

The logo of Galgotias University is a circular emblem with a stylized 'G' shape in the center. The 'G' is composed of several curved, overlapping bands in shades of yellow, orange, and blue. The background of the emblem is a light, textured grey.

TOPIC: FILTRATION

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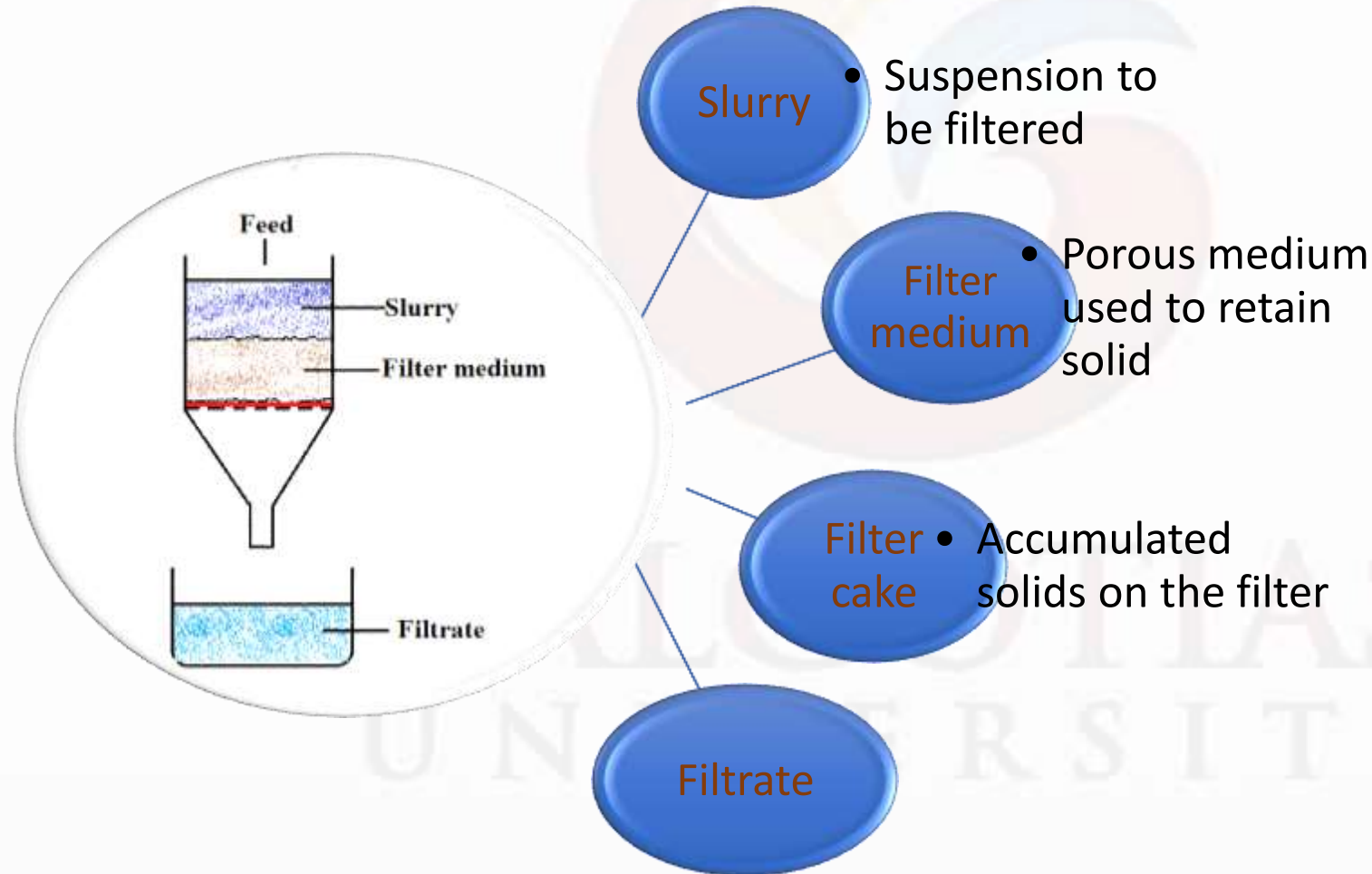


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Course Code : BPHT3004

Course Name: Pharmaceutical Engineering

Filtration: It may be define as a process of separation of solids from a fluid by passing the same through a porous medium that retains the solids but allows the fluid to pass through.



