Fluid :- A fluid is a substance that under an applied shear stress continuously flow.

⇒ The term fluids are a subset of the phases of matter and it includes both gases and liquids.

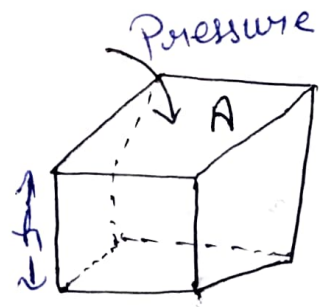
Fluid flow :- It can be defined as the flow of substances that are not permanently resistant to deformation.

The study of fluid can be divided into following type

- Fluid Static
  - ⇒ Study of behaviour of liquid at rest
- Fluid Dynamics
  - → Study of behaviour of liquid at motion

Pressure equation :-

$$\text{Pressure} = \frac{\text{weight}}{\text{Area}} \quad \text{— ① equation}$$



$\because$ Weight $= mg$

↳ acceleration due to gravity

$$\text{Pressure} = \frac{mg}{A}$$

$\because m = \rho \times V$

So,

$$\text{Pressure} = \frac{\rho \times V \times g}{A} \quad \text{— (ii) equation}$$

$\because V = A \times h$

$$\Rightarrow \text{Pressure} = \frac{\rho \times \cancel{A} \times h \times g}{\cancel{A}}$$

$$\Rightarrow \boxed{\text{Pressure} = \rho \times h \times g}$$

Where,

ρ = Density

g = accelaration due to gravity

h = height

<u>Measurment of pressure</u> :-

The device which are used to calculate the pressure difference is known as manometer.

Types of manometer

- 1. Simple manometer
  - a. Piezometer
  - b. U-tube manometer
  - c. Single Column manometer
- 2. Differetial manometer
  - a. U-tube diffential manometer
  - b. Inverted U-tube diffential manometer
- 3. Inclined manometer

a. Piezometer

⇒ Piezometer is one of the simplest form of manometer.

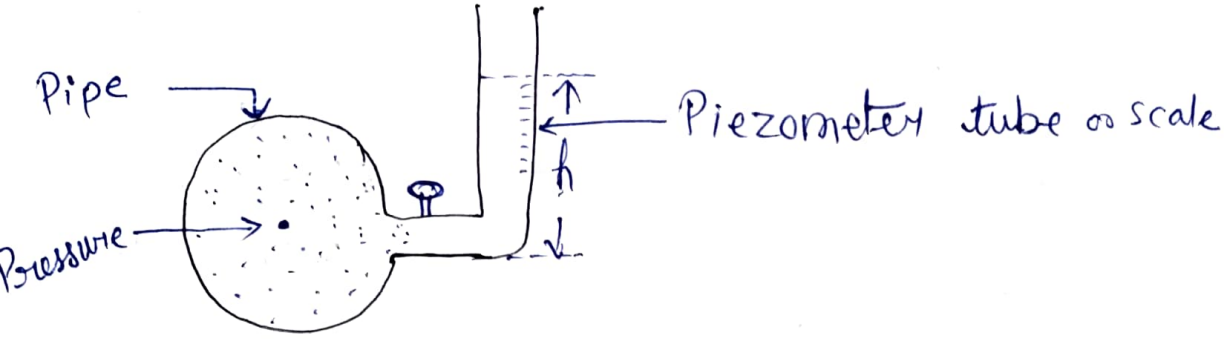
⇒ Used to measure moderate pressure of liquid.

Construction :-

⇒ It consist of a glass tube which is inserted into the wall of vessel.

⇒ The tube extends vertically upwardly to such a hight that the liquid can freely rise their in without overflowing.

⇒ The pressure ~~of~~ at any point in the liquid is indicated by the hight of liquid in the tube above that point.



$$\boxed{P = \rho g h}$$

where,

P = Pressure
ρ = fluid density
g = Accelaration due to gravity
h = height of liquid column

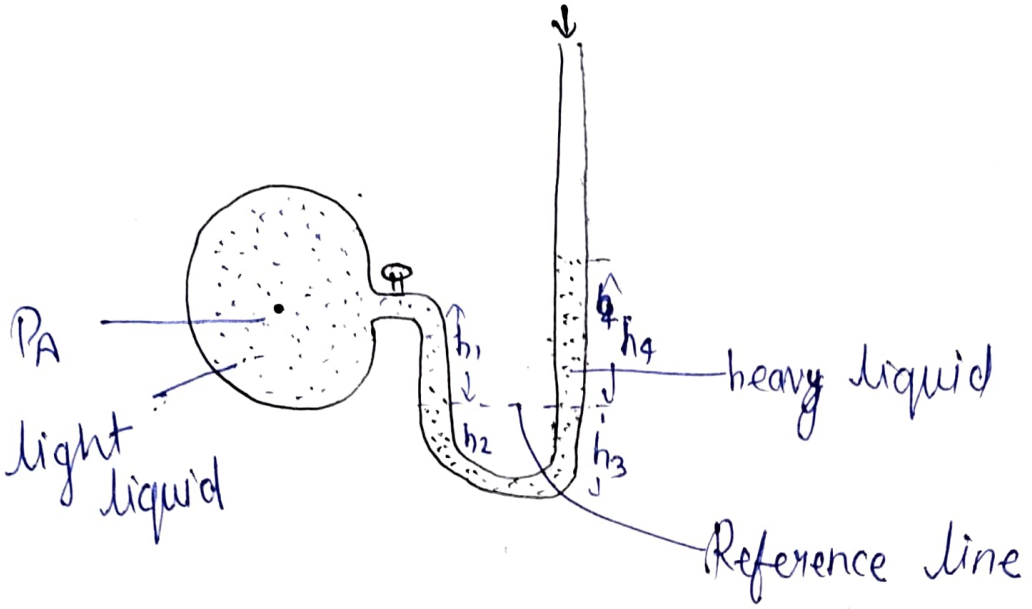
(B) U-tube Manometer :-

⇒ Used to measure pressure difference of gas.

Construction :-

⇒ It consist of a glass tube folded like the letter "U".

⇒ In this type of manometer one end of the tube is attached to the point where the pressure is to be measured and the other end is open at atmospheric pressure.



$$P_A = -\rho_A h_1 g - \rho_B h_2 g + \rho_B h_3 g + \rho_B h_4 g \quad \{\because h_2 = h_3\}$$

$$P_A = -\rho_A h_1 g - \cancel{\rho_B h_2 g} + \cancel{\rho_B h_2 g} + \rho_B h_4 g$$

$$\boxed{P_A = -\rho_A h_1 g + \rho_B g h_4}$$

Where,

P_A = Pressure

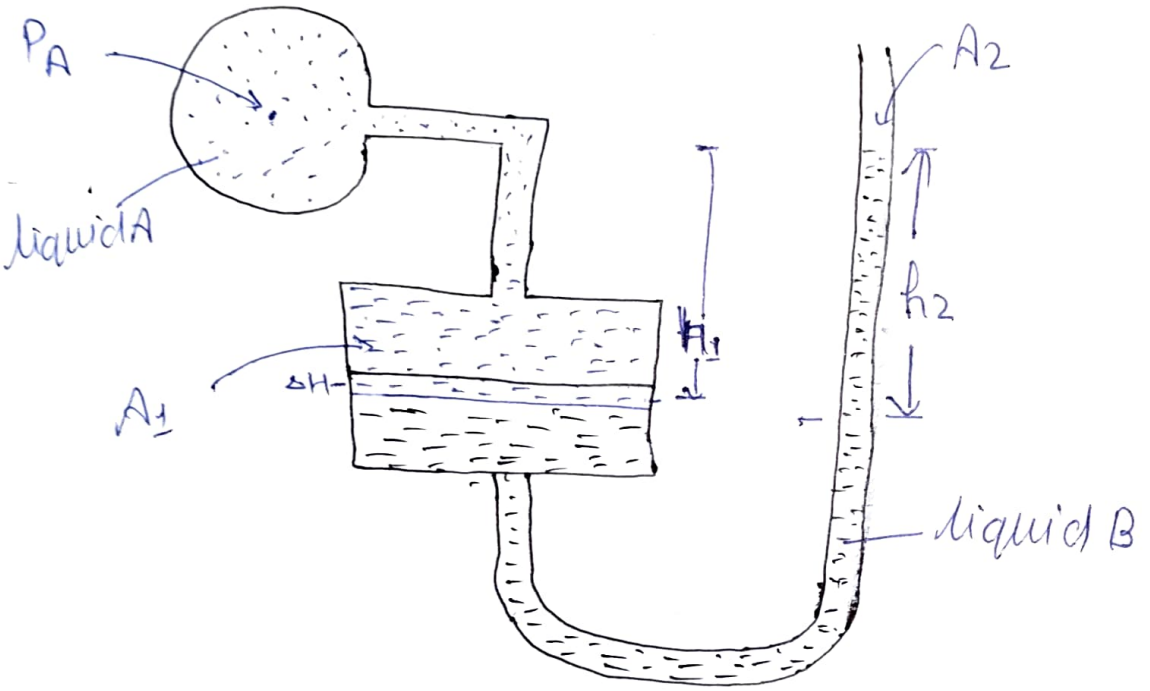
ρ_A = Density of light liquid

ρ_B = Density of heavy liquid

(c) Single Column Manometer :-

It is a modified form of a U-tube manometer, in which a reservior having a large cross sectonal area (approx 100 times) compared to the tube area is connected to one of the manometer limb.

For any variation in pressure, the change in liquid level in the reservoir will be very small, which can be neglected and therefore the pressure is given by the height of the liquid at the other limb.



Volume of Reservior = Volume of pipe

$$l \times b \times h = l \times b \times h$$

$$\Rightarrow A_1 \times \Delta h = A_2 \times h_2$$

$$\Rightarrow \Delta h = \frac{A_2 + h_2}{A_1} \quad \text{—} (1)$$

$$P_A = -S_1 h_1 - S_1 \Delta h + S_2 \Delta h + S_2 h_2$$

$$P_A = -S_1 h_1 + \Delta h(-S_1 + S_2) + S_2 h_2$$

$$P_A = -S_1 h_1 + S_2 h_2 + \Delta h(-S_1 + S_2)$$

$$P_A = -S_1 h_1 + S_2 h_2 + \frac{A_2 \times h_2}{A_1}(-S_1 + S_2)$$

$$\boxed{P_A = -S_1 h_1 + S_2 h_2}$$ if $\frac{A_2 \times h_2}{A_1}(-S_1 + S_2) = \Delta h =$ neglect

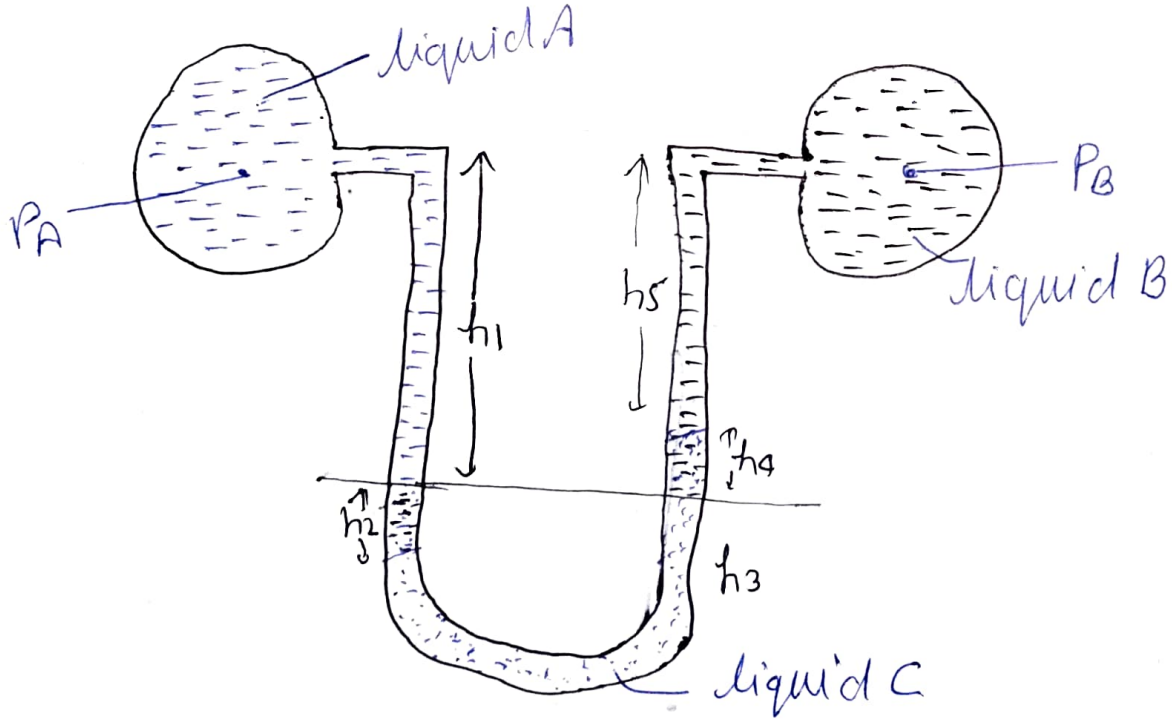
2. Differential manometer

(A) U-tube measure the difference of pressure between any two point in a fluid contained in a pipe or between two different pipes.

