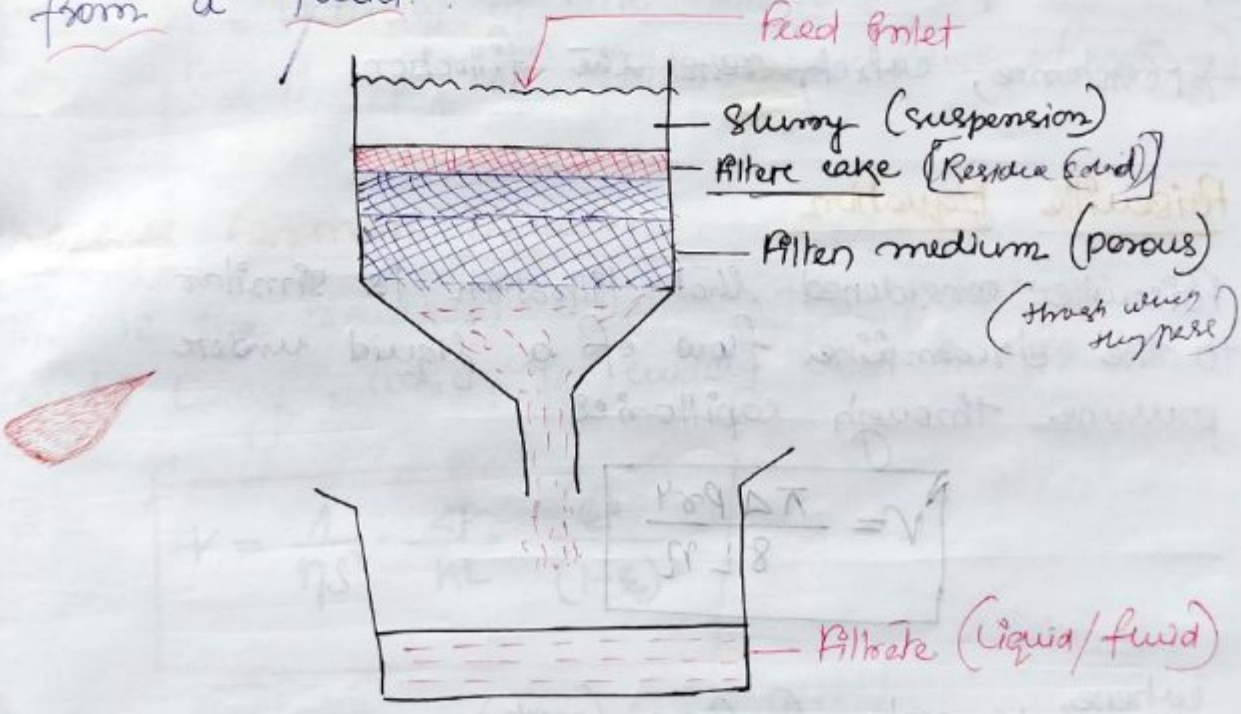
Filtration (Unit - IV)

⇒ It is defined as a process of separation of solids from a fluids by passing mixture or slurry (solid + fluids) through a porous medium that retain the solids but allows the fluids to pass through.

(or)

⇒ Process of separation of solids particles from a fluid.



Applications

→ Production of sterile products.
✗ (Hepa filter or laminar air bench)
✓ (Membrane filters)
→ Production of bulk drugs.
→ Production of liquid dosage
→ Waste water treatment.
→ Food industry (Remove unwanted matter)
→ Clay industry (Kaolin, bentonite separated & purified from filtration)
→ Chemical industry. (Dyes, pesticides, additives, are purified)

Theories of Filtration

For filtration, the flow of liquid follow basic rules that govern the flow of any liquid through the medium offering resistance.

$$\text{Rate of filtration} \Rightarrow \frac{\text{Driving force}}{\text{Resistance}}$$

→ Driving force is the pressure differential b/w the upstream and down stream of the filter

→ Resistance, which resist the filtration.