Applications of filtration

- **Production of sterile products:**
 - HEPA filters or laminar air bench
 - Membrane filters.
- Production of bulk drugs
- Production of liquid dosage
- Effluents and waste water treatment



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Types of filtration

Surface/ screen filtration

- It is a screening action by which pores or holes of medium prevent the passage of solids.
- Mechanism involved : straining and impingement
- For this, plates with holes or woven sieves are used.
- Efficacy is defined in terms of mean or maximum pore size.

• Depth filtration

- In this slurry penetrates to a point where the diameter of solid particles is greater than that of the tortuous void or channel.
- Mechanism : Entanglement
- The solids are retained with a gradient density structure by physical restriction or by adsorption properties of medium.

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- The size of particles retained is slightly higher than the mean pore size of medium.
- Mechanical strength of filter medium is less, unless it is made of stainless steel.
- It has low capacity.
- The size of particles retained is more predictable.
- Equipment is expensive because ancillary equipment such as edge clamps is required.
- Ex. Cellulose membrane filter.

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- The size of particles retained is much smaller than the mean pore size of medium.
- Mechanical strength of filter medium is high.
- It has high capacity.
- The size of particles retained is less predictable.
- Equipment is cheaper because ancillary equipment is not required.
- Ex. Ceramic filters and sintered filters.

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Theories of filtration

The flow of liquid through a filter follows the basic rules that govern the flow of any liquid through the medium offering resistance.

The rate of flow may be expressed as-

The rate of filtration may be expressed as volume (litres) per unit time (dv/dt).

Driving force = pressure upstream – pressure downstream

Resistance is not constant.

It increases with an increase in the deposition of solids on the filter medium.

Therefore filtration is not a steady state.

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Poiseuille's Equation

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

Poiseuille's Equation is-

Where, V = rate of flow, m^3/s (l/s)

ΔP = Pressure difference across the filter, Pa

r = radius of capillary in the filter bed, m

L = thickness of filter cake (capillary length), m

η = viscosity of filtrate, Pa.s

If the cake is composed of bulky mass of particles and the liquid flows through the interstice, then flow of liquids through these may be expressed by this equation.

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Darcy's Equation

Poiseuille's law assumes that the capillaries found in the filter are highly irregular and non-uniform.

Therefore, if the length of capillary is taken as the thickness of bed, a correction factor for radius is applied so that the rate is closely approximated and simplified.

The factors influencing the rate of filtration has been incorporated into an equation by Darcy, which is:

Where, K = permeability coefficient of cake, m^2

A = surface area of porous bed (filter medium), m^2

Other terms are same as previous equation

K depends on characteristics of cake, such as porosity, specific surface area and compressibility.

Filter Media

The surface upon which solids are deposited in a filter is called the “Filter medium”

Properties of ideal filter medium:

It should-

- 1) be capable of delivering a clear filtrate at a suitable production rate.
- 2) have sufficient mechanical strength.
- 3) be inert.
- 4) retain the solids without plugging at the start of filtration.
- 5) Not absorb dissolve material.
- 6) Sterile filtration imposes a special requirement since the pore size must not exceed the dimension of bacteria or spores.

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Filter Aids

The objective of filter aid is to prevent the medium from becoming blocked and to form an open, porous cake, hence, reducing the resistance to flow of the filtrate.

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

Characteristics of filter aids:

Chemically inert and free from impurities.

