PHARMACEUTICAL ENGINEERING

UNIT 4 NOTES

FILTRATION

- OBJECTIVES
- APPLICATIONS AND FACTORS
- FILTRATION EQUIPMENTS

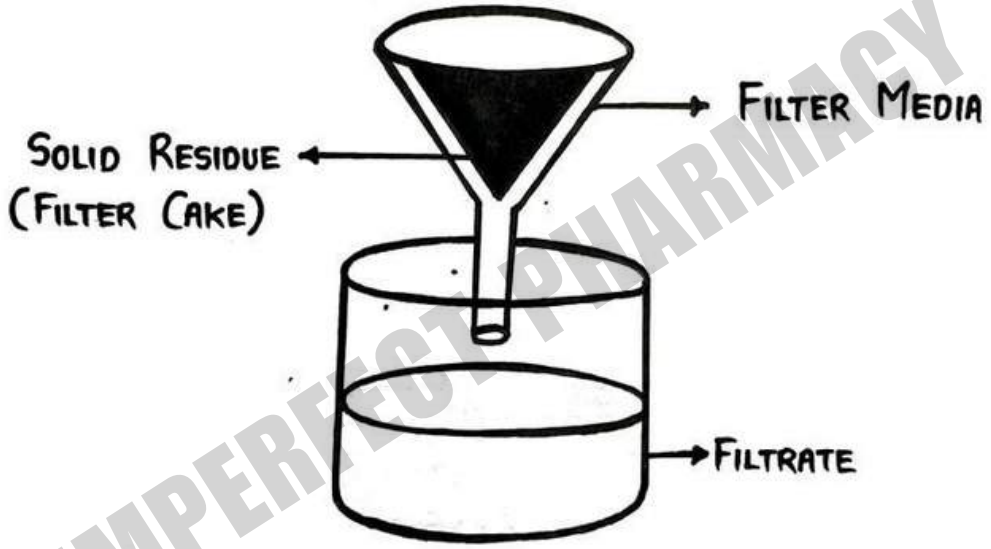
CENTRIFUGATION

- OBJECTIVES
- APPLICATIONS OF CENTRIFUGATION
- CENTRIFUGATION EQUIPMENTS

IMPERFECT PHARMACY

FILTRATION

- Filtration is a physical or mechanical process used to separate solid particles from a liquid or gas by passing the mixture through a filter medium that allows the fluid to pass but retains the solid particles.
- The principle of Filtration relies on the size difference between the particles and the pore size of the Filter Medium.



VARIOUS TERMS IN FILTRATION

- Slurry : The suspension of solid or liquid to be filtered.
- Filter Medium : The porous medium used to retain the solids is known as Filter Medium.
- Filter Cake : The accumulated solids on the filter are refferred to as Filter Cake.
- Filtrate : Filtrate is the liquid that passes through a filter.

OBJECTIVES OF FILTRATION

- Separation of Solids from liquids or gases.
- Purification of Liquids
- Concentration of desired components
- Waste Management

APPLICATION OF FILTRATION

- Water Purification
- Air Purification
- Food & Beverages
- Chemical Industry
- Laboratory Experiments
- Environmental Protection
- Sterilization

FACTORS AFFECTING FILTRATION

There are several factors that can influence the efficiency and effectiveness of the Filtration.

- Particle Size
- Filtration Medium
- Viscosity of the Fluid
- Filtration Pressure
- Temperature
- Concentration of Solids
- Cake Formation
- Filter Surface Area

① Particle Size

- The size of particles to be filtered plays a significant role in determining how easily they can be separated from a Liquid or Gas.
- Larger particles are more easily trapped by the filter while smaller particle might escape until e unless very fine filters used.

② Filtration Medium

- The type of filter material used (e.g. cloth, paper, membrane, sand) determines how well it can capture particles.
- A material with smaller pores may filter out finer particles but could lead to slower filtration rate.

③ Viscosity Of The Fluid

- Viscosity refers to the thickness of the fluid being filtered
- Higher viscosity liquids flow more slowly through the filter, which can reduce the filtration rate.

④ Filtration Pressure

- The pressure applied to force the liquid or gas through the filter also affects the filtration rate.
- Higher Pressure increases the filtration rate by forcing more liquid through the filter in a shorter amount of time.

⑤ Temperature

- Temperature can influence both viscosity and solubility of particles in the liquid.
- Higher Temperature generally reduce viscosity, making filtration faster.

⑥ Concentration Of Solids

- The amount of solid particles suspended in the fluid also influence the efficiency of the Filtration.
- A higher concentration of solids can lead to quicker clogging of the filter, decreasing its efficiency.

⑦ Cake Formation

- As filtration progresses, particles tend to accumulate on the filter surface, forming a 'cake' of solids.
- Formation of this cake can block filter pores, reducing the filtration rate.

⑧ Filter Surface Area

- It refers to surface area available for filtration in the system.
- A larger surface area allows for a greater volume of fluid to pass through at once, increasing filtration speed.

