Filtration

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→ Objectives
→ Factors influencing
→ Filter aids
→ Plate filter
→ Frame filter
→ Filter leaf
→ Rotatary drum filter
→ Meta filter
→ Cartridge filter
→ Membrane filter
→ Seidl2 filter
→ Theories

Applications

- Production of sterile products (HEPA) or (Laminar Bench)
  - ↳ Bacteria proof filters, particle size of 0.2 μm removed.
- Production of bulk drugs
- Production of liquid oral formulations.
  - ↳ dewaxing of oils.
  - ↳ removing suspended oils from aq. soln (syrups, elixers)
  - ↳ " of unsprable solids.
- Effluent & waste water treatment.

Mechanism

straining | Impingement | Entanglement | Attractive forces

Theories

→ Rate of flow = $\frac{\text{driving force}}{\text{Resistance}}$ or $\frac{\text{Volume}}{\text{time}}$ (dv/dt)

→ Driving force is pressure differential b/w upstream & downstream of filter

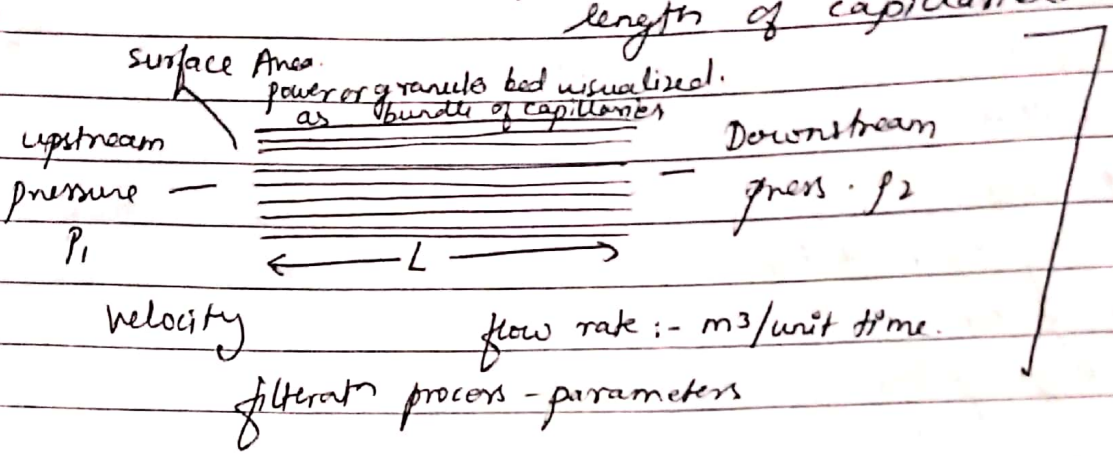
→ filteratn, not steady state as resistance not constant & ↑ with ↑ in deposition of solid on surface.

→ Rate of fil. Max at beginning & resistance acts with deposition

"Faith is the bird that feels the light when the dawn is still dark." - Rabindranath Tagor

& resistance depends upon various factors —

Resist. to movement = press. upstream − press. downstr.
length of capillaries.



Poiseuille's Eqn → He considered that filteration is similar to the streamline flow of a liq under press. thru capillaries.

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

V = rate of flow (m^3/s)
ΔP = press diff across filters, Pa
r = radius of capillary in filter bed, m
L = Thickness of filter cake (capillary length)
η = viscosity of filtrate, Pa-s.

conditions
Cake → belly mass
liq → flows thru interstices

Darcy's Eqn

$$V = \frac{K A \Delta P}{\eta L}$$

↗ depends on porosity, specific surface area of cake
K = permeability coeff. of cake
A = surface area of the porous bed.

Permeability defined quantitatively as flow rate of a liquid of unit viscosity across a unit area of cake having unit thickness under a pressure gradient of unity

Kozeny-Carman Eqn

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

ε = porosity of cake
k = Kozeny const.
S = Specific surface area of particles comprising cake

Bed depth less than actual path travelled by liq.
Actual path is not straight throughout but winding or tortuous.

Factors Affecting

- liq ppts (density, viscosity & corrosiveness)
- solid ppts (particle shape, size, charge, density, rigidity)
  → tendency of adhering or flocculating.
- Temp of suspension
- Objectives (solid or liquid or both to be collected)
- Solid prop. in the slurry.

Surface Area of filter medium

- Rate can be ↑ either using a larger filter or connecting a no. of small units in parallel.
- Pleating the filter paper or using pleated funnels ↑ the effective surface area of filtration.

Pressure drop across Filter medium

- ROF ∝ overall press. drop across filt med. & filt cake.
- It is achieved in no of ways :-

→ **Gravity** - simple method of obtaining press diff is maintaining a head of slurry above filter med.
- Press developed depends on density of slurry.
- Roughly a head of 10 m of water creates a p.d. of 100 kpa.

→ **Applying Pressure** : on surface of slurry i.e. pump slurry onto filter.
By this method p.d. achieved > p.d by reduced pres.

→ **Reducing Pres.** → Pres underneath filter med. may be reduced below atmospheric pres by connecting to vacuum.

→ **Centrifugal force** → ↑ rate of filt.

Viscosity of filtrate → ROF ∝ $\frac{1}{\text{vis of fluid}}$

"Faith is the bird that feels the light when the dawn is still dark."—Rabindranath Tagor

Filter Aids

Filter aid forms a surface deposit which screens out the solids and also prevents the plugging of the supporting filter medium.

Characteristics : The important characteristics of the filter aids are:

(a) Chemically inert to the liquid being filtered and free from impurities.

(b) Low specific gravity, so that filter aids remain suspended in liquid.

(c) Porous rather than dense, so that pervious cake can be formed.

(d) Recoverable.

Disadvantages : The filter aids remove the coloured substances by absorbing them. Sometimes active principles such as alkaloids are adsorbed on the filter aid. Rarely, filter aids are a source of contaminants such as soluble iron salts, which can provoke degradation of sensitive ingredients. Liquid retained in the pores of the filter cake is lost in the manufacturing process.

Examples of filter aids are:

Keiselguhr	Talc	Charcoal	Asbestos
Paper pulp	Bentonite	Fullers earth	

Activated charcoal is used for removal of organic and inorganic impurities. Kieselguhr is a successful filter aid and as little as 0.1 percent can be added to the slurry. The rate of filtration is increased by 5 times or more, at the above concentration, though the slurry contains 20% solids.

Filter Media

The *filter medium* acts as a mechanical support for the filter cake and is also responsible for the collection of solids.

Characteristics : Filter medium should have the following characteristics.

(1) It should have sufficient mechanical strength.

(2) It must be inert, for example, it should not show chemical or physical interaction.

(3) It should not absorb dissolved material.