Types
- → U-tube differential manometer
- → Inverted U-tube manometer.

(A) U-tube differential manometer :-

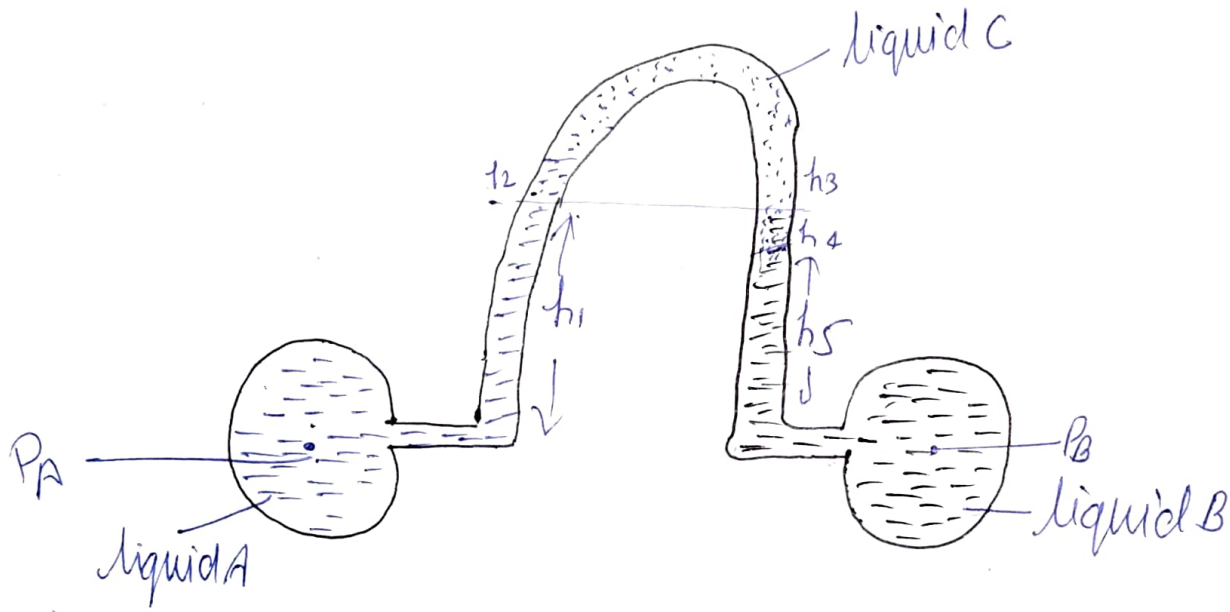
- ↳ used to measure the fluid pressure difference between these two pipes.
- ↳ Two pips are in parallel position.



$$P_A = -\rho_A g h_1 + \rho_C g h_4 + \rho_B g h_5$$

$$\boxed{P_A - P_B = -\rho_A g h_1 + \rho_C g h_4 + \rho_B g h_5}$$

3 Inverted U-tube manometer :-

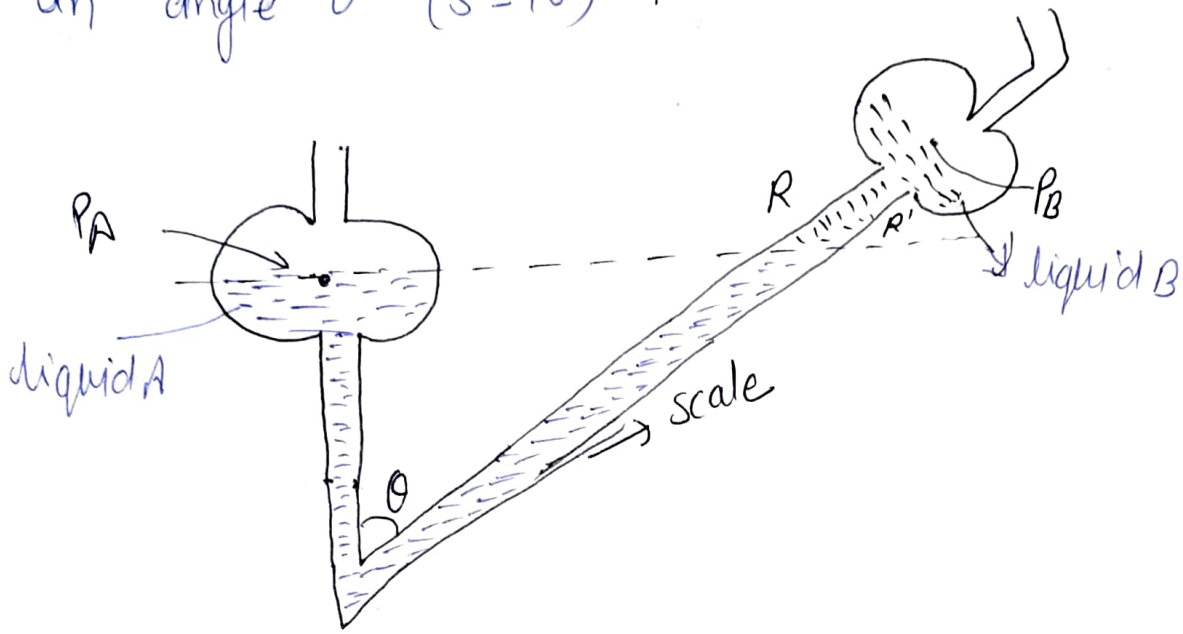


$$P_A = \rho_A g h_1 - \rho_C g h_4 - \rho_B g h_5 - P_B$$

$$\boxed{P_A - P_B = \rho_A g h_1 - \rho_C g h_4 - \rho g h_5}$$

3. Inclined Manometer

- Used to measure very small pressure difference.
- The one arm of the manometer is inclined at an angle θ $(5^\circ - 10^\circ)$.



⇒ The distance moved by meniscus is given by R.

⇒ Fluid in inclined move longer distance R'.

$$P_A - P_B = gR'(P_A - P_B)\sin\theta$$

$$\boxed{\Delta P = gR'(P_A - P_B)\sin\theta}$$

Fluid Dynamic :-

It deals with the study of fluid in motion.

⇒ Generally three types of fluid flow in pipe -

- Laminar flow
- Turbulent flow
- Transient / Transitional flow

① Laminar flow :-

The laminar flow is that in which the fluid particles move in straight layer.

⇒ There is no exchange of fluid particles from one layer to another layer.

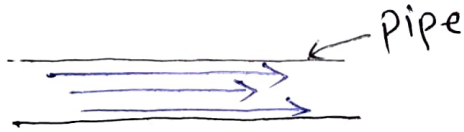


Fig. laminar flow.

② Turbulent flow :-

When velocity is increased, fluid particles move in random manner instead of straight path; This type of flow is called turbulent flow.

⇒ As a result complete mixing of fluid particles is produced.

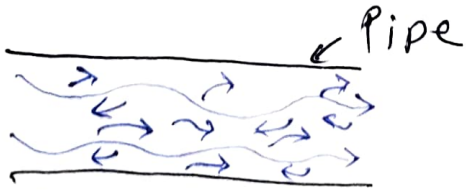


Fig. Turbulent flow

③ Transitional flow :-

The transitional flow is a mixture of laminar and turbulent flow with turbulence at the center of the pipe and laminar flow near the edge.

Fig. Transitional flow

Reynold Experiment :-

⇒ Performed by Osborne Reynold in 1883.

In this experiment a glass tube was connected to reservoir of water in such a way that the velocity of water flowing through the tube could be varied

⇒ At the inlet end of ~~tube~~ tube a nozzle was fitted through with a fine steam of coloured water can be introduced.

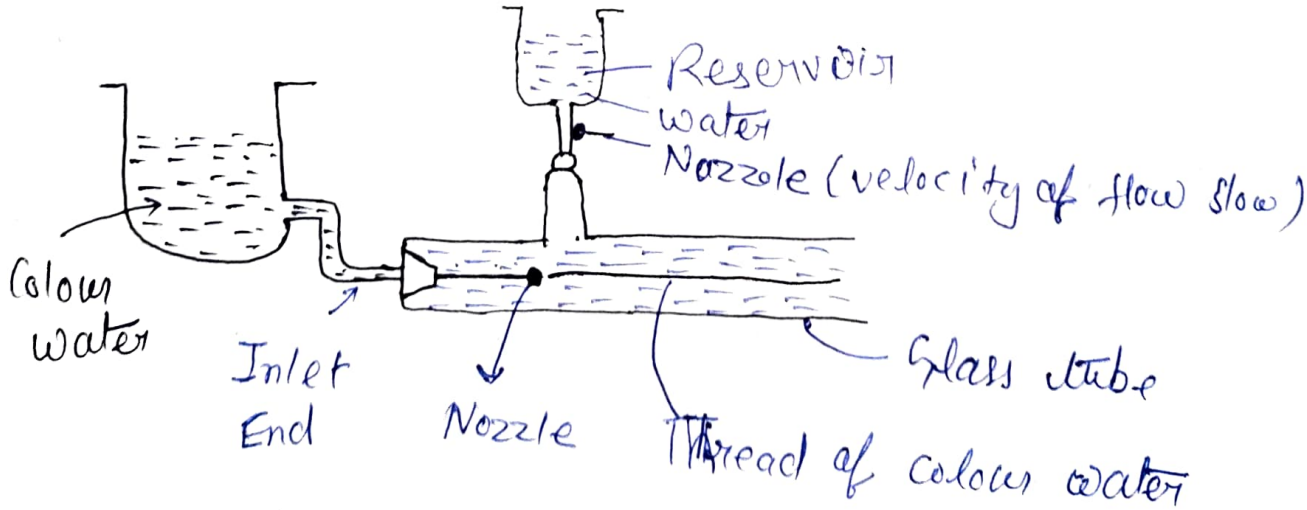


Fig: Reynold Experiment

Conclusion :-

1. When the velocity of water was low the thread of colour maintained itself through the tube
2. As the velocity of water was increased it was found that at a definite velocity the the thread disappeared, and the entire mass of liquid was uniformly colour.

⇒ Reynold Number :-

It is the ratio of inert forces to viscous forces.

→ It is denoted by "Re".

$$Re = \frac{\text{inert forces}}{\text{viscous forces}}$$

$$\boxed{Re = \frac{D u \rho}{\eta}}$$

Where,

D = Diameter of pipe
u = velocity of fluid
ρ = density of fluid / liquid
η = viscosity of liquid

Fluid flow
- → laminar flow = $Re < 2000$
- → turbulent flow = $Re > 4000$
- → Transitional flow = $Re = 2000 - 4000$

Re

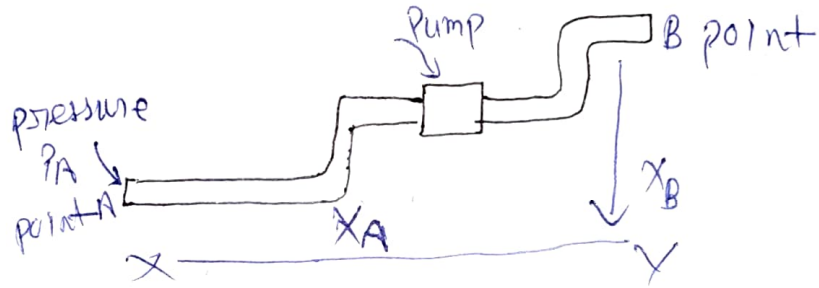
Application :-

1. To predict the flow of liquid / fluid.
2. Heat transfer in liquid also depends on flow.

Bernoulli's Theorem

When the principle of conservation of energy is applied to flow of fluid the resulting equation is called Bernoulli's theorem.

⇒ Consider a pump working under a isothermal condition between point A and point B.