THEORIES OF FILTRATION

- The liquid flowing through a filter follows the basic rules governing the flow of any liquid through a medium.
- The rate of flow can be expressed as:

$$\text{RATE} = \frac{\text{Driving force}}{\text{Resistance}}$$

- Theory of filtration can be explained by following equations:

① Poiseuille's Equation
② Darcy's Equation
③ Kozeny - Carman Equation

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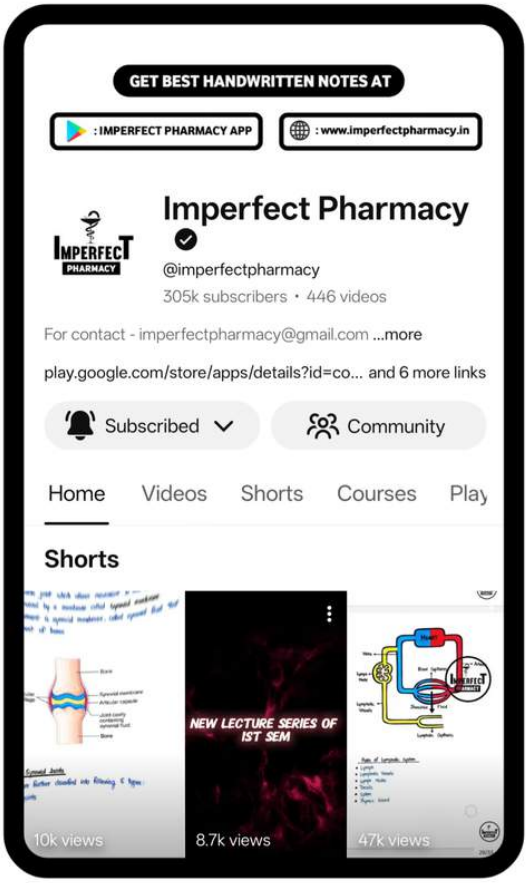

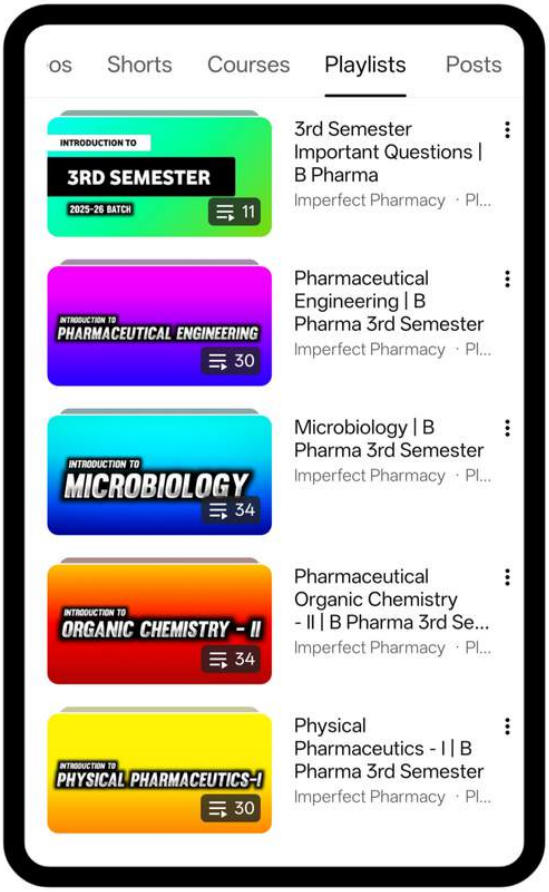

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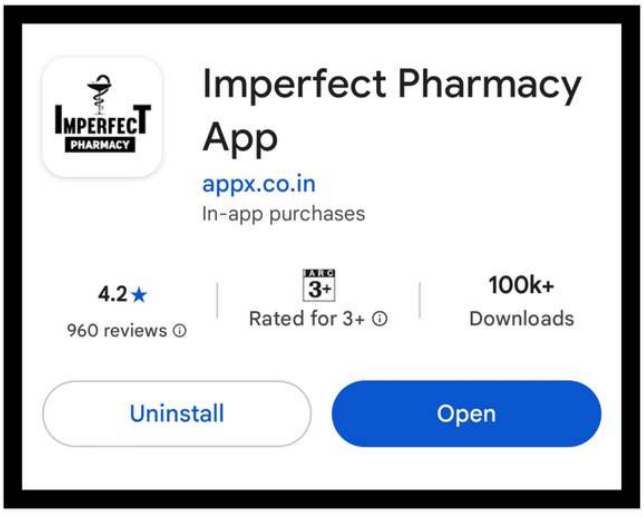


① POISEUILL'S EQUATION

- Poiseuille's Equation is based on assuming filtration similar to laminar / stream-line flow

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

- Here,
  - V = Rate of Flow
  - ΔP = Pressure Difference across the filter media
  - r = radius of filter's pores
  - η = Viscosity of the Fluid
  - L = thickness of filter cake

- This equation assumes laminar flow and a steady incompressible fluid.

② DARCY'S EQUATION

Darcy's Equation is based on permeability of filtration medium

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

Here,
- k = Permeability Coefficient of Cake
- A = Surface Area of filter medium
- ΔP = Pressure Difference across the Filter Media
- η = Viscosity of the Fluid
- L = Thickness of Filter Cake

③ KOZENY - CARMAN EQUATION

It is an extended version of Darcy's Law & depends on porosity of the cake formed.

