

UNIT OPERATION

UNIT IV : FILTRATION

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Definition

- 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.

- Clarification: When solid are present in very low concentration, i.e., not exceeding 1.0% w/v, the process of its separation from liquid is called clarification.

Principle of Filtration

Since the filter medium is permeable only to the fluid, it retains the solid particles and permits only the fluid to pass through which is collected as the filtrate. The volume of filtrate collected per unit time (dV/dt) is termed as the rate of filtration.

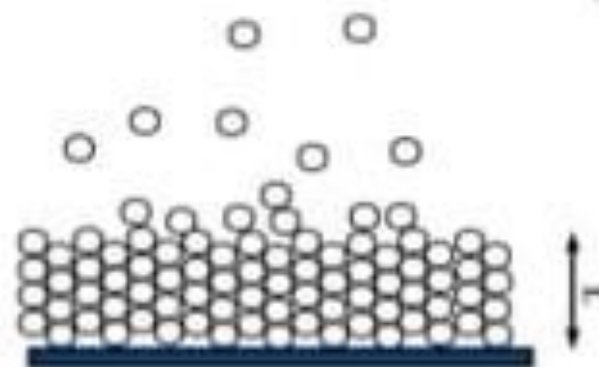
As the filtration proceeds, solid particles accumulate on the filter medium forming a packed bed of solids, called filter cake.

As the thickness of the cake increases

→ resistance to flow of filtrate increases

→ rate of filtration gradually decreases.

If rate is maintained to be constant then pressure difference driving force ($-\Delta P$) will increase.



Therefore, a batch filter is operated either at constant pressure or at constant rate.

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-

$$\text{Rate} = \text{driving force} / \text{resistance}$$

- 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.

Continue.....

- 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

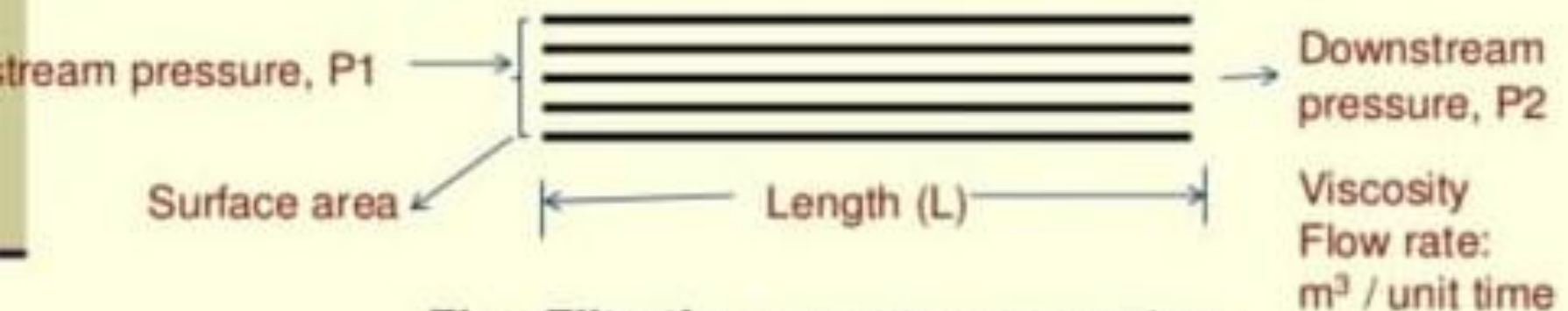


Fig.: Filtration process parameters.

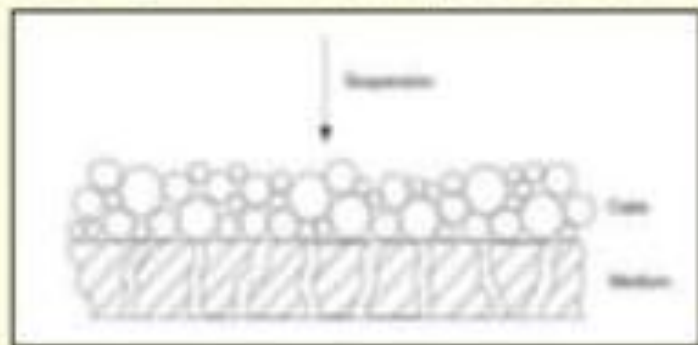
- Resistance to flow is related to several factors given in fig.