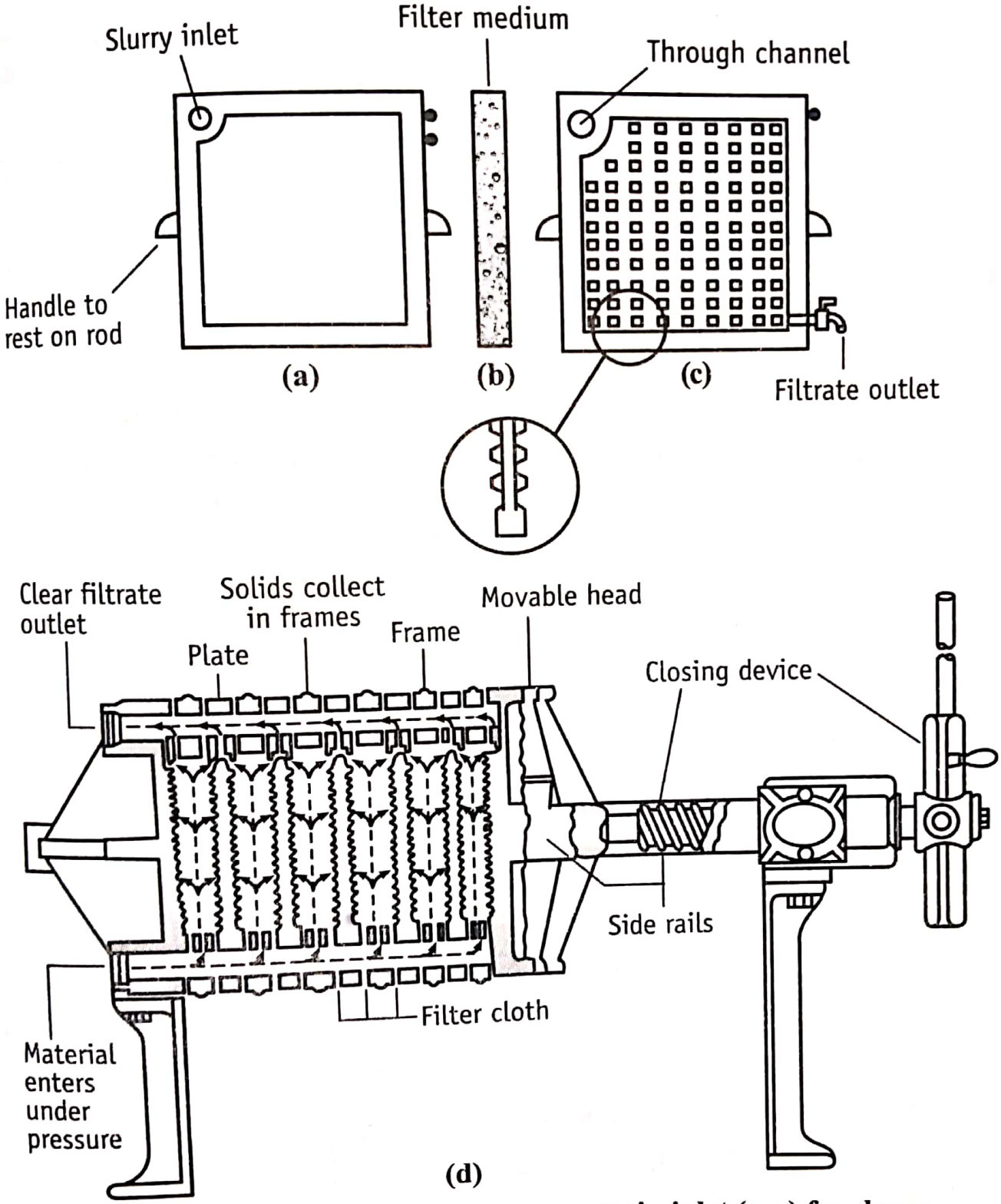
Plate and Frame Filter Press

Principle : The mechanism is surface filtration. The slurry enters the frame by pressure and flows through the filter medium. The filtrate is collected on the plates and sent to the outlet. A number of frames and plates are used so that surface area increases and consequently large volumes of slurry can be processed simultaneously with or without washing.

Construction : The construction of a plate and frame filter press is shown in Figure 8-7. The filter press is made of two types of units, plates and frames. These are usually made of aluminium alloy. Sometimes, these are also lacquered for protection against corrosive chemicals and made suitable for steam sterilisation.

Frame contains an open space inside wherein the slurry reservoir is maintained for filtration and an inlet to receive the slurry. It is indicated

by two dots in the description (Figure 8-7). The plate has a studded or grooved surface to support the filter cloth and an outlet. It is indicated by one dot in the description (Figure 8-7). The filter medium (usually cloth) is interposed between plate and frame.



(a) Frame—Maintains the slurry reservoir, inlet (eye) for slurry.
(b) Filter medium
(c) Plate along with section—supports the filter medium, receiving the filtrate and outlet (eye).
(d) Assembly of plate and frame filter press.

Figure 8-7. Plate and frame filter press.

Working : The working of the frame and plate process can be described in two steps, namely filtration and washing of the cake (if desirable).

Filtration operation : The working of a plate and frame press is shown in Figure 8-8. Slurry enters the frame (marked by 2 dots) from the feed channel and passes through the filter medium on to the surface of the plate (marked by 1 dot). The solids form a filter cake and remain in the frame. The thickness of the cake is half of the frame thickness, because on each side of the frame filtration occur. Thus, two filter cakes are formed, which meet eventually in the centre of the frame. In general, there will be an optimum thickness of filter cake for any slurry, depending on the solid content in the slurry and the resistance of the filter cake.

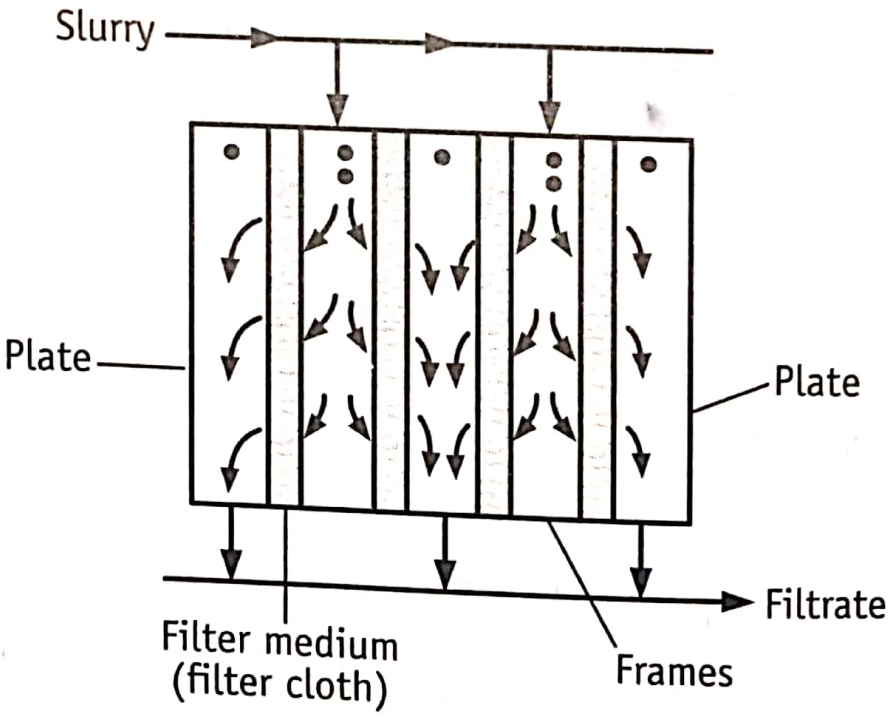


Figure 8-8. Plate and frame filter press, principle of operation (filtering).