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

Here
- A = Area of Filter Medium
- S = Specific surface Area of the Cake
- η = Viscosity of the filtrate
- P = Pressure difference across the filter
- k = kozeny Constant
- L = Thickness of filter cake
- ε = Porosity of the Cake

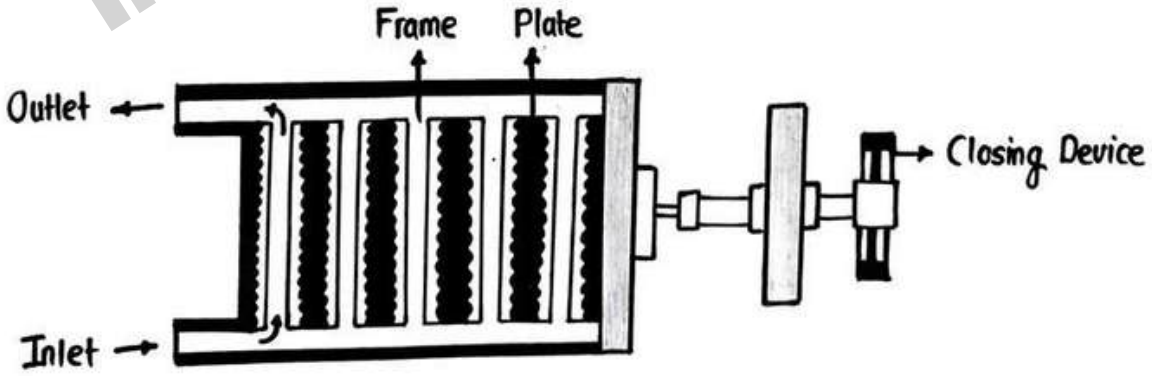
① PLATE & FRAME FILTER

PRINCIPLE

- The Plate & frame filter press works on the principle of filtration under pressure.
- A slurry (suspension of solid particles in liquid) is forced through a filter medium.
- The solid particles are retained on the medium, forming a cake. while the clear liquid passes.

CONSTRUCTION

- Plate & Frame : Alternating Plates & Frames are stacked together. Plates have a filter cloth, while frames form the chamber for slurry.
- Filter Cloth : A porous material stretched over the plate, acting as filter medium.
- Channels : An Inlet for slurry and Outlet for Filtrate
- Closing Device : A system that compress the plates & frames for no leakage.
- Pump : Provides the required pressure for slurry to flow through medium.



WORKING

- The slurry is pumped into the press through the feed channel.
- Under pressure, the liquid passes through the filter cloth into the drainage channels, leaving solid particles behind.
- Solid particles accumulate on the cloth, forming cake.
- The clear liquid exits the system through the outlet ports.
- Once filtration is completed, the press is opened & cake is removed manually or mechanically.

ADVANTAGES

- High Filtration Efficiency
- Customizable
- Handles High Pressure

DISADVANTAGES

- Time Consuming
- Space Requirments

APPLICATION

- Filtration of Pharmaceuticals
- Clarification of fruit Juices
- Removal of Precipitated proteins from Insulin

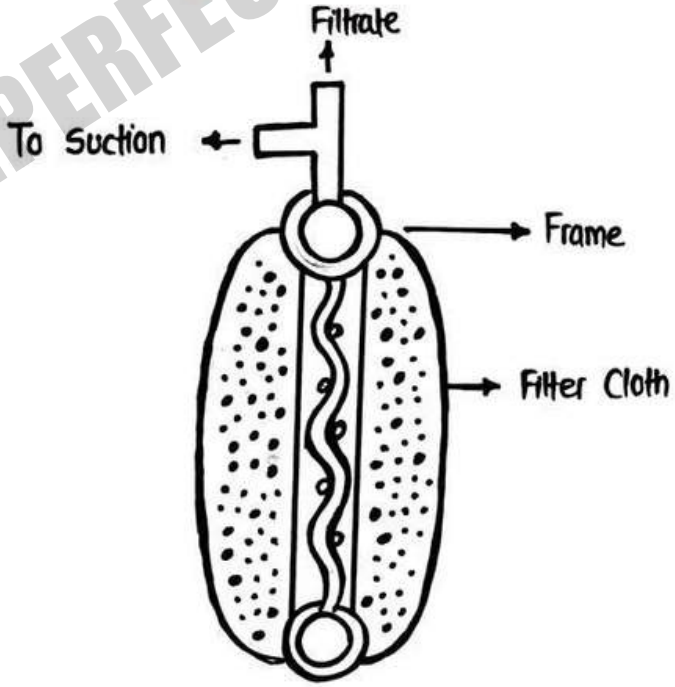
② FILTER LEAF

PRINCIPLE

A filter leaf is a filtration device widely used for solid-liquid separation & works on the principle of surface filtration & vaccum filtration.

CONSTRUCTION

- Filter leaf: The main component, consisting of a perforated metal plate or mesh, covered with a filter medium.
- Filter Tank: A Closed vessel containing the liquid slurry to be filtered
- Outlet Pipe: Connected to the filter leaf, through which filtrate flows out.
- Filter Medium: A layer of cloth or fine mesh placed over leaf.
- Frame: A supporting structure that holds the filter leaf



WORKING

- The filter leaf is placed in a slurry filled tank or chamber.
- During the process, either pressure or vaccum is applied to the slurry for effective filtration rate.
- The clear liquid passes through the filter medium and is collected via outlet pipe.
- Solids accumulate on the filter medium, forming a cake.
- After filtration, the cake is removed by shaking or backwashing the leaf

ADVANTAGES

- Multiple leaves can be used for large area.
- Simple Design
- Efficient Filtration

DISADVANTAGES

- Clogging
- Manual Cake Removal

APPLICATION

- Filtration of Fine Chemicals
- Purification of Pharmaceuticals
- Water Treatment

