

Satuan Operasi Proses (4-0)

FILTRASI

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Contents

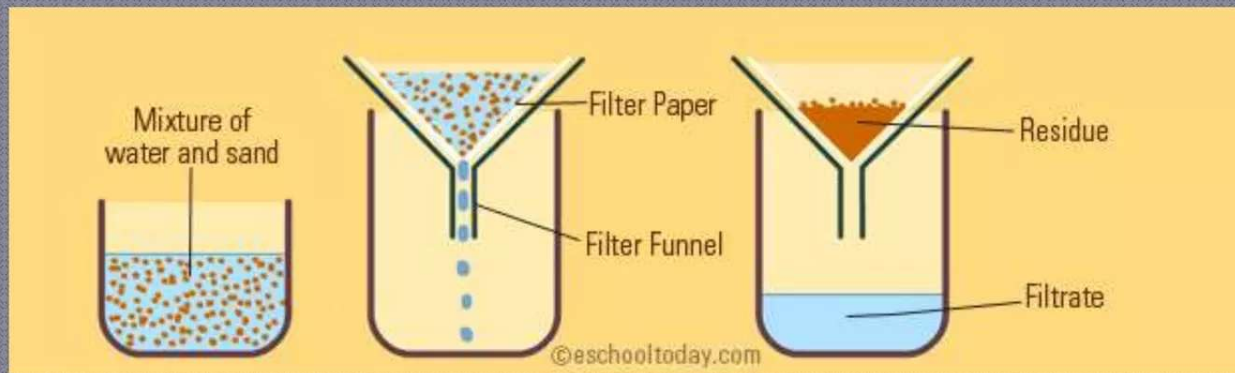
2

1. Introduction
2. Process of filtration
3. Mechanisms of Filtration
4. Theories of filtration
5. Classification of filtration

Introduction

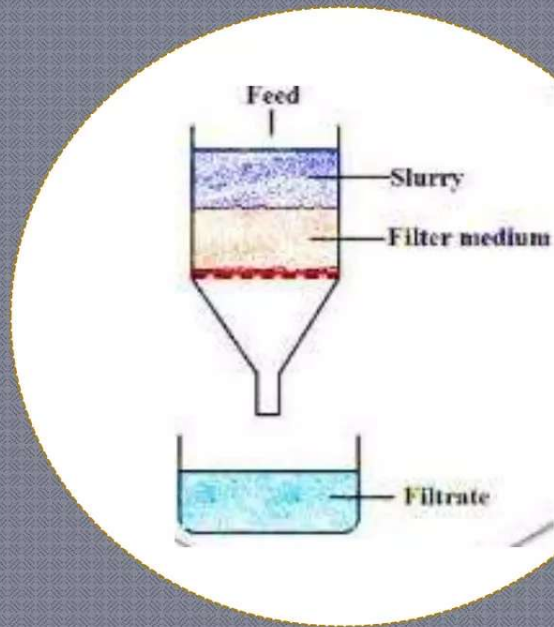
3

Filtration may be defined 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.



