$

Now According to Bernoull's Theorem

$$P_A + \rho g h_A + 1/2\, \rho u_A^2 = \text{constant}$$

Total Energy Per Unit Volume At Point 'B'

- Potential Energy Per Unit Volume at B = $\frac{mgh_B}{V} = \rho g h_B$
- Pressure Energy at Point B Per Unit Volume = $\frac{P_B V}{V} = P_B$
- kinetic Energy per unit volume at B = $\frac{1}{2}\frac{mu_B^2}{V} = \frac{1}{2}\rho u_B^2$

Now according to Bernoull's Equation

$$P_B + \rho g h_B + \frac{1}{2}\rho u_B^2 = \text{constant}$$

- Now According to Bernoull's Theorem the sum of Total energy remains constant or same at any cross section.
- Hence, Total Energy at Point A = Total Energy at Point B

$$P_A + \rho g h_A + \frac{1}{2}\rho u_A^2 = P_B + \rho g h_B + \frac{1}{2}\rho u_B^2$$

- Now If We divide the above equation by ρg. We get

$$\frac{P_A}{\rho g} + h_A + \frac{u_A^2}{2g} = \frac{P_B}{\rho g} + h_B + \frac{u_B^2}{2g}$$

- The above equation is called as Bernoull's Equation in terms of Pressure Head, where :
- $P_A/\rho g$ = Pressure Head at A
- h_A = Potential Head at A
- $u_A^2/2g$ = kinetic Head at A
- $P_B/\rho g$ = Pressure Head at B
- h_B = Potential Head at B
- $u_B^2/2g$ = kinetic Head at B

- Now Practically, For transportation of Fluid, Pump added certain amount of energy, that can be expressed as = W (in joules)
- Also during, the transport some energy get lost in the form of heat due to Frictional Forces, can be expressed as = F (in joules)

- Now, After combining above two factors in our Bernoull's equation (in terms of pressure head), we get :

$$\frac{P_A}{\rho g} + h_A + \frac{U_A^2}{2g} + W - F = \frac{P_B}{\rho g} + h_B + \frac{U_B^2}{2g}$$

LIMITATIONS OF BERNOULLI'S THEOREM

Bernoull's Equation is applicable only when :

- Fluid is Non viscous
- Flow is Steady (Streamline)
- Fluid is Incompressible
- Friction losses are neglegible

APPLICATION OF BERNOULLI'S THEOREM

- Working of Centrifugal Pumps.
- Working of Venturi Meter, Pitot tube, Orifice Meter etc.
- Working of Aeroplane.
- Blowing of Roofs.

FLOW METERS

- Flow Meters are basically the devices used for measurment of rate of Fluid Flow or the amount of Fluid moving through a pipe.
- The 4 most common types of flow meters are :

① Orifice Meter
② Venturi Meter
③ Pitot tube
④ Rotameter

ORIFICE METER

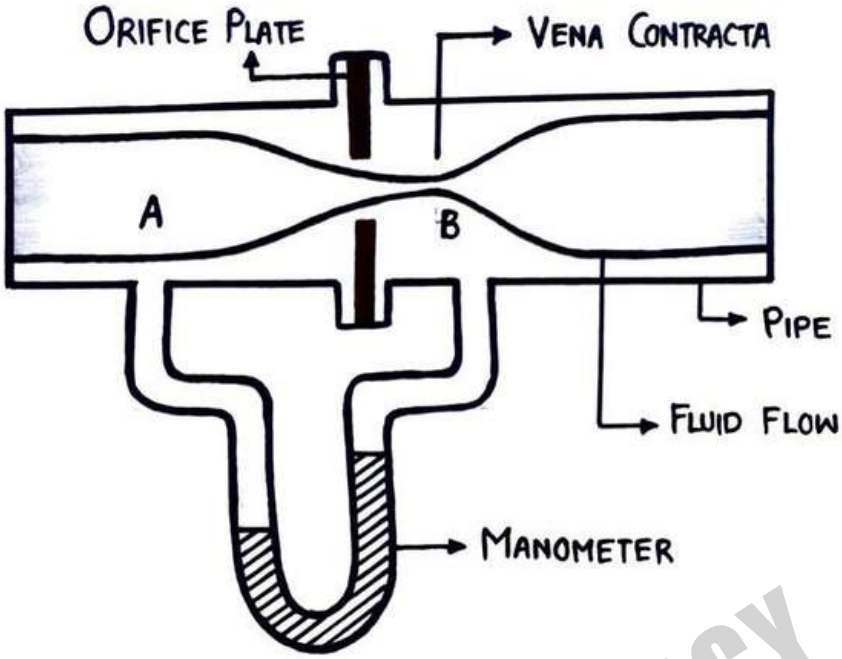
- An Orifice Meter is a device the rate of fluid flow through a pipe.
- It works by recording the pressure decrease across a hole in the device.
- It is a type of Flow Meter.

PRINCIPLE

- It basically works on the principle of Bernoull's Theorem.
- It basically creates a pressure difference by reducing the cross-sectional area that determines the flow rate through the pipe.

CONSTRUCTION

- Orifice Meter is actually a thin plate with a hole inside commonly known as 'Orifice Plate.'
- It is placed b/w long pipes along with Manometer at Point A & B



WORKING

- When fluid is allowed to pass through the cross-section of the orifice, the velocity of fluid at Point B increases compared to Point A.
- Now as a result, Pressure at Point B decreases compare to Point A and this pressure difference can be calculated by Manometer.
- The Flow rate can be measured by using the following formula :

$$\sqrt{u_o^2 - u_A^2} = C_o \sqrt{2g\Delta H}$$

- Now Here
  - u_o = Velocity at the point of orifice meter
  - u_A = Velocity at Point A
  - C_o = Coefficient of Orifice
  - ΔH = Difference in Pressure Head

- Now If orifice diameter is 1/5th of pipe or even less, then value of u_A becomes very small compared to u_o & can be ignored, New Equation :

$$\boxed{u_o = C_o \sqrt{2g\Delta H}}$$

USES

- Orifice Meter is mainly used to measure Flow rate of Fluids.
- It plays a crucial role in maintaining & controlling the flow of fluids.
- In Power Plants and Industrial Boilers, Orifice Meters are used to measure the flow of steam.
- They are also used to measure the flow of crude oils & various petrolium products in refineries.

ADVANTAGES / MERITS

- It cost is low compared to other flow meters
- Requires less space for installation.
- Its design & construction is very simple.
- Its maintainance is also low.