⇒ In a steady state the total energy per unit mass consist of pressure, kinetic and potential energies are constant.

⇒ At point A liquid is flowing through pipe at certain pressure.

Pressure Energy may be written as –

$$\text{Pressure Energy} = \frac{P_A}{g \rho_A} \quad \text{—(1)}$$

where, P_A = Pressure at point A, ρ_A = density of liquid.
g = Acceleration due to gravity

Potential Energy :- It is defined as the energy possesed by the body by virtue of its position.

$$\text{Potential Energy} = x_A \quad \text{—— (ii)}$$

Kinetic Energy :- It is defined as the energy possesed by the body by virtue of its motion.

$$\text{Kinetic Energy} = \frac{U_A^2}{2g} \quad \text{—— (iii)}$$

where, U = Velocity of liquid
g = Acceleration due to gravity

⇒ Total Energy at point A = Pressure Energy + Kinetic Energy + Potential Energy

$$\boxed{= \frac{P_A}{g\rho_A} + \frac{U_A^2}{2g} + x_A = \text{Constant.}} \quad \text{(iv)}$$

$$\text{Total Energy at point B} = \frac{P_B}{g\rho_B} + \frac{U_B^2}{2g} + x_B = \text{Constant} \quad \text{(v)}$$

So,

Total Energy at point A = Total Energy at point B

$$\boxed{\frac{P_A}{g\rho_A} + \frac{U_A^2}{2g} + x_A = \frac{P_B}{g\rho_B} + \frac{U_B^2}{2g} + x_B} \quad \text{—— (vi)}$$

For transportation of fluid, pump add certain amount of energy which can be written as-

Energy added by pump = W

During transport some energy get convert to heat due to frictional forces

Energy loss due to friction = F

$$\boxed{\frac{P_A}{g\rho_A} + \frac{U_A^2}{2g} + X_A + W - F = \frac{P_B}{g\rho_B} + \frac{U_B^2}{2g} + X_B} \quad \text{(vii)}$$

This is called Bernoulli's Equation.

Application :-

⇒ It is used to measure rate of flow of fluid using flowmeter.

⇒ It is used in working of centrifugal pump.

Energy losses

When a fluid flows through a pipe the fluid experiences some resistant due to which part of energy is lost.

⇒ This loss of energy is classified as

- Friction losses
- Losses in fitting
- Enlargement losses
- Contraction losses

① Friction Losses :- The fluid flow can be viscous.

Frictional forces during flow of fluid cause loss in pressure (ΔP).

Following equation are used to calculate the friction losses.

$$\boxed{\Delta P_f = \frac{2 f u^2 L \rho}{g_c D}}$$

This equation is called fanning equation.

where,

ΔP_f is pressure drop

f = Friction factor

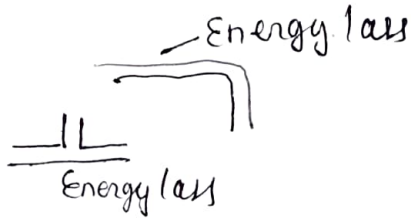
u = velocity of fluid

ρ = density of fluid

D = Diameter of pipe

② Losses in fitting :-

Equation = $\boxed{h = \frac{K v^2}{2g}}$



where,

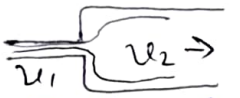
h = pressure Losses

K = K-factor for the fitting

v = Velocity of fluid

g = Acceleration due to gravity.

③ Enlargement Losses :-



Sudden Enlargement

If there is gradual enlargement in cross section of pipe then there is no loss of energy, Because fluid adapt itself to changed section without disturbance.

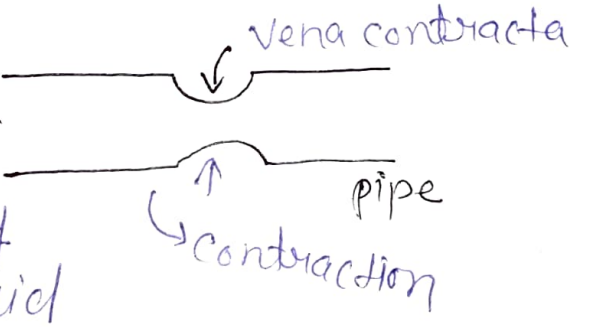
$$\Delta H = \frac{(v_1 - v_2)^2}{2g}$$

Where,

ΔH = loss of Head due to sudden enlargement

v_1 & v_2 are velocities in smaller and larger cross section.

④ Contraction Losses :-



When cross section of pipe reduced suddenly, energy is lost because flow of fluid get disturbed.

⇒ The point at which diameter of fluid steam get less then initial volume of diameter is called vena contracta.

$$\Delta H_c = \frac{K v_2^2}{2g}$$

Where,

ΔH_c = loss of head due to sudden Contraction

v_2 = velocity of fluid

K = Constant.

Measurment of Flow

Flow meter:- A flow meter is a device used to measure the flow rate or the amount of a gas or liquid moving through pipe. Two type ① Direct measure or weighing
② hydrodynamic method

Types

- Orifice meter
- Venturi meter
- Pitot tube
- Rotameter.

① Orifice Meter:-

Orifice meter is also known as variable head meter.

The orifice meter consist of thin plate having narrow or sharp aperture. Orifice plate is place between long straight pipe when fluid steam passes through narrow constriction, there will be increase in velocity. According to Bernoulli's theorem ~~head~~ there will be decrease in pressure at that point.

The difference in pressure head between main channel and point of constriction may be read by manometer.

- This pressure difference is related to rate of flow of fluid.

When Bernoulli's equation is applied between point A and B then,

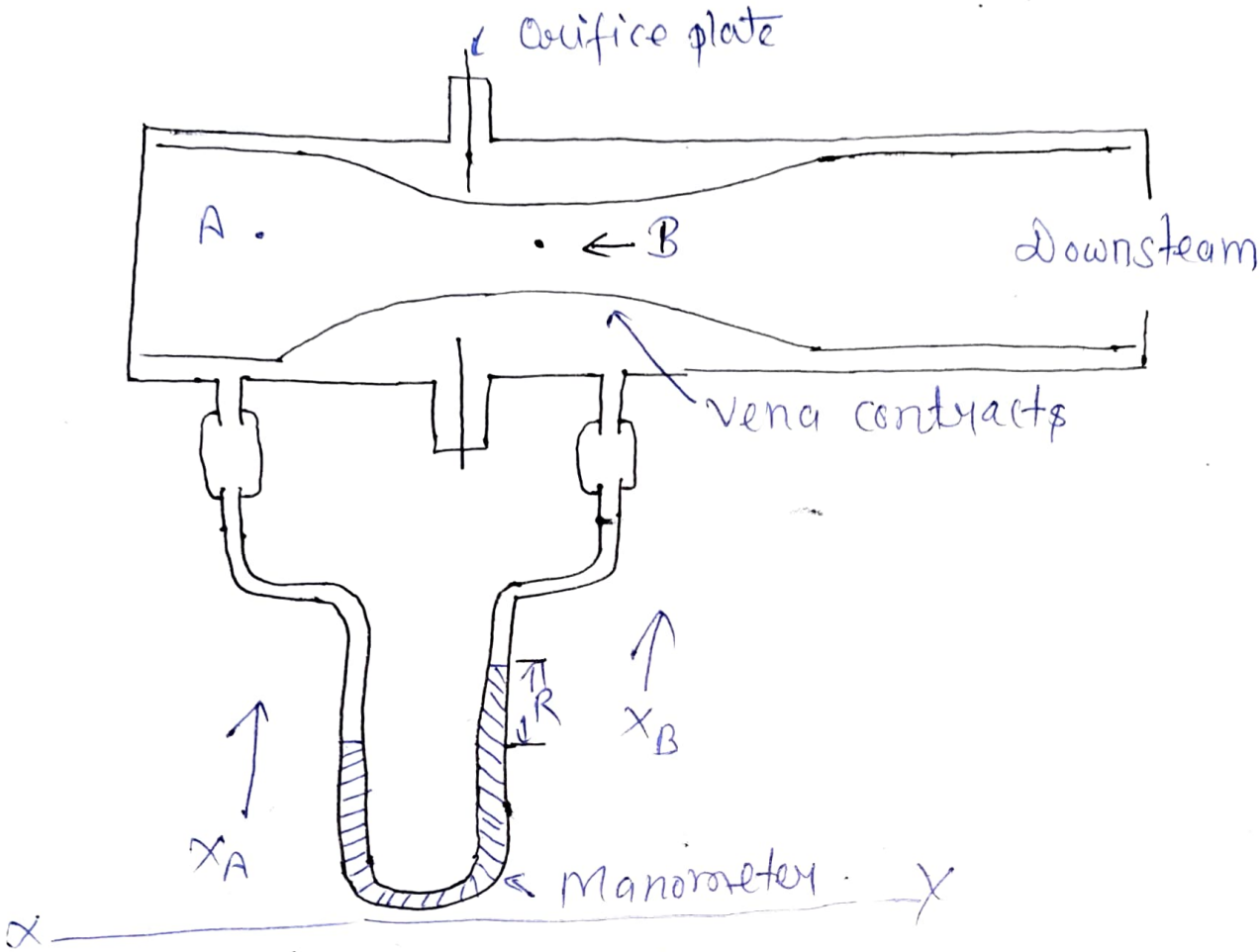


Fig. Orifice meter

① $X_A = X_B$ (As section of pipe is horizontal)

② $F = 0$ (As friction loss in this short section of pipe is negligible)

③ $W = 0$. (As no work is done on liquid between these two point)

by putting all above point in Bernoulli's equation –

$$u_B^2 - u_A^2 = \frac{2g\,(P_A - P_B)}{g\rho}$$

or

$$u_B^2 - u_A^2 = \frac{2g\,\Delta P}{2\rho}$$

From the principle of static $\because \Delta H = \frac{\Delta P}{g\rho}$

then,

$$u_B^2 - u_A^2 = 2g\,\Delta h$$

After taking underroot of both

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

The flow area becomes minimum at a short distance on the down steam side of the orifice plate which is known as the vena contracta.

→ In practice diameter of steam at vena contracta is not known while that of orifice diameter is known.

Therefore, to correct the differences b/w velocities at orifice and vena contracta a constant C_0 is introduce in above equation and further it get modified in term of velocity through orifice u_0

$$\boxed{u_0 = C_0\sqrt{2g\Delta h}}$$

$$\sqrt{u_0^2 - u_A^2} = C_0\sqrt{2g\,\Delta H}$$

Where C_0 is coefficient of orifice and its value depend on ratio of orifice diameter. on position of orifice tap and on Reynolds number.

If orifice diameter is 1/5th of pipe diameter or less then U_A is small compared to U_0

The equation will be measured by manometer.

② Venturi meter :-

Venturi meter is also known as variable head meter.

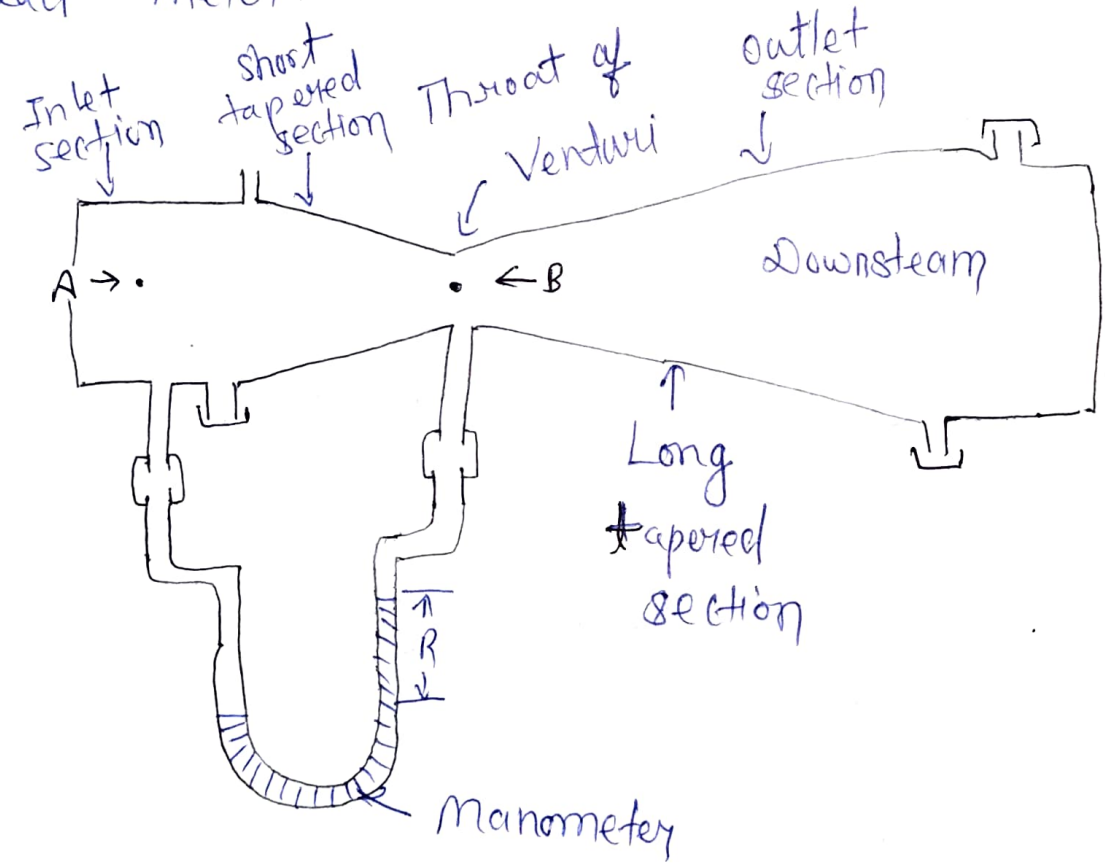


Fig. Venturi Meter

Venturi meter consist of two tapered section with throat (constricted position) of center. In the upstream cone of the venturi meter, velocity is increased, pressure is decreased.