The filtrate drains between the projections on the surface of the plate and escapes from the outlet. As filtration proceeds, the resistance of the

cake increases and the filtration rate decreases. At a certain point, it is preferable to stop the process rather than continuing at very low flow rates. The press is emptied and the cycle is restarted.

Washing operation : If it is necessary to wash the filter cake, the ordinary plate and frame press is unsatisfactory. Two cakes are built up in the frame meeting eventually in the middle. This means that flow is brought virtually to a stand still. Hence, water wash using the same channels of the filtrate is very inefficient, if not impossible. A modification of the plate and frame press is used. For this purpose, an additional channel is included (Figure 8-9). These wash plates are identified by three dots. In half the wash plate, there is a connection from the wash water channel to the surface of the plate.

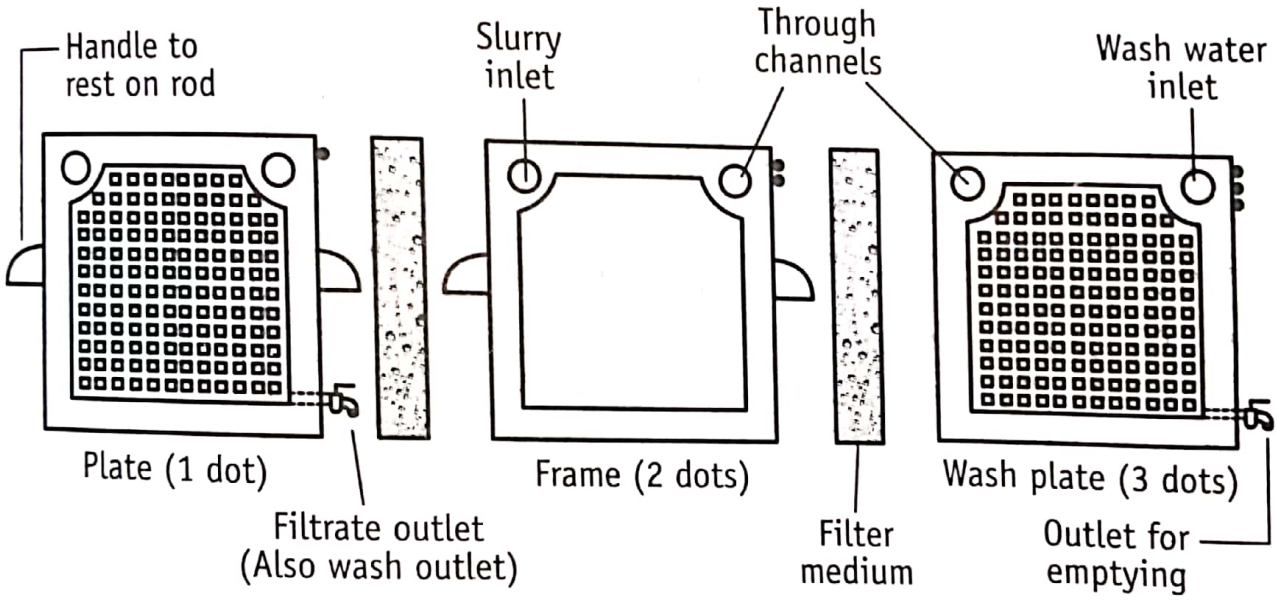


Figure 8-9. Plate and frame filter press with water wash facility.

The sequence of arrangement of plates and frames can be represented by dots as 1.2.3.2.1.2.3.2.1.2.3.2.1 so on (between 1 and 1, 2.3.2 must be arranged). Such an arrangement is shown in Figure 8-10 (a) and (b) for the operations of filtration and water washing, respectively.

The procedure for washing the press is shown in Figure 8-10. The steps are as follows.

(1) Filtration proceeds in the ordinary way until the frames are filled with cake.

(2) To wash the filter cake, the outlets of the washing plates (three dots) are closed.

(3) Wash water is pumped into the washing channel. The water enters through the inlets on to the surface of the washing (three dots) plates.

Uses : Filter sheets composed of asbestos and cellulose are capable of retaining bacteria, so that sterile filtrate can be obtained, provided that the whole filter press and filter medium have been previously sterilized. Usually steam is passed through the assembled unit for sterilization.

Examples include collection of precipitated antitoxin, removal of precipitated proteins from insulin liquors and removal of cell broth from the fermentation medium.

Heating/cooling coils are incorporated in the press so as to make it suitable for the filtration of viscous liquids.

Advantages:

(1) Construction of filter press is very simple and a variety of materials can be used.

- Cast iron for handling common substances.
- Bronze for smaller units.
- Stainless steel is used thereby contamination can be avoided.
- Hard rubber or plastics where metal must be avoided.
- Wood for lightness though it must be kept wet.

Disadvantages:

(1) It is a batch filter, so there is a good deal of 'down-time', which is non-productive.

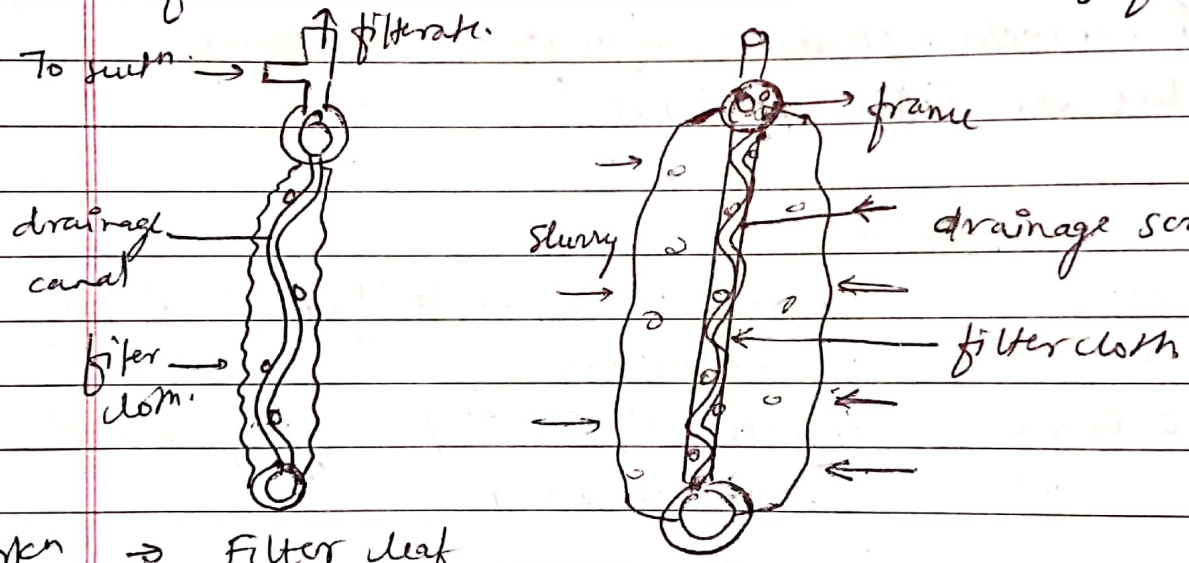
(2) The filter press is an expensive filter. The emptying time, the labour involved and the wear and tear of the cloth resulting in high costs.