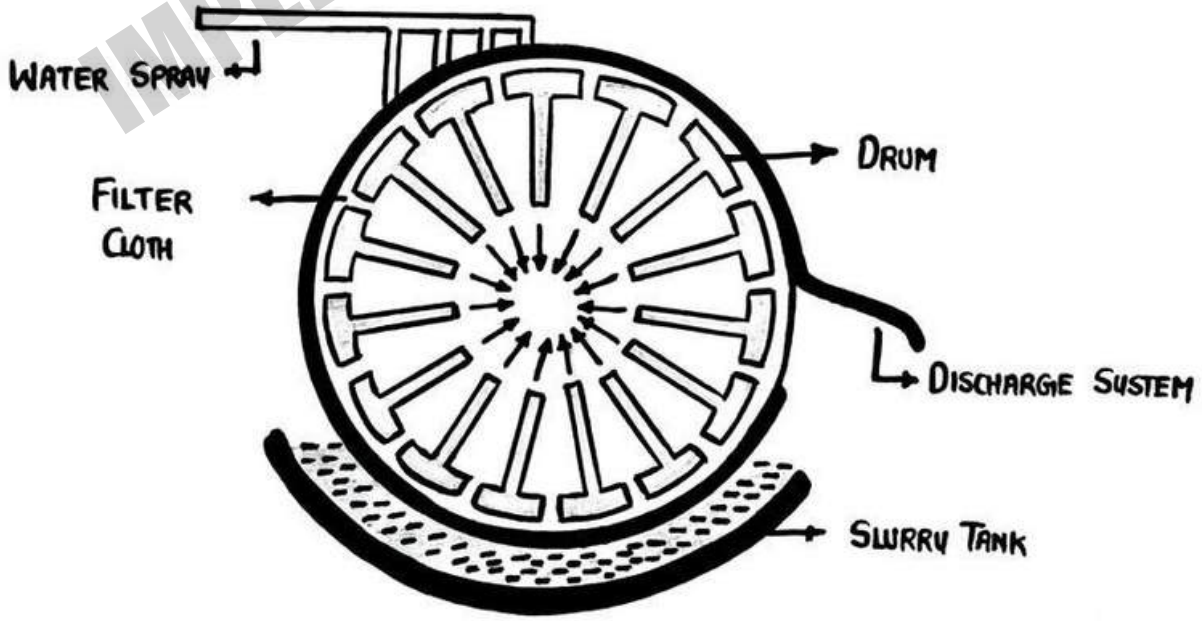
③ ROTARY DRUM FILTER

PRINCIPLE

- A Rotary Drum Filter operates on the principle of vaccum filtration.
- It consist of a cylindrical drum covered with a filtering medium that rotates partially submerged in a slurry.
- As Drum Rotates, a vacuum is applied internally. Creating a pressure difference that draws liquid through the filter medium while retaining solids on the drum's surface.

CONSTRUCTION

- Drum : A Cylindrical Drum, made of metal, covered by a filter cloth.
- Slurry Tank : Contains the slurry to be filtered.
- Vaccum System : Creates suction inside the drum to aid filtration.
- Discharge System : A device that removes accumulated cake from drum.
- Drive Mechanism : Rotates the drum at a controlled speed.



WORKING

- The Drum is partially submerged in the slurry tank.
- As the drum rotates, a vacuum is applied to the inner surface.
- This creates a suction force, causing the liquid to pass through the filter medium, leaving a cake of solid particles on drum's surface.
- The drum continues to rotate and the cake undergoes additional processes such as washing or drying, depending on application.
- A discharge mechanism removes the cake, and the cycle repeats.

APPLICATION

- Filtration of slurries in chemical industries
- Filtration of fruit juices.
- Separation of Active Ingredients.

ADVANTAGES

- Low Maintainance Requirments.
- Effective for handling large volume of slurry
- Low Labour Cost

DISADVANTAGES

- Complex Design
- High Initial Cost

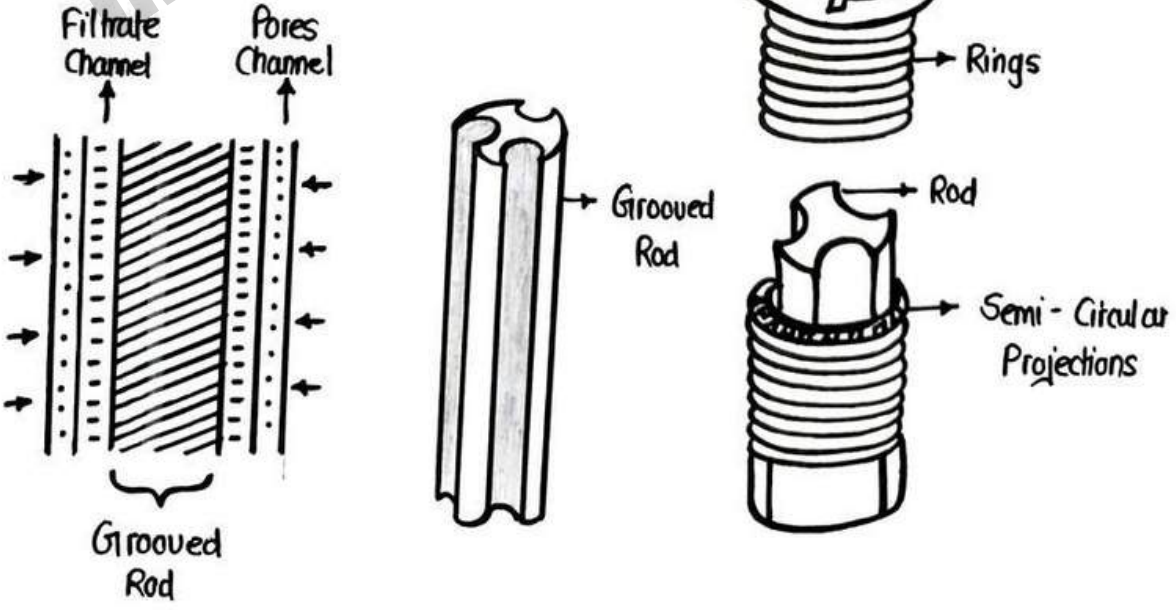
④ META FILTER

PRINCIPLE

- The Meta filter operates on the principle of Depth Filtration
- It removes impurities or solid particles from liquids by passing the fluid through a porous medium, often consist of layer of metal rings.