DISADVANTAGES / DEMERITS

- It tends to clog thus cannot be used in very viscous Fluids.
- Accuracy is depend on care during installation.

VENTURI METER

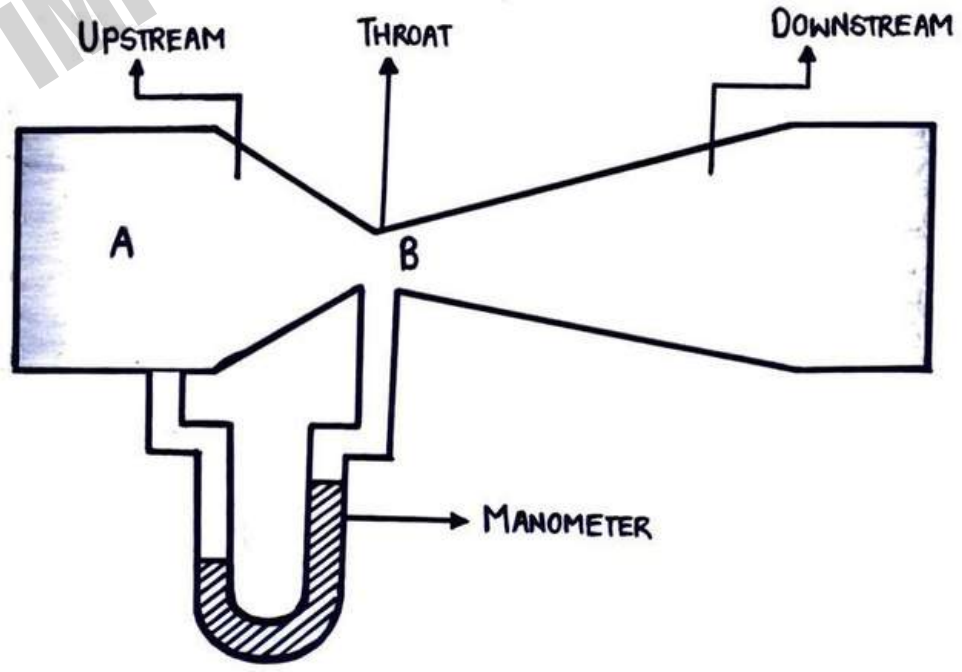
- Venturi Meter is a device used to measure Flow rate of Fluid.
- It works by creating a pressure difference across a throat.
- It is a type of Flow Meter.

PRINCIPLE

- It works on the Principle of Bernoull's Theorem.
- It creates a pressure difference by reducing the cross-sectional area due to its cone like structure.

CONSTRUCTION

- A Venturi-Meter consist of two tappered section inserted in a pipe.
- Venturi Meter is placed between long straight pipes to prevent any changes in flow.
- The Upstream cone is normally shorter than downstream.
- A Manometer is connected at Point A & B



WORKING

- In a venturi Meter, Velocity of Fluid increased at Throat (Point B).
- Now it results in decrease in pressure at point B and the pressure difference between A & B is calculated by using a Manometer.
- The flow rate through Venturi Meter can be calculated by :

$$\sqrt{u_v^2 - u_A^2} = C_v \sqrt{2g\Delta H}$$

- Where,
  - u_v = Velocity at throat of Venturi
  - u_A = Velocity at point A
  - C_v = Coefficient of Venturi
  - ΔH = Difference in Pressure Head

- Now IF diameter of venturi << diameter of Pipe, then $u_A << u_v$ and

$$\boxed{u_v = C_v \sqrt{2g\Delta H}}$$

USES

- It is used for measuring Rate of Flow of Fluids.
- It is used to measure flow of various crude oils, natural gases etc.
- They are used as reference standards for calibrating other Flow Meters.

ADVANTAGES

- It is most widely used due to its high resistance.
- Gives Accurate Measurment.
- Available in very large pipe sizes.

DISADVANTAGES

- It requires more space.
- Its cost is high.

PITOT TUBE

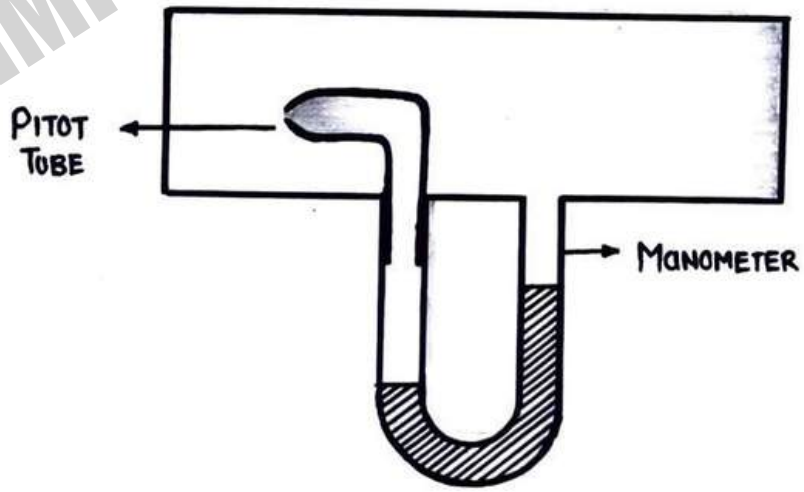
- It was named after a French Engineer, Henri Pitot.
- It is used to measure Fluid Velocity.
- It is a type of Flow Meter.

PRINCIPLE

- It works on the poinciple of Bernoull's Theorem.
- It is based on the poinciple that if velocity of the flow at a point becomes zero, the pressure is increased due to conversion of kinetic Energy into Pressure Energy.

CONSTRUCTION

- It consist of two hollow tubes that measures pressure at different points in a pipe.
- The tubes are joint or we can say bent at right angle.



WORKING

- The Pitot Tube installed in the Flow streams measures the direct pressure at the contact Pitot tube hole.
- The Pressure in the Pitot tube becomes high that creates a pressure difference which is measured by Manometer.
- The Velocity of the flow is given by :

$$u = C_p \sqrt{2g\Delta H}$$

Where,
- u = Velocity of Flow at point of Insertion
- C_p = Coefficient of Pitot Tube.

USES

- Pitot Tube are most commonly used on Aircraft to measure Airspeed.
- They are used as Flow Meters to measure Flow rate of liquids.

ADVANTAGES

- It provides precise movement of Fluid Velocity.
- It is simple and economical to install.

DISADVANTAGES

- It is unsuitable for dirty and sticky Fluids.
- It often requires Calibration and Corrections.