Poiseuille Equation

Poiseuille considered that filtration is similar to the streamline flow of a liquid under pressure through capillaries.

$$V = \frac{\pi \Delta P r^4}{8 L \eta}$$

where, V = rate of flow (m³/s)

ΔP = pressure difference across the filter, Pa.

r = radius of the capillary for the filter bed.

L = thickness of the filter cake.

η = viscosity of the filtrate.

Darcy's Equation

The factor influencing the rate of filtration has been incorporated into an eqn.

$$V = \frac{KA\Delta P}{\eta L}$$

where, K = permeability coefficient of cake (m^2)
A = Surface area of filter medium (m^2)
ΔP = Pressure difference. (Pa)
η = Viscosity of the filtrate
L = Thickness of filter cake. (length of capillary).

Kozeny - Carman Equation

This is the resultant equation for poiseuille and Darcy, which is widely used in filtration.

$$V = \frac{A}{\eta S^2} \cdot \frac{\Delta P}{KL} \cdot \frac{\varepsilon^3}{(1-\varepsilon)^3}$$

where,
ε = porosity of the cake (bed)
S = Surface area of the particles comprising the cake.
K = Kozeny constant.

Factors influencing filtration

(i) **Surface area of filter media**

Acc. to Darcy's rate of filtration is directly proportional to surface area of filter media.

SA ∝ Filtration | S.A ↑ = filtration ↑

(ii) **Particle size of solids**

Particle size ↑ = Rate of filtration ↑

(iii) **Filter cake (Resistance)**

Filter cake ↑ = Filteration ↓

$$\text{Filter cake} \propto \frac{1}{\text{Rate of filtration}}$$

(iv) **Viscosity**:

$$\text{Viscosity} \propto \frac{1}{\text{Rate of filtration}}$$

OR Viscosity ↑ = Filtration ↓

(v) **Pressure Difference (ΔP)**

The rate of filtration is directly proportional to the overall pressure drop across filter media and filter cake.

(ΔP) pressure diff. ∝ Rate of filtration.

So, Pressure difference ↑ = Filtration ↑

Filter leaf

Principle: Filter leaf is an apparatus consisting of a longitudinal drainage screen covered with a filter cloth.

→ The mechanism is surface filtration and acts as sieve or strainer.

→ Vacuum or pressure can be applied to increase the rate of filtration.

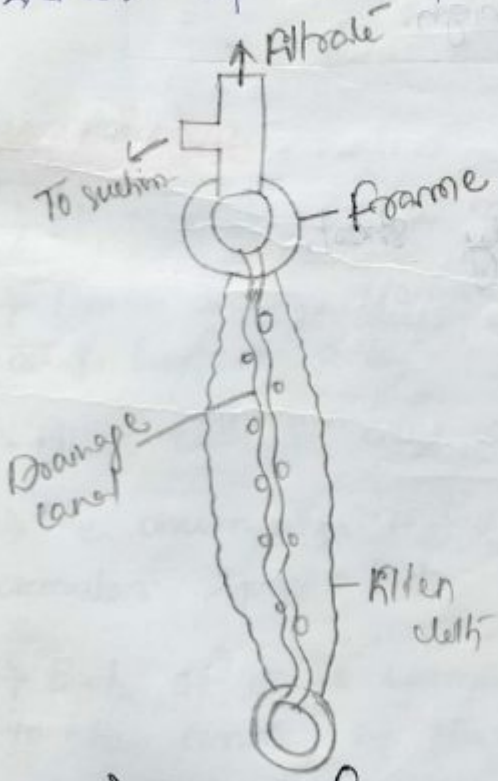
Construction

→ It consists of narrow frame enclosing a drainage screen or grooved plate.