CONSTRUCTION

- Metal Rings : Made of stainless steel have internal diameter of 15 mm & external diameter of 22 mm. Each ring features semi-circular projections creating gap of 0.2 mm.
- Groved Rod : A rod on which metal rings are tightly packed.
- Outlet : For Fluid exit.



WORKING

- The meta filter assembly is placed in a vessel.
- The slurry passes through the channels between the rings.
- The clear liquid rises up and collected from the outlet in receiver.
- Accumulated solids can be removed by backflushing with water.

APPLICATION

- Clarification of syrups, elixers.
- Filtration of viscous liquids.
- Filtration of Injection solutions

ADVANTAGES

- Cost Effective
- High Pressure Tolerance
- Easy Maintainance

DISADVANTAGES

- Limited filtration
- Not a continuous Process

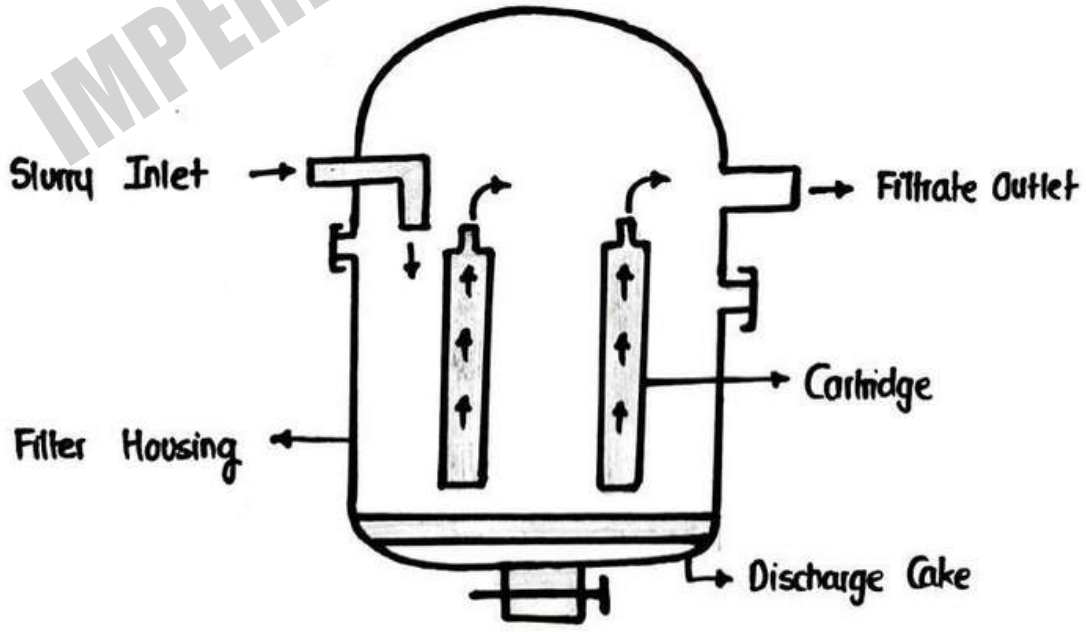
⑤ CARTRIDGE FILTER

PRINCIPLE

- The cartridge filter operates on the principle of surface and depth filtration.
- When liquid passes through cartridge, it traps particles either on its surface or within its porous medium.

CONSTRUCTION

- Filter Cartridge : The core component, made of various materials like polypropylene, cellulose or activated carbon.
- Filter Housing : A container that holds the cartridge securely. It can be made up of plastic, metal or steel.
- Sealing Mechanism : To ensure a tight seal & prevent fluid bypass.
- End Caps : Sealed ends of the cartridge to direct flow of fluid.



WORKING

- Contaminated fluid enters the filter housing through the inlet port
- The fluid passes through the filter cartridge, where contaminants are trapped either on the surface or within the pores of the filter medium
- Clean fluid exits the filter housing through the outlet port.

ADVANTAGES

- High Efficiency
- Versability.
- Compact Size

DISADVANTAGES

- Maintaince Cost
- Not suitable for large volumes.

APPLICATION

- Filtration of Water. Syrups
- Filtration of fuels, Lubricants
- Filtration of injectable solutions

⑥ MEMBRANE FILTERS

PRINCIPLE

- Membrane filters works on the principle of seiving and adsorption.
- The membrane acts as a semi-permeable barrier, allowing fluid to pass while retaining particles, microorganisms or dissolved solids.

CONSTRUCTION

- It consist of a thin-semi permeable membrane made of material like cellulos acetate, polysulfone or ceramics
- Its pore size vary from 0·1 µm to 0·001 µm.

WORKING

- The fluid is forced through the membrane filter
- The membrane's pores trap particles, microbes or contaminants larger than the pore size.
- Clean fluid or gas exits the filter, while trapped contaminants remain on membrane's surface.