ROTAMETER

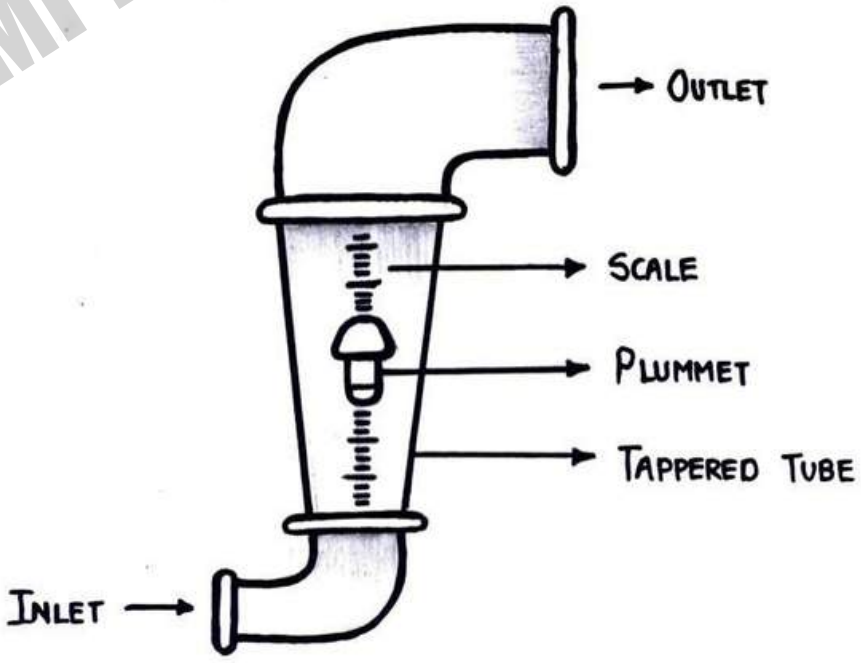
- A Rotameter is a device that measures volumetric Flow rate of fluid in a closed tube.
- It belongs to a class of Flow Meters.

PRINCIPLE

- The Rotameter principle works on force of gravity & upthrust.
- It consist of variable area through which liquid passes.

CONSTRUCTION

- It consist of a verticle tapered tube having a narrow down end.
- The tube is usually made of glass to which a linear scale is attached.
- A Solid Plummet / Float is placed in the tube.
- Plummet may be made of Lead, Aluminium, Glass or Plastic.



WORKING

- First Rotameter is fitted in a pipe.
- As the flow is upward through a tappered tube, the flow of fluid varies.
- The Plummet, which is surrounded by the Fluid rises and falls depending on Rate of Flow.
- The Greater the Flow rate, higher will be the Plummet rise.
- The readings can be calculated in the attached scale.

USES

- It is used in chemical industries & oil industries.
- It is used for oxygen flow rate in medical areas.
- It controls supply of air in Fermenters.

ADVANTAGES

- It doesn't require any external electricity or Flow.
- Its cost is relatively low.
- It is good for measuring small flows.

DISADVANTAGES

- It can only be installed in Vertical Positions.
- The glass tube is tough to handle

SIZE REDUCTION

- Size Reduction is a process of reducing large drug substances into smaller particles.
- It is also known as Comminution or Pulverization.
- In case of solid substances, the process of size reduction is done by Grinding and Cutting.
- In case of liquids, it is done by Emulsification or Atomisation.

ADVANTAGES

- Content Uniformity : With smaller particle size, number of particles increases, larger the number of particles, better is mixing, therefore better content uniformity can be achieved.
- Uniform Flow : Smaller and controlled particle size promotes flow of powder, this helps in tablet compression & capsule filling.
- Effective Drying : Rate of drying increases as size reduction increases the surface area.
- Improved Stability : Smaller particle size decreases the sedimentation rate, thus increases stability of suspensions.
- Improved Absorbtion : Smaller the particle size, Faster the absorbtion.

DISADVANTAGES

- Drug Degradation : Thermolabile substances having chances of degradation due to the heat produced during milling.
- Poor Mixing : Very small particles possess strong cohesive forces which leads to aggregation during mixing.
- Contamination : There are chances of contamination during milling & grinding.

Objectives

- Size Reduction leads to increase surface area that inhances the rate of physical or chemical process.
- Reducing the size of particles leads to ease of mixing & improves dissolution rate, solubility etc.
- Dosage Forms like capsules, insufflations, suppositories requires the particle size to be less than 60 mm in size.
- Stability of emulsions can be increased by decreasing the size of oil globules.
- Smaller Particle size leads to higher rate of drug absorbtion.
- Opthalmic and Dermal preparations should be free from coarse and gritty particles to avoid irritation.

MECHANISM OF SIZE REDUCTION

There are various methods with different mechanism used for particle size reduction process.

① Impact
② Attrition
③ Compression
④ Cutting

IMPACT

- In this method the material is hitted with an object moving at high speed in order to reduce its particle size.
- Example : Hammer Mill.

ATTRITION

- In this method, the particles surfaces moves / rubbed with respect to each other and produces shear forces which reduces the particle size.
- Example : Fluid Energy Mill

COMPRESSION

- In this method, the material is crushed blw rollers by the application of pressure, mainly used for hard materials.
- Example : Roller Mill

CUTTING

- In this method, materials are cut with the help of sharp blades.
- Example : Cutter Mill.

LAW GOVERNING SIZE REDUCTION

There are mainly 3 laws that governs the process of size reduction:

① Kick's Law
② Rittinger's Law
③ Bond's Law

KICK'S LAW

According to this law, the energy required to reduce the size of the particles is directly proportional to the ratio of size reduction.

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

Here k_K = Kick's Constant
d_1 = Initial Diameter
d_2 = Final Diameter

RITTINGER'S LAW

According to this law, energy required for size reduction is directly proportional to the new surface area produced.

$$E = k_R (S_n - S_i)$$

Here k_R = Rittinger's Constant
S_n = New Surface Area
S_i = Initial Surface Area

BOND'S LAW

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

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

Here, E = Energy Required
W = Bond Work Index
d_1 = diameter of sieve that allow 80% of feed mass to pass
d_2 = diameter of sieve that allows 80% of ground mass to pass.

FACTORS AFFECTING SIZE REDUCTION

There are various Factors that affects the process of size reduction as follows :

- Hardness
- Toughness
- Abbresiveness
- Stickiness
- Slipperness
- Melting Point
- Explosiveness

HARDNESS

- The size reduction of soft materials is comparatively easier than hard substances.
- Harder the material, more it is difficult to reduce the size.