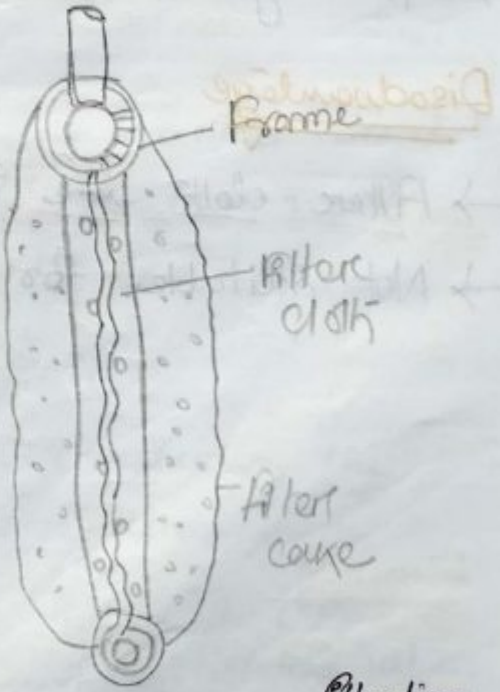
→ The frame may be of any shape, circular, square or rectangular.

→ The whole unit is covered with filter cloth.

→ The outlet for the filtrate connects to the interior of the frame through suction.



a) Filter leaf



b) Filter leaf during filtration.

Working

(i) The filter leaf is immersed in the slurry.
(ii) Vacuum system is connected to the filtrate outlet.
(iii) The slurry passes through the filter cloth.
(iv) Finally, filtrate enters the drainage canal and goes through the outlet into the receiver.
(v) Air is passed to flow in the reverse direction which facilitates removal of cake.

Uses

→ The filter leaf is satisfactory, if the solid content of the slurry is not too high, about 5%. i.e. dilute suspension.

Advantage

→ It is the simplest form of filter used for batch process.
→ Efficiency of washing is high.

