

Filtration Equipments

The basic requirements are

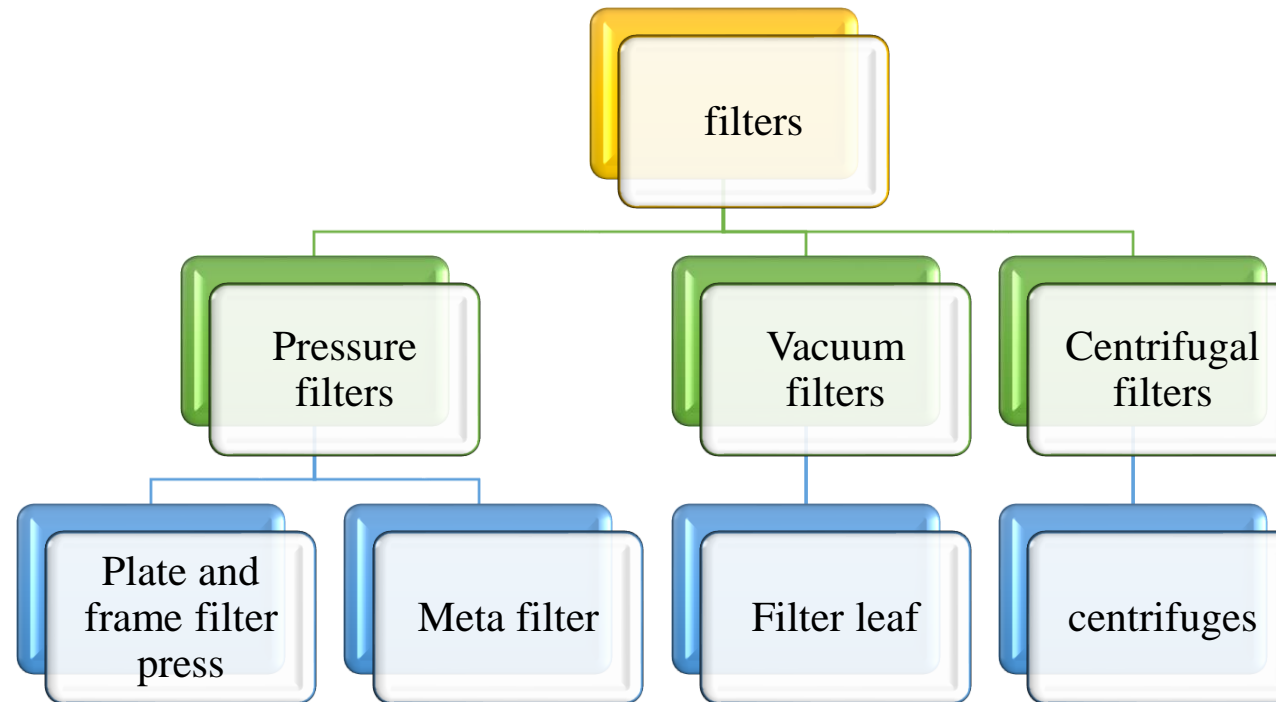
- Should support for the filter medium
- Access flow through the filter cloth
- Provision for removing filter cake

Types of filtration equipments

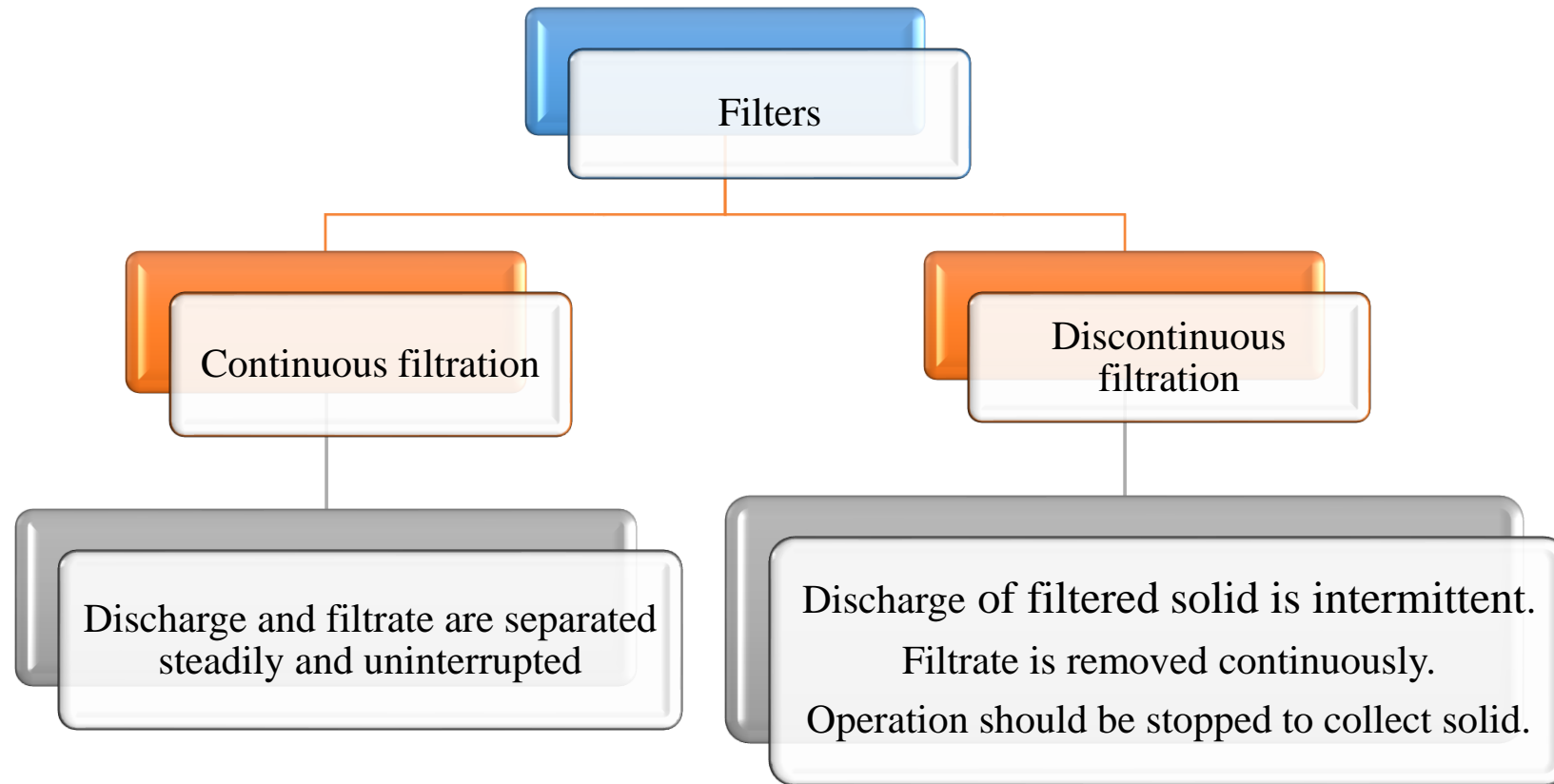
- Plate and frame filter
- Rotary filter
- Centrifugal filter
- Air filter

Classification of filtration equipments

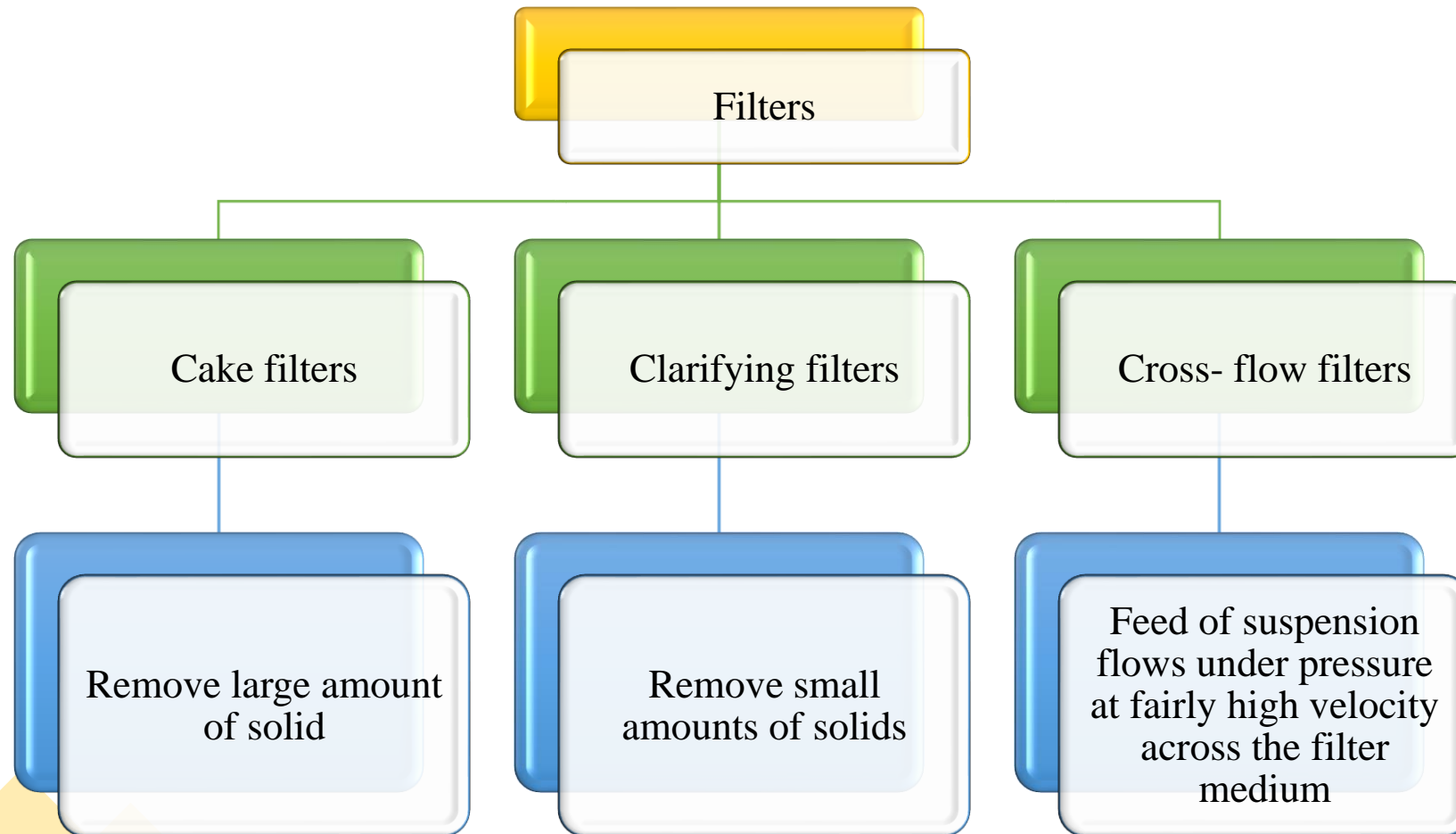
- Based on application of external force:



Based on operation of filtration



Based on nature of filtration



Laboratory scale filtration

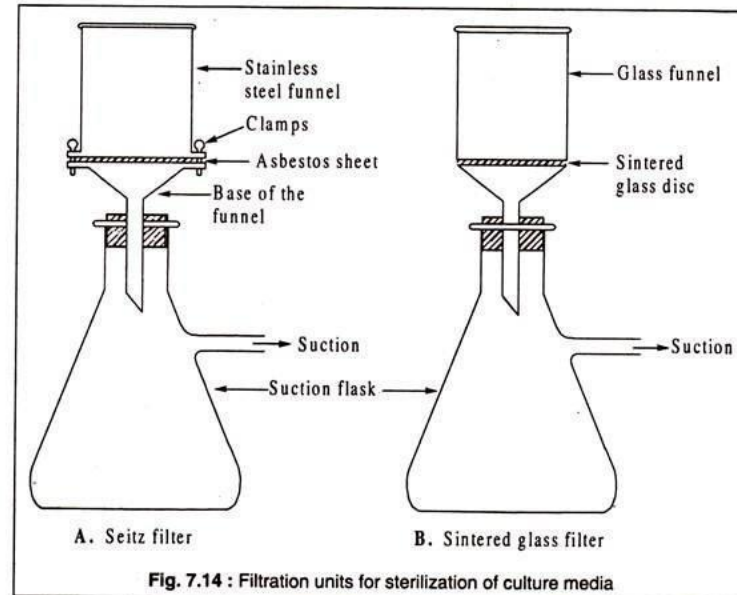
Filter paper and funnel

Buchner funnel and filter paper

Sintered glass filter

Seitz filter

Membrane filter



Selection of filters depends upon below factors

Material related

Properties of fluid- viscosity

Nature of solids- size, shape, distribution and packing characteristics of particles

Conc. of solid in suspension

Quantity of material to be handled

Whether it is necessary to wash the solid

Whether any form of pretreatment will be helpful.