(3) Operation is critical, as the frames should be full, otherwise washing is inefficient and the cake is difficult to remove.

filter leaf

Principle — - longitudinal drainage screen covered with filter cloth.
- Mech. is surface filtration & acts as sieve or strainer.
- Vacc. or press can be applied to ↑ the rate of filtration.

Cons — - Narrow frame enclosing a drainage screen or grooved plate.
- Whole unit covered with filter cloth.
- filter outlet connects to the interior of frame thru suctn.



Working → Filter leaf immersed into slurry

↓

Vacuum system connected to filterate outlet

↓

slurry passes thru filter cloth

↓

filtrate enters the drainage canal & goes thru outlet

Air passed to flow in reverse directn with facilitate cake removal.

(Eg.) → If solid not con ↑ (5% i.e, for dil. suspensn)

Adv → Versatile

→ Labour cost moderate

→ Washn efficiency ↑

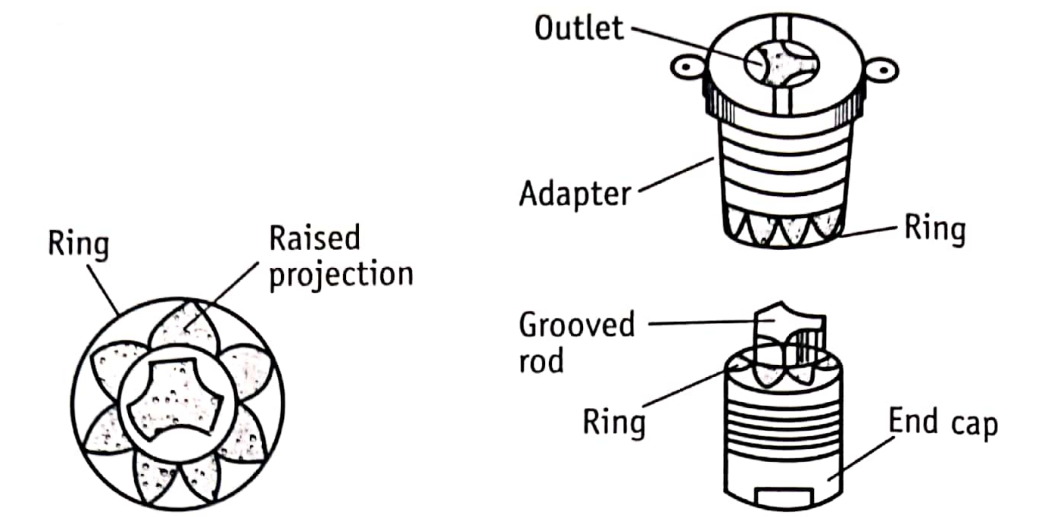
Metafilter

Principle : Metafilter functions as a strainer (surface filtration) for the separation of particles. In this method, metal rings contain semicircular projections, which are arranged as a nest to form channels on the edges. This channel offers resistance (strainer) to the flow of solids (coarse particles). The clear liquid is collected into a receiver from the top.

Construction : The construction and assembly of a metafilter is shown in Figure 8-14. The metafilter consists of a series of metal rings. These are threaded so that a channel is formed on the edges. It contains a grooved drainage column on which a series of metal rings are packed. These rings are usually made of stainless steel and have dimensions of about 15.0 millimetres internal diameter and 22.0 millimetres external diameter.

Each metal ring has a number of semicircular projections (0.8 millimetres in thickness) on one side of the surface as shown in Figure 8-14a. The projections are arranged the same way up. These rings are tightened on the drainage column with a nut. Therefore, metafilter is also known as *edge filters*.

Working : The working principle of a metafilter is shown in Figure 8-15. These filters are placed in a vessel and may be operated by pumping the slurry under pressure or occasionally by the application of reduced pressure to the outlet side. The slurry passes through the channels formed on the edges between the rings. The clear liquid rises up and collected from the outlet into the receiver. Metafilter functions as a strainer (surface filtration).



(a) Surface view of a ring **(b) Assembly of rings on column**

Figure 8-14. Metafilter

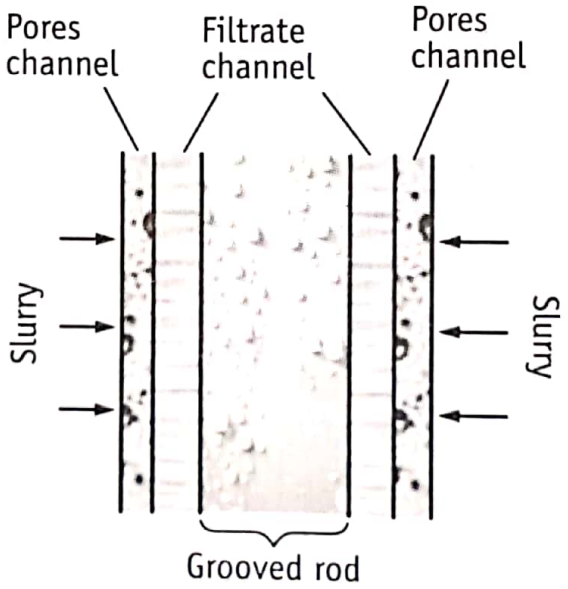


Figure 8-15. Mechanism of filtration through metafilter

For the separation of fine particles, a bed of suitable material such as kieselguhr is first built up. The pack of rings serves essentially as a base on which the true filter medium is supported.

Uses : Metafilter can be used for:

- clarification of syrups
- filtration of injection solutions
- clarification of insulin liquors
- filtration of viscous liquids can be achieved by applying pressure.

Advantages:

(1) Metafilter can be used under high pressures, without any danger of bursting the filter medium.

Cartridge Filter

Principle : Cartridge filter is a thin porous membrane in which pre-filter and membrane filter are combined into a single unit. The filtration action is mainly sieve-like and the particles are retained on the surface.