Resistance to movement = $[\text{pressure upstream} - \text{pressure downstream}] / \text{length of capillaries}$

Types of filtration

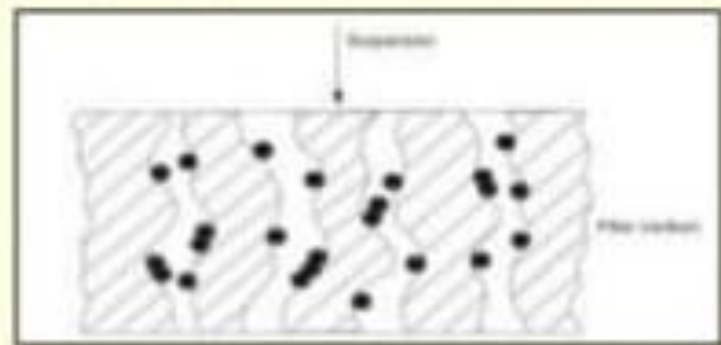
■ Surface/ screen filtration

- 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.



Difference between surface and depth filtration

Surface filtration

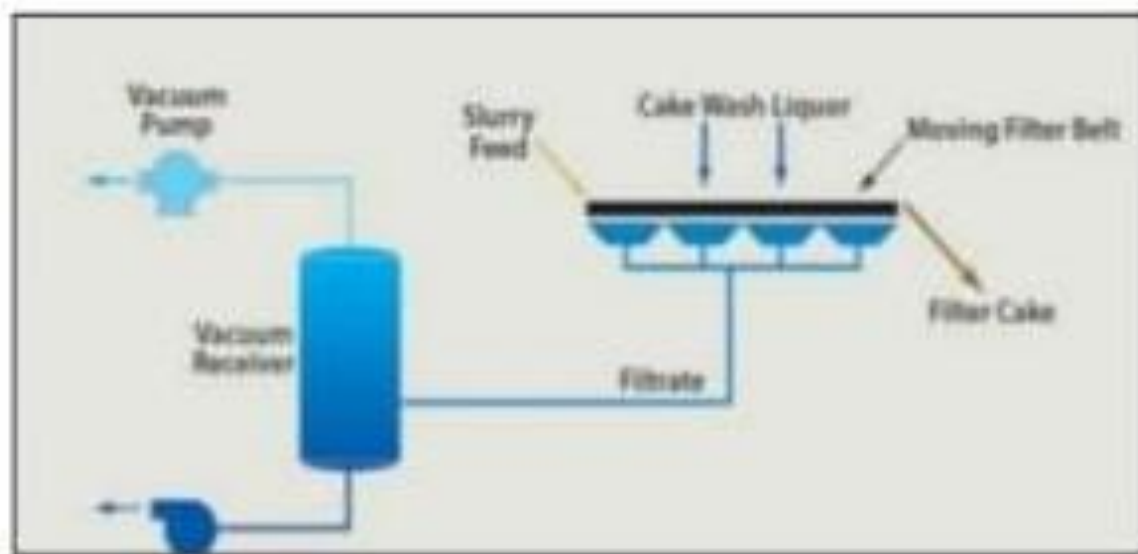
- The size of particles retained is slightly higher than the mean pore size of medium.
- Mechanical strength of filter medium is less, unless it is made of stainless steel.
- It has low capacity.
- The size of particles retained is more predictable.
- Equipment is expensive because ancillary equipment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

Depth filtration

- 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.