Low specific gravity, so remain suspended in liquids.

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

Recoverable.

Disadvantages:

Remove the coloured substances by absorbing them.

Sometimes active principles such as alkaloids are absorbed on filter aid.

Rarely, filters are source of contamination such as soluble iron salts, which can provoke degradation of sensitive ingredient.

Filter aids may be used in either or both two ways:

- 1) Pre- coating technique: by forming a pre-coat over the filter medium by filtering a suspension of the filter aid .
- 2) Body- mix technique: A small proportion of the filter aid (0.1-0.5 %) is added to the slurry to be filtered. This slurry is recirculated through the filter until a clear filtrate is obtained, filtration then proceeds to completion.

Different flow rates can be achieved depending on grade of aid-

1. Low flow rate: fine grade filter aids- mainly used for clarity
2. Fast flow rate: coarse grade filter aids- acceptable filtrate.

Examples of filter aids

Diatomite (Keiselgur) , obtained from natural siliceous deposits.

Perlite , it is an aluminium silicate. Cellulose, Asbestos, charcoal, talc, bentonite , fullers earth etc.

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.

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The Filter press is made of two types of units, plate and frames.

Usually made of aluminium alloy.

Sometimes, these are also lacquered for protection against corrosive chemicals and made suitable for steam sterilization.

Frame

➤ It contains a 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.

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.

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- 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.
- It is normally described by dots as 1.2.1.2.1 so on.
- 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

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Working can be divided into two steps-

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

When washing of cake is also required modified plate and frame filter is used.

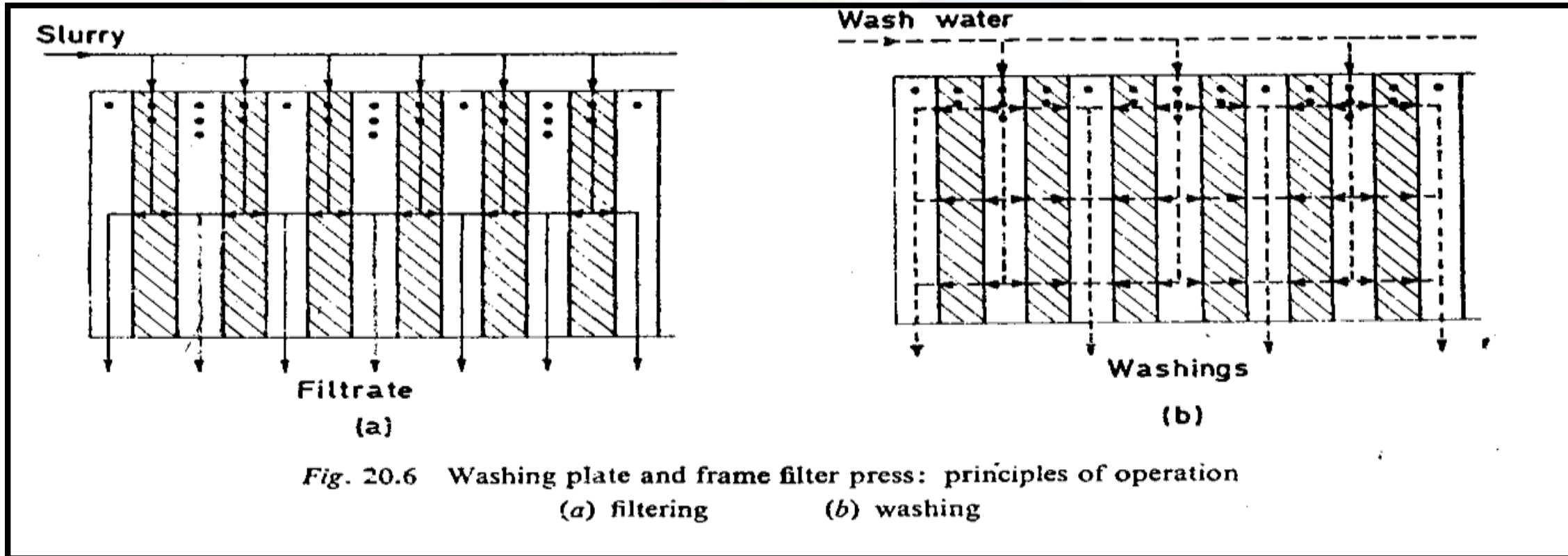
For this purpose an additional channel is included called as washing plate and are identified by 3 dots.