Equipment and process related

Flow rate

Should be absolute in sense, limit to size of particles passing through the filter should be known.

Should be sterilisable by heat, radiation or gas

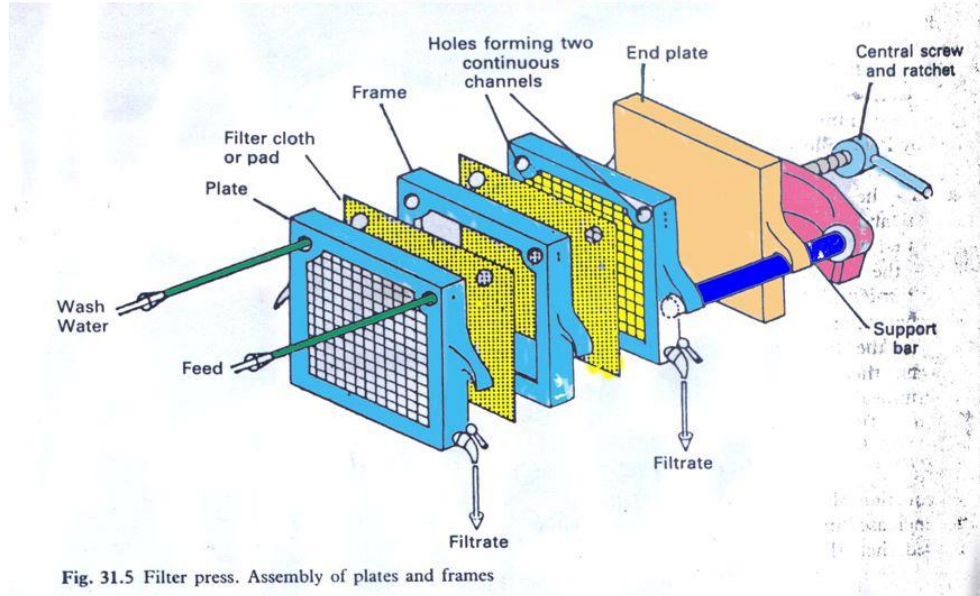
Should be economical.

Plate and frame filter press

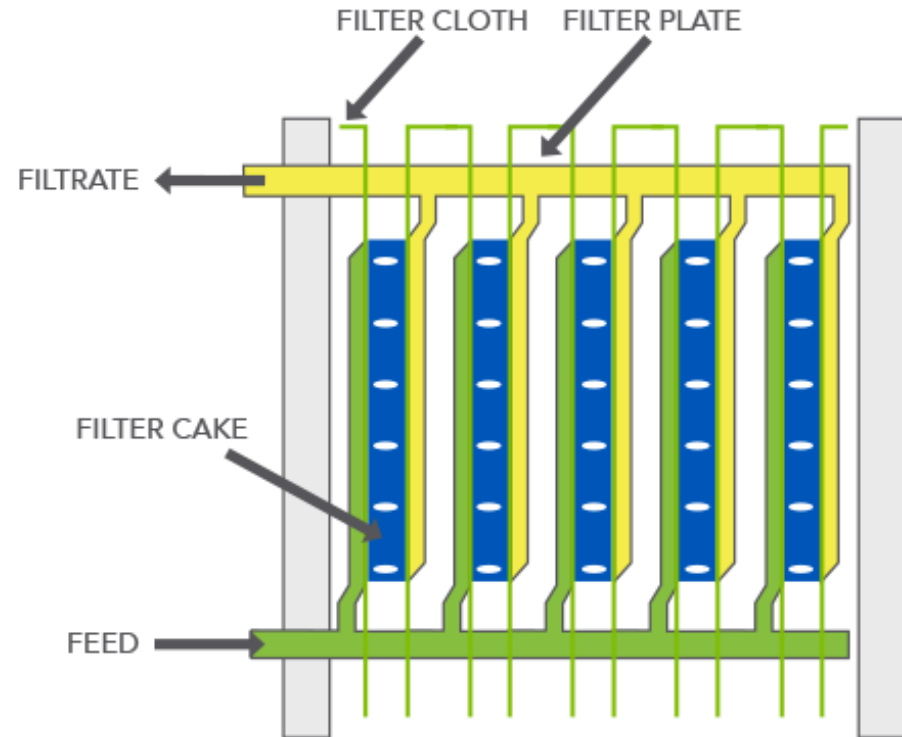
Principle:

- Mechanism is surface filtration.
- The slurry enters the frame by pressure and flows through filter medium.
- The filtrate is collected on the plates and send to 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.

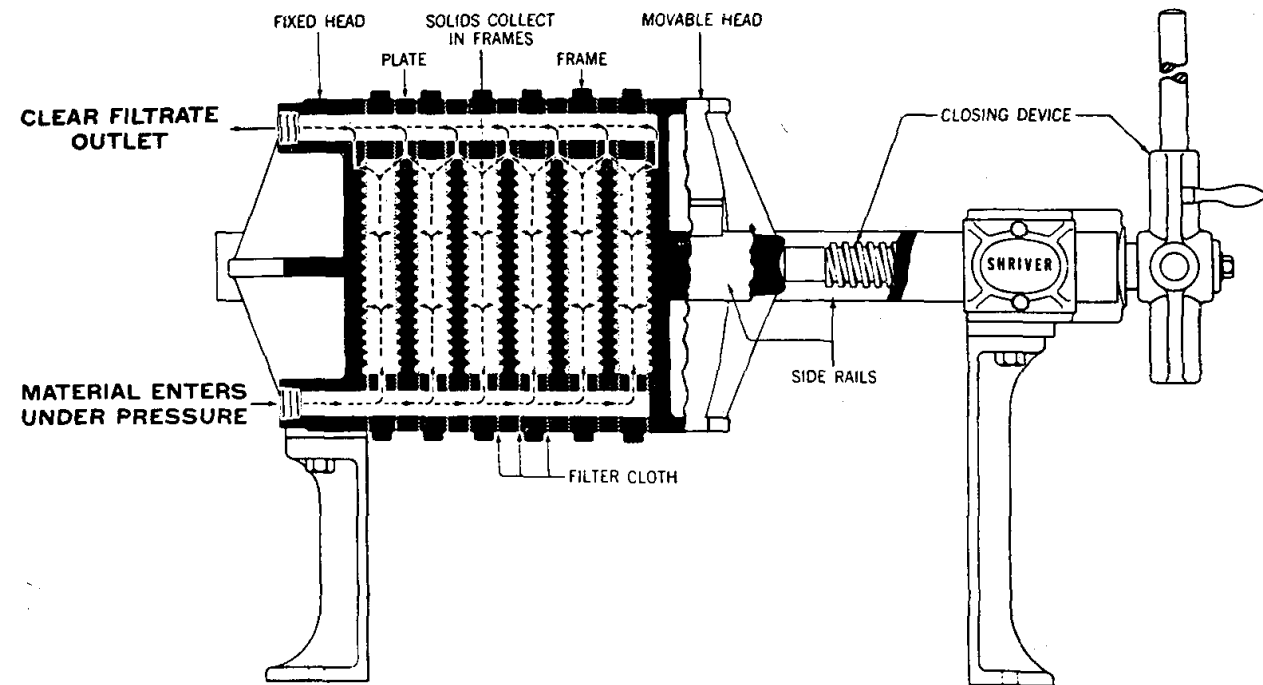
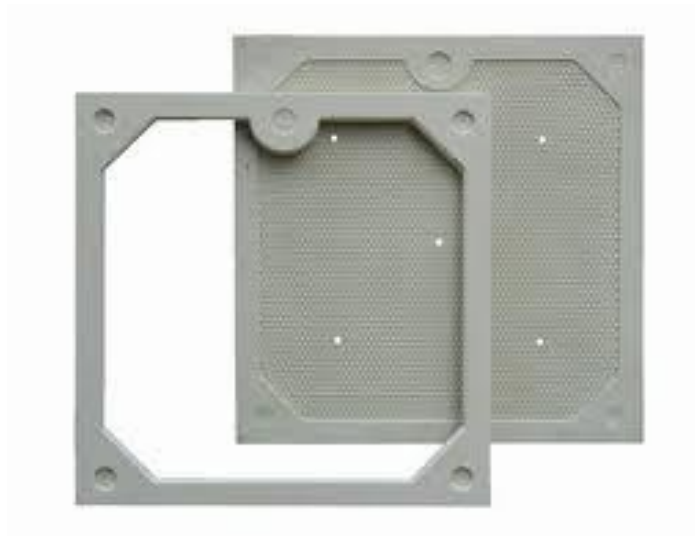
Plate and Frame Press



FILTER PRESS TECHNOLOGY

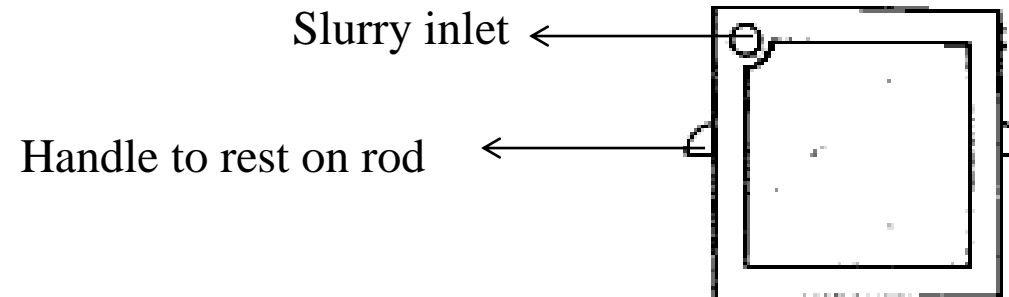


Assembly of plate and frame filter



Construction

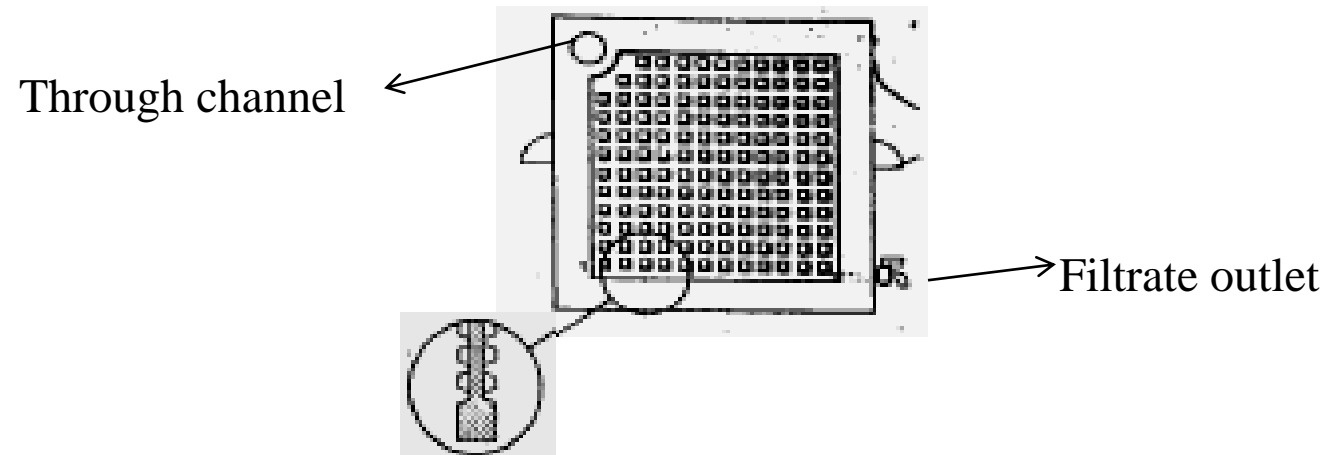
- Filter press is made of two types of units, **plate and frames**.
- Usually made of aluminium alloy.
- **Frame**
 - It contains an open space inside wherein the slurry reservoir is maintained for filtration and an inlet to receive the slurry.
 - It is indicated by **two dots** in description.
- Frames of different thickness are available.
- It is selected based on the thickness of cake formed during filtration.
- Optimum thickness of frame should be chosen.



Continue....

Plate

- The plate has a studded or grooved surface to support the filter cloth and an outlet.
- It is indicated by **one dot** in description.



Continue....