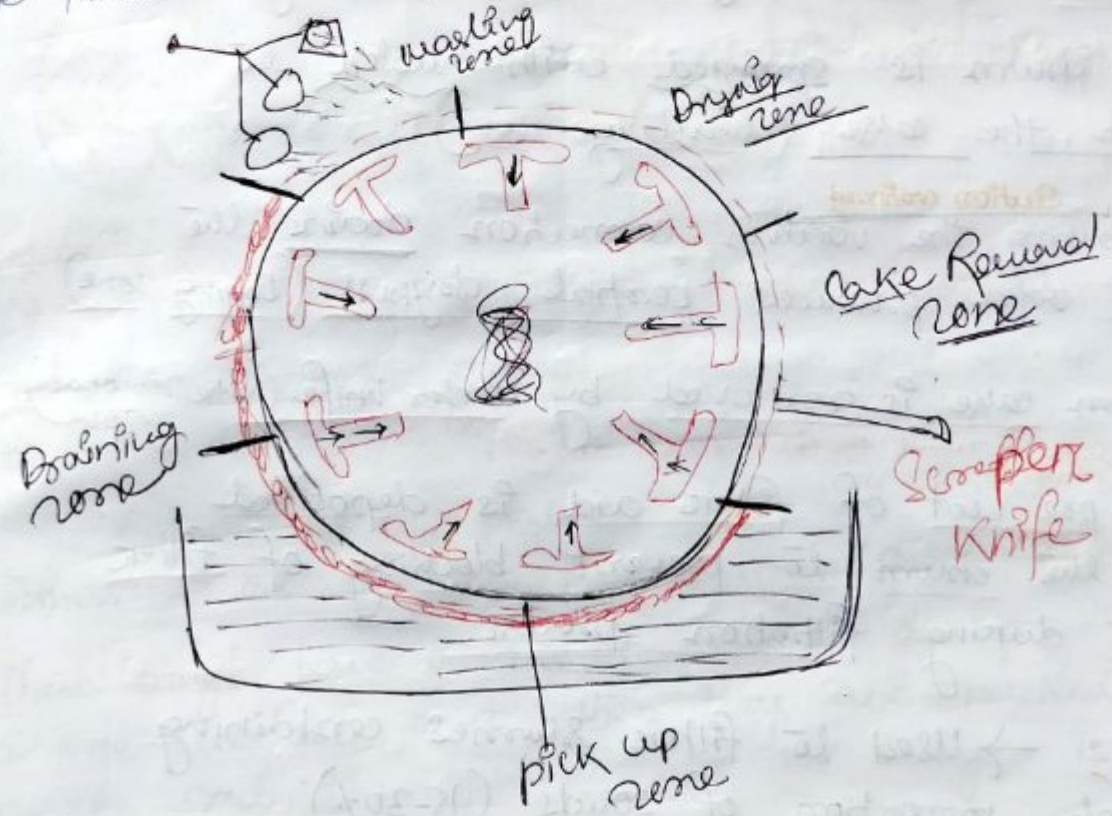
Disadvantage

→ Filter cloth life is relatively short.
→ Not suitable for high

Rotary Drum Filter

Principle: It is based on the principle of filtering the slurry through sleeve-like mechanism on a rotating drum surface under the condition of vacuum.

→ In addition, compression drying and removing the filter cake is possible.



Construction

→ It consists of a metal cylinder mounted horizontally.

→ Drum have, diameter → 3 metres, length → 3.5m and surface area → 20m².

→ Filter cloth is used as filter media.

→ The drum is radially partitioned dividing the annular space into separate compartments.

→ Each of it is connected by a internal pipe to the centre of the drum through a rotating valve.

Working

→ The drum is dipped into the slurry (speed of drum is less than 1 revolution per minute) and vacuum is applied to the outlet, which is connected to the filtrate receiver. (Pick up zone)

→ When the cake has formed ①, the cake drained or partially dried by vacuum. (Drying zone)

→ The drum is sprayed with water to wash the cake. (washing zone).

Section continued

→ Retaining the vacuum connection drains the cake and produces partial dryness (Drying zone).

→ Then cake is removed by doctor knife (Cake removal zone)

→ Cake is rinsed due to compressed air (Rinsing)

→ A pre-coat of filter aid is deposited on the drum to prevent blocking of filter cloth during filtration process.

Uses → Used to filter slurries containing high proportion of solids (15-30%)

→ Used in filtration of calcium carbonate, starch etc.

Merits → Automatic & continuous

→ Labour cost is low due to automatic and continuous process.

→ Filter has large surface area.

→ Cake is removed simultaneously.