Types of filtration equipment

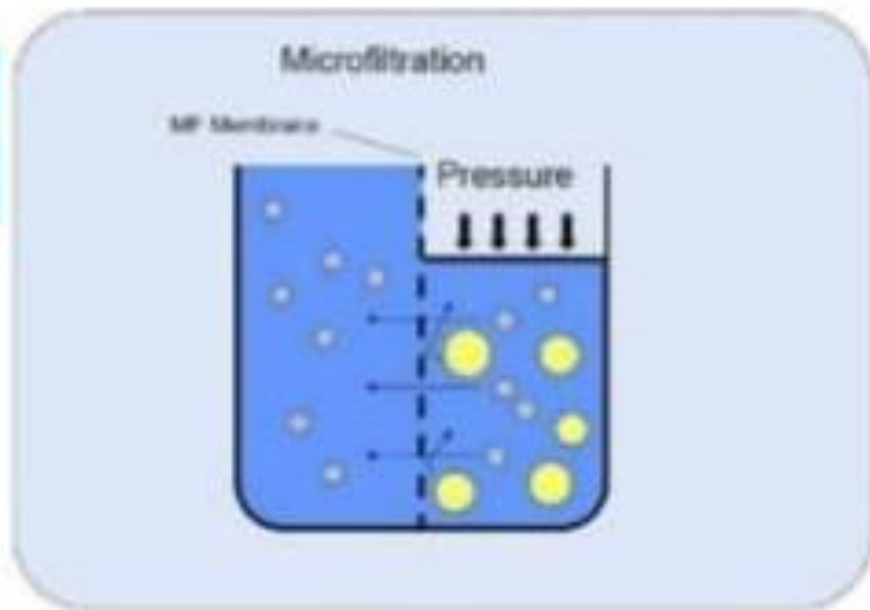
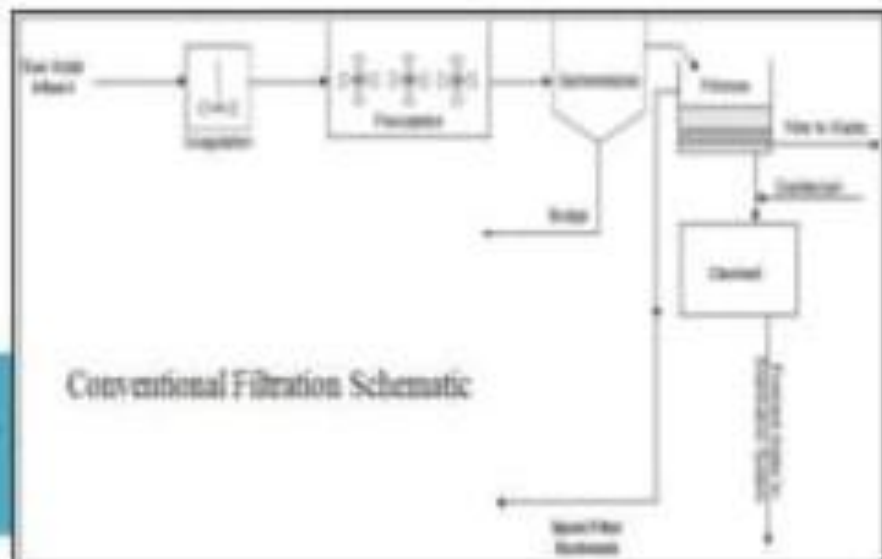
The industrial filtration equipment differs from laboratory filtration equipment only in the amount of material handled and in the necessity for low-cost operation.