Pressure drop in the upstream cone is utilized to measure the rate of flow through the instrument venturi meter hold same principle as of orifice meter.

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

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

Where,

u_v = velocity ~~of~~ at throat venture.

u_A = velocity at point A

C_v = Coefficient of venturi

③ Pitot tube :- Discovered by Henri Pitot

Pitot tube is also called insertion meter.

It consist of two concentrically arranged ~~(point A)~~ ~~that~~ have tubes bent at right

angle. The tube (point A) that have pointed upstream measure pressure head & velocity head.

⇒ The tube (point B) which is at right angle to flow measures pressure head only. The difference is above reading indicates velocity head.

⇒ Reading R of manometer measures velocity head in meter.

⇒ According to Bernoulli's equation, velocity head of fluid may be obtained by-

$$\Delta H_p = \frac{u^2}{2g}$$

So, $U_p = C_p \sqrt{2g.\Delta H}$

Where,

u = velocity of flow at point of insertion.

ΔH_p = difference in head from manometer.

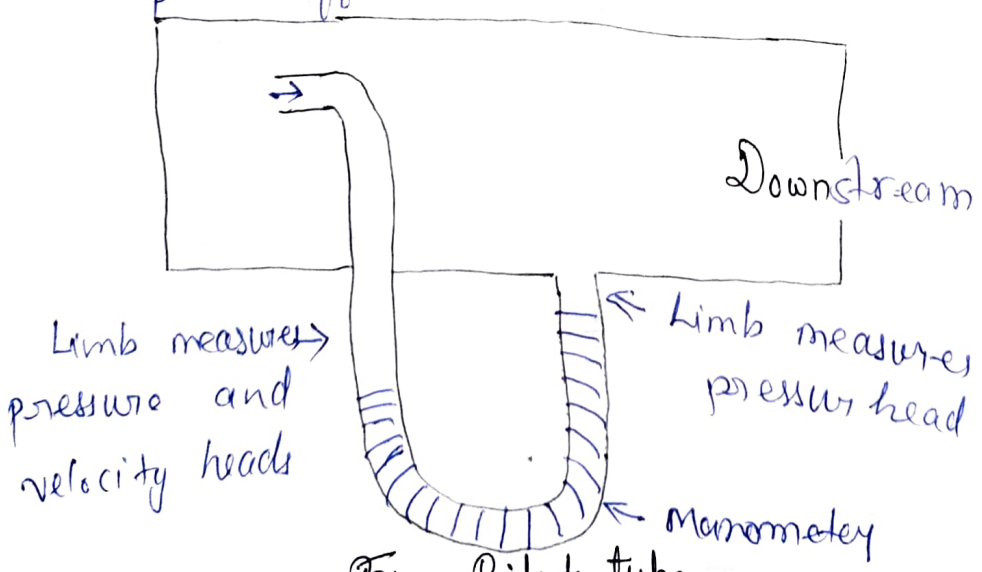


Fig: Pitot tube

(4) Rotameter :-

It is also known as variable area meter.

Rotameter consist of gradually tapered glass mounted vertically in a frame with the large end up. Solid float or plummet is placed in the tube. The diameter of the float is smaller then the diameter of the bottom of the tapered tube

⇒ Float is usually made from non corrosive materials such as aluminium, lead, glass & plastic

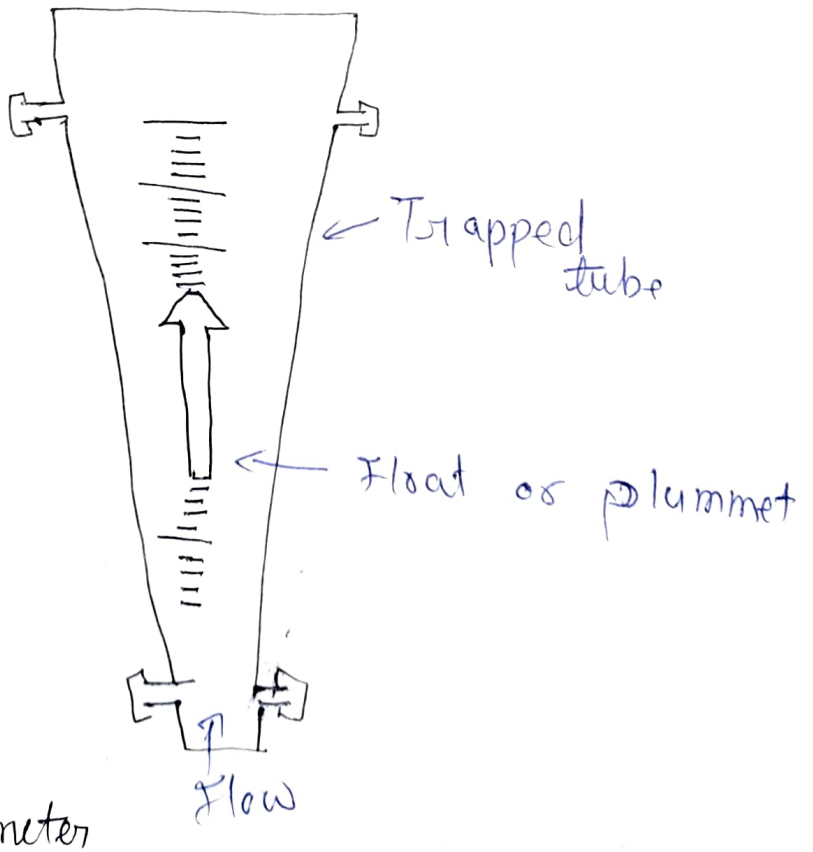


Fig: Rotameter

⇒ When fluid flows upward through the tapered tube and suspends freely a float (which is submerged ~~indicating~~ in the fluid). Float is the indicating element.

⇒ When no fluid flows through the meter, the rotameter float rests at the bottom of the tube.

⇒ But as the fluid begins to flow from the lower side of the tube the float rises. As the flow increases the float rises further in the tube these increasing the area available for flow keeping differential pressure across it constant on the other ~~head~~ hand as the flow rate decrease the float falls in the tube thus decreasing the area with constant pressure drop across it.

⇒ The head loss across the annulus is equal to weight of plummet.

⇒ The flow may be read by upper edge of plummet as index.

⇒ The tube is marked in divisions and the reading of the meter is obtained from the scale reading at the reading.

edge of the float, which is taken at the largest cross section of float.

Size Reduction

Q1 Size Reduction :-

The raw material are generally present in the large size which cannot be used by the industries so, that materials need to be converted into smaller size particles or powder.

"Conversion of large sized material into small sized particles or powder is called as size reduction."

Objectives of Size Reduction

Why we need of size reduction? -

→ for increase surface area
→ Easy in mixing.
→ Stability of suspension because fine particles size reduce the rate of sedimentation.
→ to increase absorption.
→ Reduce irritation
→ Appearance.

⇒ Mechanisms :-

(i) Cutting
(ii) Compression
(iii) Impact
(iv) Attrition
(v) Impact & Attrition

1. **Cutting :-** In this method, we reduced large drug molecules into small pieces through cutting (using sharp blade, knife etc).

⇒ It is ~~its~~ mostly used for soft & fibrous drugs or material.

Eg- cutter mill.

2. **Compression :-**

In this mechanism, drug molecules crush or reduces through compression or by applying high pressure on it.

⇒ It is mostly use for hard nature drugs.

Eg- Roller mill.

3. **Impact :-**

In this mechanism, drug molecules converted into small particles through any types of impact or object. Amount of drug remain ~~constant~~ constant.

e.g. Hammer mill.

4. **Attrition :-**

In this mechanism, the drug particles collision between the two particles having high kinetic energy or a high velocity particle with a stationary phase.

e.g. fluid energy mill.

(v) Combined impact and attrition :-

In this method, Impact and Attrition both apply simutaneously.
e.g. Ball mill.

Laws Governing Size Reduction :-

(i) Kick's law
(ii) Rittinger's law
(iii) Bond's law

(i) Kick's law :-

The energy required to reduce the size of particle is proportional to the ratio of initial size of particle to the final size of particle.

$$\text{Energy} \propto \frac{\text{initial size}}{\text{final size}}$$

$$\boxed{E = K_K \ln\left[\frac{d_1}{d_2}\right]}$$

Where,

E = Energy required
K_K = Kick's constant
D_1 = Average initial size of particle
D_2 = final particle size.

(ii) Bond's law :-

The total work input required to reduce particle size is proportional to the square root of the diameter of product particles.

$$W = 10 W_i \left(\frac{1}{\sqrt{d_2}} - \frac{1}{\sqrt{d_1}} \right)$$

where,

W = Energy consumed
d_1 = size of feed
d_2 = size of product
W_i = bond index.

(iii) Rittinger's law :-

The energy required for size reduction is proportional to the new surface create.

i.e. Energy $\propto$ New Surface.

$$E = K_R \left[\frac{1}{d_1} - \frac{1}{d_2} \right]$$

where,

E = Energy
K_R = Rittinger Constant
d_1 = initial size
d_2 = final size

⇒ Factors affecting size reduction :-

(i) Hardness
(ii) Toughness
(iii) Stickyness
(iv) Material structure
(v) moisture content
(vi) Softening temperature.
(vii) Sliperriness or soapiness

(i) Hardness :-

The hardness of the material affects the process of size reduction.

⇒ It is easier to break soft material to a small size than hard material.

(ii) Toughness :-

The crude drugs of fibrous nature or having higher moisture content are generally tough in nature.

⇒ A soft but tough material may present more problem in size reduction, than a hard but brittle substance.

(iii) Stickyness :-

Stickiness causes a lot of difficulty in size reduction. This is due to the fact that material adheres to the grinding surface or sieve surface of the mill.

(iv) Material Surface :-

Materials which show some special structure may cause problem during size reduction.

⇒ ~~Suspen~~ eg. long particles reduces through cutting.

Small & hard particles reduces through impact.

(v) Moisture Content :-

The presence of moisture in the material influences a number of its properties

such as hardness, toughness or stickyness which in its turn affects the particle size reduction.

⇒ The material should be either dry or wet.

(vi) Softening temperature :-

Some substance melt at increasing temp. during size reduction e.g. waxy substances and create the problems in size reduction.

⇒ This can be avoided by cooling the mill.

(vii) Slipperiness or Soapiness :-

This is a measure of the coefficient of friction of the surface of the material.

⇒ If the coefficient of friction is low, the crushing may be more difficult.

⇒ Equipments Used in Size Reduction

1. Hammer mill → Impact
2. Ball mill → Impact & attrition
3. Fluid Energy mill → Impact & attrition
4. Edge runner mill → Crushing & shearing
5. End runner mill → Crushing & shearing

1. Hammer Mill

Principle:- The principle of Hammer mill is based on impact that is hit by an object moving at a high speed.

⇒ The main mechanism involved is pulverisation or grinding of the materials.

Construction:-

The Hammer mill consists of three basic parts as follows:

⇒ Hopper, which delivers the materials.