Construction : The construction of a cartridge filter is shown in Figure 8-16a. Cartridge filter has a cylindrical configuration made with disposable or changeable filter media. These are made of either plastic or metal. It consists two membrane filters (sieve-like) made of polypropylene: a prefilter and an actual filter for filtration. A protective layer surrounds them. The cartridges are housed in a holder. A number of cartridges can be placed in the same housing. The housing is closed with a lid. The housing has provisions for slurry inlet and filtrate outlet.

Working : The slurry is pumped into the cartridge holder. It passes through cartridge filter unit by the mechanism of straining. The clear liquid passes to the centre and moves up to collect through the outlet.

Uses : Cartridge filter is particularly useful for the preparation of particulate free solutions for parenteral and ophthalmic uses. This filter holder will process 1000 to 15000 litres of sterile solution per hour.

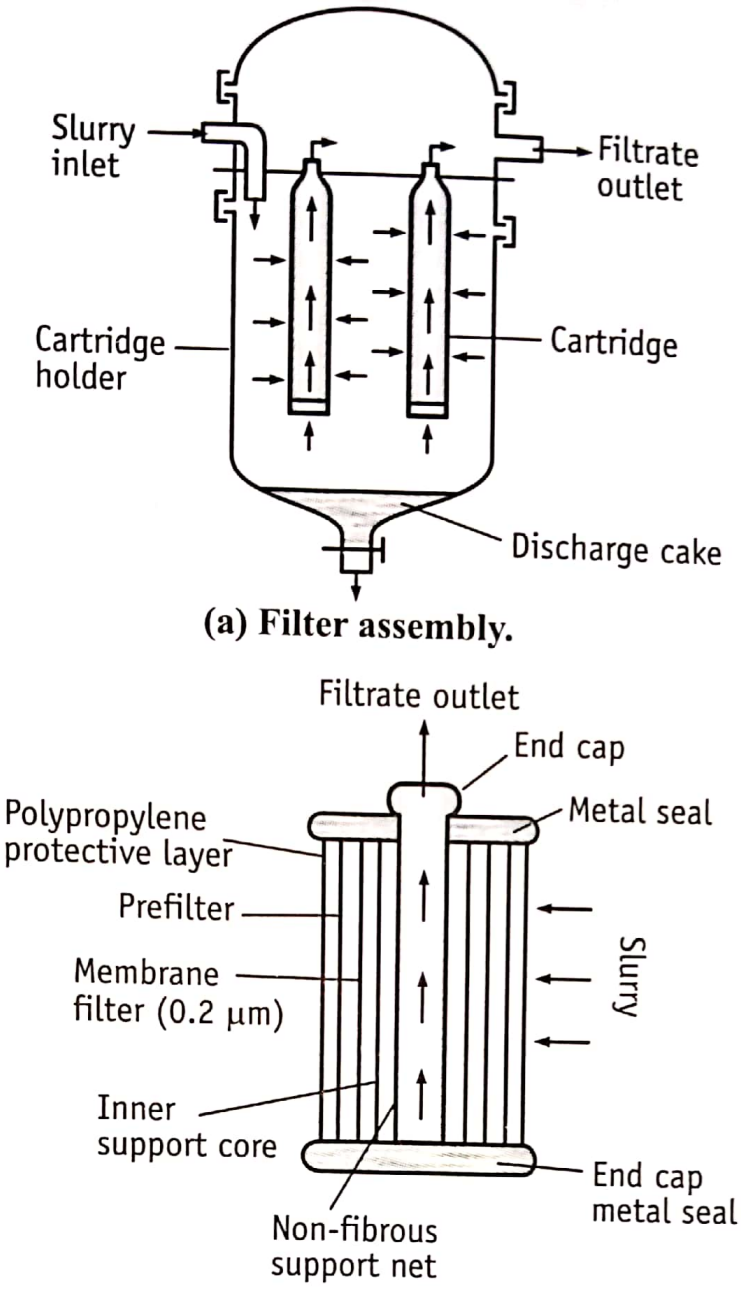
Advantages : (1) Stainless steel construction permits autoclaving for sterile operations.

(2) Cartridges with self-cleaning devices are advantageous.

(3) Rapid disassembling as well as reusing of filter media is possible.

(4) Cartridges are not brittle, when they are dry.

(5) They are used as in-line continuous filtration, which reduces handling of solutions. It minimizes the chances of contamination.



(a) Filter assembly.

(b) Cartridge filter unit

Figure 8-16. Cartridge filter.

Disadvantages : (1) Cost of disposable elements offsets the labour saving in terms of assembly and cleaning of cartridge clarifier.

(2) A number of manufacturers provide the components, which are generally not interchangeable between suppliers.

Drum Filter

Principle : Rotary drum filter functions on the principle of filtering the slurry through sieve-like mechanism on a rotating drum surface, under the conditions of vacuum. In addition, compression, drying (using hot air) and removing the filter cake (using a knife) are possible.

Construction : The construction of a rotary drum filter is shown in Figure 8-17. It consists of a metal cylinder mounted horizontally. The

drum may be up to 3 metres in diameter and 3.5 metres in length and gives a surface area of 20 metre square. The curved surface is a perforated plate, which supports a filter cloth. The drum is radially partitioned dividing the annular space into separate compartments. Each of it is connected by an internal pipe to the centre of the drum through a rotating valve.

Working : The drum is rotated at a speed less than one revolution per minute. The drum just enters the slurry in the trough (Figure 8-17). As it dips, vacuum is applied in this segment so that the solid is build up on the surface. The liquid passes through the filter cloth into an internal pipe and valve. Finally the filtrate reaches the collecting tank.

As the drum leaves the slurry section, it enters the drainage zone. Here excess of the liquid is drawn inside. Special cake compression rollers may be included at this stage, so that the cake is consolidated by the compression of the cake. This improves the efficiency of washing and drying process.

- Vacuum is applied to carry the slurry along with the drum
- Drainage zone
- Water washing arrangement
- Drying zone - dry air supply
- Cake removal zone

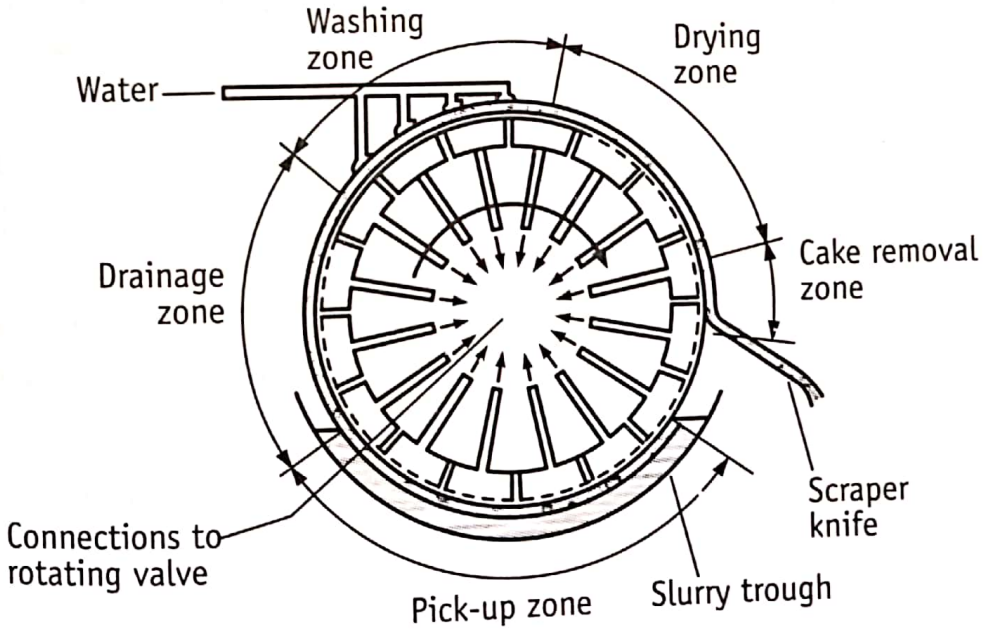


Figure 8-17. Drum filter.