Demerits

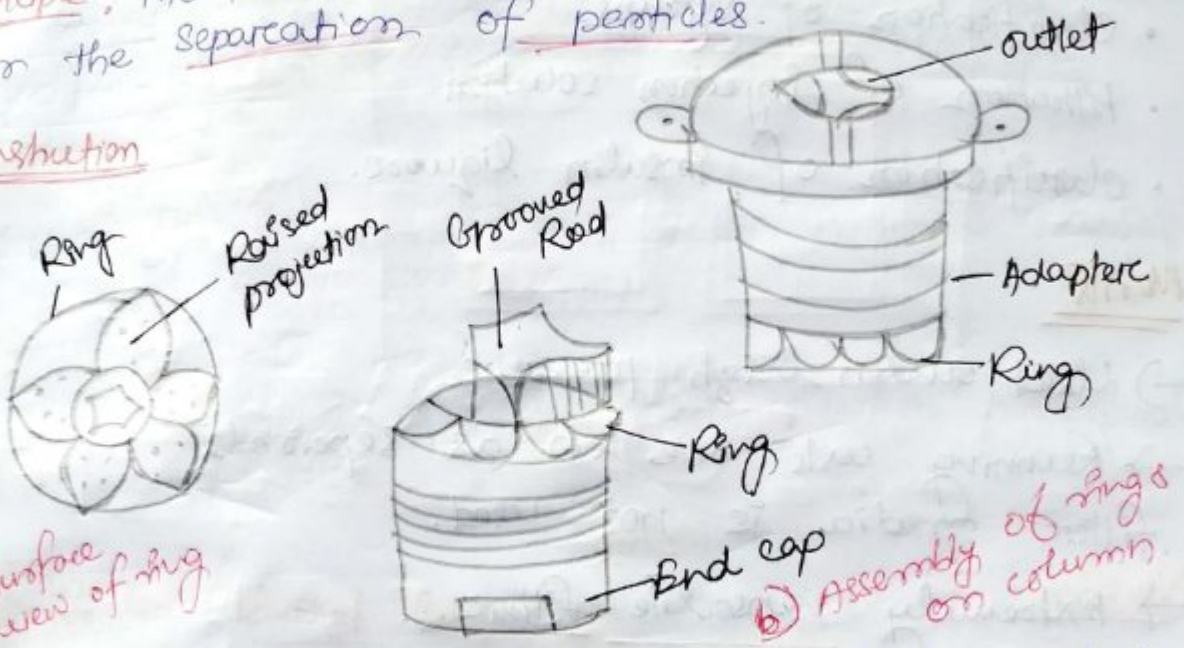
→ Expensive equipment

→ Cake tends to crack.

Meta filter

Principle: Metafilter functions as a surface filtration for the separation of particles.

Construction



a) Surface view of ring

b) Assembly of rings on column

→ It consists of a grooved, drainage rod on which are packed a no. of metallic rings.

→ Rings made up of stainless steel and have thickness → 0.8 mm, inside diameter = 15 mm, outside = 22 mm.

→ These rings have a no. of semicircular projection on one surface and when they are packed on the rod, the opening b/w the rings is about 0.2 mm.

∴

Working

→ These filters are placed in a vessel and operated by pumping the slurry with pressure/vacuum at outlet.

→ The slurry passes through the channel formed on the edges b/w the rings.

→ The clear liquid rises up and collected into the receiver.

Uses

It can be used for ——

- Clarification of syrups.
- Filtration of injection solution
- clarification of Insulin liquors.

Merits

→ Used under high pressure.

→ Running costs are low as seperate filter media is not used.

→ Extremely versatile filters.

Centrifugation

→ Centrifugation is the process in which separation of particles take place by using centrifugal force.

→ Used for separating either two immisible liquids or a solids from a liquid.

→ Widely used or helpful when filtration process is not application.

Perforated Basket Centrifuge

Principle: Separation occurs through perforated wall depends on the difference in the densities of solids and liquid phases.