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).

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Diagrammatic procedure



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.

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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.

- 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.

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.

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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.

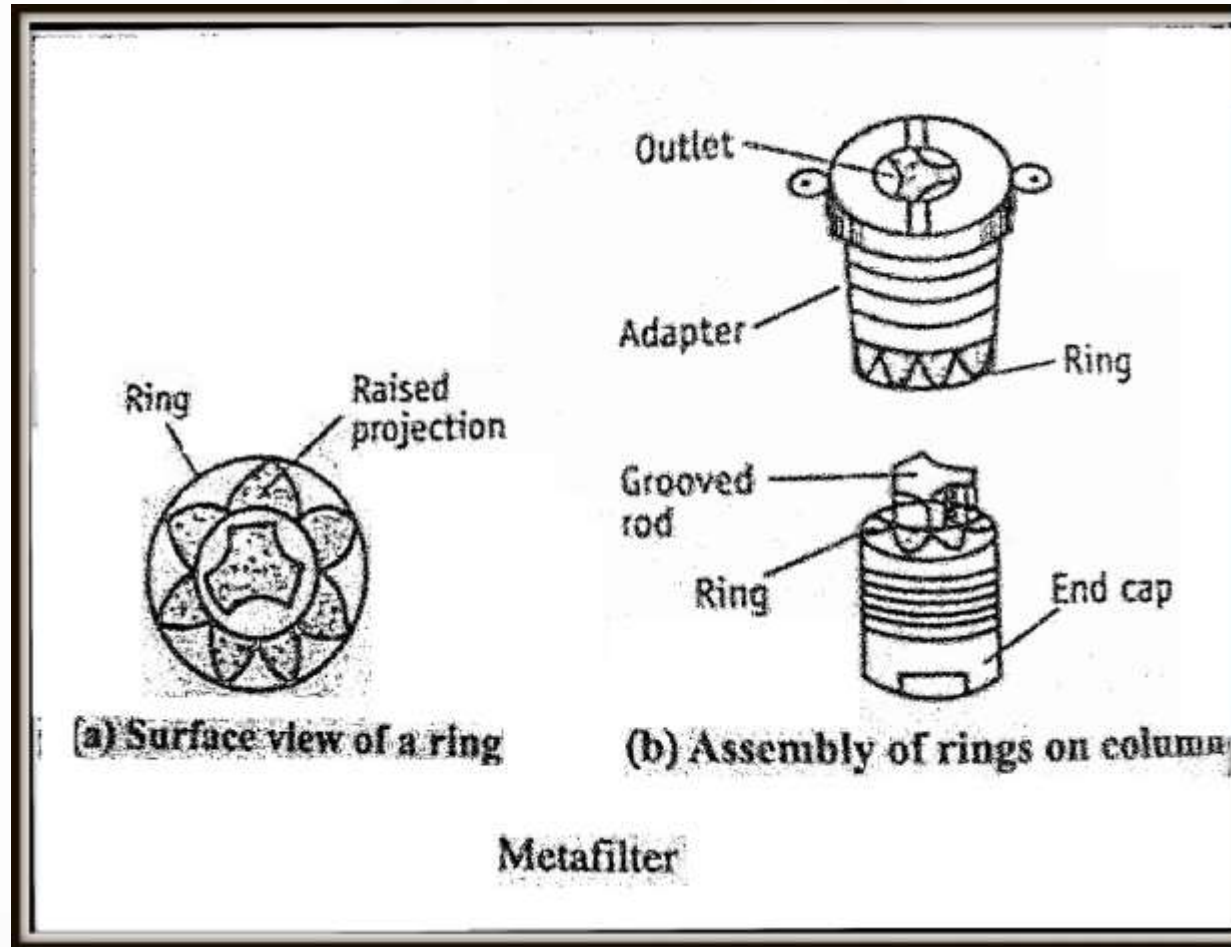
These rings are tightened on the drainage column with a nut.