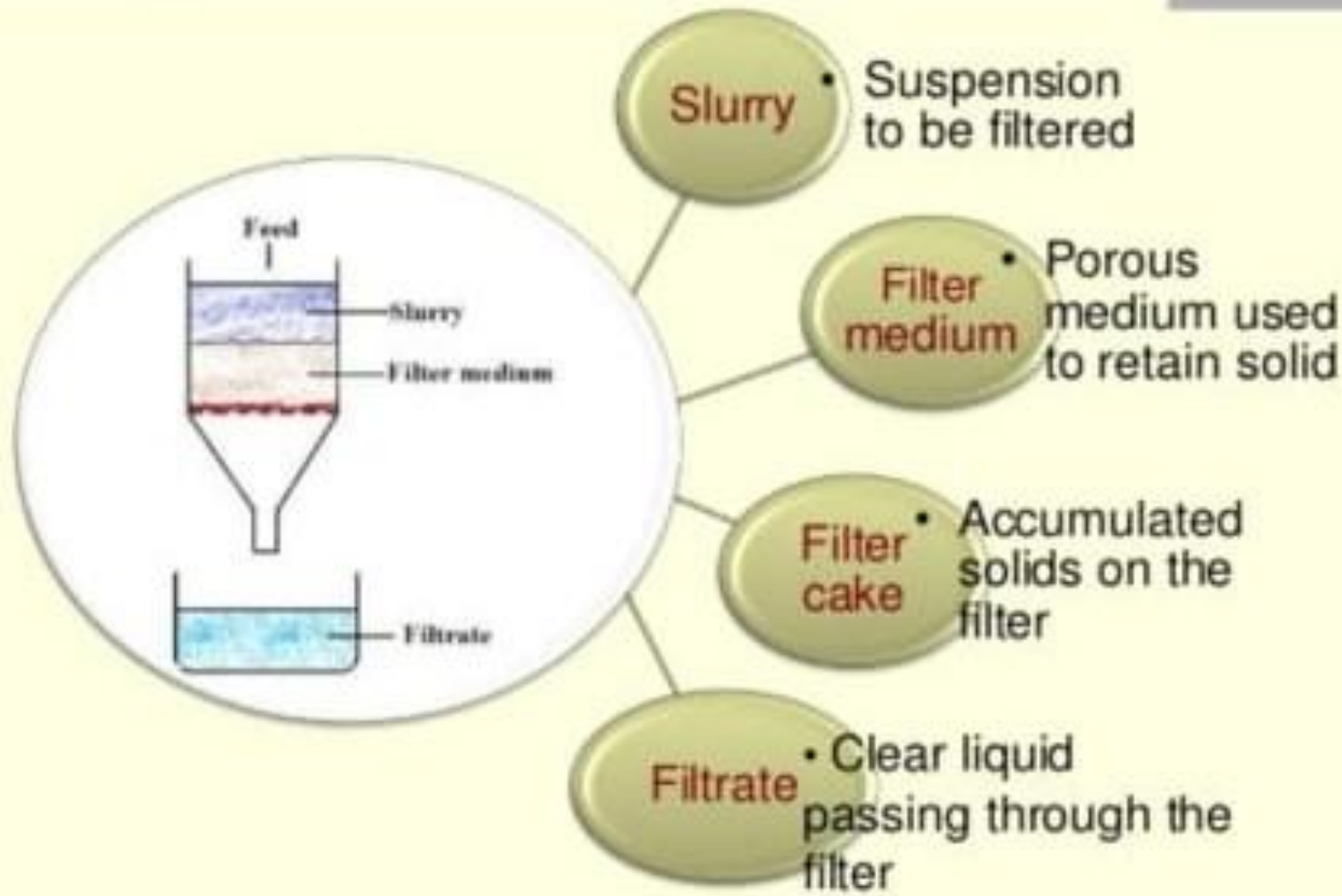
FILTRATION

**CONVENTIONAL
FILTRATION**

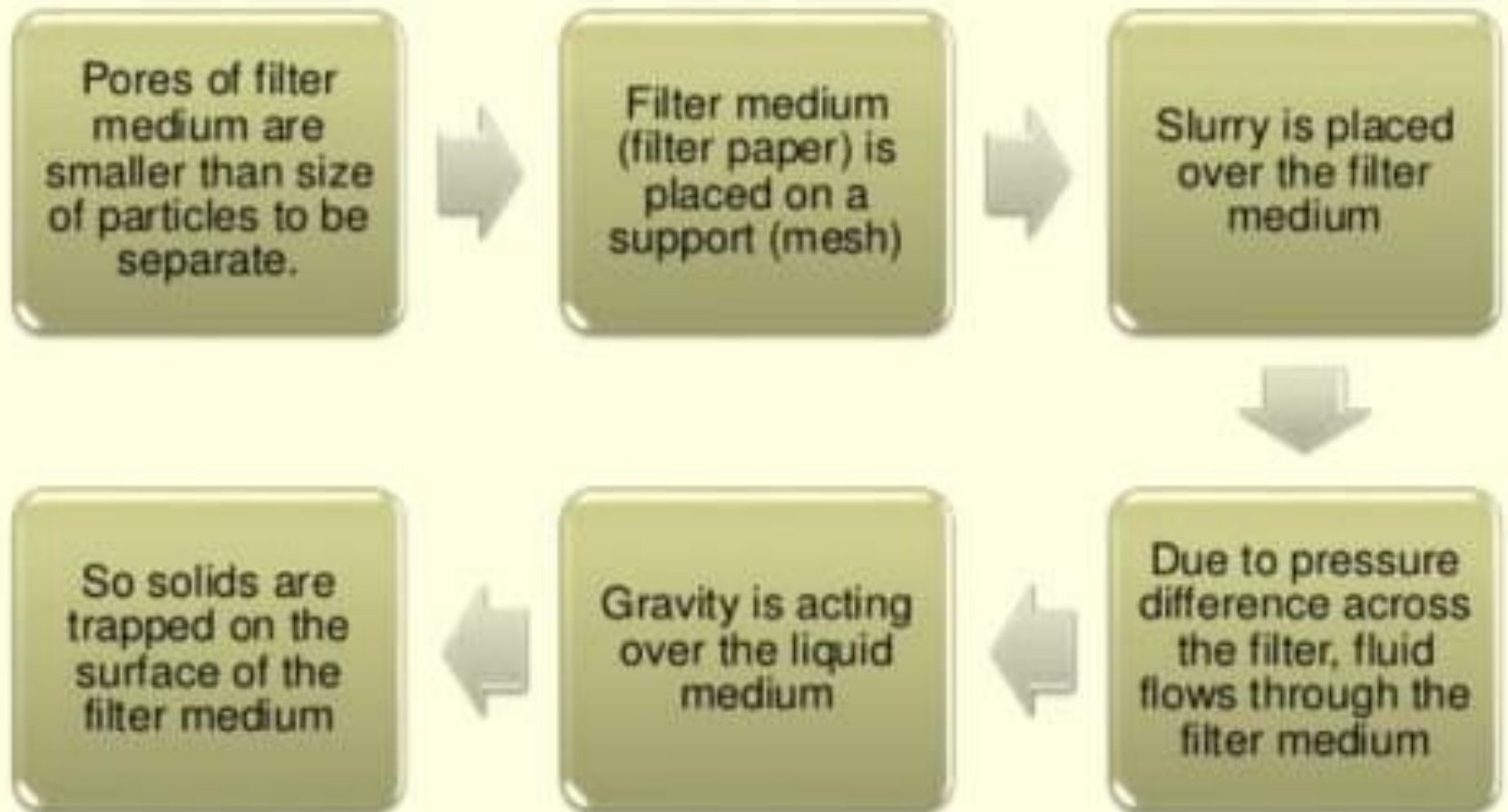
MICROFILTRATION



Terms used in filtration



Process of filtration



Mechanism of filtration

- The mechanism whereby particles are retained by a filter is significant only in initial stages of filtration.

Straining

- Similar to sieving, i.e., particles of larger size can't pass through smaller pore size of filter medium.

Impingement

- Solids having the momentum move along the path of streaming flow and strike (impinge) the filter medium. Thus the solids are retained on the filter medium.

Entanglement

- Particles become entwined (entangled) in the masses of fibres (of cloths with fine hairy surface or porous felt) due to smaller size of particles than the pore size. Thus solids are retained within filter medium.

Attractive forces

- Solids are retained on the filter medium as a result of attractive force between particles and filter medium, as in case of electrostatic filtration.