As the drum leaves the drainage zone, it enters the water wash section. Water is sprayed on the cake. A separate system of vacuum is applied on the panel in order to suck the wash liquid and air through the cake of solids. Wash liquid is drawn through the filter into a separate collecting tank.

Then the cake enters the drying zone, where hot air is blown on the cake. The cake may have the moisture content less than one percent. Finally the cake is removed using a doctor knife and discharged.

All these steps are completed in one rotation of the drum. Now the drum is ready to receive a fresh lot of slurry.

Uses : Drum filter is used for continuous operation and is utilised to filter slurries containing high proportion of solids up to 15 to 30 percent. In the production of penicillins, the extract is separated from mycelium (cell mass) by drum filters. These are used for collecting calcium carbonate, starch and magnesium carbonate.

Advantages : (1) Cake is removed simultaneously during operation. Therefore, suitable for use with concentrated slurries.

(2) The labour costs are very low on account of automatic and continuous operation of the rotary filter.

(3) The filter has large surface area.

(4) The speed of rotation can be varied and the cake thickness can be controlled. For example, if the solids form an impenetrable cake, the thickness may be limited to less than 5 millimetres. On the other hand, if the solids are coarse and form a porous cake, the thickness of 100 millimetres or more, can be obtained.

Disadvantages : (1) Rotary drum filter is expensive equipment with complex functioning. It contains moving parts and also requires a number of accessories such as vacuum pumps, vacuum receivers, traps etc.

(2) The cake tends to crack due to the air drawn through by the vacuum system. This makes washing and drying processes inefficient.

Memb. filter

Principle – Act like a sieve & the particulate matter is retained on the surface of the membrane.

Const – cellulose acetate, cellulose nitrate or mixed cellulose esters,
- These are supported on rigid base of perforated metal, plastic or coarse sintered glass.
- These bases have ↑ retention characteristics due to pore size, ↑ dielectric constant & surface sensitivity.
- Available in diff. pore size.

Pore size	Utility
0.010 to 0.10	Remove virus particle from air & H2O
0.03 to 0.65	remove bacteria.
0.8, 1.2, 3.0 to 5.0	particle sizing & purifying aerosol, radioactivity

- If sol have considerable quantity of suspended solid prefiltered soln from suitable depth filter avoids clogging of membrane.

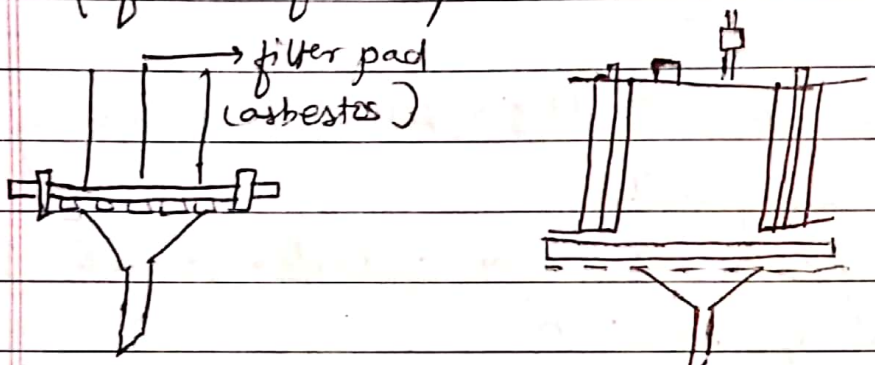
Uses – Disc memb with nutrient broth are used for study of growth of micro-org. & colony counts.
- Memb filt. can be autoclaved.
- Used for sterile filtration

Adv – Rapid.
- Adsorptn negligible & not prone to fibre contamination
- Available as disposable items.
- Bacterial growth on memb. not observable.

Disad – Expensive.
- Brittle when dry & tough when wet.
- clogged
- Not resistant to solvents

Seitz filter

- Consists of pad of - Compressed asbestos as a filtering medium.
- Typical = 2mm thick & size range is down to well below 1 μm diameter.
- finest pore size gives perfect filteration & retains small viruses.
- Industrial use = thicker pads used & specially made plate & frame filter press.



(a) Negative press use

(b) positive press use

Uses :- - for sterile filteration.
- Viscous soln filtered.
- for air filteration.
- surface charging & electrostatic attractions. have significant influence in removing particles.

Adv - Pads = expensive & filteratn = rapidly clogging =
- Better than ceramic & sintered glass filter

Disad - pliable & fragile when wet & supported on a perforated metal, plastic disc.
- New pad used fore each filteratn.
- fibrous pads not suitable for sterilizing products containing alcohol or oil.

Centrifugation

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→ centrifugal force = a driving force = for separation.

Applications

- Bulk drug production
  crystall. drug (Asprin) from mother liquor.
- Product^{n} of biological products
  Proteinaceous drugs & macromolecules dnt as colloidal dispers^{n} in water, separated by centrifugat^{n}.
- Biopharmaceutical analysis of drugs
  Drug in blood, urine dnt is colloidal dispers^{n}.
- Evaluat^{n} of suspn^{s} & Emuls^{n}
  Rapid empirical test parameter for evaluat^{n} of suspn^{s} & emuls^{n}.
- Determinat^{n} of mol. wt of colloids.
  Polymers mol wt determined with help of ultracentrifugation.

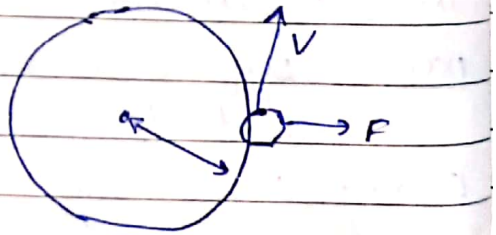
Principle of Centrifugation

→ "Sedimentation"

→ At centripetal force, accelerat^{n} causes separation → denser substance separate along radial direct^{n} / Lighter obj = tend to move up the tube.

→ Process separates object with particle size more than 5μm.