Term used in filtration

4



Slurry

Suspension to be filtered

Filter medium

Porous medium used to retain solid

Cake

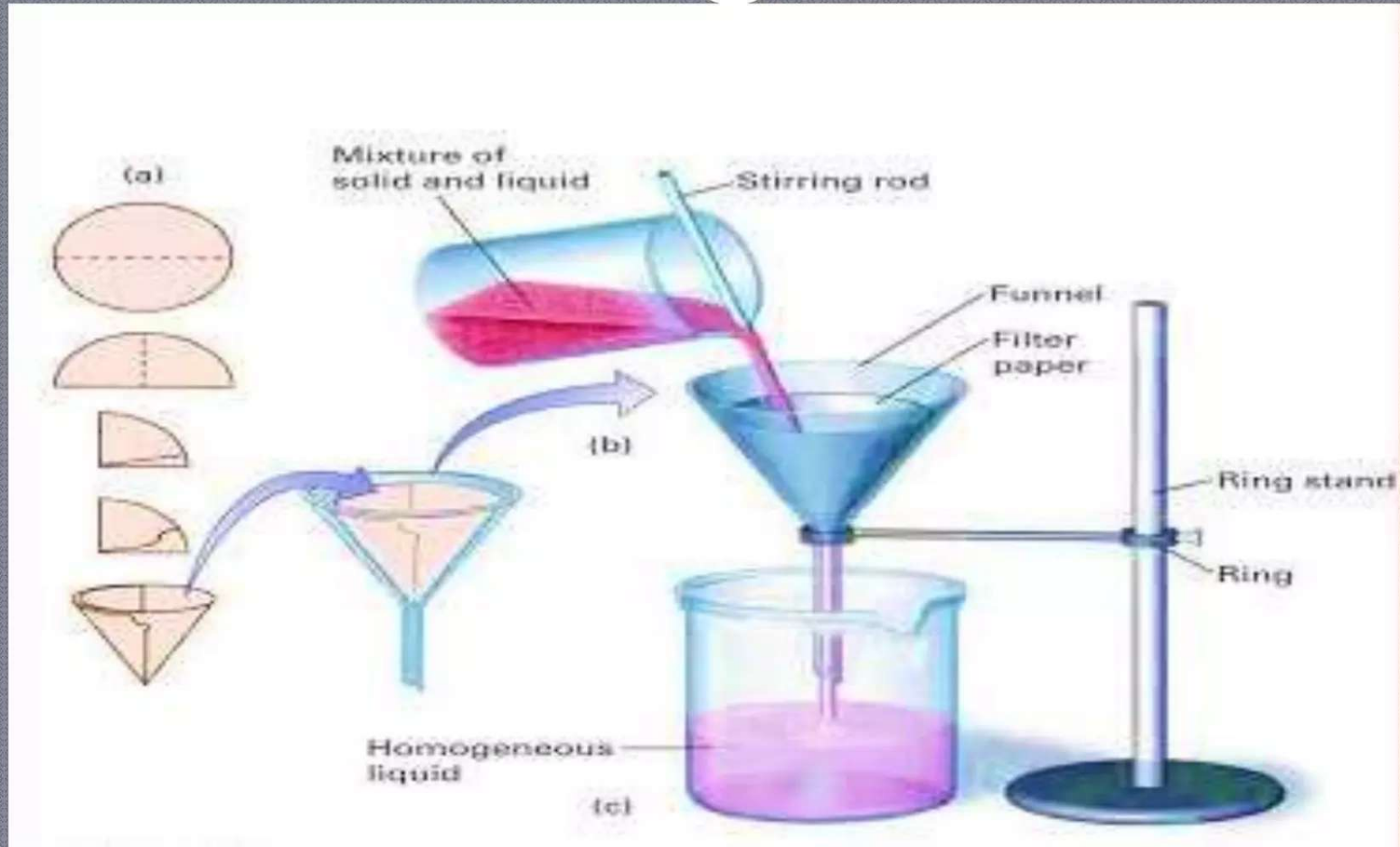
Accumulate solid on filter medium

Filtrate

Clear liquid passed through the medium

Process of filtration

5



Pores of filter medium are smaller than size of particles to be separate.

Filter medium (filter paper) is placed on a support (mesh)

Slurry is passes over the filter medium

Due to pressure difference across the filter, fluid flows through the medium

Gravity is acting over the liquid medium

So solid are trapped on the surface of the filter medium

Mechanisms of Filtration

7

1. STRAINING
2. IMPINGEMENT
3. ENTANGLEMENT
4. ATTRACTIVE FORCES

Types of filtration

8

Based on the mechanism:

1. Surface filtration
2. Depth filtration



Theories of filtration

9

- 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-
Rate = driving force / resistance
- 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

The rate of flow will be greatest at the beginning of filtration process, since the resistance is minimum.

After forming of filter cake, its surface acts as filter medium and solids continuously deposit adding to thickness of the cake.

Powder or granule bed visualized as a bundle of capillaries.

Poiseuille's Equation

11

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

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

- 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

Darcy's Equation

12

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:

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

Where,

K = permeability coefficient of cake, m²

A = surface area of porous bed (filter medium), m²

Other terms are same as previous equation

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

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

- This equation is valid for liquids flowing through sand, glass beds and various porous media.
- This model is applied to filter beds or cakes and other types of depth filter.
- This equation is further modified by including characteristics of K by Kozeny-Carman.

Kozeny-Carman (K-C) equation

14

Kozeny-Carman equation is widely used for filtration.

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

Where,

ε = porosity of cake (bed)

S = specific surface area of particles comprising the cake m^2 / m^3

K = Kozeny constant (usually taken as 5)

Other terms are same as previous equations

Limitations:

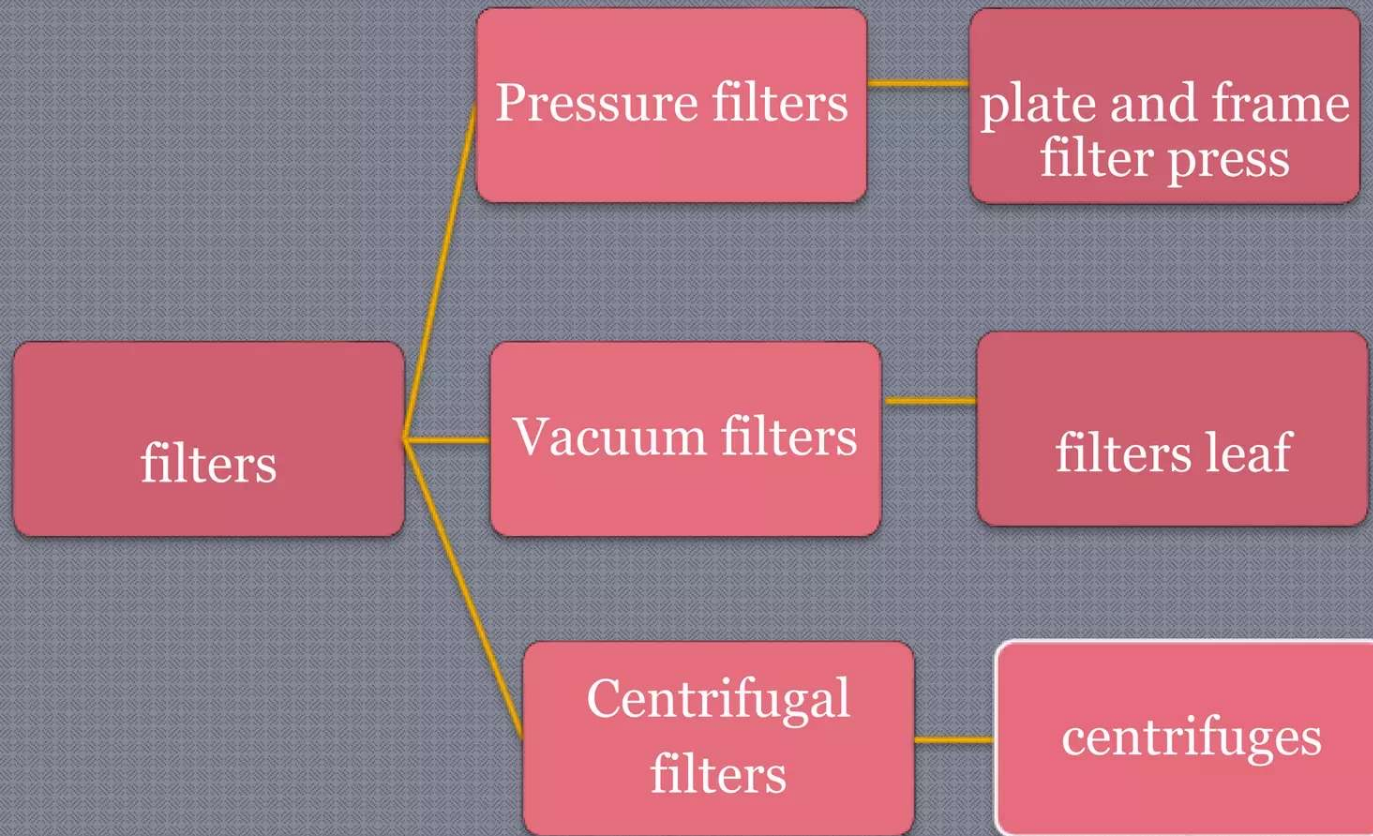
It does not consider the fact that depth of granular bed is lesser than the actual path traversed by the fluid.