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

Factors influencing filtration

Properties of solid

- Particle shape
- Particle size
- Particle charge
- Density
- Particle size distribution
- Rigidity or compressibility of solid under pressure
- Tendency of particle to flocculate or adhere together

Properties of liquids

- Density
- Viscosity
- corrosiveness

Properties of solid in slurry

- Rate of formation of filter cake especially in early stage of filtration

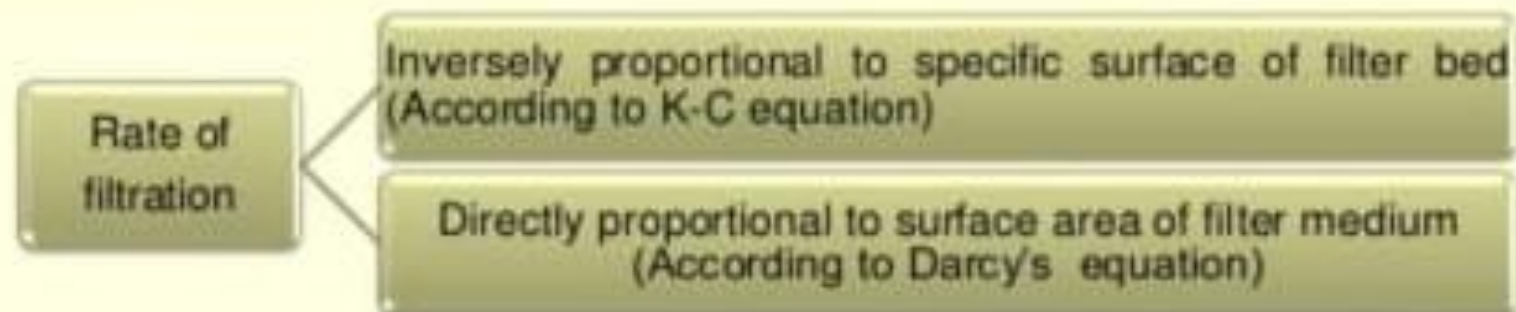
Objectives

- Whether the solid or liquid or both are to be collected

Temperature

- Temperature of suspension

Surface area of filter medium



- Rate can be increased either using **large filter** or **connecting a number of small units in parallel**.
- Filter press works on principle of connecting units in parallel.

Pressure drop across the filter medium

- According to K-C equation the rate of filtration is proportional to the overall pressure drop across both the filter medium and filter cake.
- The pressure drop can be achieved in a number of ways:

Gravity

- A pressure difference could be obtained by maintaining a head of slurry above the filter medium.
- The pressure developed will depend on the density of the slurry

Vacuum
(Reducing pressure)

- The pressure below the filter medium may be reduced below atmospheric pressure by connecting the filtrate receiver to a vacuum pump and creating a pressure difference across the filter.

Pressure

- The simplest method being to pump the slurry into the filter under pressure.

Centrifugal force

- The gravitational force could be replaced by centrifugal force in particle separation

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.

Material used as filter media

Woven material

- Made up of wool, silk, metal or synthetic fibres (rayon, nylon etc.).
- These include a- wire screening and b- fabrics of cotton, wool, nylon.
- Wire screening e.g. stainless steel is durable, resistance to plugging and easily cleaned.
- Cotton is a common filter ,however, Nylon is superior for pharmaceutical use, since it is unaffected by mold, fungus or bacteria and has negligible absorption properties .
- The choice of fibre depends on chemical

Perforated sheet metal

- Stainless steel plates have pores which act as channels as in case of meta filters.

Bed of granular solid built up on supporting medium

- In some processes, a bed of graded solids may be formed to reduce resistance of flow.
- Ex. Of granular solids are gravel, sand, asbestos, paper pulp and keiselgur.
- Choice of solids depends on size of solids in process.

Prefabricated porous solid units

- Used for its convenience and effectiveness.
- Sintered glass, sintered metal, earthenware and porous plastics are used for fabrication.

Membrane filter media

- These are cartridge units and are economical and available in pore size of 100 μm to even less than 0.2 μm .
- Can be either surface cartridges or depth type cartridges.
- **Surface cartridges**
 - These are corrugated and resin treated papers and used in hydraulic lines.
 - Ceramic cartridges and porcelain filter candles are examples.
 - Can be reuse after cleaning.
- **Depth type cartridges:**
 - Made up of cotton, asbestos or cellulose.
 - These are disposable items, since cleaning is not feasible.