Centrifugal Effect or Relative Centrifugal Force



Body of mass 'm' kg, radius 'r' meters & velocity 'v' ms^{-1}.

Force acting in radial direction (Centrifugal force) $(F) = \frac{mv^2}{r}$ —(1)

Same body experiences gravitational force, G as –

$G = mg$ —(2)

Centrifugal effect expressed as ratio of centrifugal force to gravitational force and the centrifugal effect is a force, which is a no. of times

"The butterfly counts not months but moments, and has time enough." – Rabindranath Tagor

greater than gravitational force, ratio may have value as high as 10^4.

(Centrifugal Effect) C = $\frac{\text{force acting in radial direction}}{\text{gravitational force}}$ = $\frac{F}{g}$

$v = 2\pi r n$, n = speed of rotational

$$C = \frac{mv^2}{r\,mg} = \frac{v^2}{gr}$$

$$\therefore C = \frac{(2\pi r n)^2}{gr} = \frac{4\pi^2 r^2 n^2}{gr} = \frac{4\pi^2 r n^2}{g}$$

$\because 2r = d$, d = diameter of rotation,

$$C = \frac{2\pi^2 d n^2}{g} \quad \longrightarrow (X)$$

& we know, $g = 9.807\ m/s^2$,

$\therefore$ we get simplified eqn as — $C = 2.013\, n^2 d$

Where $n = s^{-1}$ & d = meters.

$\therefore$ Conclusion $\longrightarrow$ $C \propto$ diameter
$C \propto$ (Speed of rotation)^2

(X) helps in selecting type of centrifuge —

* Centrifugal sedimentation of very small particle $\longrightarrow$ ↑ centrifugal effect, $\therefore$ small diameter equipment is used, operated at very ↑ speed.
ex $\longrightarrow$ Tubular Bowl Centrifuge

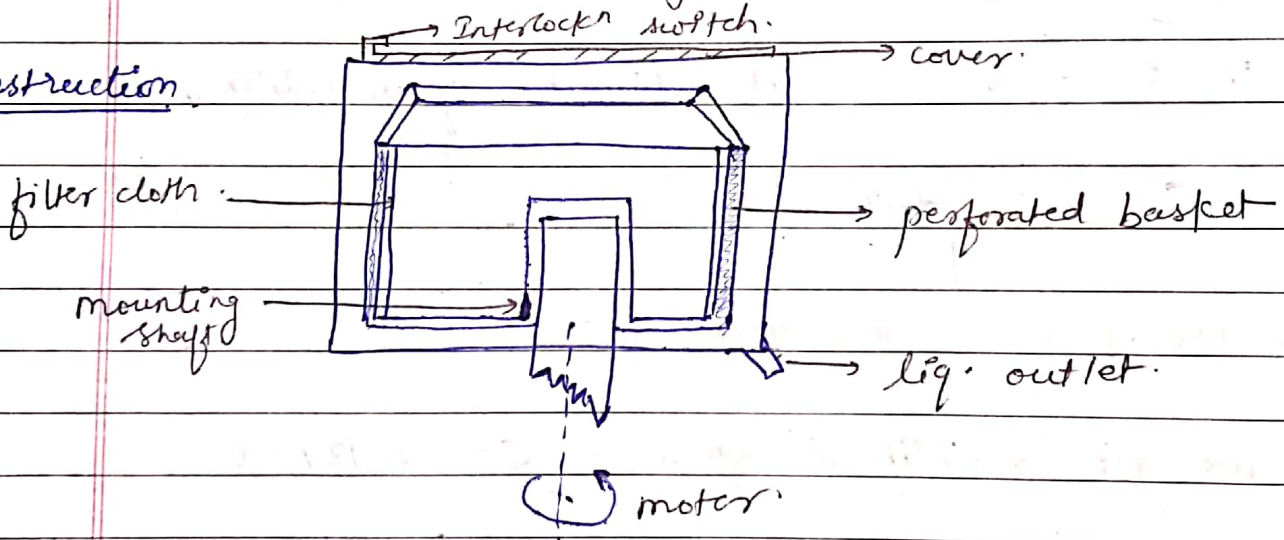
* Large amount material to be processed $\longrightarrow$ ↓ centrifugal effect is sufficient, large centrifuge at low speed will be economical.

Perforated Basket Centrifuge

→ A basket mounted above driving shaft.
→ Under-driven arrangement.
→ Used for batch processes.

Principle :- It is a filteration centrifuge.
- Sepration is through a perforated wall based on the difference in densities of solid & liquid phase.
- Bowl = perforated side-walls.
- Dur^n centrifugation, liquid phase passes thru perforated side walls, while solid phase = retained in the bowl.
- Solid removal → cutting sediment → when centrifuge stops.

Construction



- Basket → steel or copper or monel (any material resisting corrosion)
  - ↳ diameter = 0.90m (selected as per crystal size)
  - ↳ capacity = 0.085 m^3
- → suspended → vertical shaft → driven by a motor using suitable power supply such as belt spralleys, water turbines & electric motors.
  - ↳ 5 kilowatt = to start
  - ↳ 2 kilowatt = for running
- Casing surrounds basket, which collects filtrate & discharges it at the outlet.

Working — Material → basket (optimum material or else it will exert strain)
↓ power applied
↓ Basket Rotates (150 RPM) & max speed attained quickly.
↙ Power running < Power starting
↓
liquid = perforated walls
solid = basket

Uses – To separate crystalline drugs.
- Remove unwanted solid from liquid.
- Sugar crystal separation.

Adv – Rapid process
- Product has very low moist content.
- Dissolved solid separated from cake.

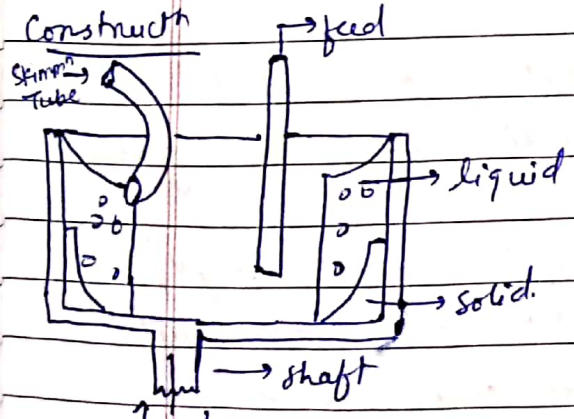
Disad – Batch process
- Labour cost ↑
- wear & tear occurs.

use :- Useful when deposited solids offer ↑ resistance to liq. flow.

Non-perforated Basket Centrifuge

Principle :- A sedimentation centrifuge.
→ Separatn based on density differences of liq & solid phases w/o a porous barrier.
→ Bowl has non-perforated side walls.
→ During centrifugatn, solid retained on the basket sides, liquid remains at the top which is removed by skimming tube.

Constructh



- A basket (steel or suitable metal)
- → suspended on suitable vertical shaft & is driven by a motor using suitable power system.