TOUGNESS

- It is even more important than hardness.
- Soft but tough materials can cause more problem in reducing size.
- Example : It is more difficult to break a rubber than a chalk-stick

ABBRESIVENESS

- It is the property of hard materials.
- During the grinding of abrasive substances, the final product may be contaminated with grinding mill's worn metal

STICKINESS

- Stickiness cause considerable difficulty in size reduction as they get sticked to the grinding or sieve surfaces of the mill.
- Example : Gummy or Resinuous Substances.

SLIPPERINESS

- It is just opposite to stickiness.
- They also lead to difficulty in size reduction as they act as a lubricant and slips & hence lowers the efficiency of grinding surfaces.

MELTING POINT

- Solids with low Melting Point often becomes soft & melt due to the heat generated during the milling.
- The problem can be overcome by cooling the mill.

EXPLOSIVENESS

- Some substance possess explosive nature.
- Such materials must be ground wet or in the presence of inert atmosphere.

EQUIPMENTS USED FOR SIZE REDUCTION

The most common size reduction mills used in Pharmaceutical Industries are as follows :

① Hammer Mill
② Ball Mill
③ Fluid Energy Mill
④ Edge Runner Mill
⑤ End Runner Mill

HAMMER MILL

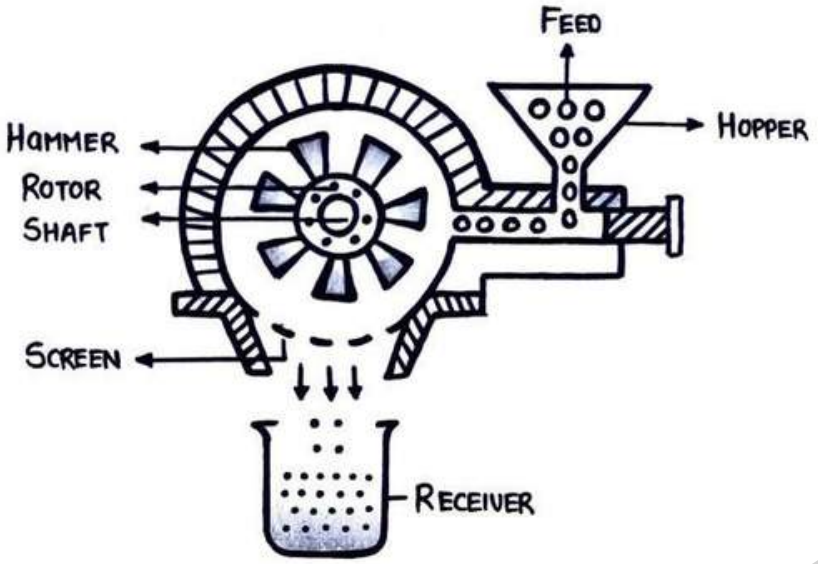
Hammer Mill is a type of crusher used for grinding and reducing the size of large particles.

PRINCIPLE

It operates on the principle of Impact between rapidly moving hammers mounted on Rotor & shaft.

CONSTRUCTION & WORKING

- A hammer mill is basically a steel drum containing a rotating shaft on which hammers are mounted.
- The hammer swings are fixed to the central rotor.
- The rotor rotates at high speed inside the drum.
- The material is put into the hopper which is connected with drum.
- The material is powdered to the desired size due to fast rotation of hammers & collected under the screen connected with outlet



USES

- It is used to grind pharmaceutical raw materials, herbal medicines and sugar.
- They are used for powder making in chemical & pharmaceu. industries.
- Used to obtain size of 10 - 400 mm.

ADVANTAGES

- Rapid in action & capable of grinding different types of materials.
- Easy to install & operate.
- Low maintainance cost.
- Requires moderate energy.

DISADVANTAGES

- Cannot be used for solids having ~~high~~ melting ~~poin~~ low melting point.
- It may get damaged in case of uncontrolled feed rate.

BALL MILL

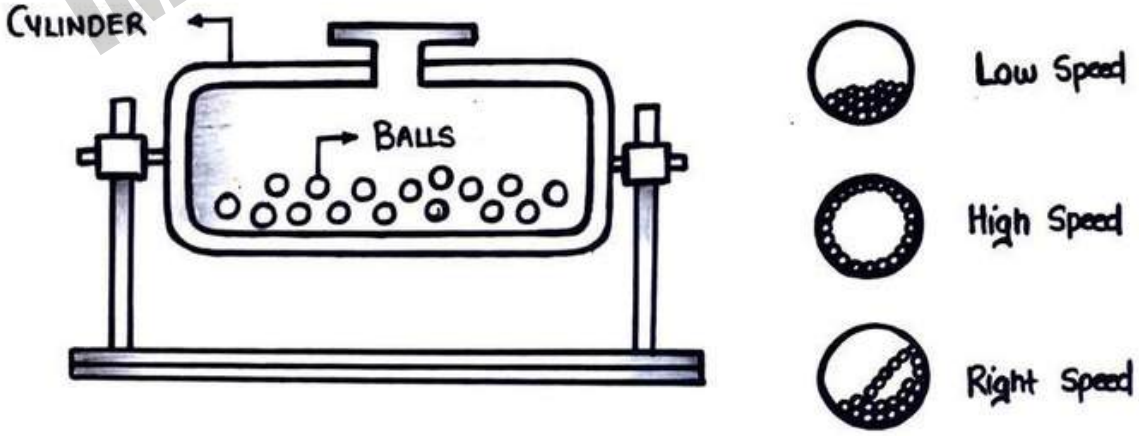
- Ball Mill is one of the type of grinder used to grind or blend materials into superfine powders.
- These powders are further used in mineral dressings, paint & ceramics.

PRINCIPLE

- The ball mill works on the principle of combined Impact & Attrition.
- Rapidly moving balls are used for reducing the size of larger particles.

CONSTRUCTION & WORKING

- The ball mill consist of a hollow cylinder mounted on a shaft & rotating about its horizontal axis.
- The cylinder contain balls generally made of metals that occupies 30-50% volume of the cylinder.
- The drug to be ground is placed inside the cylinder along with balls to about 60% volume of the cylinder.
- The mill is allowed to rotate on a correct speed.



Uses

- Used for production of Opthalmic & Parentral Products.
- Used for both dry & wet grinding.
- Used for production of Fine Powders without dust.

Advantages

- Very Fine Powder can be obtained.
- Suitable for both wet & dry grinding.
- Low Production & Installation cost.