ADVANTAGES

- High Filtration Efficiency
- Precise Separation
- Compact Design

DISADVANTAGES

- Limited Lifespan
- Prone to Clogging

APPLICATION

- Sterilization
- Microfiltration of Milk
- Filtration of Culture Media

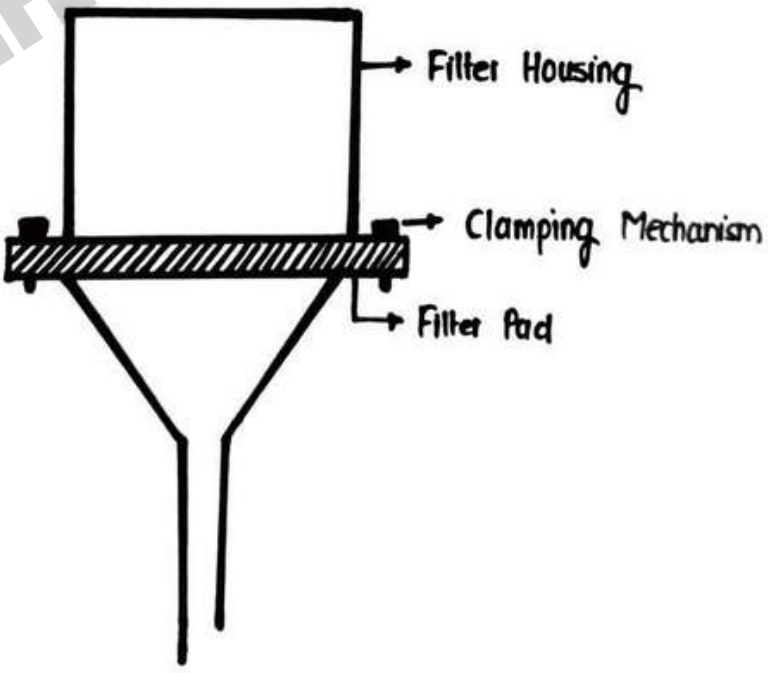
⑦ SEITZ FILTER

PRINCIPLE

- The seitz filter operates on the principle of depth filtration.
- It consist of a thick filter pad made of cellulose fibres, asbestos or diatomaceous earth that trap contaminants throughout its depth.

CONSTRUCTION

- Filter Pad : A thick sheet of porous material such as cellulose, asbestos or diatomaceous earth, with a pore size small enough to trap microorganisms and small particles.
- Filter Housing : Holds the filter pad securely.
- Clamping Mechanism : Ensures a tight seal between the filter pad and housing to prevent bypassing of unfiltered liquid.



WORKING

- The filter pad is placed in the housing, and the system is sealed
- The liquid to be filtered enters through the inlet port and passes through the filter pad
- Particles and microorganisms are trapped within depth of filter pad. Clean liquid exits through the outlet port.

ADVANTAGES

- High Filtration Efficiency
- Cost Effective

DISADVANTAGES

- Single Use Pads
- Clogging.

CENTRIFUGATION

- Centrifugation is a process used to separate components of a mixture based on their density by spinning the mixture at high speeds.
- The centrifugal force generated that causes the denser particles to move outward from the container while less dense components remain closer to the centre.
- Centrifugation & filtration, both are separation techniques, but centrifugation is often required instead of filtration because it can separate substances based on their densities.

OBJECTIVES

- Separation of components.
- Concentration of Biological or chemical samples by removing excess liquid.
- Isolation and Purification of substances.
- Clarification of Liquids

PRINCIPLE

- The principle of centrifugation is based on application of centrifugal force to separate particles in a mixture according to their size, density and viscosity of the medium.
- When a sample is spin at high speeds in a centrifuge, centrifugal force pushes denser particles away from centre, while ~~dense~~ less dense particles move towards the centre.

Application Of Centrifugation

- Isolation of Active Pharmaceutical Ingredients from Impurities.
- Separation of Blood Components (e.g. plasma, serum, RBCs etc)
- Isolating cellular components for disease diagnosis.
- Separation of cream from milk.
- Removal of impurities from oils and lubricants.
- Isolating & Purifying proteins, enzymes or antibodies.

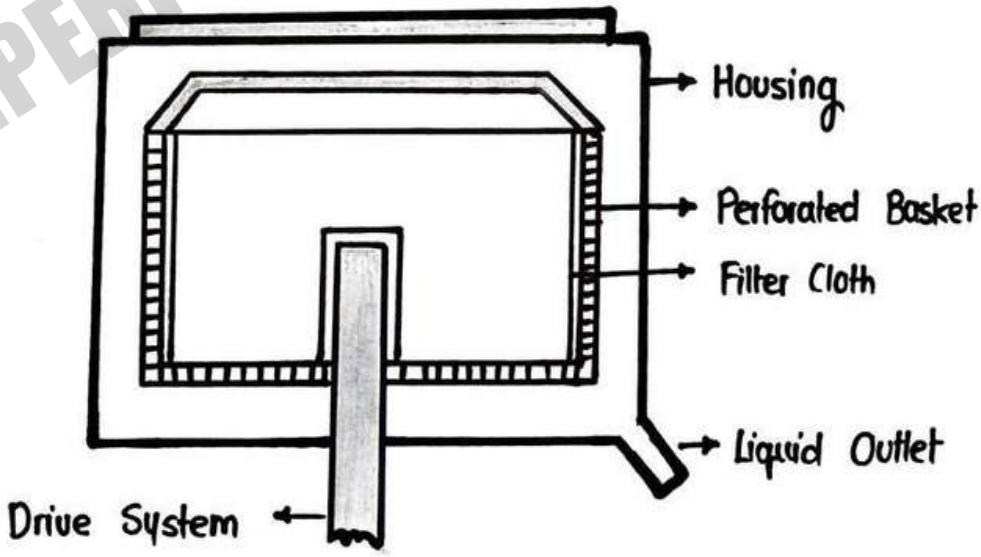
① PERFORATED BASKET CENTRIFUGE

PRINCIPLE

The perforated Basket Centrifuge operates on the principle of Centrifugal Force, which separates solids from liquids in a slurry by spinning the mixture at high speed.