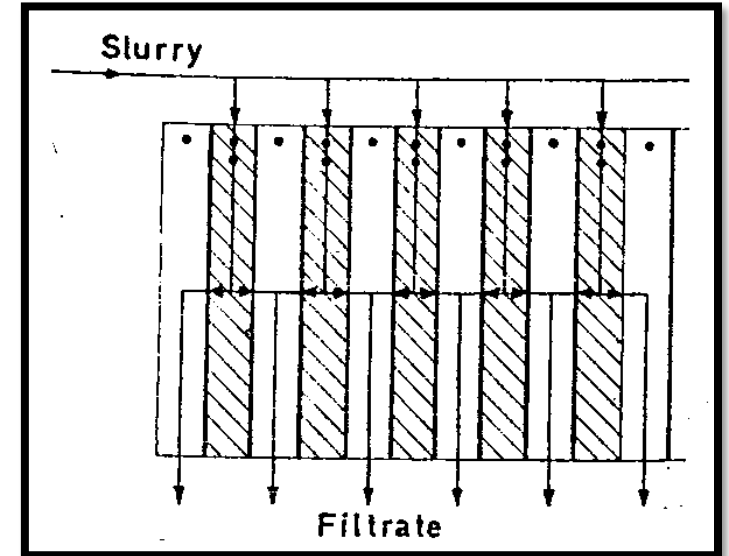
- Plate supports the filter medium, receiving the filtrate and outlet.
- The filter medium usually cloth is interposed between plate and frame.
- **Plate, filter medium, frame, filter medium and plate** are arranged in sequence and clamed to a supporting structure.
- A number of plates and frames are employed so that the filtration area is as large as necessary.
- Number of filtration units are operated in parallel.
- Channels for slurry inlet and filtrate outlet can be arranged by fitting eyes to the plates and frames, these join together to form a channel.
- In some types only one inlet channel is formed, while each plate is having individual outlets controlled by valves.

Working

Working can be divided into two steps

1. Filtration operation
2. Washing of cake (if desirable)

Frame- marked by 2 dots
Plate – marked by 1 dot



Filtration operation.....

Slurry enters the frame from the feed channel and passes through the filter medium on the surface of the plate

The solid forms a filter cake and remain in the frame

The thickness of the cake is half of the frame thickness, because on each side of frame filtration occurs

Thus, two filter cakes are formed, which meet eventually in the centre of the frame

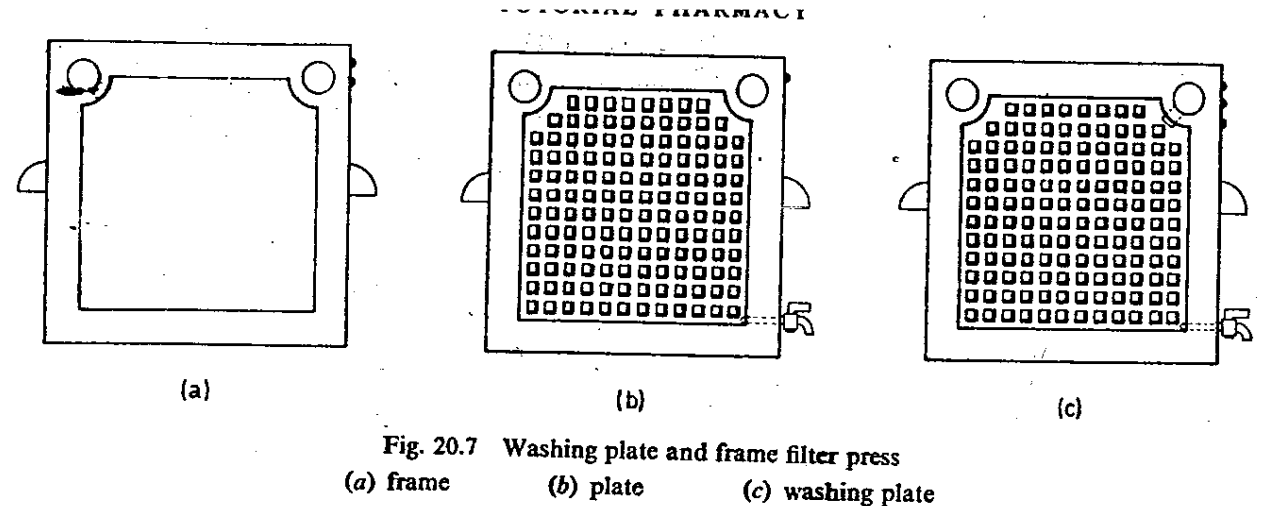
The filtrate drains between the projections of the surface of the plate and escape from the outlet

As filtration proceeds, the resistance of the cake increases and filtration rate decrease

At a certain point process is stopped and press is emptied, and cycle is restarted

Washing operation

- When washing of cake is also required modified plate and frame filter is used.
- For this purpose, an additional channel is included called as washing plate and are identified by **3 dots**.
- In the half of the washing plate, there is a connection from wash water channel to the surface of plate.
- The sequence of arrangement of plates and frames can be represented by dots as **1.2.3.2.1.2.3.2.1** so on (between 1 and 1, 2.3.2 must be arranged.)



Procedure for washing the press

Step 1

- Filtration proceeds in the ordinary way until the frames are filled with cake.

Step 2

- To wash the filter cake, the outlets of washing plates are closed.

Step 3

- Wash water is pumped in the washing channel.
- The water enters through the inlets on the surface of washing plate.

Step 4

- Water passes through the filter cloth and enters frame which contains the cake.
- Then water washes the cake, passes through the filter cloth and enters the plate down the surface.

Step 5

- Finally washed water escapes through the outlet of that plate.

Diagrammatic procedure

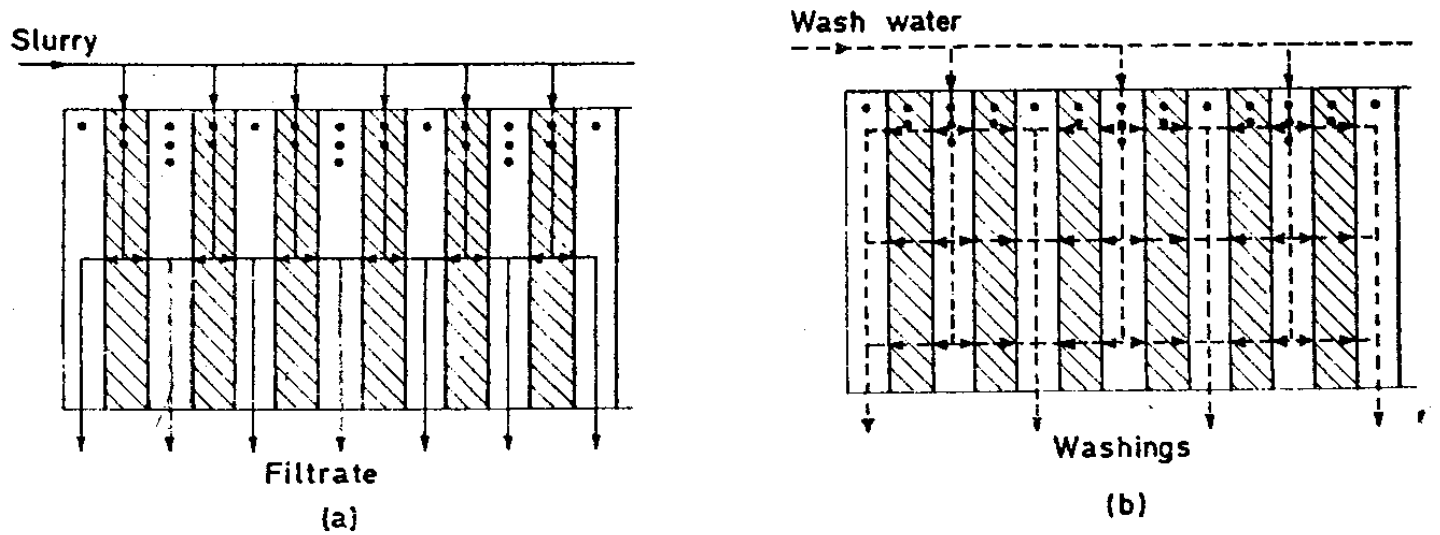


Fig. 20.6 Washing plate and frame filter press: principles of operation
(a) filtering (b) washing

Things to be noted

Water – wash is efficient only if the frames are full with filter cake.

If the solid do not fill the frame completely, the wash water causes the cake to break (on the washing plate side of the frame), then washing will be less effective.

Hence, it is essential to allow the frames to become filled with washing cake.

This helps not only in emptying the frames but also helps in washing the cake correctly.

Special provisions and Uses

Special provisions:

1. Any possible contamination can be observed by passing the filtrate through a glass tube or sight glass from the outlet on each plate.
 - This permits the inspection of quality of filtrate. The filtrate goes through the control valves to an outlet channel.
2. The filtration process from each plate can be seen.
 - In the event of broken cloth, the faulty plate can be isolated and filtration can be continued with one plate less.

Uses:

- Sterile filtrate can be obtained by using asbestos and cellulose filter sheet (for this, whole filter press and filter medium have been sterilized previously).
- Filtration of viscous liquid can also be done by incorporating heating/cooling coils in the press.

Advantages

- Construction of filter press is very simple and a variety of materials can be used.
 - I. Cast iron – for handling common substances.
 - II. Bronze - for smaller units.
 - III. Stainless steel – contamination can be avoided.
 - IV. Hard rubber and plastic- used where metals must be avoided.
 - V. Wood- for lightness though it must be kept wet.
- Provide large filtration area in relatively small floor space. The capacity being variable according to thickness of frames and number used.
- Sturdy construction permits the use of considerable pressure difference. (2000 Kilopascals normally used)
- Efficient washing of cake is possible.
- Operation and maintenance is easy.
- It produce dry cake in form of slab.

Disadvantages

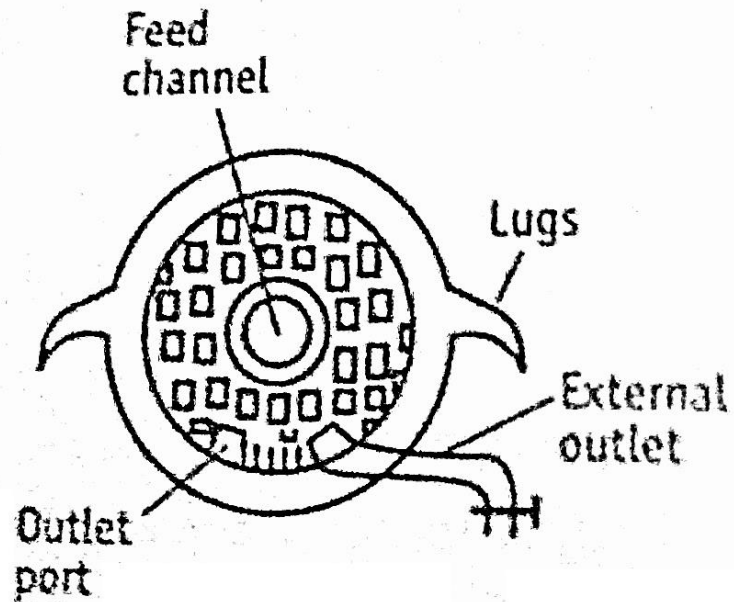
- It is a batch filter, so it is a time consuming.
- The filter press is an expensive filter, the emptying time, the labour involved, and the wear and tear on the cloths resulting in high costs.
- Operation is critical, as the frames should be full, otherwise washing is inefficient and the cake is difficult to remove.
- The filter press is used for slurries containing less about 5 % solids
- In view of the high labour costs , it is most suitable for expensive materials e.g. the removal of precipitated proteins from insulin liquors.

Chamber press

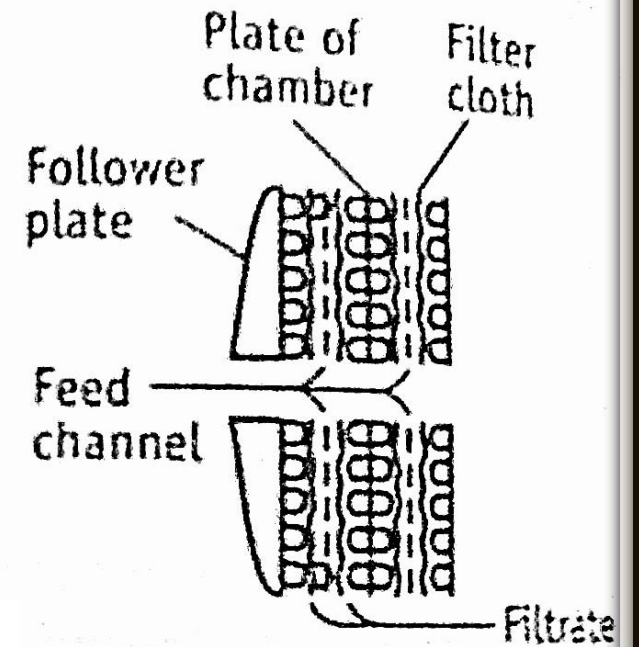
Principle

- Mechanism is surface filtration.
- The slurry enters the frame by pressure and flows through the filter cloth.
- The filtrate is collected on the plates and send to the outlet.
- A number of head plates are used, so that the surface area can be increases and consequently large volumes of slurry can be processed simultaneously.