The actual path is not same through out the bed, but it is sinuous or tortuous.

Classification of filtration equipment

16

- Based on application of external force



Based on the operation of the filtration

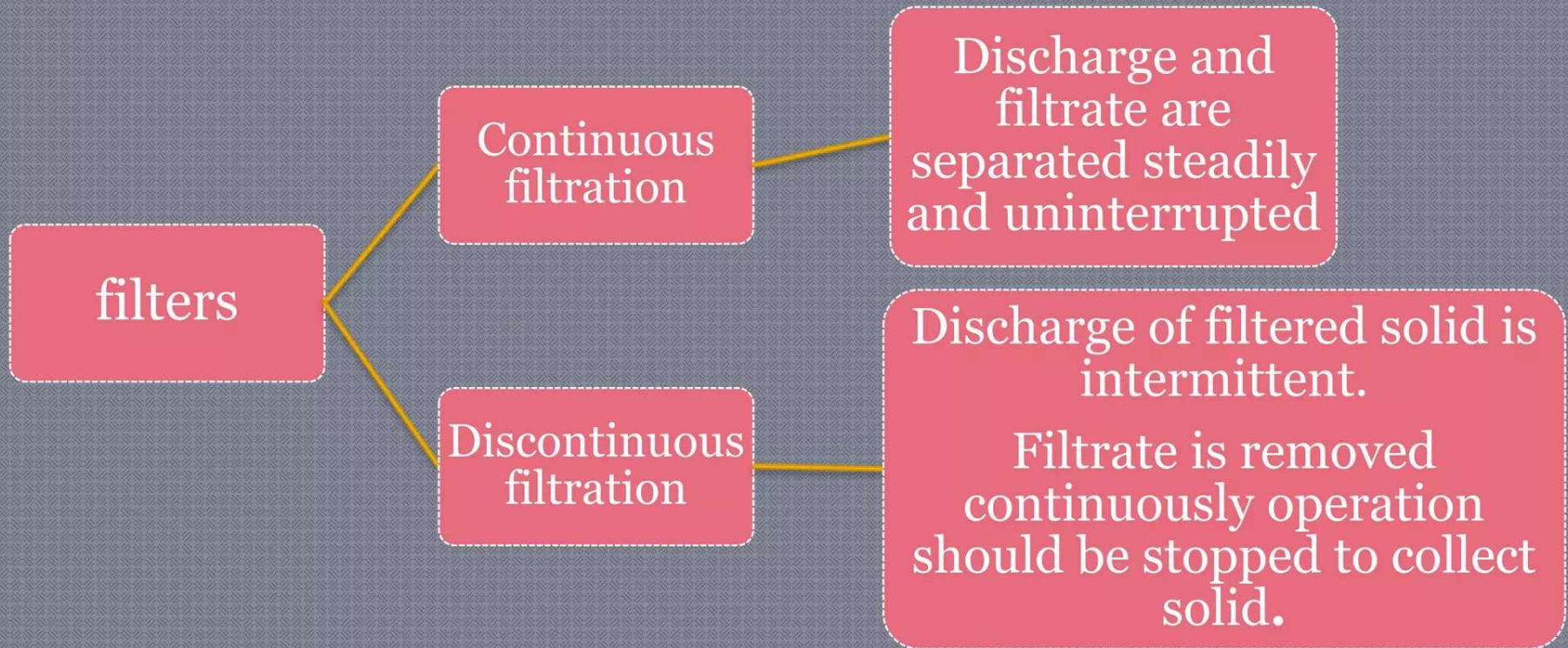


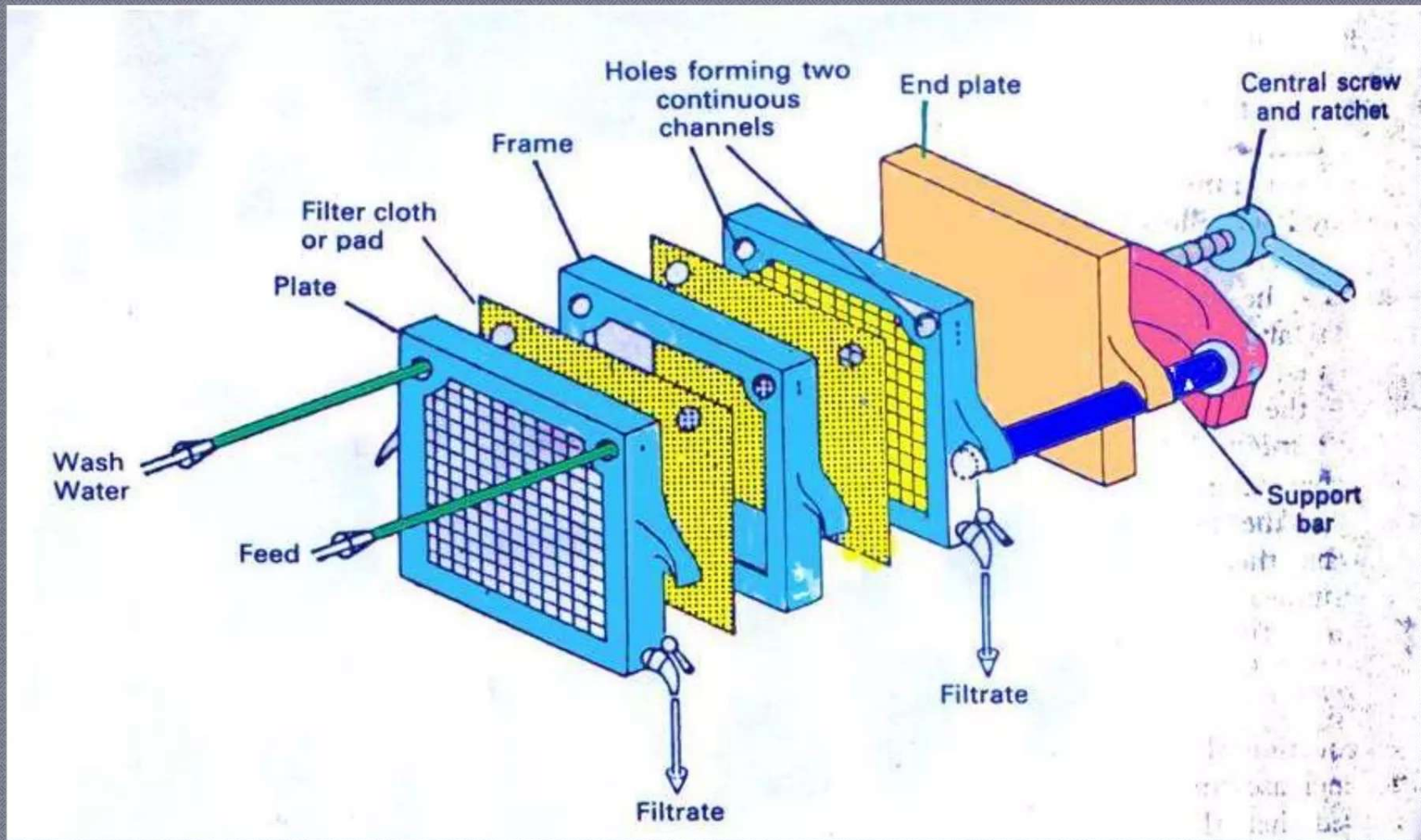
Plate and frame filter press

18

Principle:

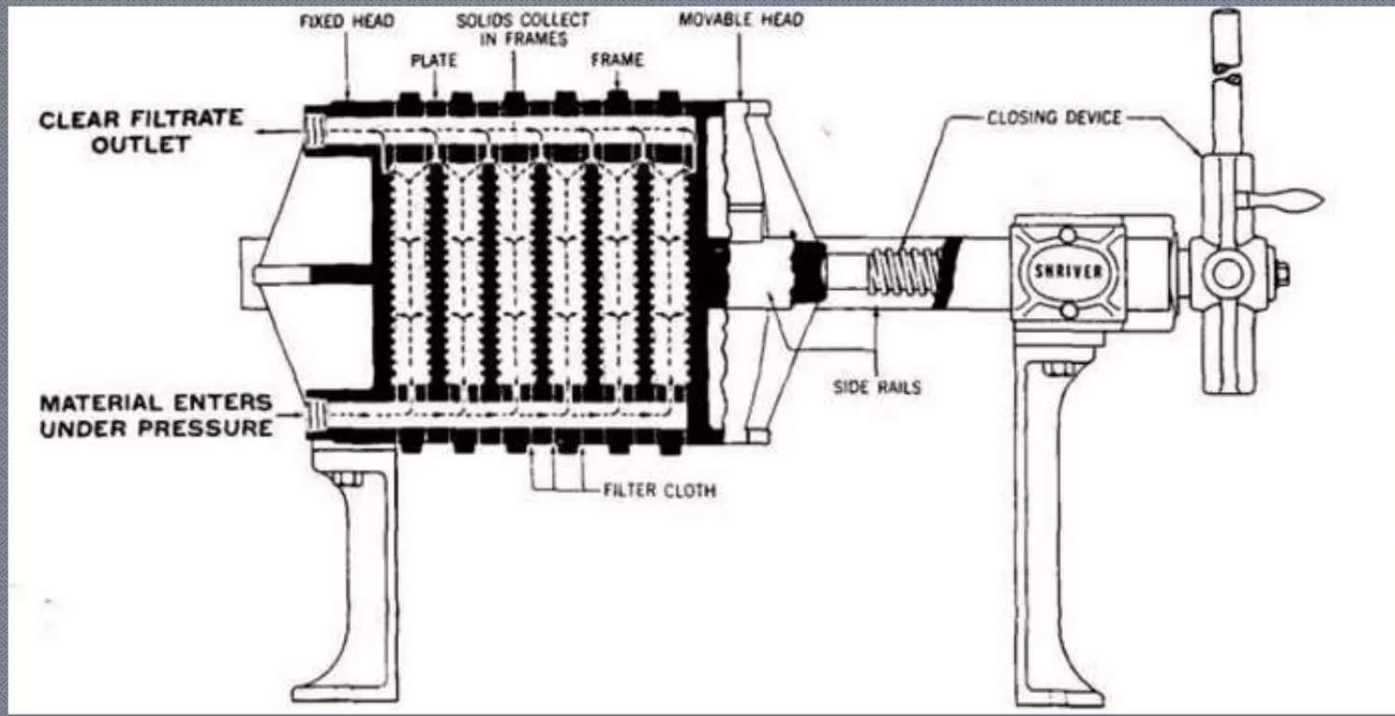
- Mechanism is surface filtration.
- The slurry enters the frame by pressure and flows through filter medium.
- The filtrate is collected on the plates and send to outlet.
- A number of frames and plates are used so that surface area increases and consequently large volumes of slurry can be processed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