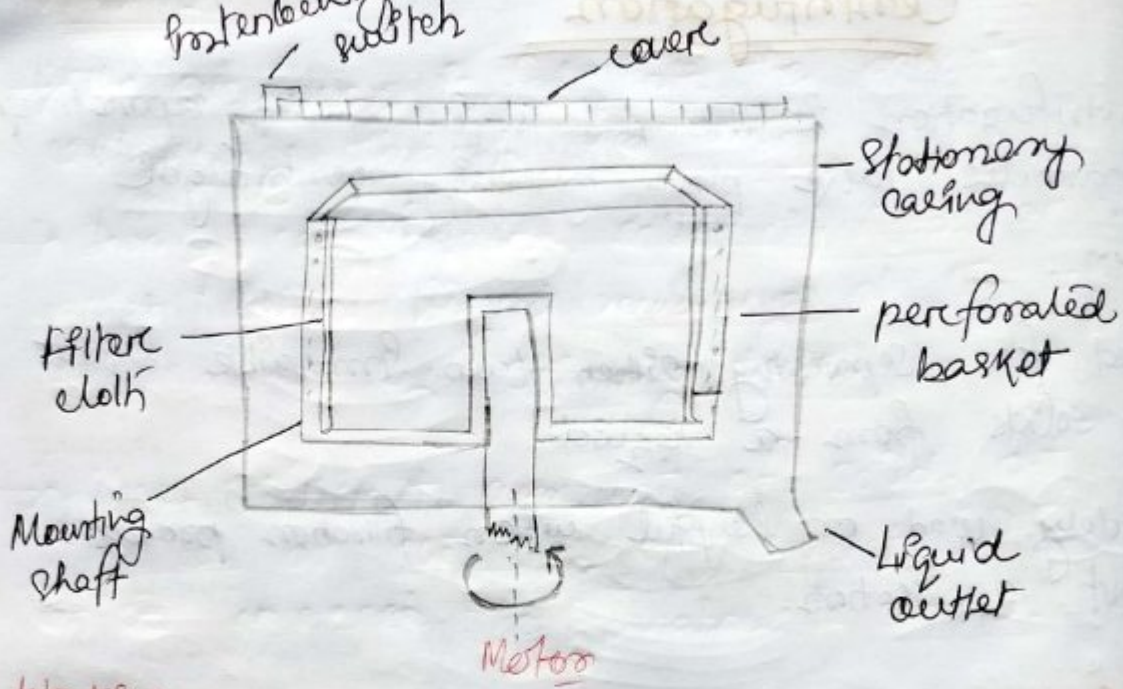
Construction

→ It consists of a basket made up of steal or any other suitable metal.

→ It is perforated with filter cloth.

→ The basket is suspended on vertical shafft and driven by a motor.

→ The basket is surrounded by casing which collect the filtrate and discharge through outlet.



Working

→ The material is loaded into the basket when basket is stationary.

→ Power is applied to rotate (5kw) then power reduced to 2kw (speed 1000 RPM)

→ The liquid passes through perforated wall while solid retains in the basket.

→ Liquid is collected through casing, centrifuge is stopped by applying brake.

→ Now unload the solid.

Uses

→ Used to separate crystalline drugs (aspirin etc) from mother liquor.

→ Used to separate precipitated protein from insulin.

Advantages

→ It occupy little space.
→ Rapid process.
→ Used when solid conc. in slurry is high.

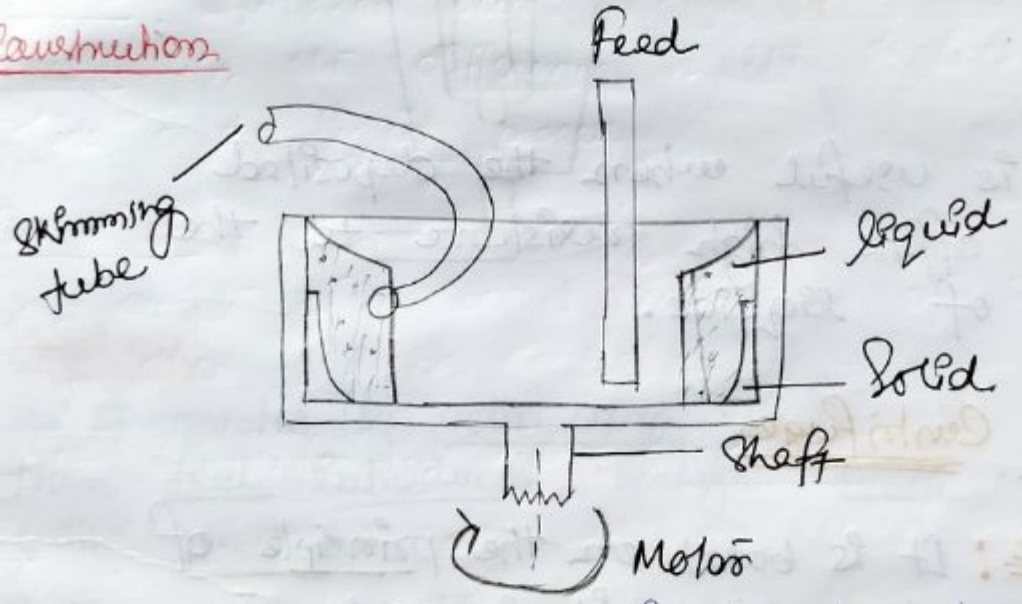
Disadvantages

→ Labour cost is high.
→ Batch process.