Diagram



(a) Cast iron plate of chamber press.



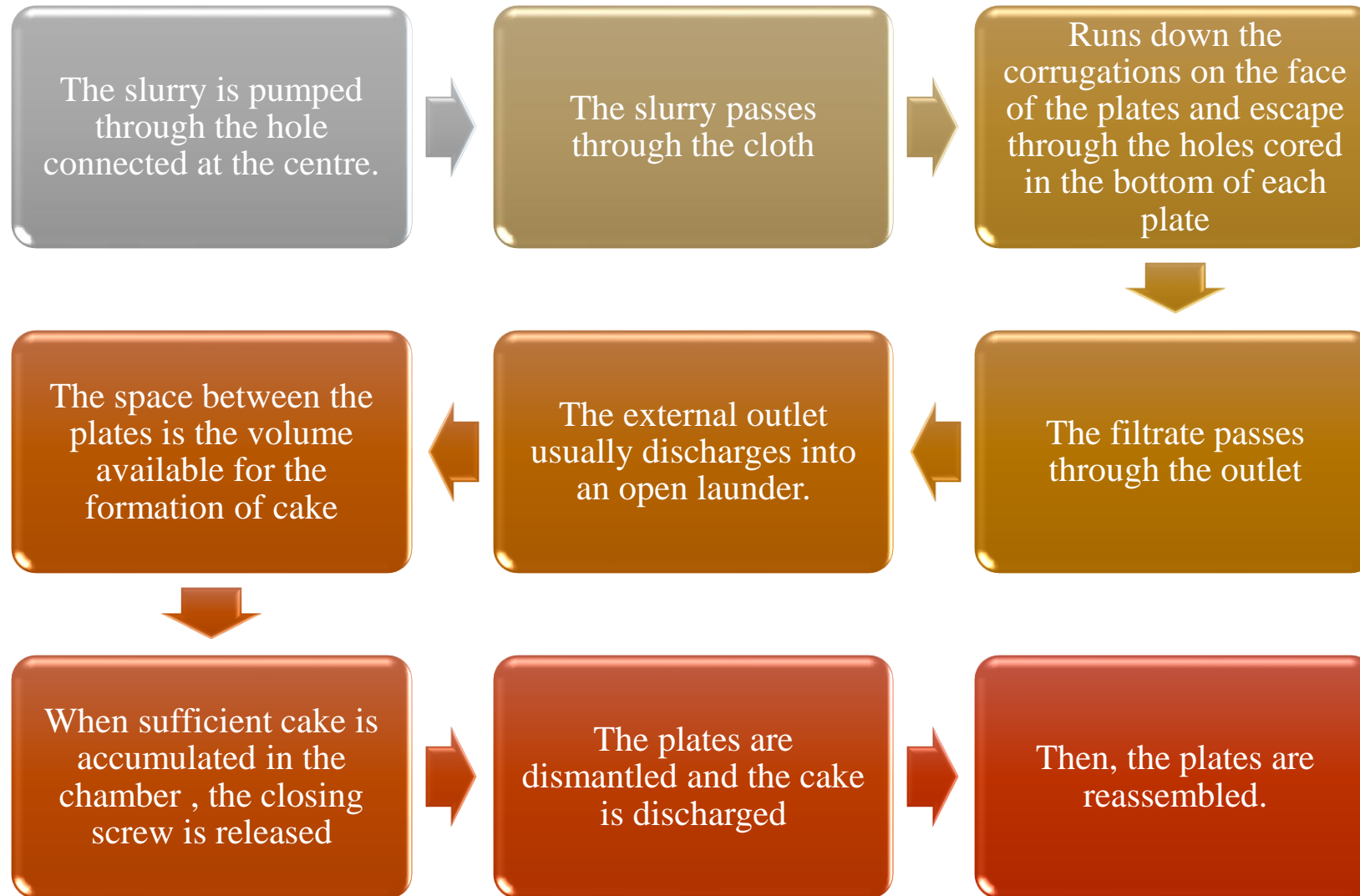
(b) Principle of filtration

Chamber filter.

Construction

- It consist of heavy fixed head plate made of cast iron and mounted on suitable frame.
- Extending from the head plate, two horizontal bars support on both ends.
- The bar supports the plate by lugs.
- At the center of the each plate, a hole is provided for introducing the feed.
- The holes of the all plate are connected on the head of the press.
- Over each press plate, a sheet of filter cloth with a hole cut in the centre and is placed.
- The filter cloth is fastened by means of rings called grommets and either screwed together or locked.
- These draw down the cloth, so that it is shaped round the plate.
- All such plates are arranged and a heavy follower plate is placed behind and tighten.
- The cloth serves as a gasket between the adjacent plates.

Working



Uses, advantages and disadvantages

Uses:

used for clarification of syrups and filtrating of injection solutions.

Advantages:

Provide large filtering area in relatively small floor space.

A number of head plates can be increased or decreased as per need.

Operation and maintenance are straight forward (no moving part).

Filter cloths are easily renewable.

Disadvantages:

Not adaptable for washing of cake.

The wear of cloth is severe.

The filtrate is usually not clear.

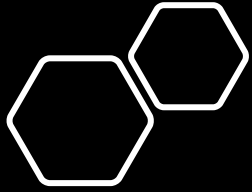
Filter leaf

Principle:

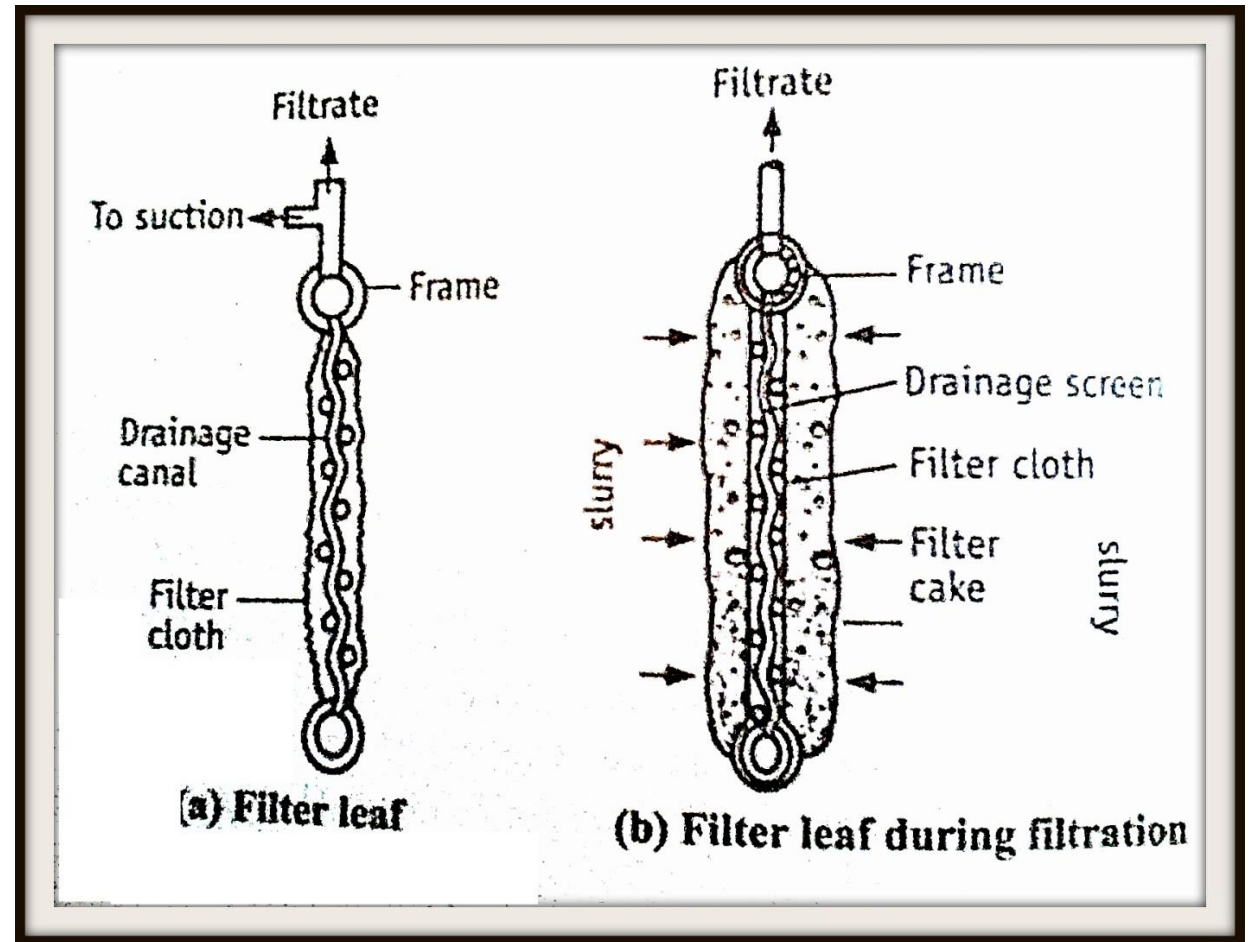
- It is an apparatus consisting of a longitudinal drainage screen covered with a filter cloth.
- The mechanism is surface filtration and acts as sieve or strainer.
- Vacuum or pressure can be applied to increase the rate of filtration.

Construction:

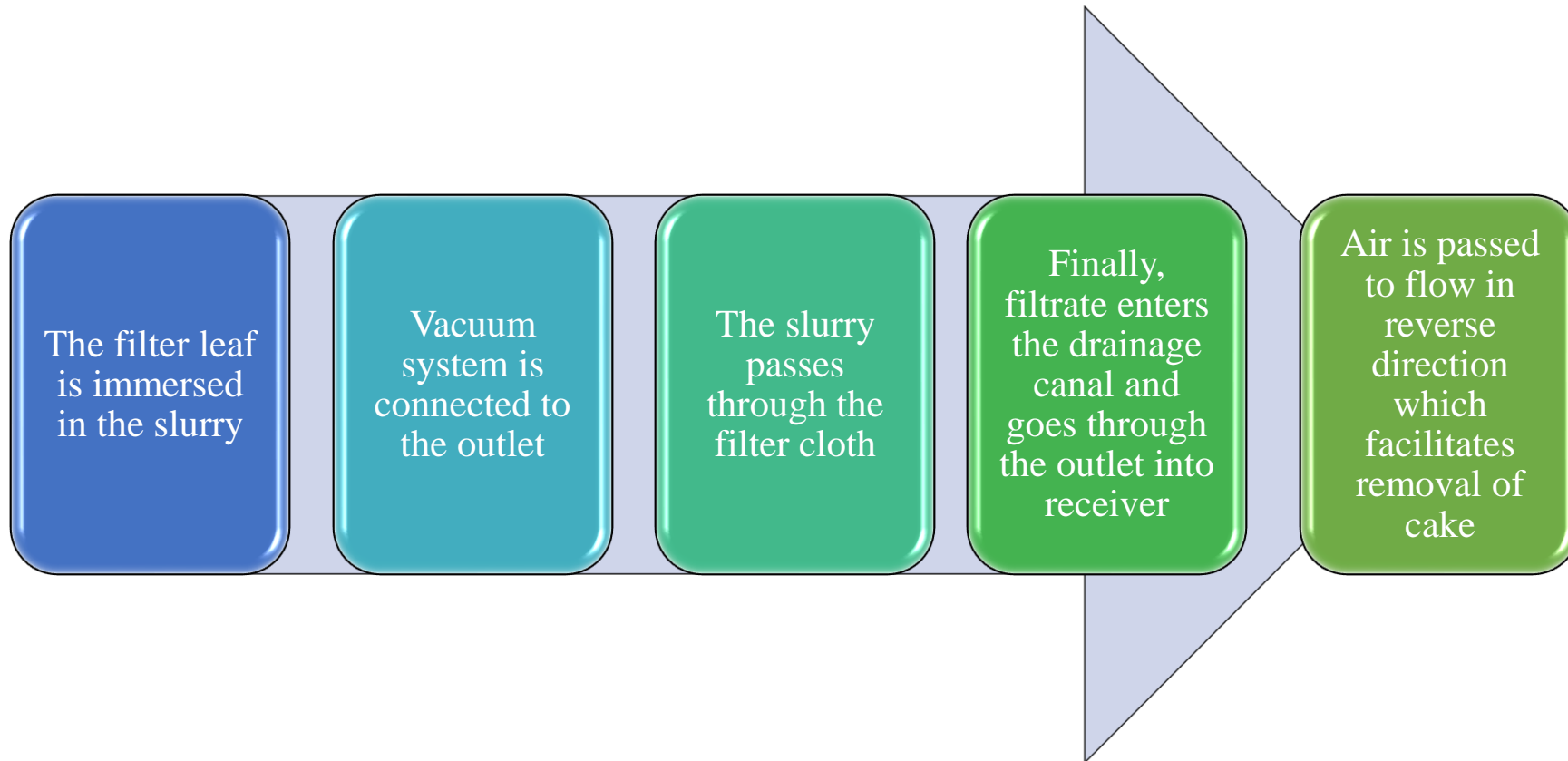
- The leaf filter is consisting of a frame enclosing a drainage screen or grooved plate.
- The frame may be any shape circular, square or rectangular.
- The whole unit being covered with filter cloth.
- The outlet for the filtrate connects to the inside of the frame through suction.