Assembly of plate and frame filter

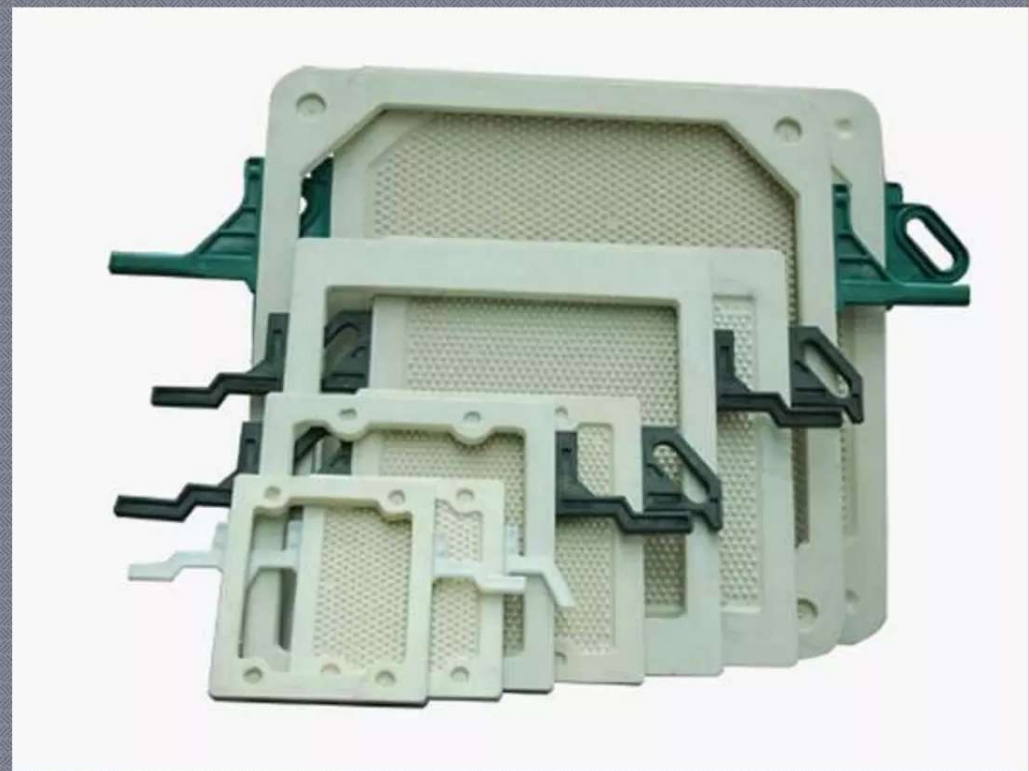
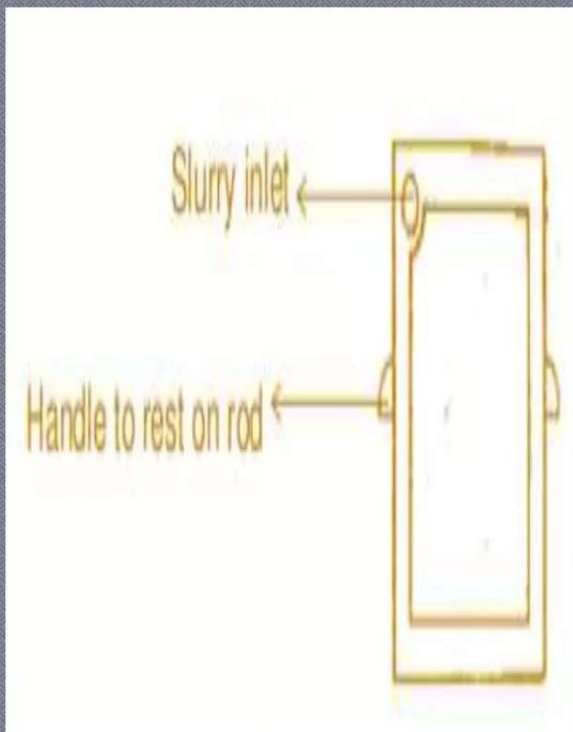
20