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:

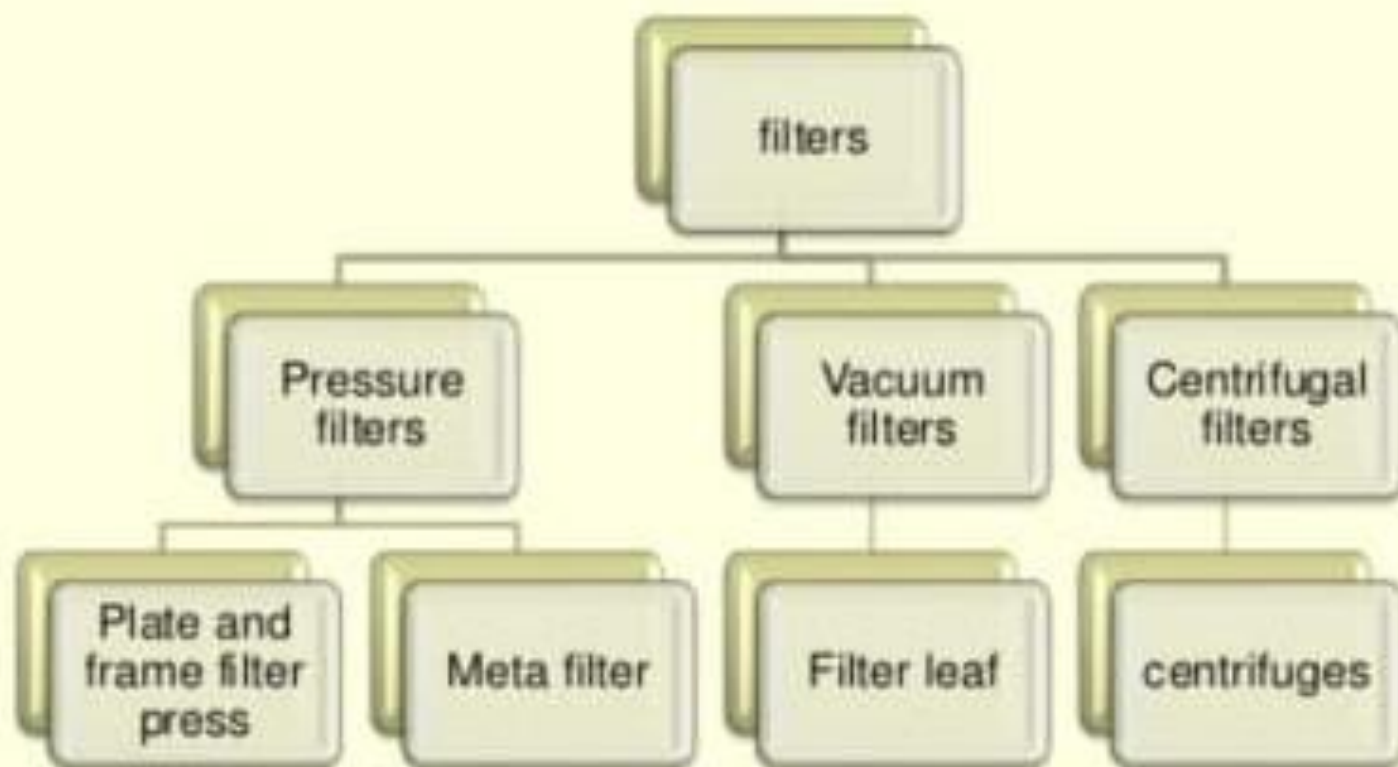
- Chemically inert and free from impurities.
- Low specific gravity, so remain suspended in liquids.
- Porous rather than dense, so that pervious cake can be formed.
- Recoverable.