⇒ Grinding mechanism usually consisting of a rotor & stator.

⇒ The discharging chute.

A hammer mill consists of a steel drum containing a vertical or horizontal rotating shaft or drum on which hammers are mounted. The hammers swings on the ends of the cross freely or fixed to the central rotor.

⇒ The rotor rotates at a high speed inside the drum while material is fed into a feed hopper.

⇒ The material is impacted by the hammer bars and expelled through screens.

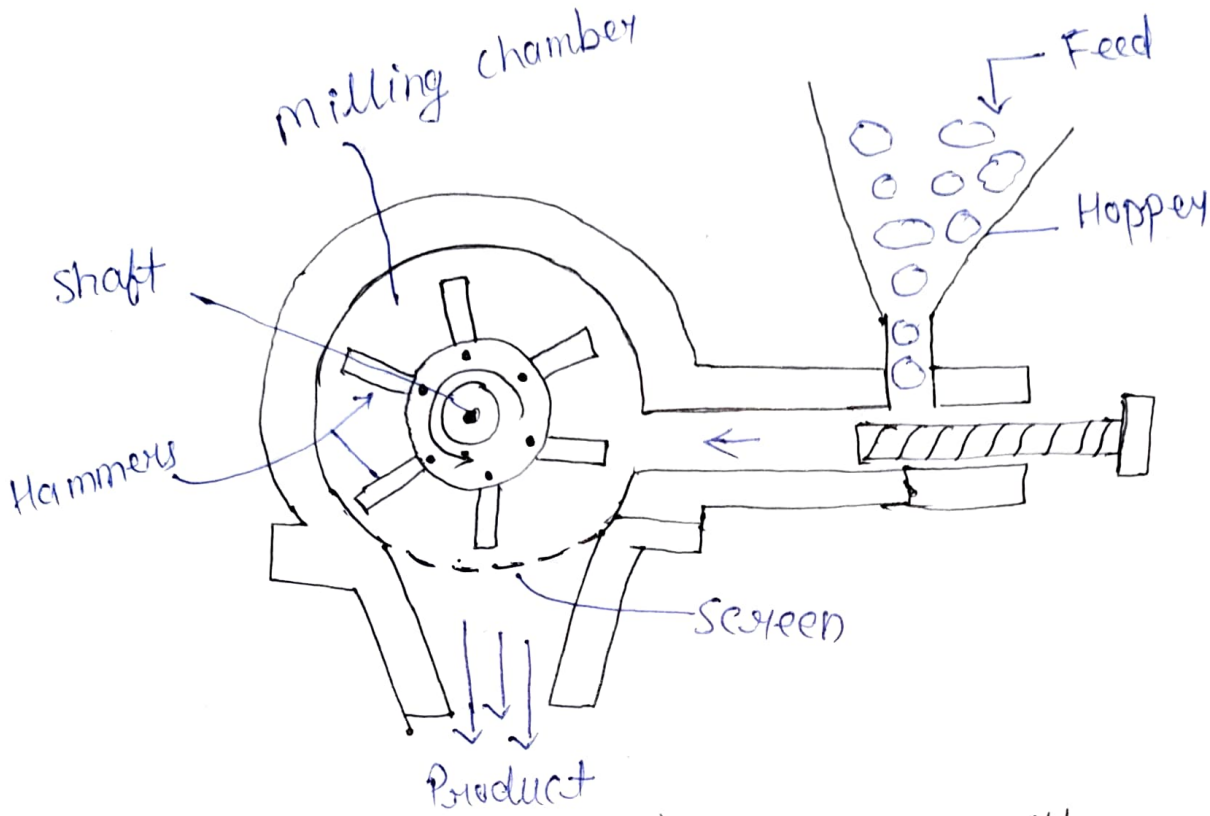
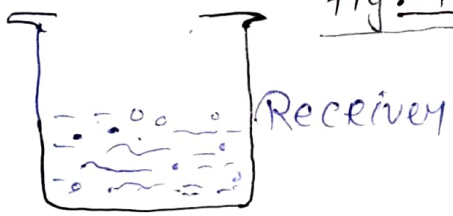


Fig. Hammer Mill



Working :-

⇒ Firstly bulky drug material store in Hopper, then, through hopper it will start to fallen down.

⇒ Start the machine and Hammer will start to hit the drug particles.

⇒ And by the impact particles started to reduce.

⇒ After reduction, particles stored in receiver through screen.

⇒ And those particles, which does not reduce again rolled in mill.

Uses :-

⇒ used to reduce particles size.
⇒ used in milling pharmaceutical raw materials, herbal medicine and sugar.
⇒ used in powdering of barks, leaves, and roots of medicinal plants.

⇒ Merits or Advantages :-

⇒ useful for big particles.
⇒ Useful for hard, tough particles.
⇒ Easy & fast in use.
⇒ It occupies small space.
⇒ Easy to maintain & clean.
⇒ It is inexpensive.
⇒ Used to reduce in very small particle through screen.

⇒ Demerits or Disadvantages :

⇒ Sound produce (Noisy)
⇒ very heat produce.
⇒ Can't use fibrous material due to heat generation.

2. Ball Mill

Principle:- It works on the principle of combination of impact & attrition.

Construction:-

→ Also known as pebble mill or tumbling mill. Ball mill consists of a hallow cylinder containing balls; mounted on a metallic frame such that it can be rotated along its longitudinal axis.

→ The ball ~~the~~ which could be of different diameter occupy 30-50% of the mill volume and its size depends on the feed and mill size.

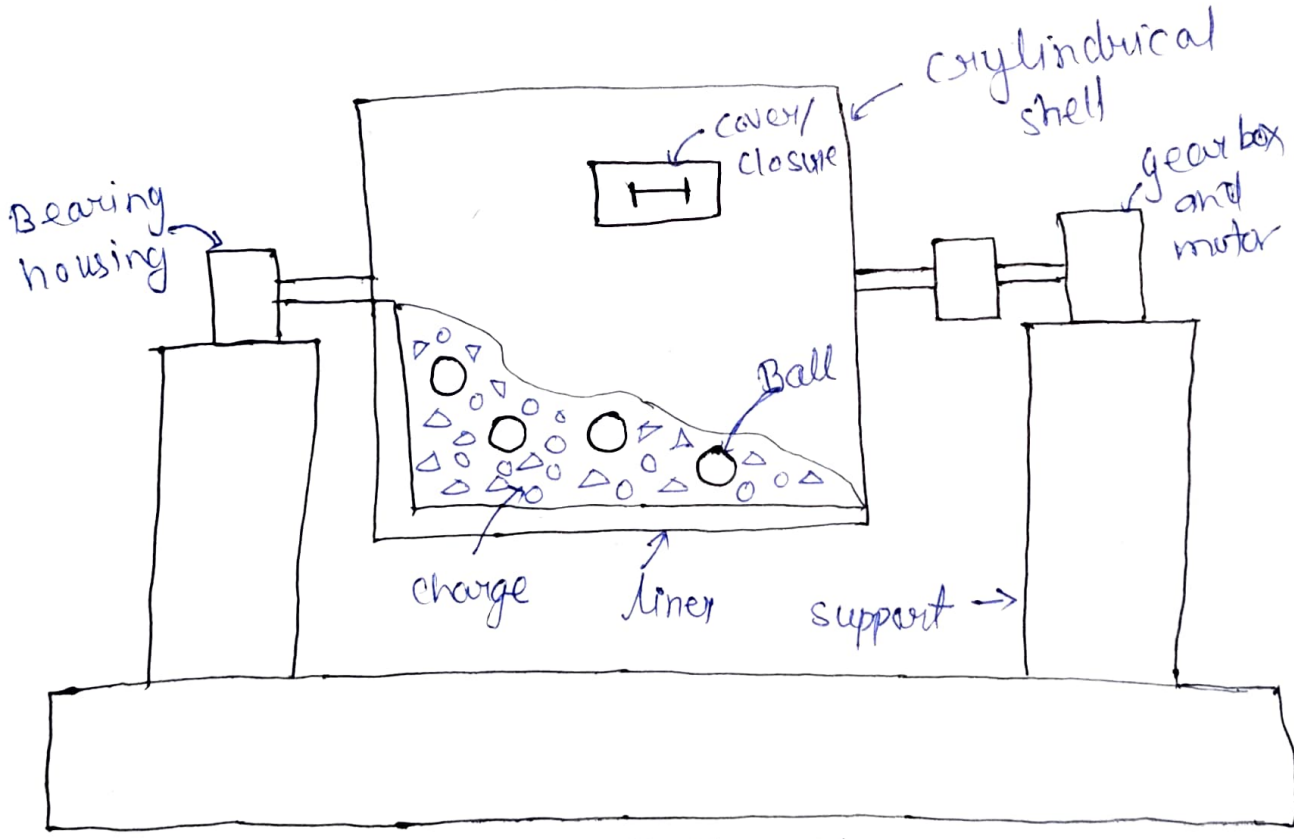


Fig. Ball Mill

Working :-

⇒ Open the cap of box and enter the drug molecules into it

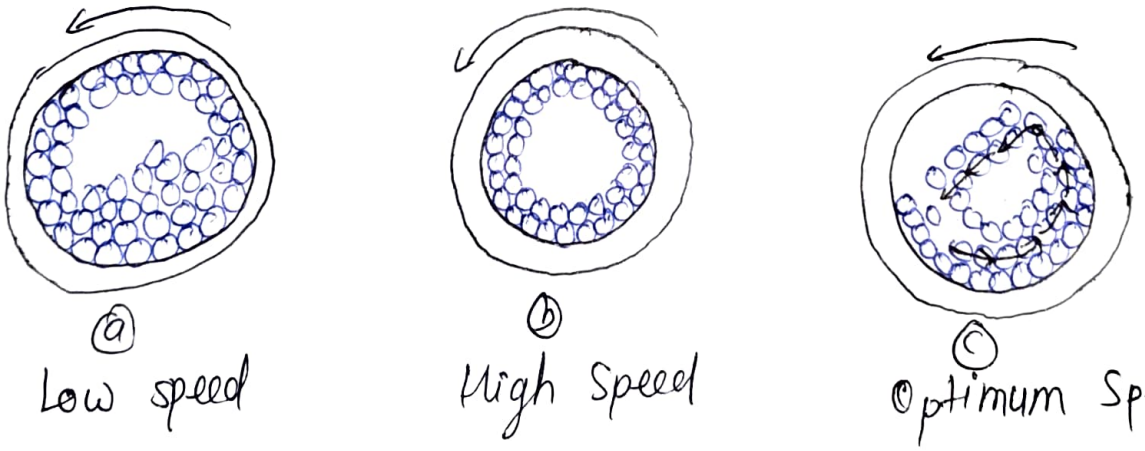
⇒ then start the mechine and adjust the speed of mill.

⇒ At low speed the balls will roll over each other and the size reduction will not occur at optimum ~~let~~ level.

⇒ At high speed the ball will stick to the walls of cylinder and no size reduction will occur.

⇒ But at optimum speed the balls will just taken up to the top and they will fallen down.

⇒ After reduction, stop the mechine then exist out the material and separate out the ball from particles



Uses :-

⇒ It is used to reduse size of particles through impact & attrition.

⇒ The mill is used to grind brittle drugs to fine powder.

⇒ Merits :-

⇒ It produces very fine powder ($\geq 10\mu$).
⇒ All types of particles reduce easily.
⇒ ~~without noise~~.
⇒ It can be used for continuous operation.
⇒ Less energy uses.

⇒ Demerits :-

⇒ very noisy machine.
⇒ It is difficult to clean the machine after use.
⇒ Relatively long time of milling.
⇒ Contamination of product may occur as a result of wear & tear which occurs principally from the balls & partially from the casing.

③ Fluid Energy Mill

Principle :-

It works on the mechanism of Attrition and Impact.

Construction :-

⇒ It ~~contain~~ consists of loop of pipe, having diameter of 20 to 200 mm depending on the height and may be up to about 2 meter.
⇒ In this mill material is suspended and conveyed at high velocity by air or steam,

which is passing through nozzles of 100 to 150 pounds per square inch.

⇒ This doesn't have any moving part.