Construction

21

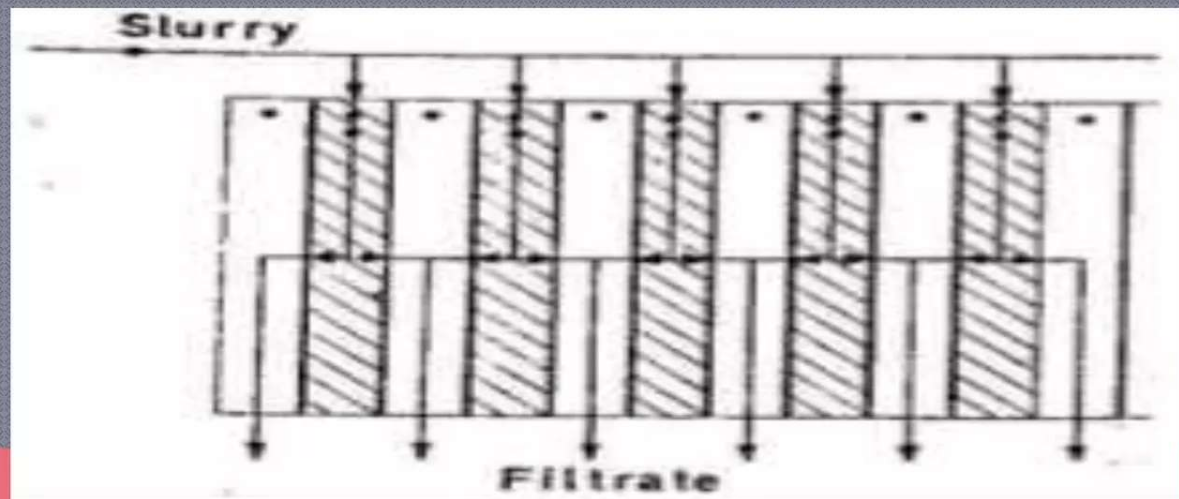
- The Filter press is made of two types of units, plate and frames.
- Usually made of aluminium alloy.
- Sometimes, these are also lacquered for protection against corrosive chemicals and made suitable for steam sterilization.



Working

23

- Working can be divided into two steps-
- 1. Filtration operation
- 2. Washing of cake (if desirable)
- Filtration operation
- Frame- marked by 2 dots
- Plate – marked by 1 dot Plate and frame



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

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

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

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

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

Procedure for washing the press

25

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

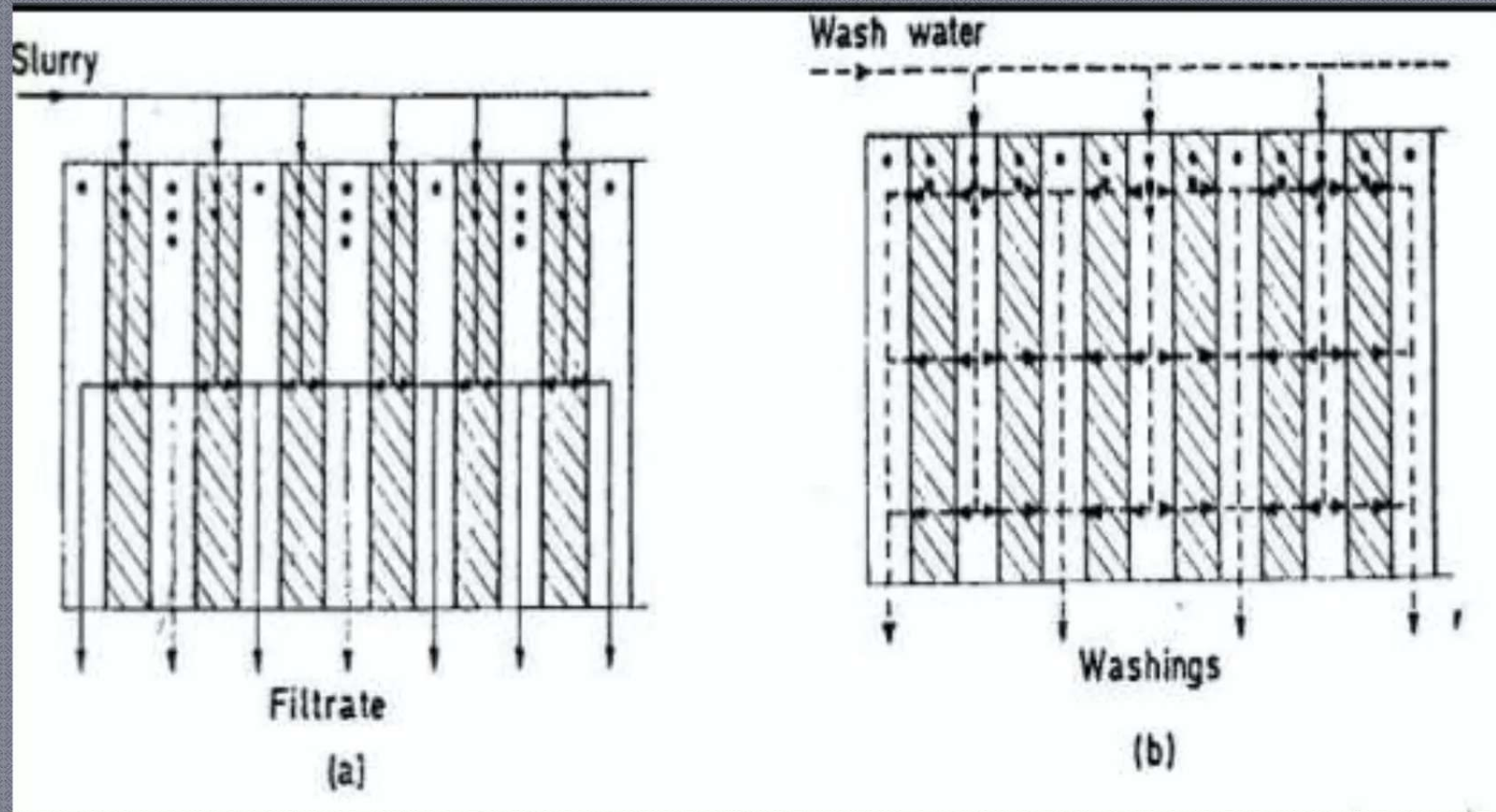
- Water passes through the filter cloth and enters frame which contains the cake
- Then water washes the cake, passes through the filter cloth and enters the plate down the surface