Disadvantages

- It produces too much noise.
- Ball Milling is a slow process.
- It consumes high unit electricity

FLUID ENERGY MILL

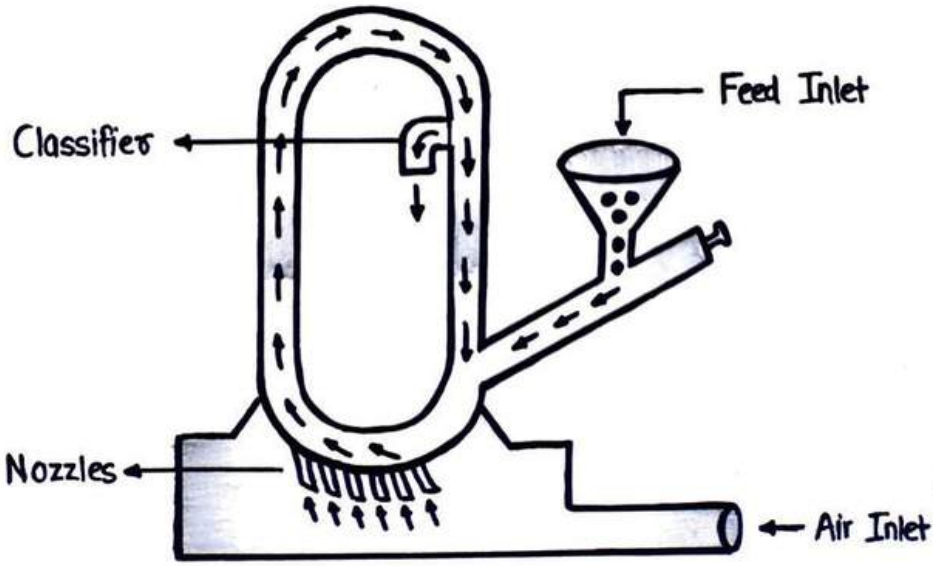
- Fluid energy mill is used for size reduction in pharmaceutical, cosmetics & food industries.
- It is also known as Jet Mill, Micronizers or Ultrafine Grinders.

PRINCIPLE

- It is based on the principle of combined Impact & Attrition.
- Size Reduction takes place by high velocity collision b/w particles.

CONSTRUCTION & WORKING

- It consist of a loop of pipe having internal diameter of 20 - 200 mm.
- Several Nozzles are fitted at the bottom of pipe through which air is inserted inside the pipe.
- A Classifier is fitted in the outlet section.
- The Feed is introduced into the mill via Feed inlet and air is injected at very high pressure through nozzles.
- Due to high velocity air cause turbulence that leads to collision of particles.
- Particles of desired size screened out through the classifier.



USES

- It is used to obtain very Fine Powders.
- It is mainly used for Heat Sensitive Materials.

ADVANTAGES

- It is suitable for Heat labile substances.
- Less chances of contamination.
- It gives particles of Ultrafine size

DISADVANTAGES

- It can't be used for milling of soft, gummy & fibrous substances.
- It is quite expensive.

EDGE RUNNER MILL

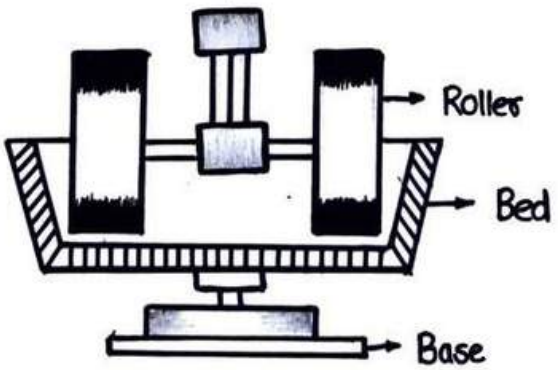
- Edge Runner Mill is also known as Roller Stone Mill.
- It contains two large grinding stones that rotates slowly in a large bowl containing the material & crushes them into fine powders.

PRINCIPLE

It works on the principle of compression and shearing force developed by rotating stones.

CONSTRUCTION & WORKING

- It consist of two heavy rollers that moves on a bed.
- Bed is generally made of stone or Iron.
- The roller rotates on a central shaft.
- The material to be ground is placed on the bed & stone is continuosly evolve on its axis.
- Size reduction is obtained by shearing along with crushing.
- Material is ground for definite period & then passed through the seives to get the powder of required size.



USES

- It is used to crush and grind nearly all types of drugs.
- It is mainly used for plant based products.
- It is used to get very fine particle size materials.

ADVANTAGES

- Very fine particle size obtained.
- Less attention required during operation.
- Simple in structure.

DISADVANTAGES

- It cannot be used for sticky materials.
- Chances of contamination due to roller material
- It makes a lot of noise

END RUNNER MILL

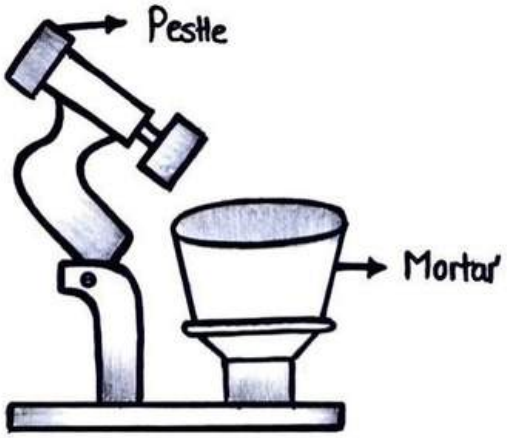
- End Runner Mill is nothing but the advance and automated version of Mortar and Pestle.
- It operates like a wet grinder used in houses.

PRINCIPLE

It works on the principle of crushing and shear forces developed due to the movement of Mortar & Pestle.

CONSTRUCTION & WORKING

- It consist of Mortar & Pestle made of either steel or stone.
- The Pestle rotates on its axis & of dumb-bell shaped.
- Mortar is generally rotated at high speed.
- The material whose size is to be reduced is placed in Mortar.
- The mortar revolves at high speed & revolving mortar causes the pestle revolv.
- The resulting material passed through seive to get powder of sufficient size.



USES

- It is used for crushing very hard & fibrous materials.
- Used for both dry & wet grinding.
- Used for grinding paint, clays & sticky materials.