CONSTRUCTION

- Basket : It is a cylindrical basket with perforated walls
- Filter Cloth : Lines the inner surface of the basket to prevent fine particles passing through perforations
- Drive System : A motor and spindle that rotate the basket at high speeds.
- Housing : An outer casing that contains the basket and collects the separated liquid.



WORKING

- The slurry or mixture is introduced into the rotating perforated basket.
- The basket rotates at high speed, generating centrifugal force.
- The liquid is forced outward through the perforations and collected in casing.
- The solid particles remain inside the basket, forming a filter cake
- After separation, liquid is drained and solid cake is manually or chemically removed.

ADVANTAGES

- Simple Design
- Efficient Separation
- Versatility
- Ease of Maintainance

DISADVANTAGES

- Labour Intervension
- Requires significant Energy

APPLICATION

- Separation of Pharmaceuticals
- Clarification of edible oils & fats
- Separation of chemicals, dyes.

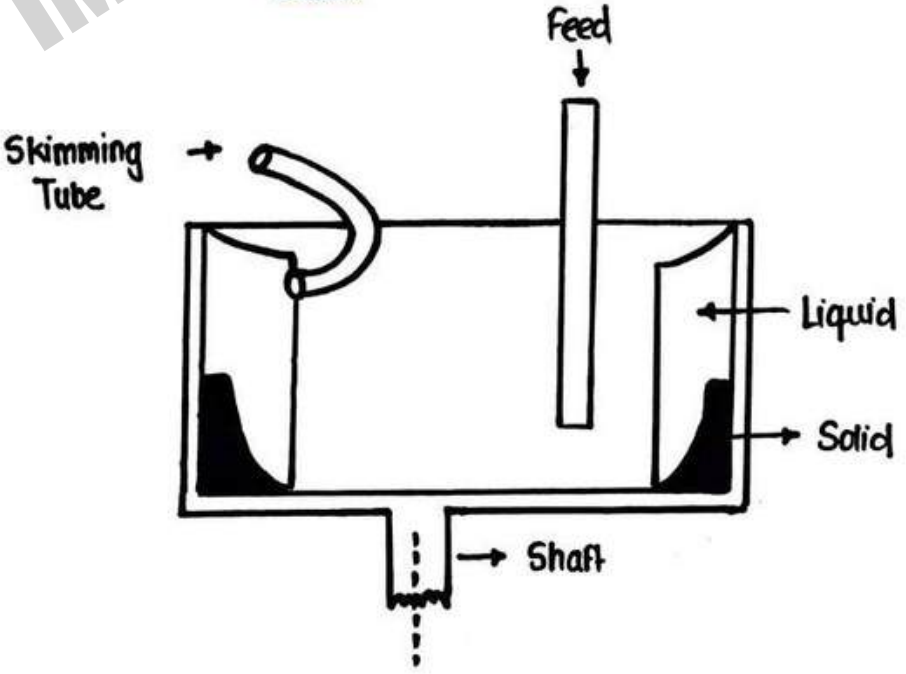
② NON PERFORATED BASKET CENTRIFUGE

PRINCIPLE

- The Non - Perforated Basket Centrifuge operates on the principle of Centrifugal Sedimentation.
- When the mixture is subjected to high speed rotation, centrifugal force causes denser liquid particles to move outward on the basket's innerwall, forming a sediment layer.
- The less dense liquid remains closer to the centre and is removed using a skimming tube.

CONSTRUCTION

- Basket : A solid ; non- perforated cylindrical basket
- Drive Mechanism : An electric motor connected to the shaft to achieve desired rotational speed.
- Casing : Encloses the basket to ensure safe operation
- Feed System : Introduces the slurry into the basket for separation.
- Skimming Tube : Removes separated liquid phase from the top of the basket



WORKING

- The slurry is introduced into the rotating basket.
- Centrifugal force drives denser solid particles outward, forming a sediment layer on the inner wall.
- The lighter liquid phase remains near the centre.
- The liquid is removed using a skimming tube.
- Once a sufficient layer of solid has accumulated, the centrifuge is stopped and solids are manually or mechanically removed.