Diagram



Working and uses



- Use for the filtration of slurry which do not contain high solid content, about 5%, i.e. dilute suspensions.

Advantages

Simplest form of filter used for batch process.

A number of units can be connected in parallel to increase the surface area of filtration.

Pressure difference can be obtained either with vacuum or using pressure up to the order of 800 kilopascals.

Labour costs for operating the filter leaf are fairly moderate.

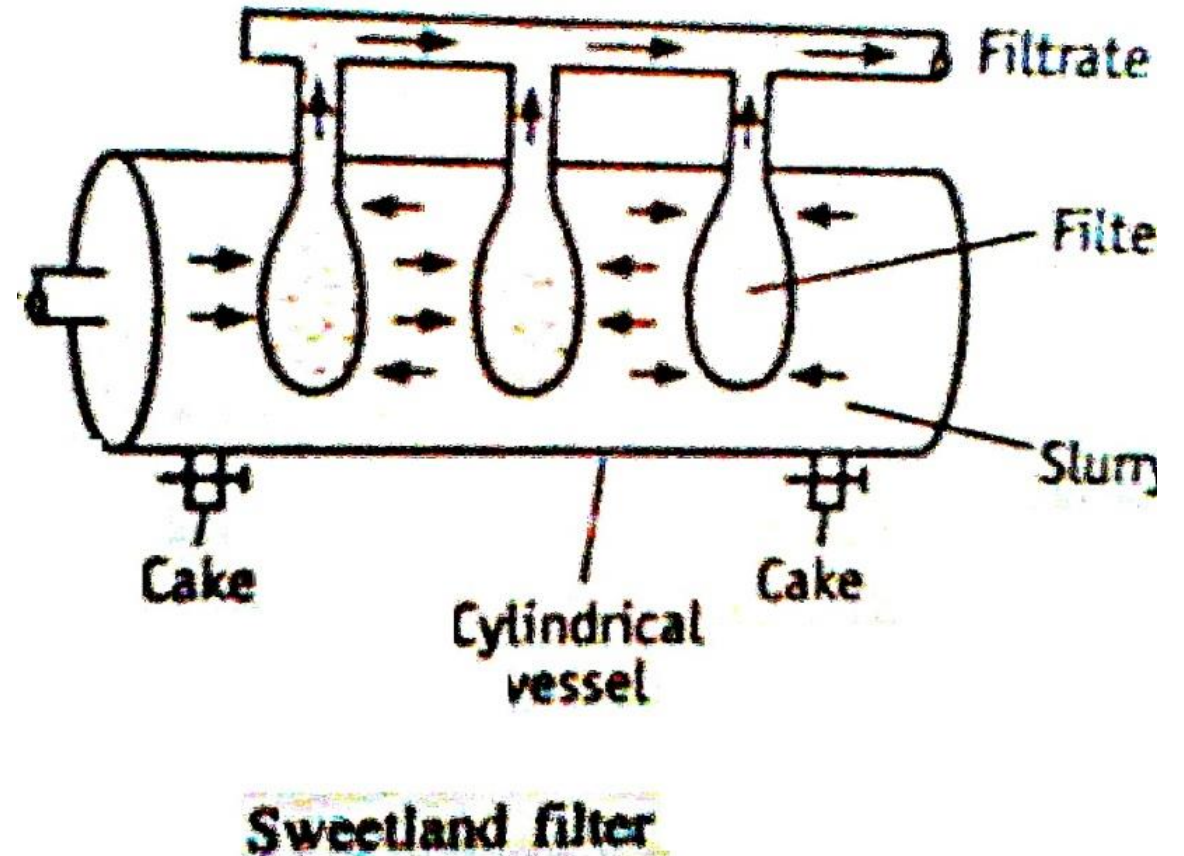
The efficiency of washing is high.

The slurry can be filtered from any vessel.

The cake can be washed simply by immersing the filter in a vessel of Water.

Sweetland filter (variant of filter leaf)

- An alternative method is to enclose the filter leaf in a special vessel into which the slurry is pumped under pressure.
- **A number of leaves are connected** to a common outlet, to provide a large area for filtration.



Metafilter

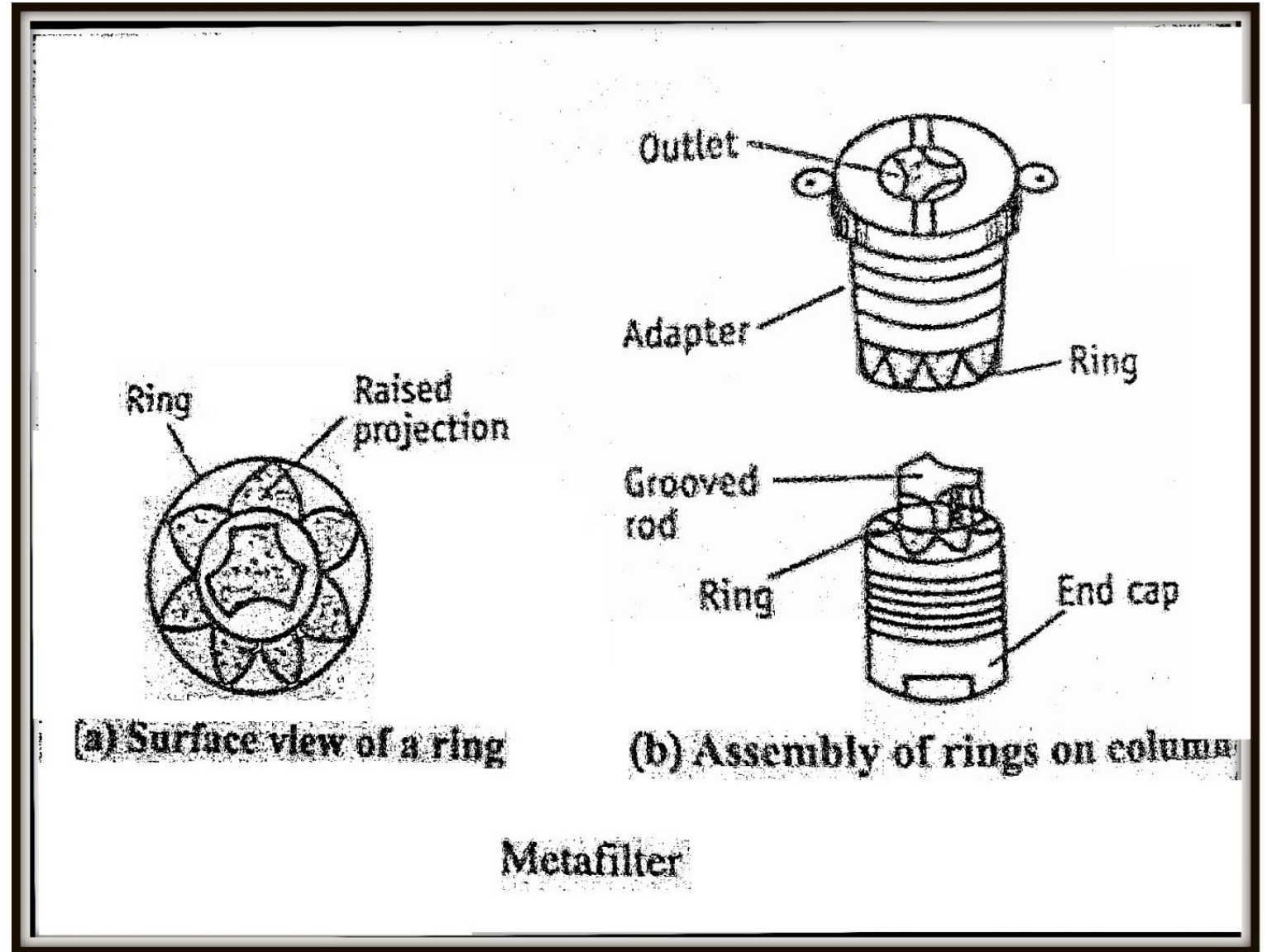
Principle:

- Mechanism is surface filtration.
- In this, 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 receiver from the top.

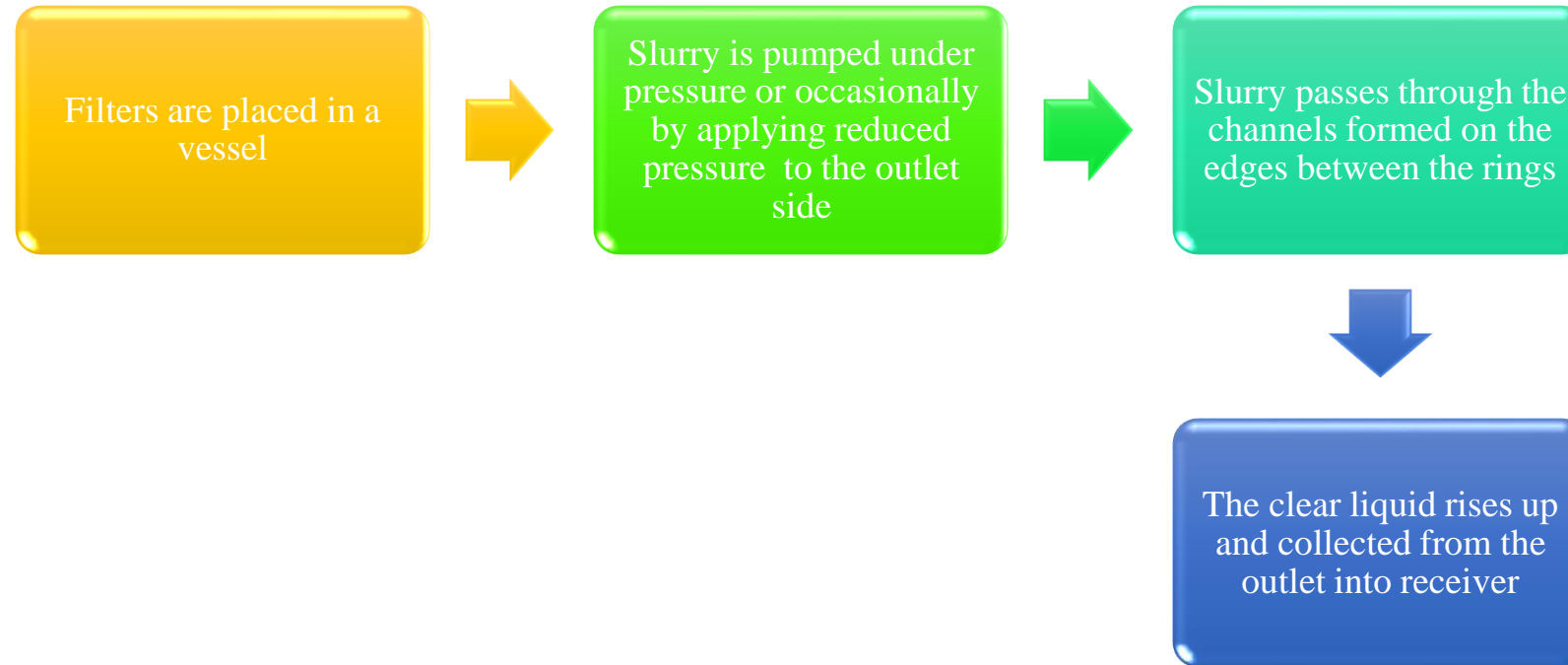
Construction

- 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 up of stainless steel and have dimensions of about 15.0 mm internal diameter and 22.0 mm external diameter.
- **Each metal ring** has a number of semicircular projections (0.8 mm in thickness) on one side of surface.
- The projections are arranged as a nest to form channels on the edges.
- These rings are tightened on the drainage column with a nut.
- Metafilters are also known as edge filters.