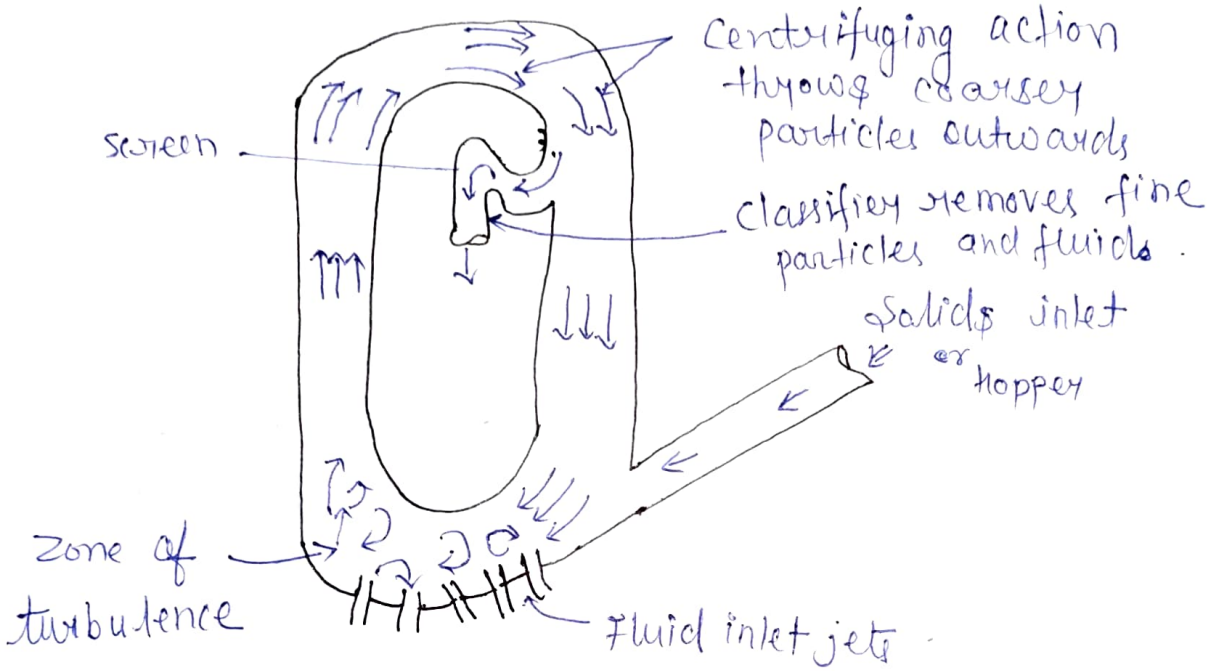


Fig. Fluid energy mill

Working :-

⇒ Firstly solid particles (drug particles which we have to reduced) introduced into pipe through Hopper then close it.

⇒ Then, air or inert gas introduced into pipe through air inlet with very high pressure.

⇒ Due to high degree of turbulance, impact and attrition forces occurs between the particles and the particles started to be smaller.

⇒ Then it will received in receiver passes through screen.

Uses :-

⇒ This mill can be used for size reduction of heat sensitive materials.

⇒ It is used in case where high purity is required.

Merits :-

⇒ The very fine size of particles can be obtained by using this mill.

⇒ Contamination of product cannot occur.

⇒ Heat sensitive materials can be used.

⇒ Required particle size can be achieved by using classifier.

Demerits :-

⇒ High energy consuming.

⇒ It may require pre-processing of materials to achieve desired size.

⇒ Generation of amorphous content due to high energy impact.

(4) Edge Runner Mill

Principle :- It works on the principle of crushing (compression).

Construction :-

⇒ It consists of two heavy ~~or~~ weight roller which rolled with the help of shaft.

⇒ The roller move on a bad, which is made of stone or granite.

⇒ And these, Roller and bad joined with base, which gives support to it.

~~Working~~ :-

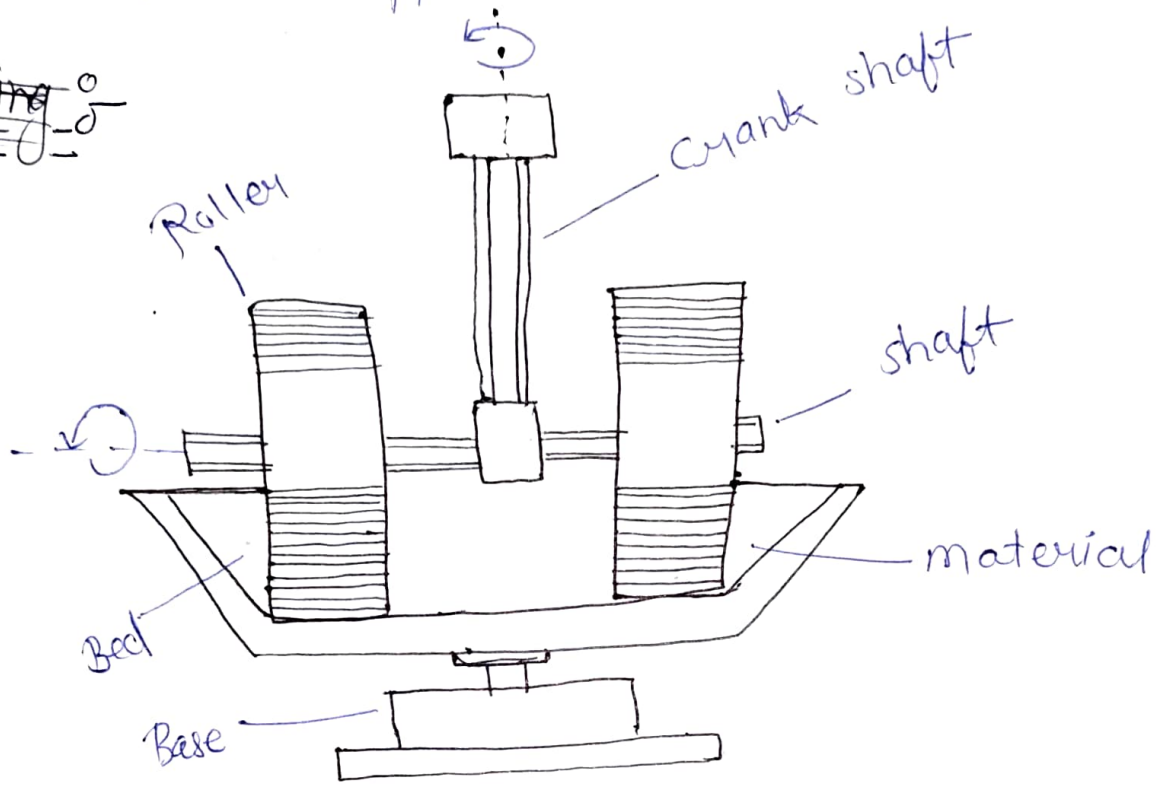


Fig: Edge Runner Mill

Working :-

⇒ Particles (material) put on the bad, b/w roller with the help of scrapper.

⇒ Then, the roller started to be rolled and also bad revolve at same time.

⇒ Bad is revolve with greater speed than roller, so, particles will be shared or crushed through roller.

⇒ Then, powder is collected and separated through seive.

Use :-

⇒ This mill is used to grind tough material to very fine particles.

⇒ This mill is used for plant based products.

Merits :-

⇒ It is mostly used for all type of the drugs.

⇒ very fine particle size is produced.

⇒ The major advantage of this mill is that it requires less attention during operation.

Demerits :-

⇒ It is not used for sticky materials.

⇒ Process is noisy.

⇒ More space than other mill.

⑤ End Runner Mill

Principle :- It works on the principle of impact and Attrition.

Construction :-

⇒ It consists of one stationary motor and one rotating pestle.

⇒ And there are also some stone present inside the motor.

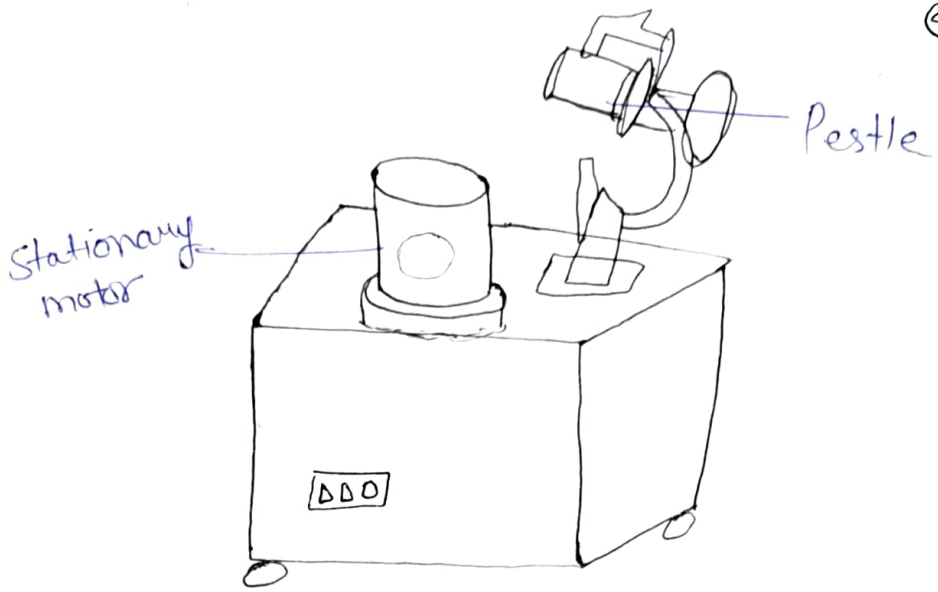


Fig. End Runner Mill

Working:

⇒ Firstly put drug particles in stationary motor which have to reduced.

⇒ Then, start the mill and pestle fallen down in stationary motor and it create impact on drugs which present in motor.

⇒ Then, it started to rotate on rotating it started crushing (attrition)

⇒ So, through impact & attrition particles started to be smaller.

⇒ After reduction collect the fine powder.

Uses: Used to reduce drugs material into very fine particles (powder).

Merits:

⇒ Easy to handle

⇒ No more heat produce

⇒ Less electricity.

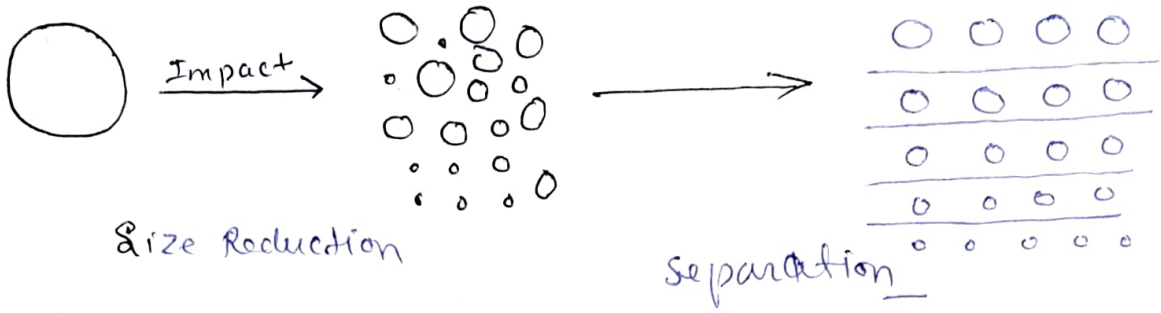
Demerits:

⇒ Not used for big particles

⇒ End runner mill is not suitable for drugs, which are in unbroken or slightly broken conditions.

Size Separation

Size Separation :- It is the after process of size reduction, in which we separate out the mixture of various size particles into two or more particles by sieve or any other process



Objectives :-

(i) Separation
(ii) Suspension
(iii) Granulation
(iv) Improve mixing
(v) Physiochemical properties.
~~(vi)~~

(i) **Separation :-** So, after we have to separate out the drug particles into different sizes, it is much more important for any work.

(ii) **Suspension :-** It is very important for suspension because in suspension we have to take very fine powder, so we have to separate out the fine drug particles into mixtures.

(iii) **Granulation :-** It is the just before step for making tablet, so we have to separate the drug particles for better making of tablet.

(iv) **Improve Mixing** :- Size separation is much more important for mixing same size particles mix well then different size particles.

(v) **Physiochemical properties** :-
Size separation is also helpful in physiochemical properties of drug molecules.
eg. Solubility, Surface tension etc.

Applications :-

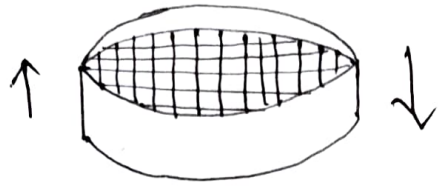
- It is much more helpful in formulation of tablet because it helps in granulation.
- ⇒ Uniform size particles are easy to fill in the capsules giving good flow properties.
- ⇒ Removal of impurities on the basis of size.
- ⇒ Also helpful in making syrup, helps in size separation for making syrup which are taking by the oral route.
- ⇒ It is also helps in making emulsion.
- ⇒ To separates undesirable particles.