Non-perforated basket centrifuge

Principle: The separation is based on the difference in the densities of solid and liquid phases without a porous barriere. (sedimentation).

Construction



→ It consists of non-perforated basket made of steel.
→ The material is loaded into basket through feed tube
→ The basket is mounted on vertical shaft which is rotated by motor.
→ The liquid is removed with the help of skimming tube.

Working

→ The suspension is fed into the basket continuously through feed tube.

→ During centrifugation, solid deposited at side of basket while liquid remaining at top which is removed by skimming tube.

→ When sufficient amount of solid get deposited at the side of basket then the operation is stopped.

→ The solids are then scraped off by hand or using a scraper blade.

Uses

→ It is useful when the deposited solids offers high resistance to the flow of liquids.

Super Centrifuge

Principle: It is based on the principle of sedimentation and it is used to separate two immisible liquid phases.

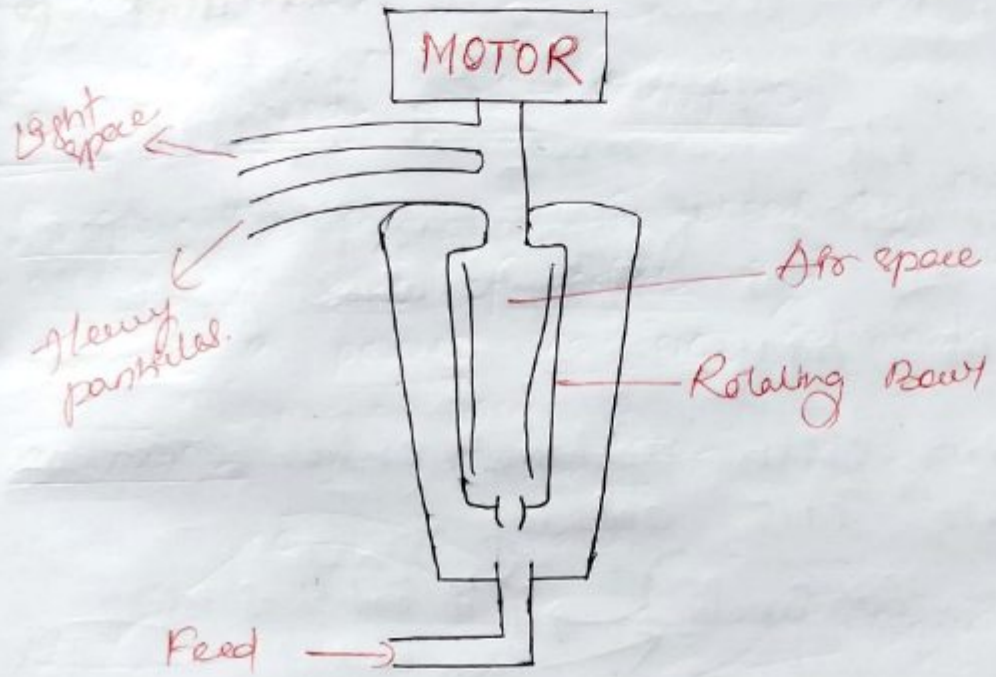
Construction

→ It consists of long, hollow, cylindrical bowl of small diameter and rotate on vertical axis.

→ Feed is introduced through the bottom through a nozzle with pressure.

→ Two liquid outlets are provided at different height.

→ It rotate approx. 2000 rpm.



Working

→ It rotates at 2000 rpm on its axis and then feed introduced through bottom nozzle with pressure.

→ Two liquid phases were separated acc. to their density, the heavier liquid moves toward the periphery and lighter liquid forms an inner layer.

→ Both liquid ascend to the upper part of bowl.

→ These removed separately from different height through modified outlets.

Uses.

→ Used for separating liquid phases of emulsions in food, biochemical and pharmaceutical industries.