Diagram

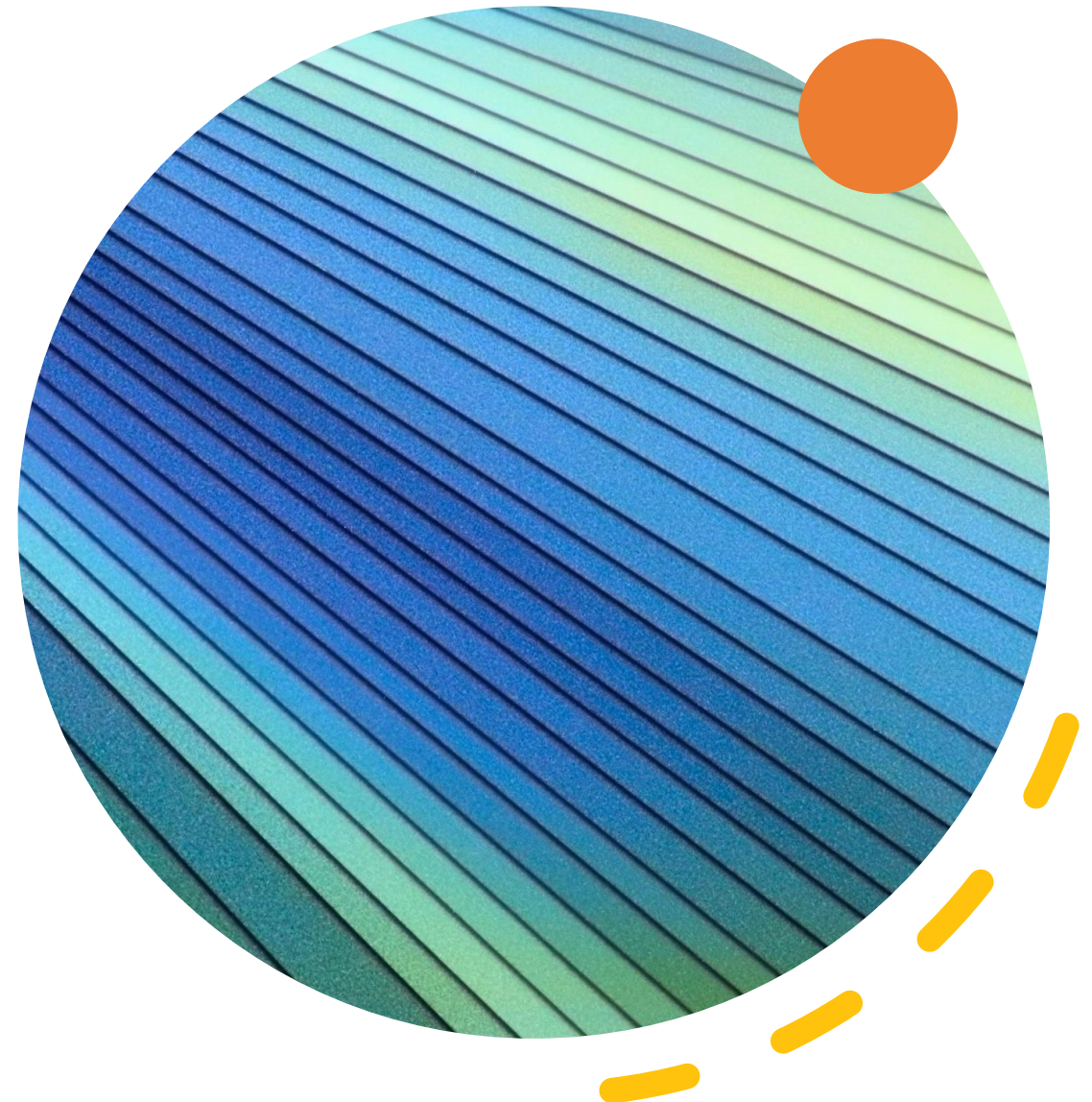
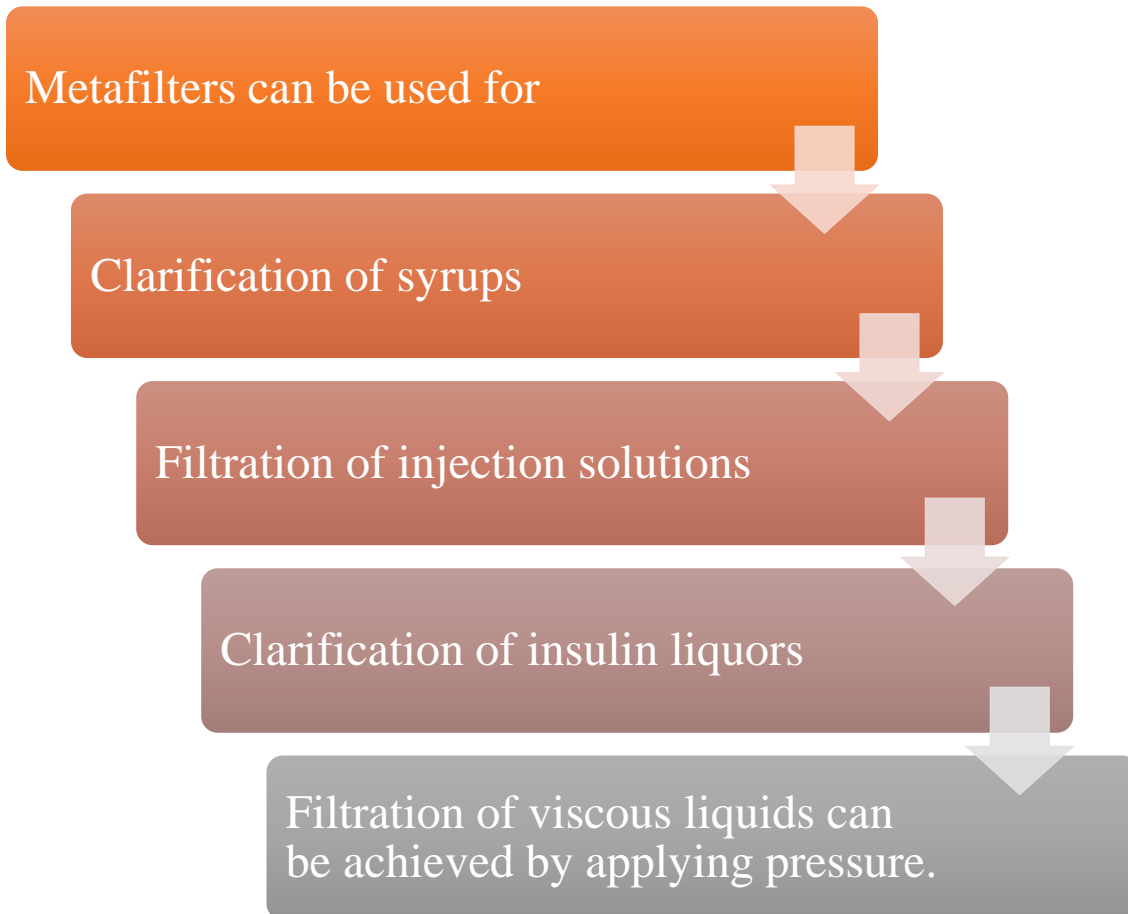


Working



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

Uses



Advantages

Can be used under high pressures, without any danger of bursting the filter medium.

Running cost are low, as separate filter medium is not used.

Can be constructed from a material that can provide excellent resistance to corrosion and avoid contamination of sensitive products.

It is extremely versatile filter because fine as well as large both type of particles can be separated.

Removal of cake can be carried out by simply back- flushing with water.

Change over from one batch to another or one product to another is easy.

Sterile products can be handled.

Cartridge filter

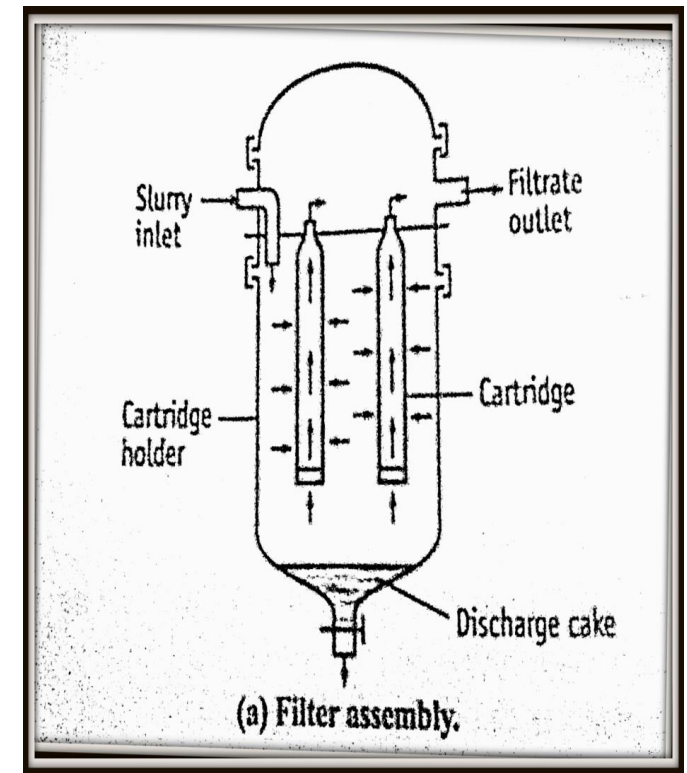
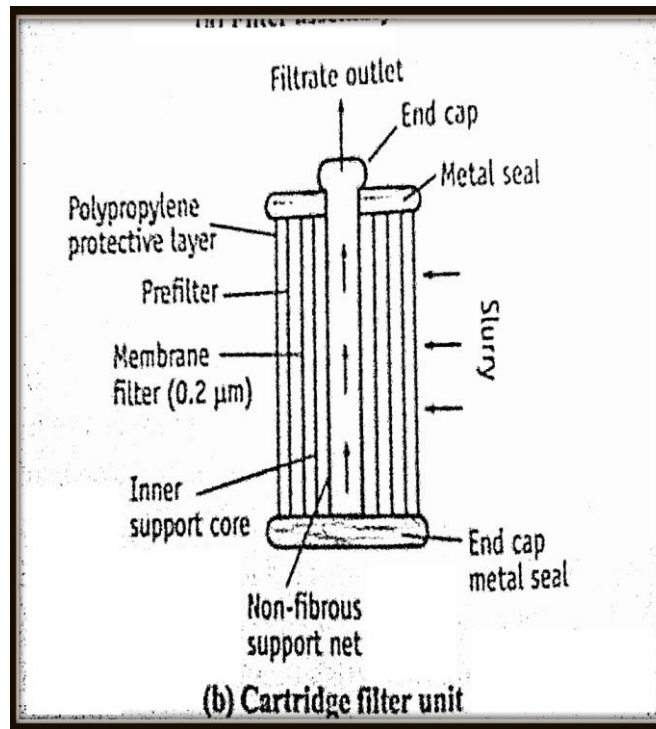
Principle:

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

Construction:

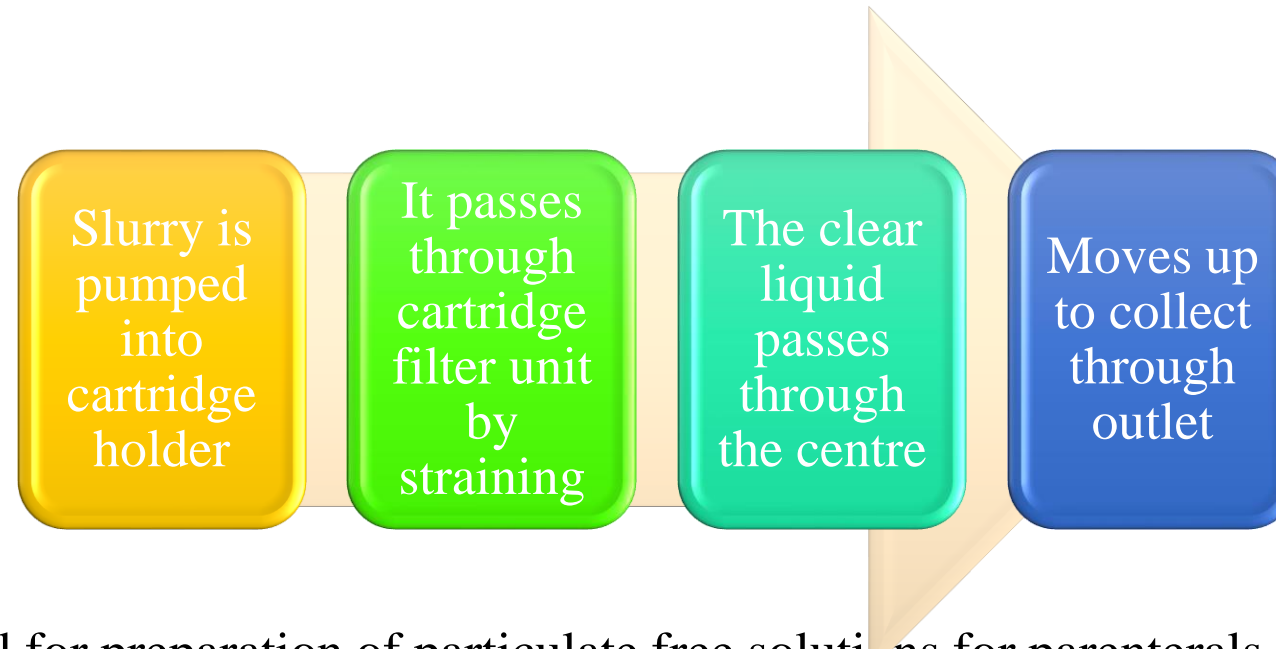
- It has cylindrical configuration made with disposable or changeable filter media.
- Made up of either plastic or metal.
- Consist of two membrane filters (sieve like) made of polypropylene: pre filter and actual filter for filtration.
- A protective layer surrounds them.
- The cartridge are housed in a holder and a number of cartridges can be placed in a same housing.
- The housing is closed with the lid.
- Housing has provisions for slurry inlet and outlets.