⇒ Mechanism of size separation :-

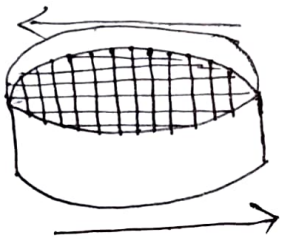
1. Agitation — Oscillation, Vibration, Gyration
2. Brushing
3. Centrifugal

① Agitation :- In which we take drug particle into sieve with specific size then start to shake it.

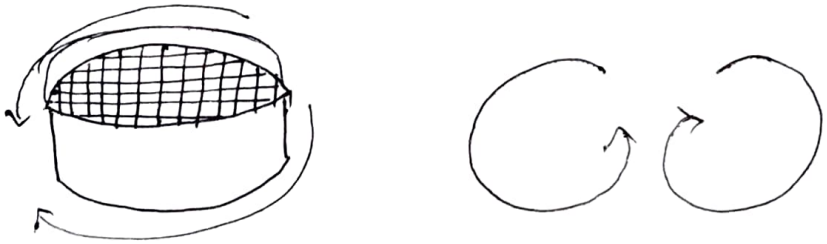
(i) Oscillation :- The movement of sieve is upward and downward is called oscillation.



(ii) Vibration :- The movement of sieve is side to side (sideways) is called vibration.



(iii) Gyration :- The movement of sieve is clockwise and anticlockwise is called Gyration.

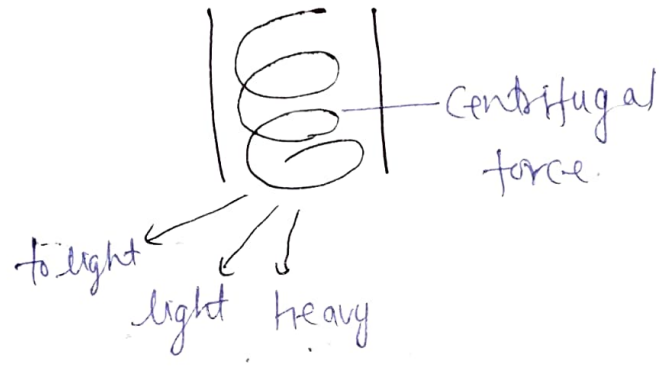


② Brushing :- In which ~~one~~ our sieve is fixed and we put drug molecules in sieve, then start to shake the drug molecules with the help of brush.

③ Centrifugal :-

It is a technique used for separation on basis of their shape, size, density and weight of substances. And it separate out with the help of medium & rotor speed.

When we remove substance with high speed, heavy ~~sh~~ staff fall near and light staff falls too for.



Official Standards for powder size

Grade of powder	all particle must pass through sieve No./Nominal mesh aperture	Sieve through which 40% of the particles pass/Nominal mesh aperture	Comparison of powder size
1. Coarse pdr.	10 / (1.70 mm)	44 / (355 μm)	1
2. Moderately coarse pdr.	22 / (710 μm)	60 / (250 μm)	1/6
3. Moderately fine powder	44 / (355 μm)	85 (180)	1/24
4. Fine powder	85 / (100 μm)	Not specified	1/90
5. Very fine powder	120 / (125 μm)	Not specified	1/2000

1. Coarse Powders:-

All the particles pass through mesh 10 and not more than 40% pass through mesh 44.

2. Moderately Coarse powder:-

Those powder which pass 100% from ~~set~~ sieve No. 22 and only 40% pass from sieve no. 60.

3. Moderately Fine powder:- Those powder which pass 100% from sieve no. 44 and only 40% pass from sieve no. 85.

4. Fine Powder:- Those powder which pass 100% from sieve no. 85.

5. Very fine powder: The grade of powder which pass 100% from sieve no. 120.

⇒ Sieves:-

A sieve is a surface having number of apertures of specific dimensions.

⇒ A material sieved is passed on the surface of screen and agitated.

⇒ By using sieves of different sizes the powder can be separated and graded.

Types:-

① Iron wire
② Brass, Phosphor-bronze and stainless steel
③ Non-metals
④ Punched plate or perforated screens
⑤ Bolting cloth sieves

⇒ Generally Iron wire is used as screen material because it is cheap but their disadvantage are corrosive nature and chances of contamination by Iron.

⇒ Brass, Phosphor-bronze and Stainless steel are the metals used due to their corrosion resistant, good strength and non-contamination qualities.

⇒ Non-metals such as nylon and terylene are also suitable because they avoid risk of metallic contamination.

⇒ For special purpose punched plates or perforated screen are used. These sieves are made by drilling holes of varying thickness in metal plate. The holes may be round, ~~t~~ rectangular or square.

⇒ For separation of fine powder Bolting cloth sieves are used. They are woven from twisted multi strand fibres made of silk, nylon and cotton. Nylon cloths are generally designated for their micrometer opening and also their availability in different grades.

Sieve Shaker

Principle: It is based on the priciple of Agitation, in which sieve will be shake.

Construction:-

⇒ In this sieve shaker a set of sieve is used;
⇒ These sieves are arranged in the descending order.
i.e. sieve of large size is at the top and and the sieve having smallest size is placed at the bottom.
⇒ The bottom sieve is attached to receiving pan.
⇒ The size separation is done by passing the powder through these sieves.

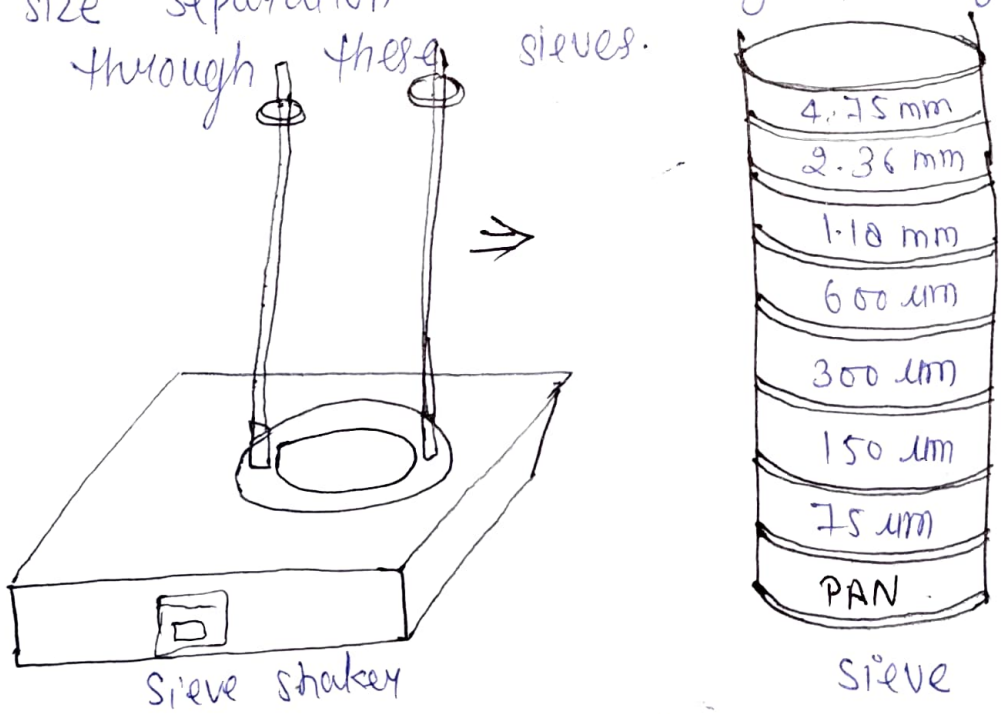


Fig. Sieve Shaker

Working:-

⇒ The powder is placed in the ~~Sieve~~ upper sieve.
⇒ The ~~help of~~ sieves are shaken with the help of mechanical sieve shaker or

electromagnetic devices.

⇒ This motion helps the particles to pass through the sieve.

⇒ The size separation is done by passing the powder through these sieves.

⇒ After particular time ~~peric~~ period of some weight of powder is retained on each sieve ~~of~~ depending on its size.

Use:- Used for separate out many sized particles at same time.

Merits:-

⇒ It requires less area for operation.

⇒ It is fast and more accurate process.

⇒ Simple & easy in use.

Demerits:-

⇒ Can't separate out in very big amount.

⇒ Sieve should be used and stored with care, since becoms damaged or distorted then it is of little value.

Cyclone Separator

Principle:- It is based on the principle of centrifugation.

Construction :-

It consist of a short vertical, cylindrical vessel with a conical base.

⇒ The upper part of vessel is fitted with a tengential inlet.

⇒ The solid outlet is at the base.

⇒ ~~F~~ Fluid outlet is ~~providing~~ provided at the center of the top portion, which extends inwardly into the separator.

⇒ Such a arrangement prevents the air-short circuiting directly from the inlet to the outlet of the fluids.

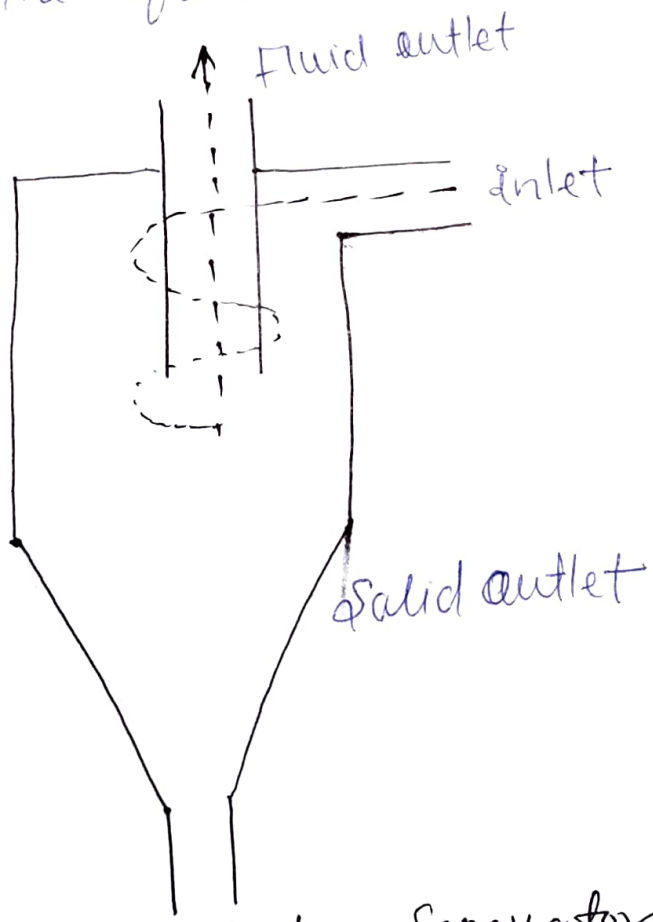


Fig. Cyclone Separator

Working :-

⇒ Firstly we enter particles (mixed) of different sizes with some air pressure.

⇒ Then, inside it, Air create centifugation force and due to this large particles fallen down and get from downside outlet

⇒ And small particles or fine powders expell out from the fluid outlet with air and we get it.

Use :-

⇒ It is used to separate solid particles from gases.

⇒ It is also used for size separation of solid in liquid

⇒ It is used in oil refineries to separate oils and gases.

Merits :-

⇒ Low capital cost.

⇒ No moving parts.

⇒ Relatively small space requirements.

⇒ Low pressure drop.

⇒ Demerits

⇒ Inability to handle sticky materials.

⇒ Difficult to obtain good separation of substances of similar densities.

Air Separator

Principle: It works on the same principle as that of cyclone separator. ie. "Centrifugation."

Construction:

⇒ It consist of a cylindrical vessel with a conical base.

⇒ In the upper part, feed inlet is present and there are two ~~outlet~~ outlet at base, one for fine particles and one for heavy or coarse particles.

⇒ A rotating plate is fitted on a shaft placed at the center of the vessel.

⇒ A set of fan blades are also fitted with the same shaft.