Workn
- Suspensn fed continously introduced in basket.
- During centrifugatn → solid retained on basket sides
  → liq remains on top, removed by skimming tube
- when suitable depth of solid deposited on walls, operation is stopped & solid is scraped off by hand or scraper blade

Under-driven, non-perforated basket centrifuge

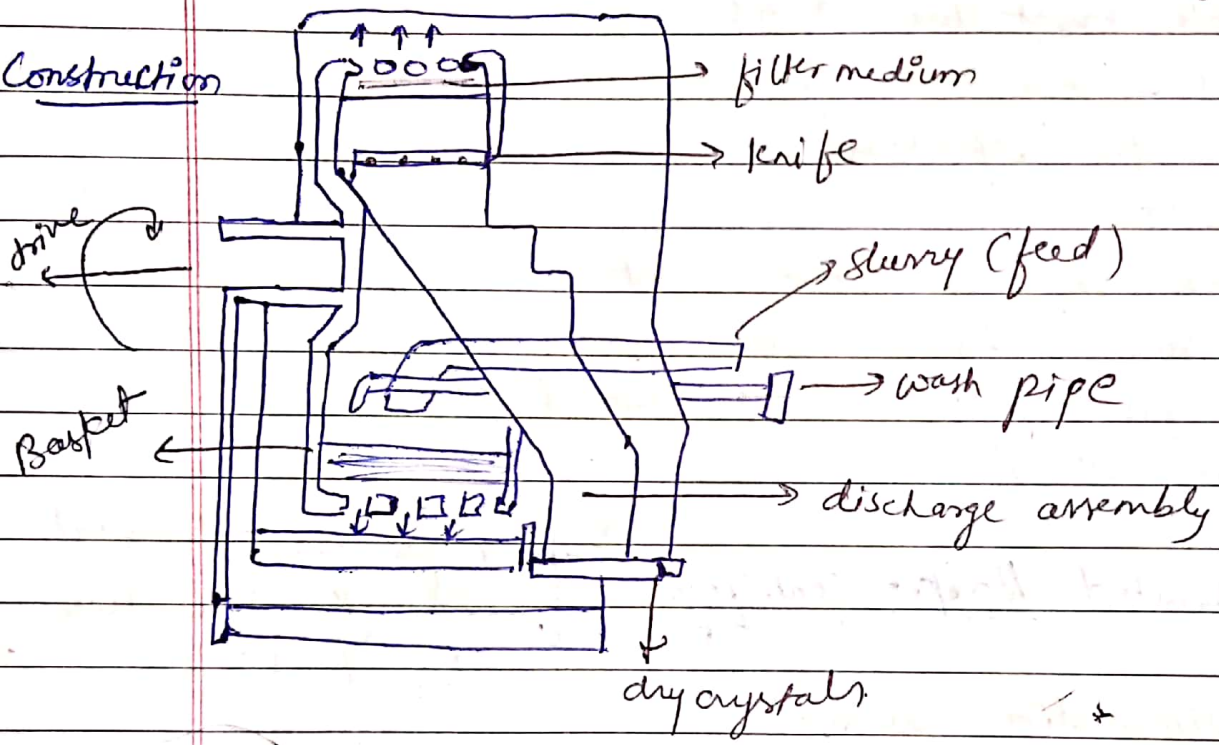
"Faith is the bird that feels the light when the dawn is still dark." – Rabindranath Tagor

Semi-continuous Centrifuge

Principle → Separation occurs thru perforated walls based on the difference in densities of solid & liquid phases.

- Bowl → perforated side wall.
- Pure centrifugation → liquid → perforated walls & solid → in bowl
- Solid → washed & removed → cutting the sediment using blade.
- It is a short cycle automatic batch centrifuge.

Construction



- vertical perforated basket → supported from horizontal shaft → driven by motor.
  - from open side → provisions made → introduce feed & wash pipe thru (Horizontal tubes)
- → feeler rides over feed, connected to diaphragm value thru air supply.
- feeler → control → feed thickness.
- hydraulic cylinder attachment made that discharge chute enters from basket side when crystal discharge is dischargable.

Working → Perforated basket → rotate & slurry introduced with pipe
→ solid retain on basket, filtrate leaves basket - (outlet)
→ cake → washed → water → filtrate outlet escapes.
→ After achieving desired thickness (50 to 70mm), feeler cuts off air supply to diaphragm valve that automatically shuts off

the entry of slurry.

→ Hydraulic cylinder → actuated, lifts the life along with discharge chute.

→ Knife — X cut cake completely but leaves crystals that acts as a filter medium for further separation in the next cycle.

- Residual crystal = Brief wash, before starting next cycle.
- Through timer & air supply mechanisms, diaphgram valve controls all steps.
- Entire cycle = semiautomatic
- discharged crystal may have 2 to 4 % of moisture.

Adv → used when solids can be drained fast from the bowl.

Disad → crystal breakage possible during discharge.

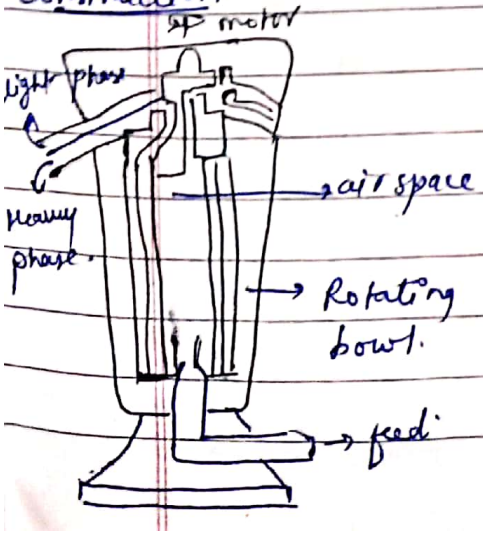
Super centrifuge

- A continous centrifuge used to separate two immiscible liq. phase

Principle

- A sedimentation centrifuge
- separation → difference in densities of immiscible liquids.
- Centrifugation done in bowl of small centrifuge.
- Heavier liq thrown against wall while lighter remains as inner layer.
- Two layers simultaneously separated using modified weirs.

Construction



[Long, hollow, cylindrical bowl = small diameter
suspended from flexible spindle at top & the bottom fitted loosely in a bush.

- Rotated on vertical axis
- feed introduced thru nozzle with pressure.
- Two liq outlets are provided at diff heights.
- Inside bowl = baffles fxt to catch liq. & force it to travel at same speed of rotation as the bowl wall.

Working

- Centrifuge rotate on vertical axis at app. 2000 RPM.
- Feed → lower part thru nozzle with pressure.
- 2 liq phases separated acc. to densities.
- Heavier = periphery & lighter = inner layer.
- Both liq. ascend to upper part of vertical bowl.
- 2 layers simultaneously removed separately from diff. heights through modified outlets.

Use –

To separate liq. phase of emulsion in food, biochemical.