ADVANTAGES

- Cost - Effective
- Suitable for High Resistance Solids
- Simple Design

DISADVANTAGES

- Time Consuming
- Manual Solid Removal
- Batch Operation

APPLICATION

- Separation of Fine crystals
- Clarification of Syrups & Juices

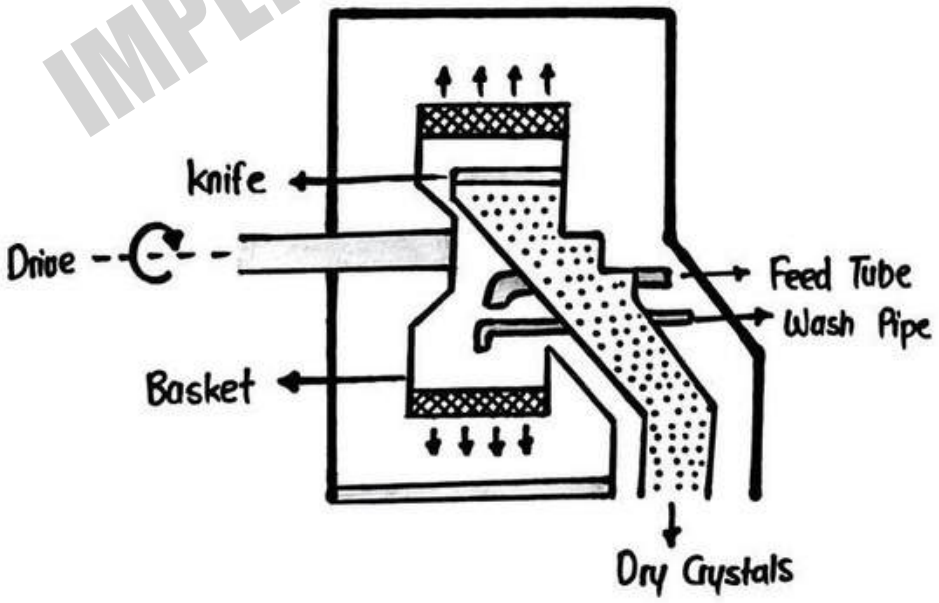
③ SEMI CONTINUOUS CENTRIFUGE

PRINCIPLE

- The semi - continuous centrifuge operates on the principle of filtration Centrifugation.
- During operation, the liquid phase passes through the perforated wall of rotating basket, while solid phase is retained inside. forming a cake

CONSTRUCTION

- Perforated Basket : A rotating basket with perforations.
- Drive Mechanism : An electric motor powers the high speed rotation.
- Feed System : Introduces the slurry into the centrifuge.
- Discharge Mechanism : Solids are removed periodically using a scraper, knife.
- Casing : Contains the basket and ensures safety during operation.



WORKING

- The slurry is introduced into the basket through the feed pipe
- Centrifugal force causes the denser solid particles to move outward and form a cake on basket's inner wall.
- The liquid phase flows outward through the perforations or exits via a discharge pipe.
- When the cake reaches a specific thickness, feeding is stopped and cake is removed using a knife or scraper.

ADVANTAGES

- Efficient solid discharge
- Versability.

DISADVANTAGES

- High Maintainance
- High Initial Cost

APPLICATION

- Separation of Crystalline Drugs
- Clarification of edible oils.
- Chemical Purification

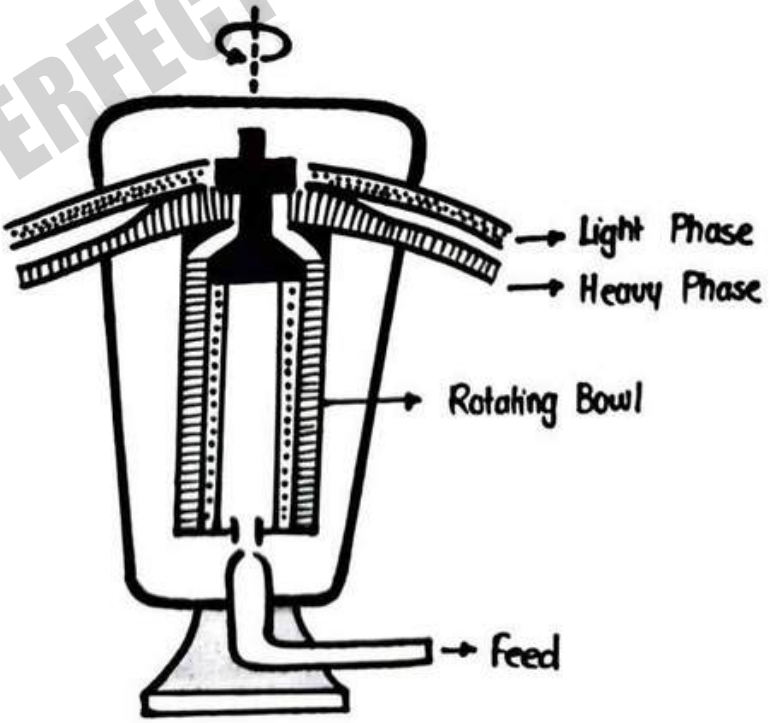
④ SUPER CENTRIFUGE

PRINCIPLE

The super centrifuge operates on the principle of Centrifugal force, where, when a mixture is subjected to rapid rotation, components with different densities are separated.

CONSTRUCTION

- Rotating Bowl : A cylindrical vessel that spins at high speeds to generate centrifugal force.
- Drive Assembly : An electric motor that drives the rotation of the bowl at approximately 2000 rpm.
- Feed System : A pressure system introduces the feed mixture into the centrifuge from the bottom.
- Discharge Outlets : Separate outlets for different liquid phases.



WORKING

- The feed mixture is introduced into the rotating bowl through the feed system.
- As the bowl rotates at high speed, centrifugal force causes denser liquids and solids to move outward, forming distinct layers based on density
- Lighter liquids remain closer to the centre.
- Separated liquids are continuously removed through designated outlets.

ADVANTAGES

- Continuous Operation
- High Separation Efficiency
- Versatility

DISADVANTAGES

- Complexity
- Higher Initial Cost

APPLICATION

- Oil Purification
- Food Production
- Chemical Refining

THANK YOU

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