Diagram



Working and uses

Working:



Uses:

- Particularly useful for preparation of particulate free solutions for parenterals and ophthalmic uses.
- This filter holder will process 1000 – 15000 litres of sterile solution per hour.

Advantages and Disadvantages

Advantages:

- Autoclaving can be done for sterile operations due to stainless steel construction.
- Cartridge with self cleaning devices are advantageous.
- Rapid disassembling as well as reusing of filter medium is possible.
- Cartridge are not brittle, when they are dry.
- Used as in-line continuous filtration, which reduces handling of solutions. It minimize chances of contaminations.

Disadvantages:

- A number of manufactures provide the components, which are generally not interchangeable between suppliers.
- Cost of disposable elements offsets the labour saving in terms of assembly and cleaning of cartridge clarifiers.

Rotary drum filter

Principle:

- Slurry filtered through sieve like mechanism on the rotation drum surface, under the condition of vacuum.
- In addition compression, drying (using hot air), and removing the filter cake (using knife) are possible.

Construction:

- It consist of a metal cylinder mounted horizontally.
- The drum may be up to 3 meters in diameter and 3.5 meters in length and gives surface area of 20 meter square.
- The curved surface being a perforated plate, supporting a filter cloth.
- Internally, it is divided into several sectors and a separate connection is made between each sector and a special rotary valve.

Diagram

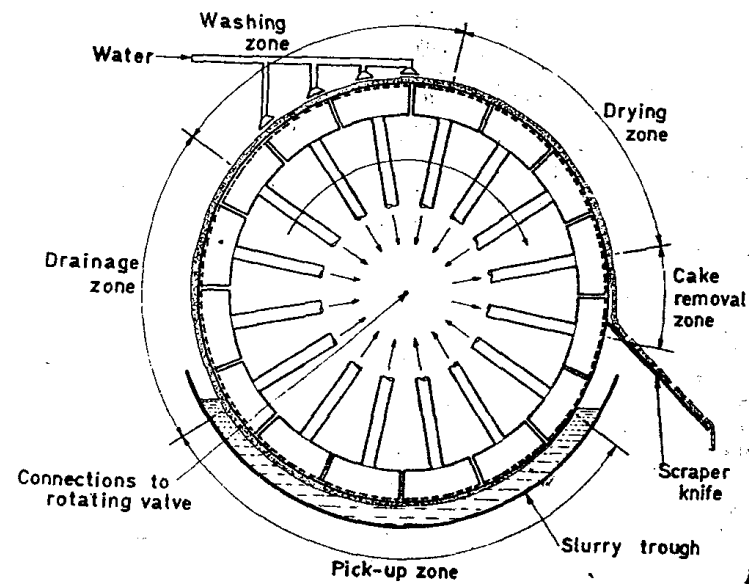
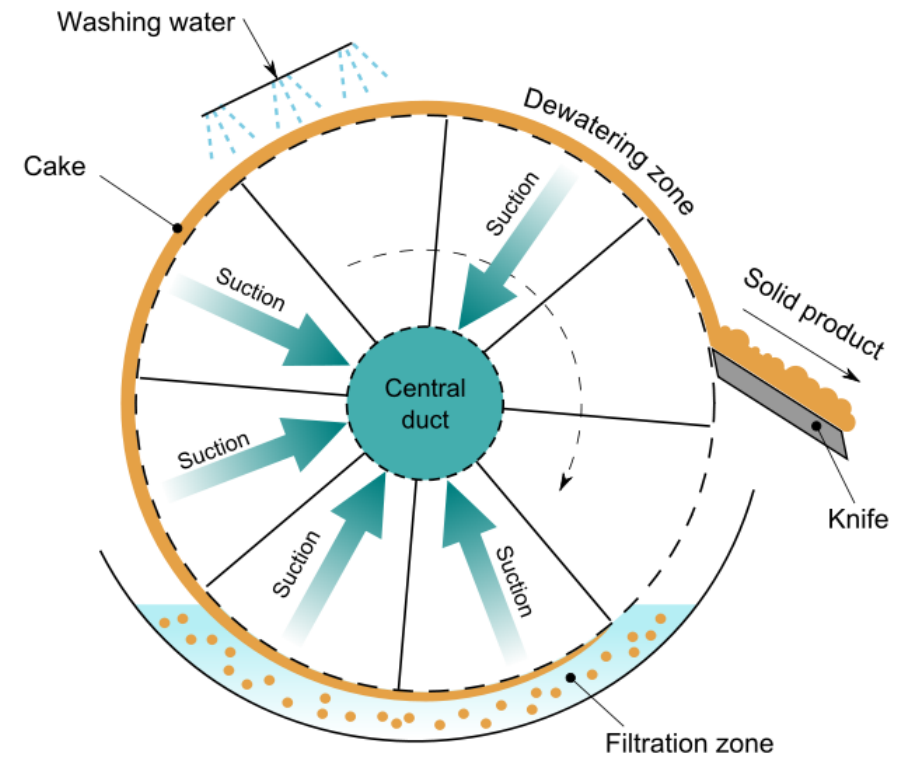


Fig. 20.8 Rotary drum filter



Working

- The drum is dipped into the slurry and vacuum applied to the outlet, which is connected to the filtrate receiver.
- When the cake has formed, the cake drained or partially dried by vacuum.
- The drum is sprayed with water to wash the cake.
- Retaining the vacuum connection drains the cake and produces partial dryness then, removed by a doctor knife.
- When the solids of the slurry are too much that the filter cloth becomes blocked with the particles, a pre-coat filter may be used.
- A pre-coat of filter aid is deposited on the drum prior to the filtration process.

Uses

- The rotary filter for continuous operation on large quantities of slurry.
- Suitable for slurry contains considerable amounts of solids in the range 15-30%.
- Examples of pharmaceutical application include
 - the collection of calcium carbonate, magnesium carbonate, and starch.
 - The separation of the mycelium from the fermentation liquor in the manufacture of antibiotics.

Advantages

The rotary filter is automatic and is continuous in operation, so that the labour costs are very low.

The filter has a large capacity , so it is suitable for the filtration of highly concentrated solutions.

Variation of the speed of rotation enables the cake thickness to be controlled.

Pre-coat of filter aid could used to accelerate the filtration rate.

Filter has large surface area.

Disadvantages

The rotary filter is a complex piece of equipment , with many moving parts and is very expensive,.

In addition to the filter itself, some accessories are connected ,e.g., a vacuum pump, vacuum receivers , slurry pumps and agitators are required .

The cake tends to crack due to the air drawn through by the vacuum system, so that washing and drying are not efficient.

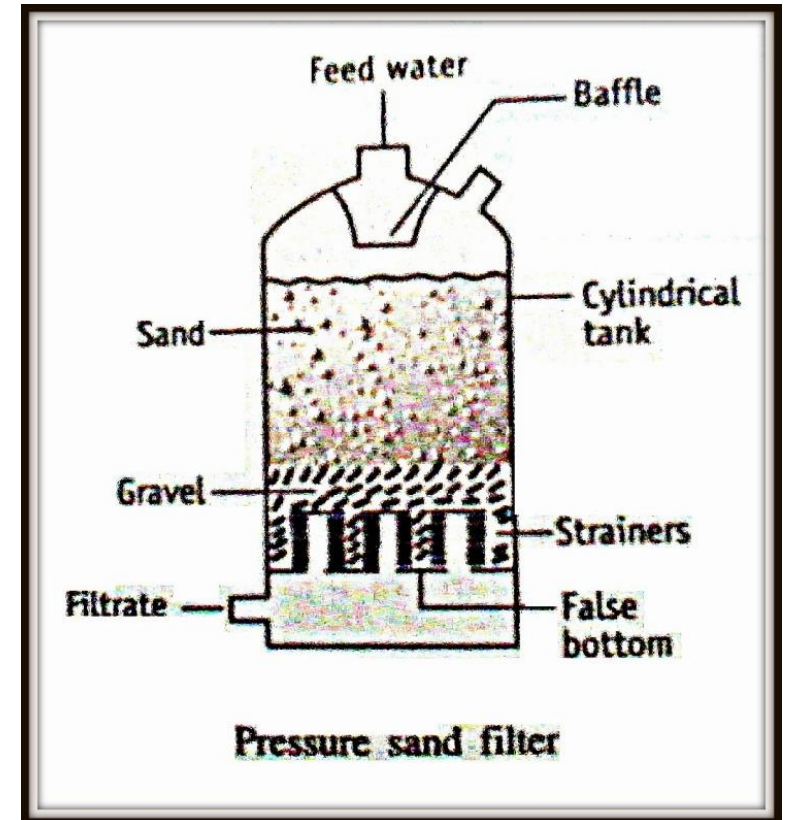
Being a vacuum filter, the pressure difference is limited to 1 bar and hot filtrates may boil.

It is suitable only for straight- forward slurries

Pressure and sand filter

Principle:

- Depth filtration
- Mechanism is impingement and entanglement of solids on account of low pressure differential.
- The slurry enters the sand bed and the clear liquid is collected from the bottom outlet.



Construction

It is a closed system and consists of cylindrical tank with a bottom containing a number of brass strainers.

These are mounted on false bottom or connected to a modified embedded in concrete.

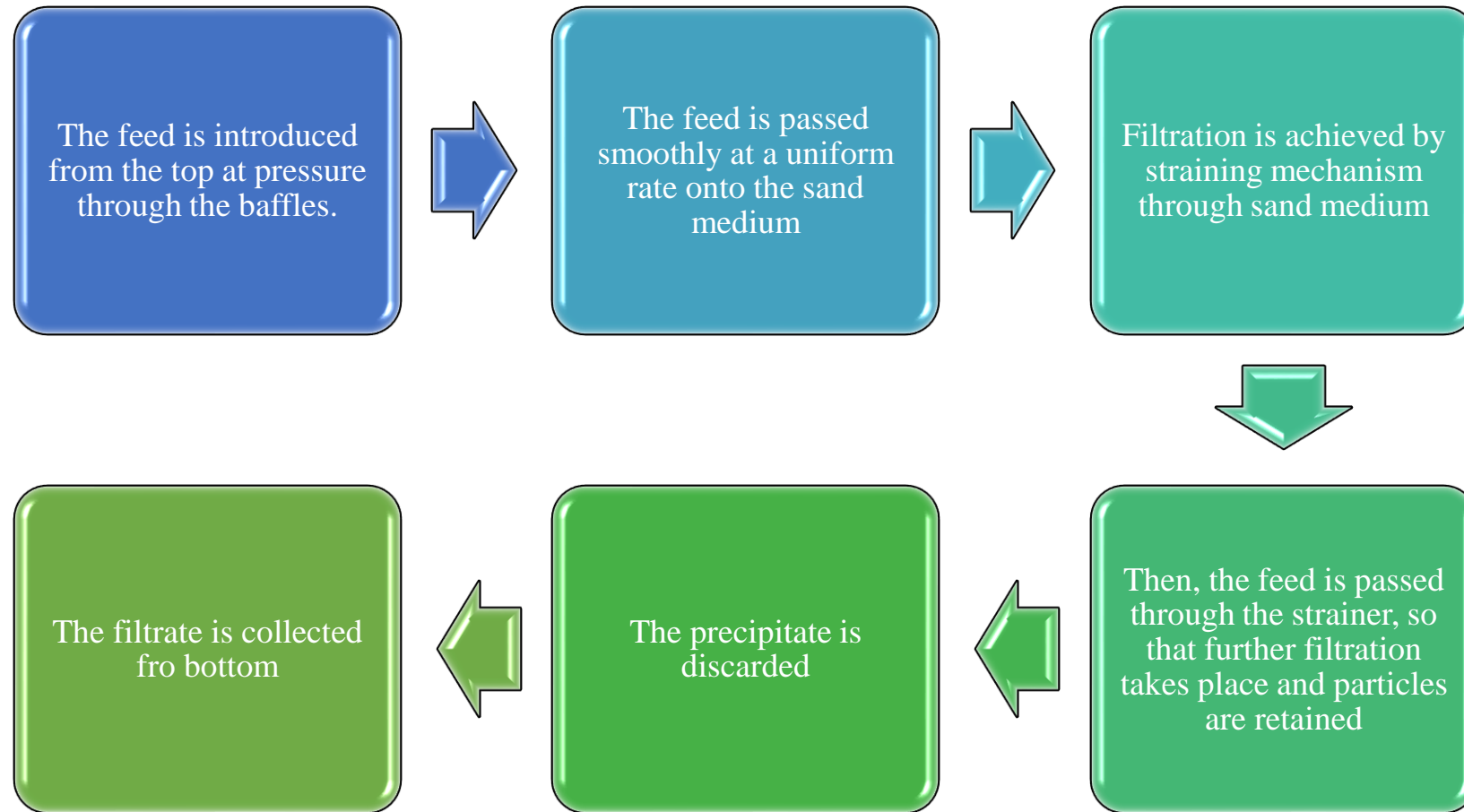
The strainers have narrow slots sawed in them.