ADVANTAGES

- Easy to clean & operate.
- Low Maintainance cost.
- Requires less attention

DISADVANTAGES

- It causes lot of noise.
- Not suitable for very hard drugs

SIZE SEPARATION

- Size Separation is defined as a pharmaceutical process that involves the separation of particles of desired size from the mixture of various size particles.
- It is also known as Seiving, Screening or Sifting.
- Size reduction gives particles of small but varying sizes and alone it is not sufficient to give particles of required size, hence size reduction & size separation performed simultaneously to obtain powders of desired size.

OBJECTIVES / APPLICATION OF SIZE SEPARATION

- To prepare granules of desired size.
- To classify materials into different sizes.
- To get uniform dosage form.
- To separate undesirable particles from a mixture.
- To know the efficiency of size reduction equipments.
- To improve mixing of powders.
- To improve solubility & stability of drugs.
- For preparations of tablets, suspensions & other pharmaceutical products.
- During the filling of capsules, the particles must be uniform in weight & doses.

MECHANISM OF SIZE SEPARATION

Size separation is mainly done by 3 methods :

① Agitation
② Brushing
③ Centrifugation

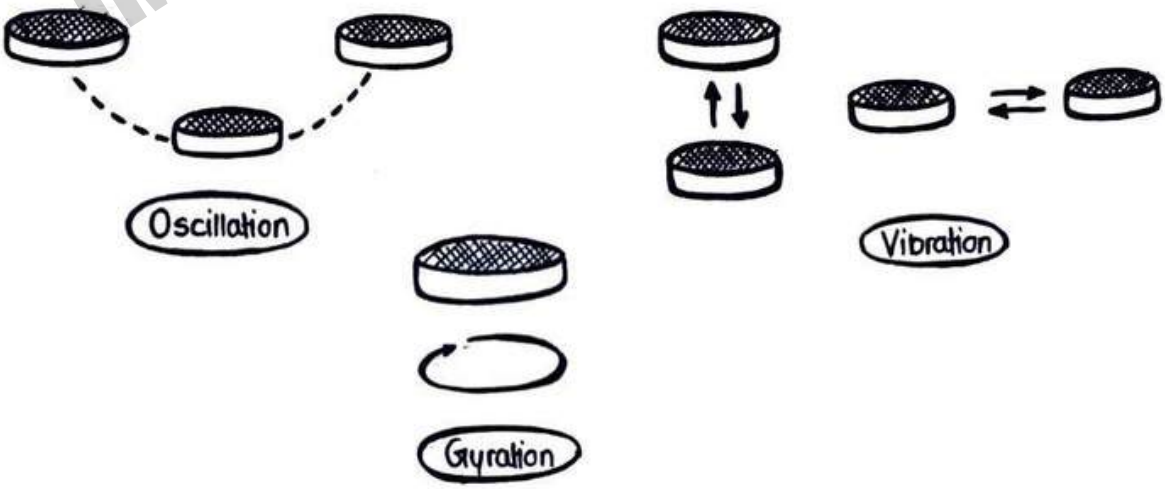
AGITATION

- It is a method of size reduction through seives.
- Seives are agitated in different number of ways. as follows :

ⓘ **Oscillation** : In this method seive moves in a oscillatory motion (to and fro movement).
Material is roll on the surface of the selve.

ⓘⓘ **Vibration** : In this method, the seive shows a type of vibration.
This motion can cause seive to move Up-Down or Left-Right.

ⓘⓘⓘ **Gyration** : Gyration is a type of rotatory motion that allows the particles to spin and pass through the meshes.



BRUSHING

- In this method a brush is used to move the particles on the surface of the seive to keep the meshes clear.
- The brush is rotated in the centre in the case of circular seive.
- This method is mainly used to separate the size of greasy and sticky powder substances.

CENTRIFUGATION

- In this method, a high speed rotor is fixed inside a vertical cylinderical seive.
- This method works on the principle of centrifugal Force.
- The particle separation occurs due to a stream of air created by rotor's rotation.

OFFICIAL STANDARDS OF POWDERS

- Generally, Powders are classified as Coarse or Fine Powders.
- But Indian Pharmacopoeia has prescribed some standards for the classification of powders.
- According to I.P., the degree of coarseness or fineness is expressed with reference to the size of seive through which powder can pass.

TABLE FOR CLASSIFICATION OF POWDERS

GRADES OF POWDER	SIZE THROUGH WHICH ALL PARTICLES PASS	SIZE THROUGH WHICH 40% PARTICLES PASS
• COARSE POWDER	10	44
• MODERATELY COARSE	22	60
• MODERATELY FINE	44	85
• FINE POWDER	85	–
• VERY FINE POWDER	120	–

COARSE POWDER

It is the powder, in which all particles pass through seive no 10 and not more than pass through seive no. 44.

MODERATELY COARSE POWDER

It is the powder, in which all particles pass through seive no. 22 and not more than 40% pass through seive no. 60.

Moderately Fine Powder

It is the powder, in which all particles pass through seive no. 44 but not more than 40%. pass through seive no. 85.

Fine Powder

A Powder in which all particles pass through the seive no. 85 is known as Fine Powder.

Very Fine Powder

A Powder in which all the particles pass through the seive no. 120 is known as Very Fine Powder.

SIEVES

- Seives are the devices used for separating wanted materials from unwanted materials.
- Seives are the simplest and most frequently used instrument for size separation.

TYPES OF SIEVES

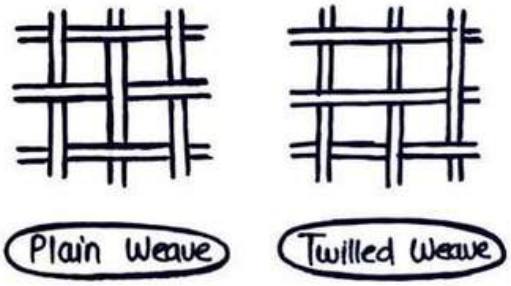
Seives can be classified as follows :

① Woven wire sieves
② Bolting Cloth Sieves
③ Bar Screens
④ Punched Plates

WOVEN WIRE SIEVES

- These are general purpose seives & widely used in pharmacy practices.
- They are of further two types :

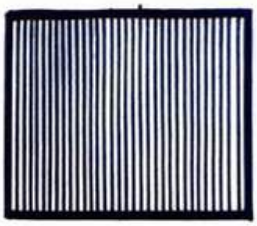
ⓘ Plain Weave Sieve
ⓘⓘ Twilled Weave Sieve



BOLTING CLOTH SIEVES

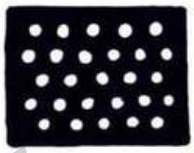
- They are generally made of nylon clothes
- They are used for separation of Fine Powders.