Metafilters are also known as edge filters.

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- 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:

Metafilters 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.

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- 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.

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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.

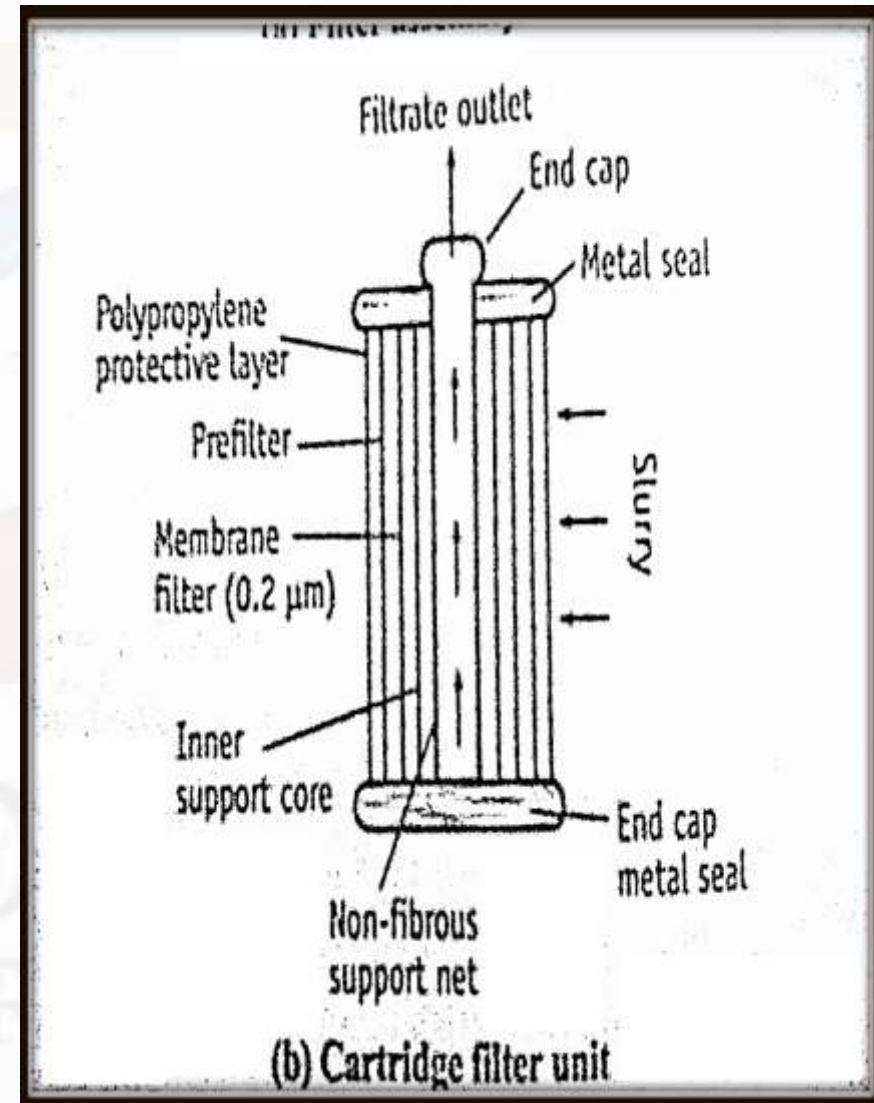
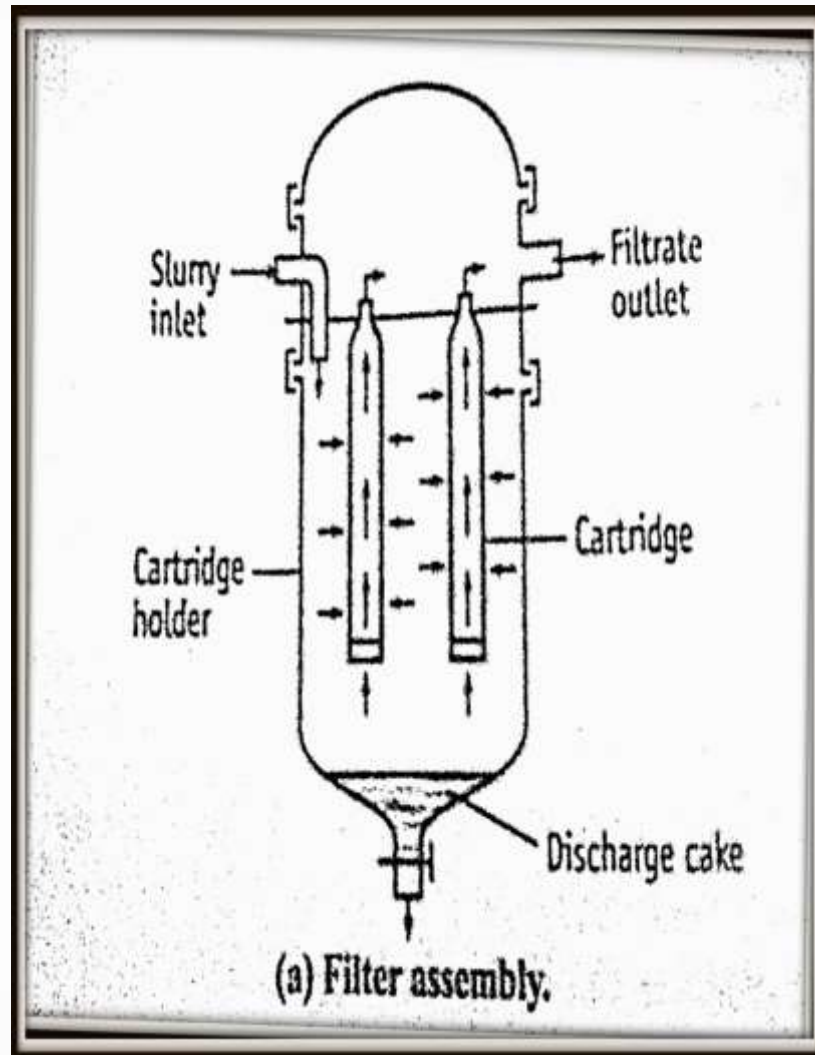
The housing is closed with the lid.