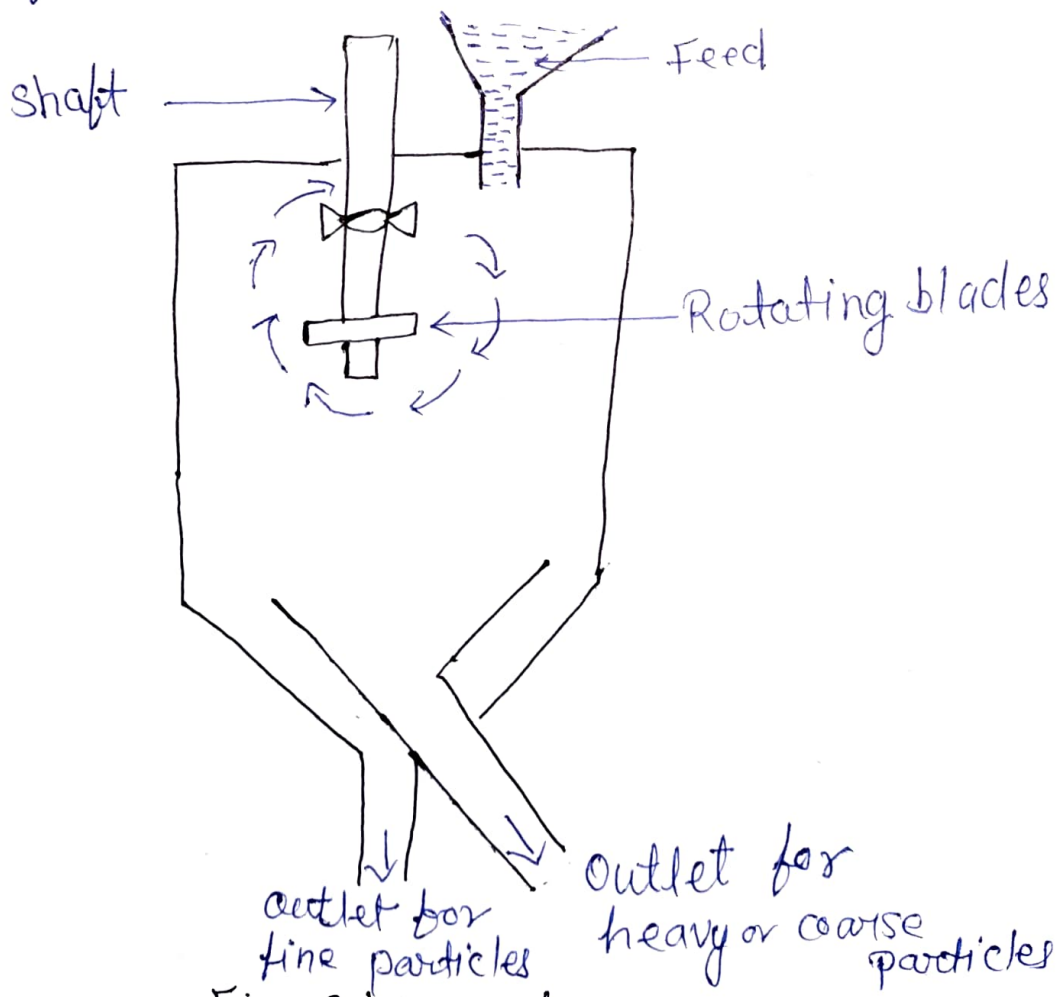


Fig: Air Separator

Working :-

- The disc and blades are allowed to rotate by means of a motor.

↓

These produce a current of air.

↓

Sample powder is introduced through feed inlet

↓

feed fall on rotating disc

↓

fine particles are picked up thrown into space → Collected at outlet meant for fine particles

Heavy particles fall downward → Collected at outlet meant for heavy particles.

Merits :-

⇒ Low maintenance.
⇒ High reliability.
⇒ Low pressure drop.
⇒ It gives efficient separation in smaller apparatus.

Demerits

⇒ Low seperation yield.
⇒ Unsuitable for separating smaller particles.

Use: Air separators are often attached to the ball mill and hammer to separate and return over sized particles for further size reduction.

Filter Bag

Principle :- In this filter, separation is occured in two step.

- Firstly, pass the dirty air through a bag (which is made from cloth), by applying suction on the opposite side of feed entry. this facilitates the separation.
- In next step, pressure is applied on that bag so adhesive powder fallen down, which is collected from the conical base

Construction :-

⇒ It consist of a ~~bag~~ number of bags made of cotton or wool fabric.
⇒ Which are fixed in a metal container.
⇒ there are one inlet in which feed enter.
⇒ One outlet at downside, from which we get solid particles or our fine powder.

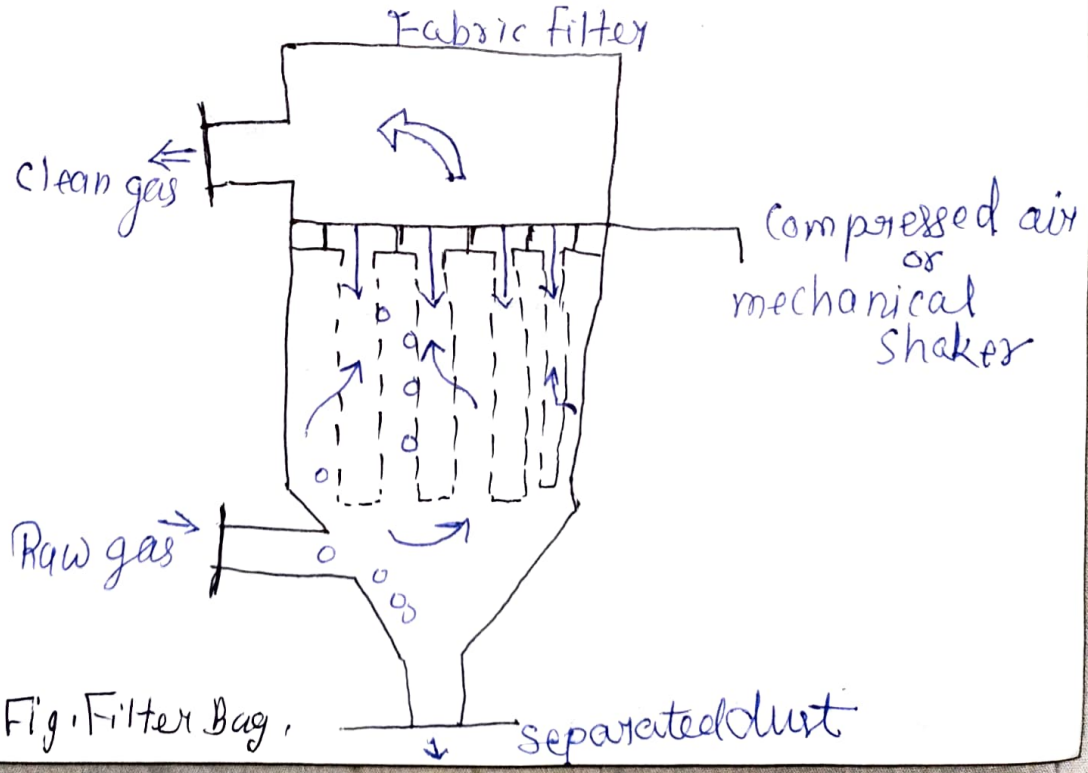


Fig. Filter Bag.

Working :-

(a) Filtering period :-

⇒ Firstly material is pass through bags and due to this particles are retained within the bags because particles size is small but not small than bag, so it retaine in bag.

(b) Shaking period :-

⇒ Then after air passed and we get cleaned air, with the help of mechanical shaker bag is shaken and then attached particles fallen down and we get it (particles).

Use :-

⇒ They are used to clean the air of a room.

⇒ Household vacuum cleaner is a simple version of bag filter.

Merit :-

⇒ These can be used to remove dust.

⇒ No high voltage requirements.

⇒ Bag filter is extremely useful for removing fines, which cannot be separated by other methods.

Demerit :-

⇒ Collection of hygroscopic materials or condensation of moisture can lead to fabric plugging, loss of cleaning efficiency.

· large pressure losses.

Elutriation Tank

Principle:- It is based on the principle of sedimentation.

Construction:-

⇒ The apparatus consist of a vertical column with an inlet near the bottom of suspension, an outlet at the base for coarse particles

⇒ Overflow near the top of fluid and fine particles.

⇒ One column will give single separation into two fractions.

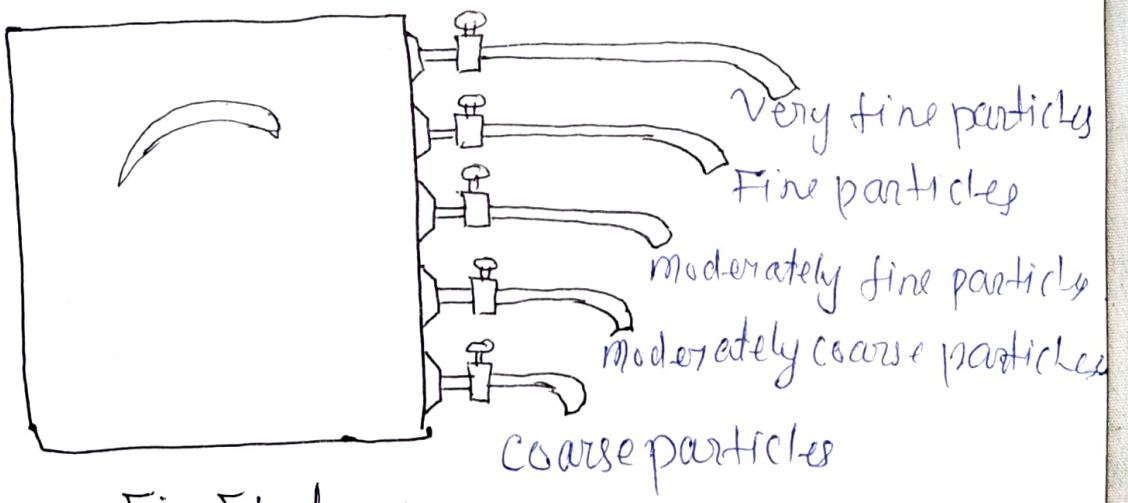


Fig. Elutriation Tank

Working:-

⇒ It is used to separate the coarse and fine particles of powders after levigation.

⇒ the dry powder or paste made by levigation process is kept in an elutriating tank and mixed with a large amount of water.

⇒ The solid particles are uniformly distributed in the liquid by stirring then, it is allowed to settle down. Depending upon the density of solid particles, it will either settle down or remain suspended in water.

⇒ The sample is withdrawn at different heights through the outlets. These are dried and thus the powder with various sized powder are collected.

Use: This technique is useful for separation of insoluble solids. ~~These~~

Merits;

⇒ It is continuous process.

⇒ Number of fractions can be collected by using columns of different areas.

Demerit

⇒ Dilution of suspension may be undesirable in some cases.

UNIT-IV Filtration

Filtration :- It may be defined as a process of separation of solid from fluid (liquid/gas) by passing through a porous medium/filter medium that retain the solid but allows the fluid to pass.

Slurry :- The suspension to be filtered is known as slurry.

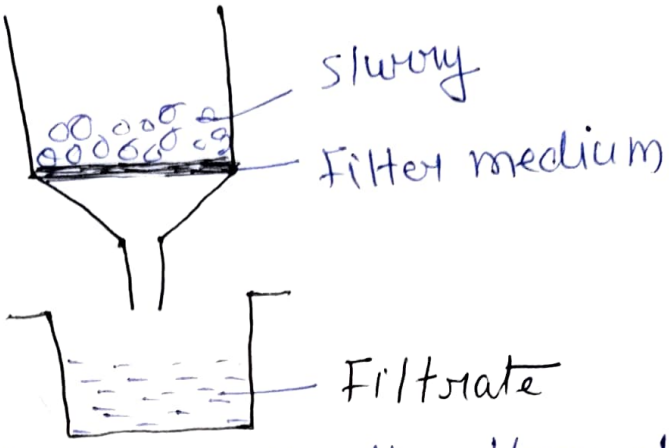
Filter medium/Porous medium :-
The porous medium is used to retain the solid from the slurry.

Filter cake :-
The accumulated solids on the filter medium is known as filter cake.

Filtrate :- The clear liquid which is passed through the filter medium is known as filtrate.

Clarification :- It is a separation process of solid from liquid, when solid are present in very low concentration. i.e. not exceeding 1% w/v.

Process of Filtration



⇒ The pores of filter medium are smaller than the size of the particles to be separated.

⇒ Filter medium is placed on a support.

⇒ When slurry is passed over the filter medium, the fluid flows through the filter medium by virtue of pressure difference across the filter.

⇒ Gravitational force is acting on it. Therefore, solid are trapped on the surface of filter medium.

⇒ After that we get the filtrate in the vessel.