BAR SCREENS



- They are mainly used for handling of very large and heavy materials.
- They are generally made of iron or aluminium.
- It is a large mechanical Filter.

PUNCHED PLATES



- They are also known as Perforated Screens.
- They are used for coarse sizing.
- They are generally made of sheet of metals having round, oval, square or rectangular perforations.

EQUIPMENTS USED FOR SIZE SEPARATION

There are various equipments used for the process of size separation, some of them are discussed below :

① Sieve Shaker
② Cyclone Separator
③ Air Separator
④ Bag Filter
⑤ Elutriation Tank

SIEVE SHAKER

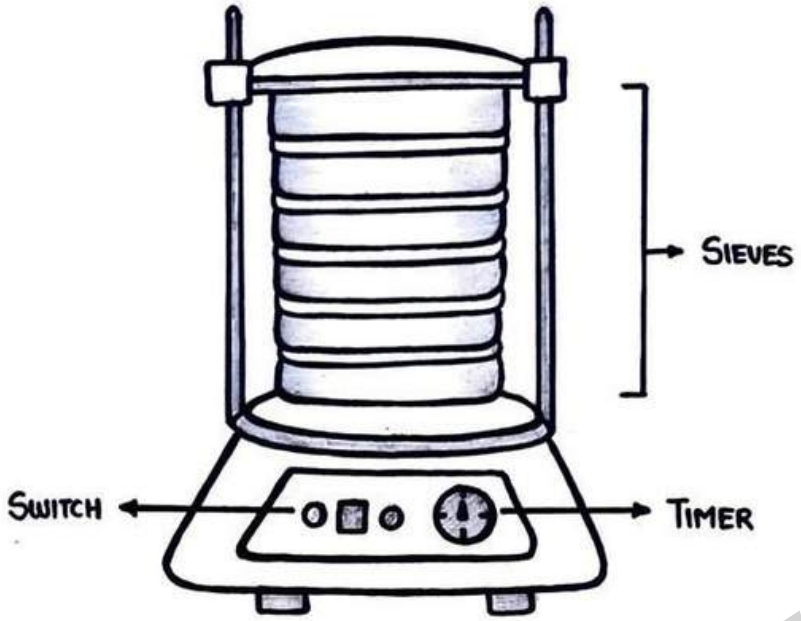
- A sieve shaker is a laboratory device used for the process of size separation.
- It is an automated version of Agitation process.

PRINCIPLE

- Sieve Shaker works on the principle of Agitation.
- The powdered drug separates out in different seives according to their sizes due to vibration.

CONSTRUCTION & WORKING

- It consist of a base on which different number of sieves are connected with each other.
- It contains standard sieves with different sieve numbers.
- Sieves are arranged such that largest is on top & smallest at bottom.
- The sample is placed on top selve & machine has started (20 minutes)
- The powder retained on each sieve is collected & weighed.



USES

- It is used for the process of size separation & size determination.
- It is used in the development of tablets & capsules.

ADVANTAGES

- It requires less power supply.
- It is not so much expensive.
- Easy to install & operate.

DISADVANTAGES

- During shaking, attrition may occur.
- Chances of clogging, if material is wet.

CYCLONE SEPARATOR

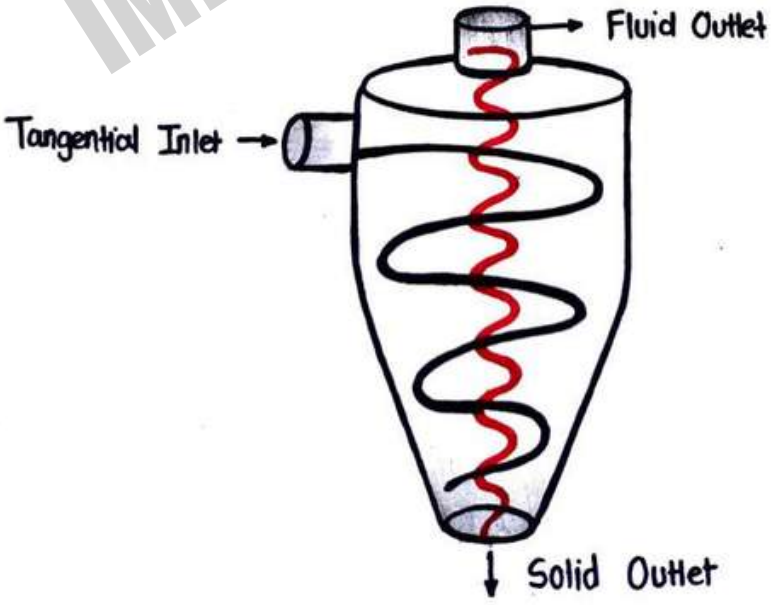
Cyclone Separator is a device that uses tangential air to create a cyclone for the process of size separation.

PRINCIPLE

- Cyclone Separator works on the principle of Centrifugation.
- It mainly used to separate solids from fluids (air).

CONSTRUCTION & WORKING

- It consist of conical & vertical cylindrical vessel.
- The cylinder consist of a tangential inlet in the upper side, a Fluid Outlet on the top & solid outlet at the bottom.
- The Feed is introduced tangentially at very high velocity into the vessel.
- The rotatory motion takes place inside the vessel & a cyclone forms.
- The solids are thrown to the walls by centrifugal force that later on leaves through the solid outlet.
- The Fluids (Air) escapes from the top through Fluid Outlet.



USES

- It is used for separation of solids and gases.
- It is used to separate coarse particles from fine dust.

ADVANTAGES

- Low investment cost.
- It can operate at high temperatures.
- Requires small space for installation.

DISADVANTAGES

- High Power Consumption.
- It cannot be used for sticky materials

AIR SEPARATOR

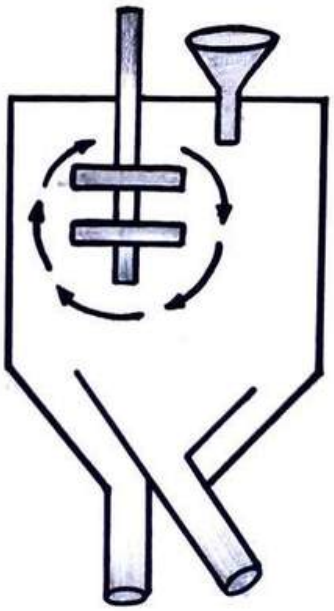
Air separator is a mechanical device that separate materials based on their sizes.