Step 5

- Finally washed water escapes through the outlet of that plate

Diagrammatic procedure

26



Uses

27

- 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

28

- 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

30

- 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.

Filter leaf

31

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.

Vertical Pressure Leaf Filter

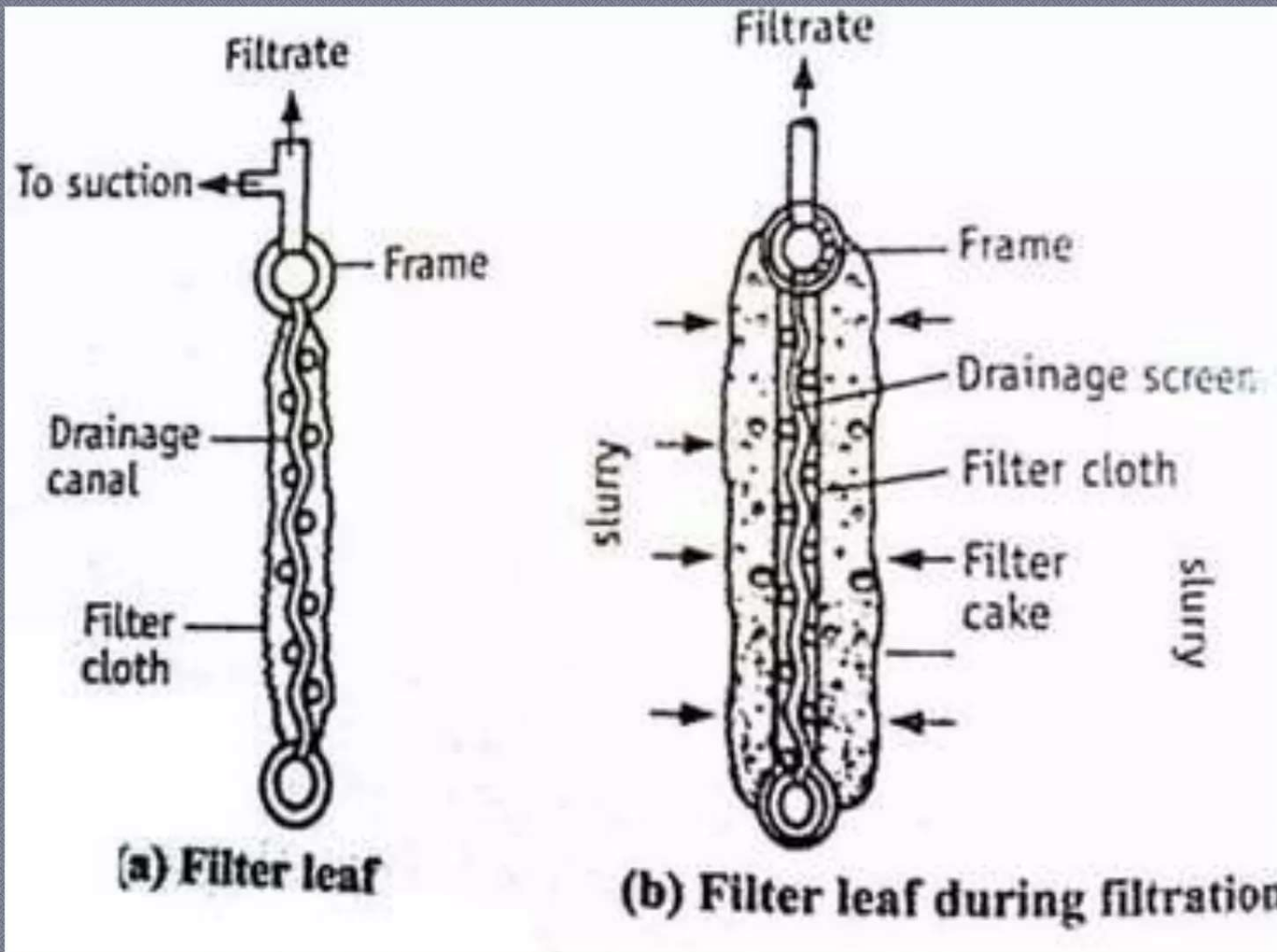


Construction:

32

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 unite being covered with filter cloth.
- The outlet for the filtrate connects to the inside of the frame through suction.



working

34

The filter leaf is immersed in the slurry

Vacuum system is connected to the outlet

The slurry passes through the filter cloth

Finally filtrate enters the drainage canal and goes through the outlet into receiver

Air is passed to flow in reverse direction which facilitates removal of cake

Uses

35

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

Advantages

36

- 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.