Above this 6-12 m depth sand layer is placed, which acts as a filter medium.

Baffles are arranged at the point of feed inlet, in order to prevent the disturbance of sand by direct stream.

Provisions is made at the bottom for collecting the filtrate.

Working



Continue.....

When the precipitate clogs the sand (indicated by reduced filtration rate), back washing permits the regeneration of the filter bed.

During this operation, water moves up through the sand bed and moves out from the inlet.

Uses:

Used for filtration of boiler feed or water for similar purposes.

Mainly used when solids are little and large volume of feed is to be handled.

They are applicable only to the separation of precipitates that can be removed from the sand.

Disadvantages

Feed containing precipitates that are gelatinous or form a coat on sand can't be filtered through the sand, because back washing does not permit regeneration.

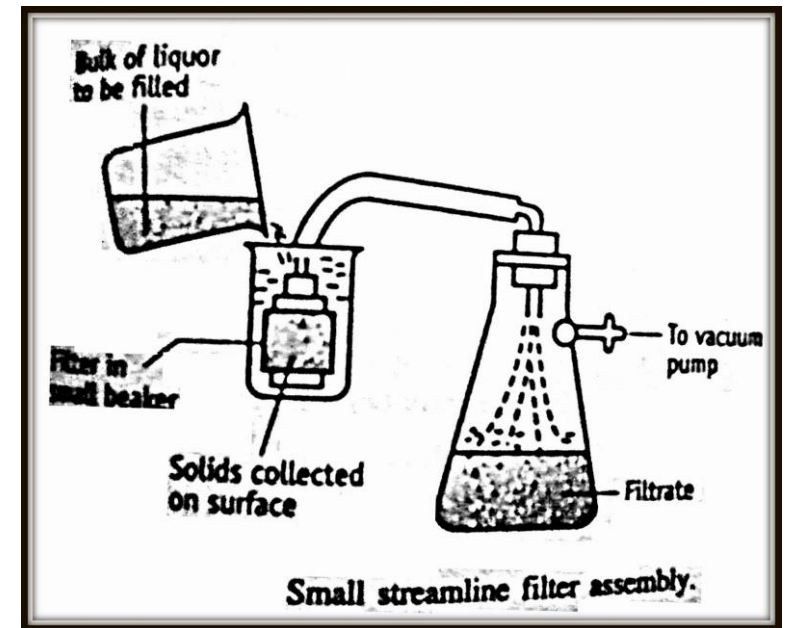
Feed containing finely divided solids can't be separate by this.

Can't remove bacteria. In such cases, coagulants such as ferrous sulphate, are added to feed before filtration.

Streamline filter

Principle:

- It consists of column of filter elements held tightly together, so that the slurry enters from the side of the column and passes through vary narrow channels between the elements.
- The filters employ paper discs.
- The filter act as a strainer to retain solids.



Assembly

It consists of specially treated filter paper discs arranged in the form of a compressed pack on an upright rod or spigot.

In assembling the filter, the two parts of the filter can be unscrewed.

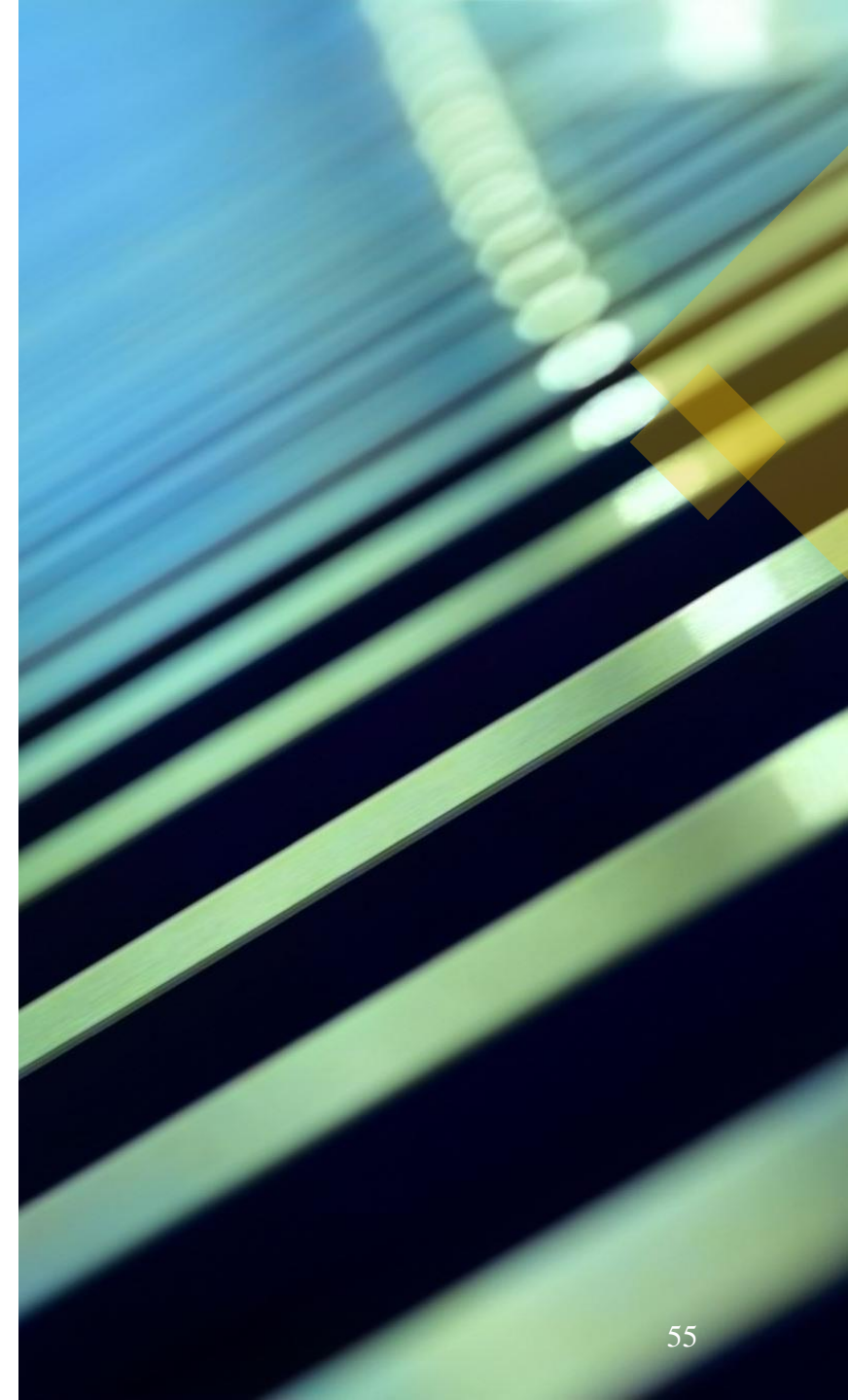
The required quantity of rings are placed on the spigot portion and two parts are then screwed together to give a compact stack of filter elements.

The extent of compression on the disc may be varied depending on the size of particles to be removed.

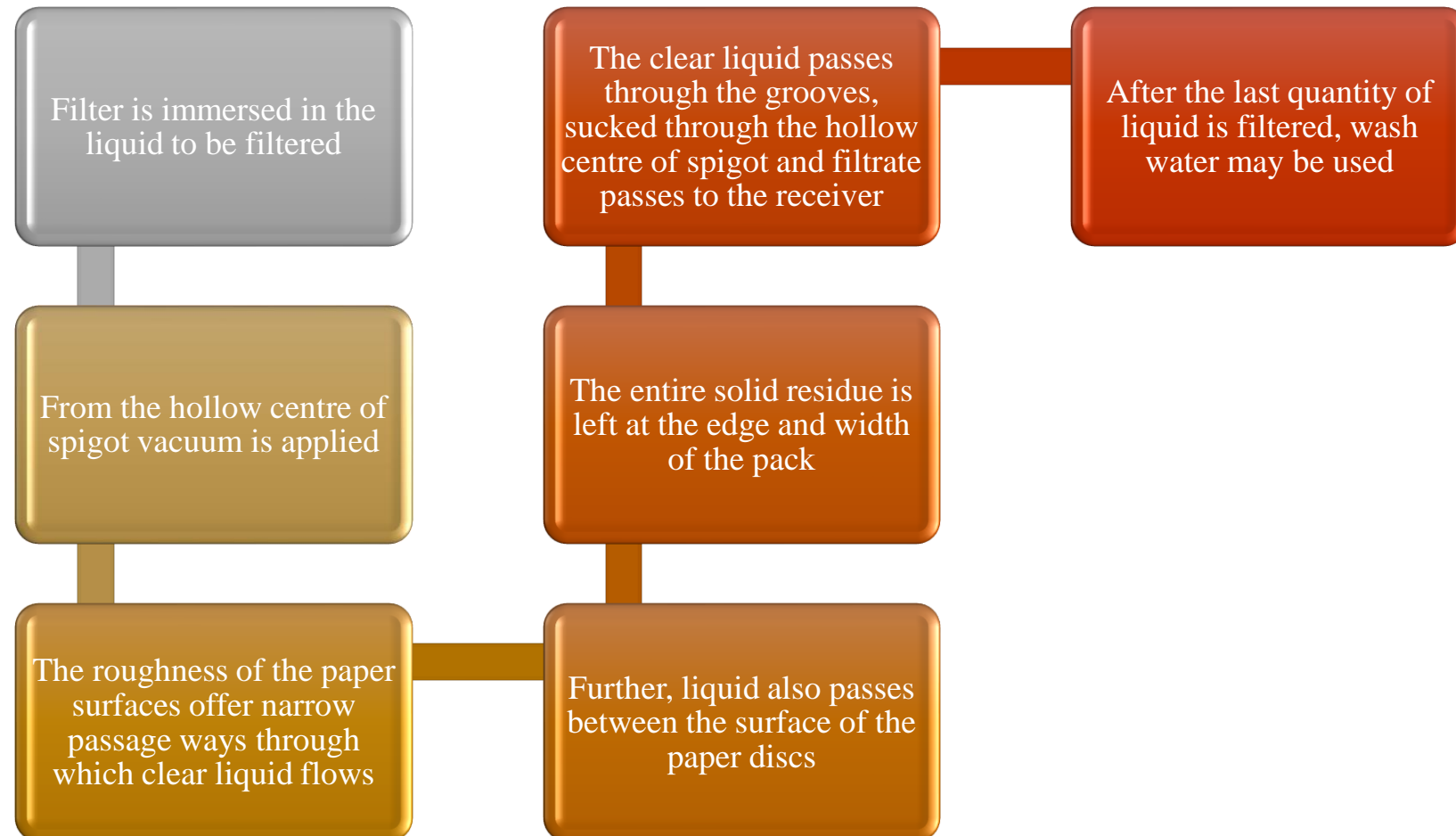
For small scale filtration, ebonite material made spigots are used.

The spigot is hollow and grooves run down the length.

From hollow centre of the spigot, vacuum is applied.



Working



Continue....

- Cleaning of streamline filter is attempted by connecting the spigot to the water tap.
- The water is passed in opposite direction.
- The residue is washed away from the edges of the stack.
- If solid residue is required, air may be blown, so that solid is peeled of, which may be collected.



Uses and Advantages

Uses:

- It removes suspended matter, trace of fines and even submicron size colloidal matter from large volumes of the slurry.
- The two parts of spigots are screwed tightly and fine precipitates can be separated for achieving high grade polishing.
- Oily, aqueous and alcoholic solutions which do not soften the fibre of the pack can also be filtered.
- Heat resistant porcelain filters are used for strongly acidic or hot strong alkaline solutions.

Advantages:

- Instead of vacuum, pressure may be applied.
- In this case, the container (in which assembly is immersed) must be sealed and should be able to withstand applied pressure.