PRINCIPLE

- The air separator works on the same principle as a Cyclone Separator.
- It separates particles with the help of Centrifugal Force.

CONSTRUCTION & WORKING

- Air separator consist of a cylindrical vessel with a conical base having a feed inlet at upper part of the vessel.
- It consist of a rotating disc & blades at the centre of the vessel.
- Two outlets also present at the base, one for finer particles and other for coarser particles.
- Feed enters through Feed inlet and falls on rotating blades.
- The rotating blades rotates & produces an air current that cause centrifugation.
- The coarser particles falls in the heavy outlet while finer ones falls in the Finer outlet.



USES

- It is used to separate sub micron size particles.
- It is used for separation of dry particles

ADVANTAGES

- It is a simple instrument
- Easy to install
- Easy to clean & maintain

DISADVANTAGES

- Not suitable for wet & sticky materials
- Slightly costlier.

BAG FILTER

Bag Filters are mainly used for removing big dust particles & filtration of air

PRINCIPLE

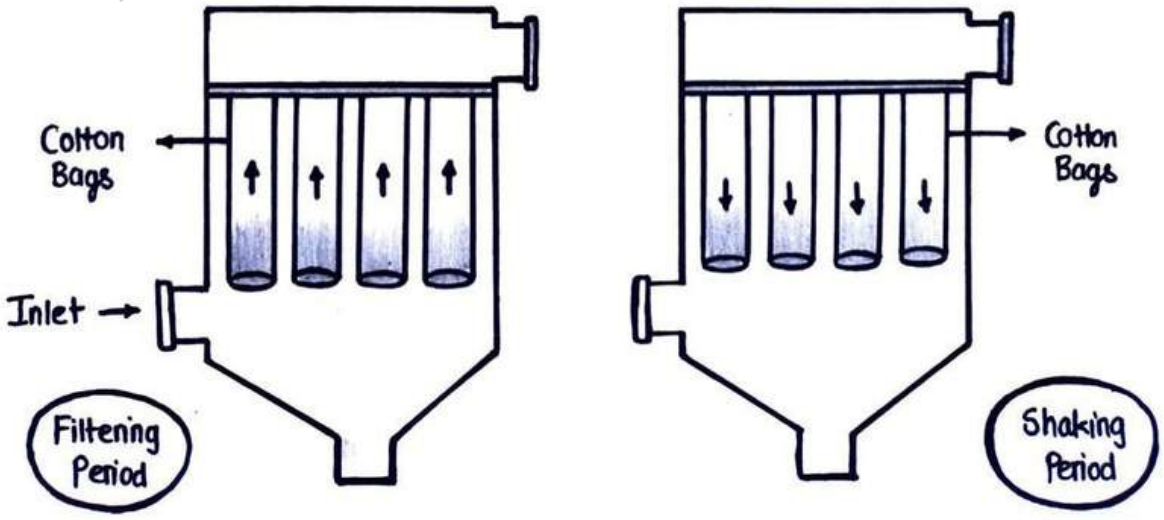
The bag filter works on two step principle.

① In the first step the gas containing the dust is passed through a bag (cloth) by applying suction & because of this separation occurs.

② In the next step bags are shaken by applying pressure so that powders attached with the bags falls & collected from base.

CONSTRUCTION & WORKING

- It consist of series of bags made of cotton or wool.
- A Hopper is arranged at the bottom of the felter to receive feed. Working consist of two steps
- First Feed is separated from air by passing it through cloth bags.
- In next step the bags are shaken to collect the fines that are adheres to the bags.



USES

- It is used to purify the air.
- It is used along with cyclone separator.

ADVANTAGES

- It can be used for removing dust
- It is cost effective

DISADVANTAGES

- It requires long time
- It is not a pure size separation equipment.

ELUTRIATION TANK

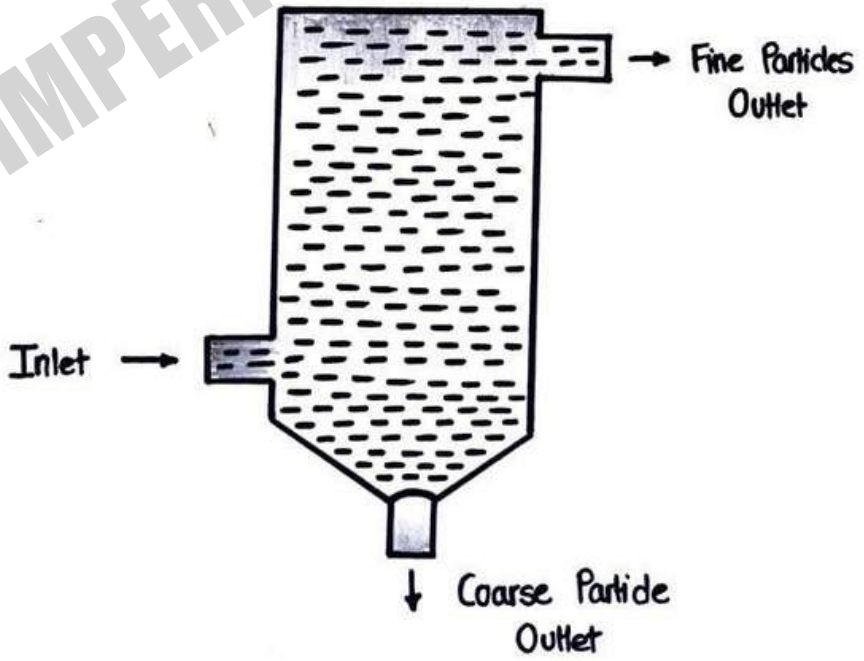
Elutriation Tank basically separates the heavier particles from lighter partides.

PRINCIPLE

- Elutriation Tank works on the principle of Elutriation, in which particles settles down on the bottom of the tank.
- Fluid Flows in the opposite direction of settling movement of particles.

CONSTRUCTION & WORKING

- It consist of a vertical column with an inlet near the bottom.
- An outlet for the coarse powder available at the base.
- The tank is filled with dry powder along with large amount of water
- The particles are allowed to settle for a given time period.
- The particles are collected at different heights according to their sizes.



USES

- Used for separating insoluble solids according to their sizes.
- Can be used in single or multiple form.

ADVANTAGES

- It is a quick process.
- Easy to install & operate.

DISADVANTAGES

- Need of dilution.
- Not provide 100% accuracy

THANK YOU

FOR CHOOSING IMPERFECT PHARMACY AS YOUR STUDY PARTNER

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