Cartridge filter

37

Principle:

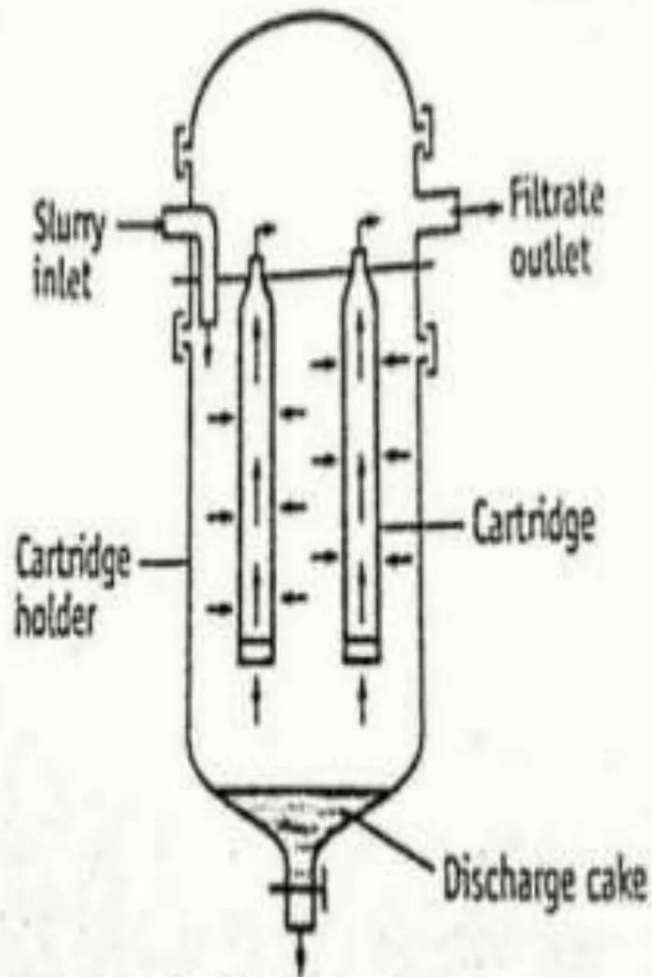
- It is a thin porous membrane in which pre filter and membrane filter are combined in a single unit.
- The filtration action is mainly sieve like and particles are retained on the surface.



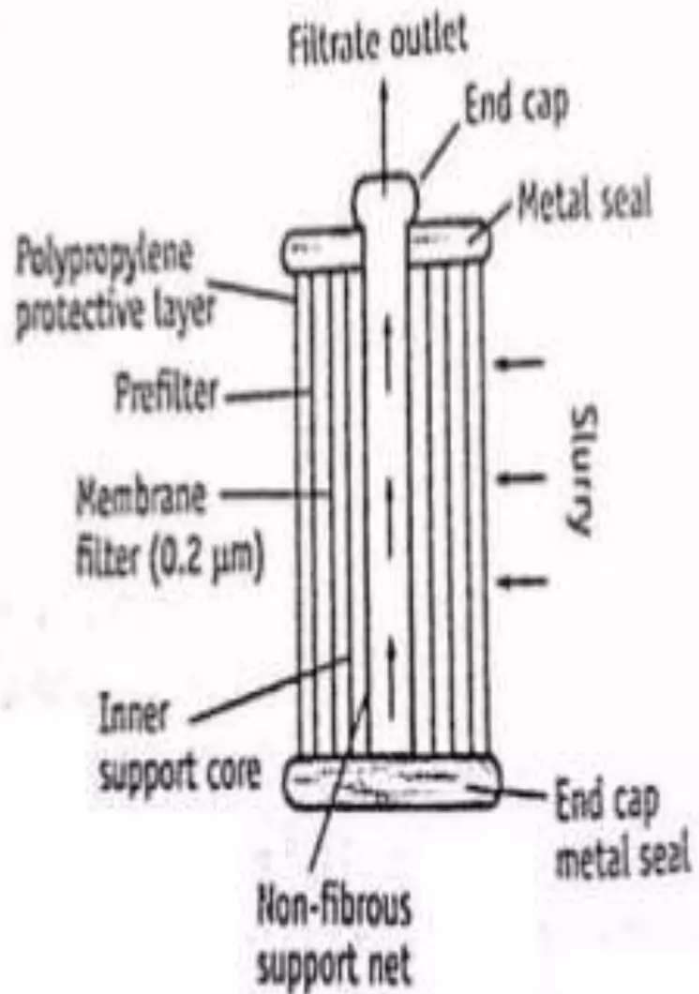
Construction:

38

- 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.



(a) Filter assembly.



(b) Cartridge filter unit

working

40

Slurry is pumped into cartridge holder

It passes through cartridge filter unit by straining

The clear liquid passes through the centre

Moves up to collect through outlet

uses

41

- 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

42

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.

Reference

1. C.V.S. Subrahmanyam, J. Thimma Setty, Sarasija Suresh, V.kusum Devi. Pharmaceutical engineering, 1st ed. Delhi: Vallabh Prakashan, pp.248-275
2. Cooper and Gunn's. Tutorial pharmacy. 1st ed. Delhi: S.K. Jain, pp.234-244
3. <https://www.slideshare.net/ritukudarha/filtration-39038033>