Housing has provisions for slurry inlet and outlets.

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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.

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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.

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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.

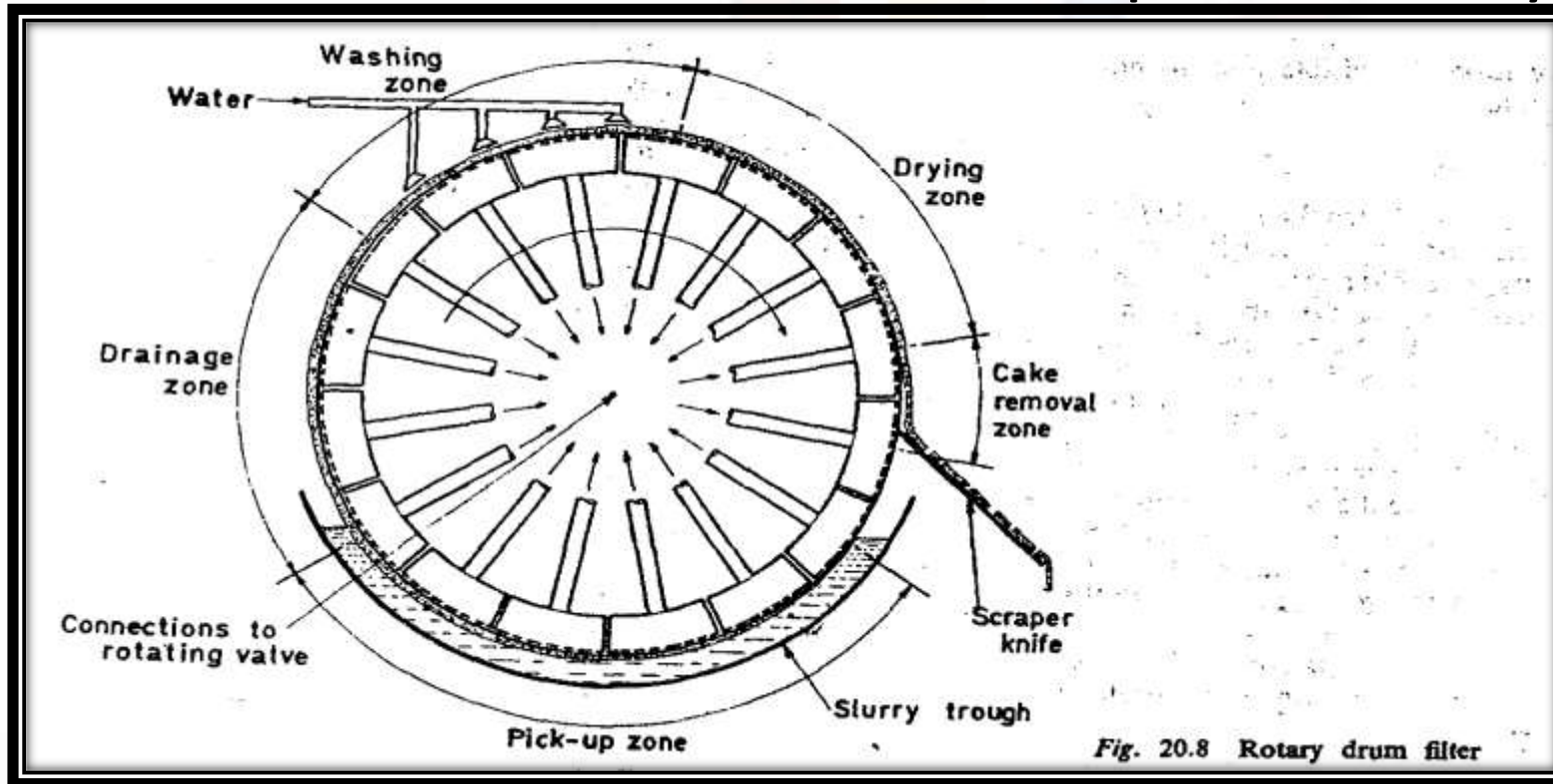
The drum may be up to 3 meters in diameter and 3.5 meters in length and gives surface area of 20 meter square.

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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.



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- 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.

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References:

- Subrahmanyam C.V.S., Setty J.T., Suresh S., Devi K. Pharmaceutical Engineering (Unit Operations-1) 2013 (Reprint) VallabhPrakashan: Delhi. pg. 230-32.
- Subhramanyam C.V.S., Setty J.T., Suresh S., Devi K. Pharmaceutical Engineering; Vallabh Prakashan: Delhi. Pg. 12-14
- Khar RK, Vyas SP, Ahmad FJ, Jain GK, “Lachman / Lieberman’s: the theory & practice of industrial Pharmacy”, 4th edition 2013;CBS Publisher & distributor Pvt Ltd. Page no. 755-89.