Disadvantages:

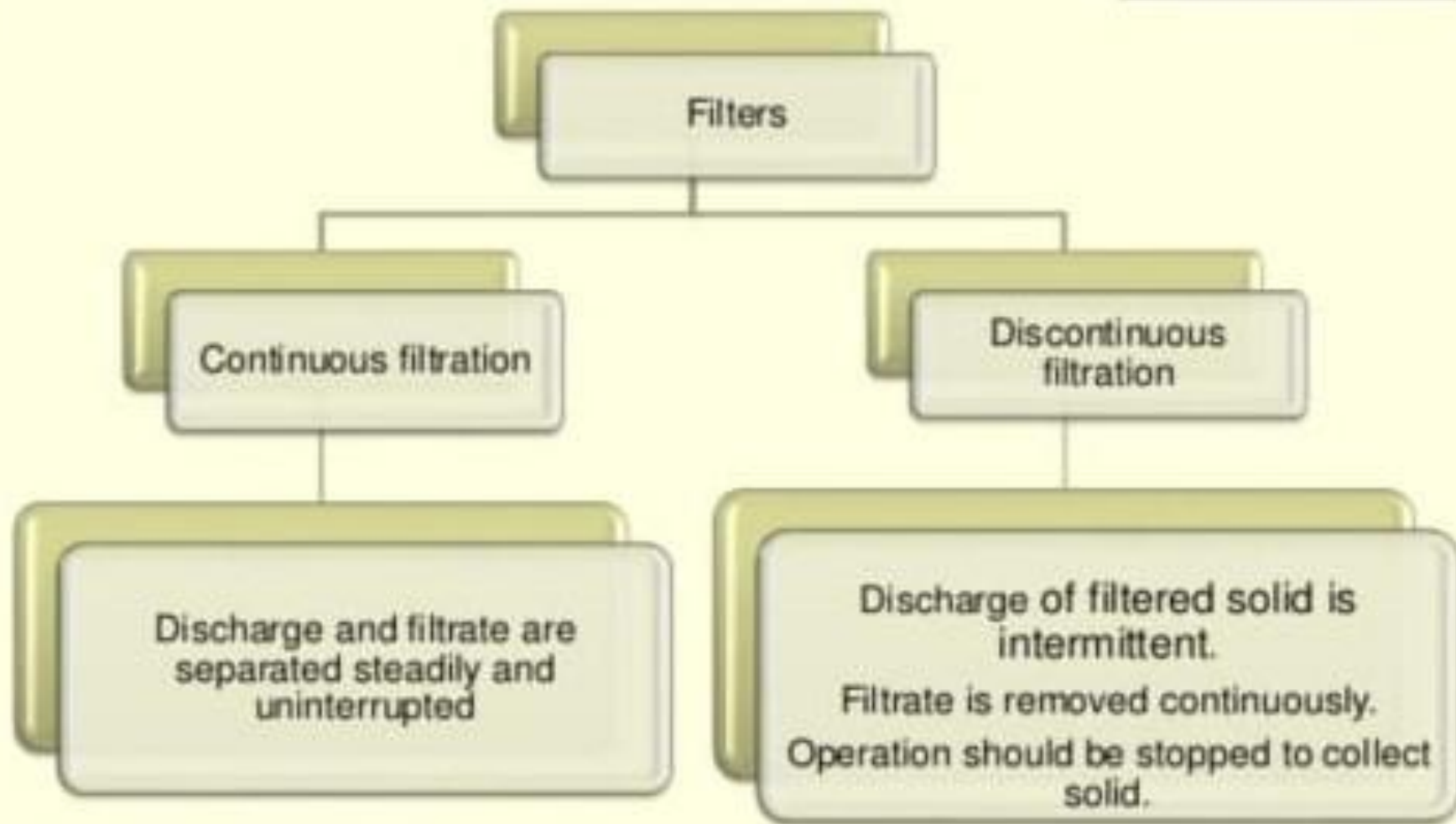
- Remove the coloured substances by absorbing them.
- Sometimes active principles such as alkaloids are absorbed on filter aid.
- Rarely, filters are source of contamination such as soluble iron salts, which can provoke degradation of sensitive ingredient.

Classification of filtration equipments

- Based on application of external force:



Based on operation of filtration



Based on nature of filtration



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.

Diagram

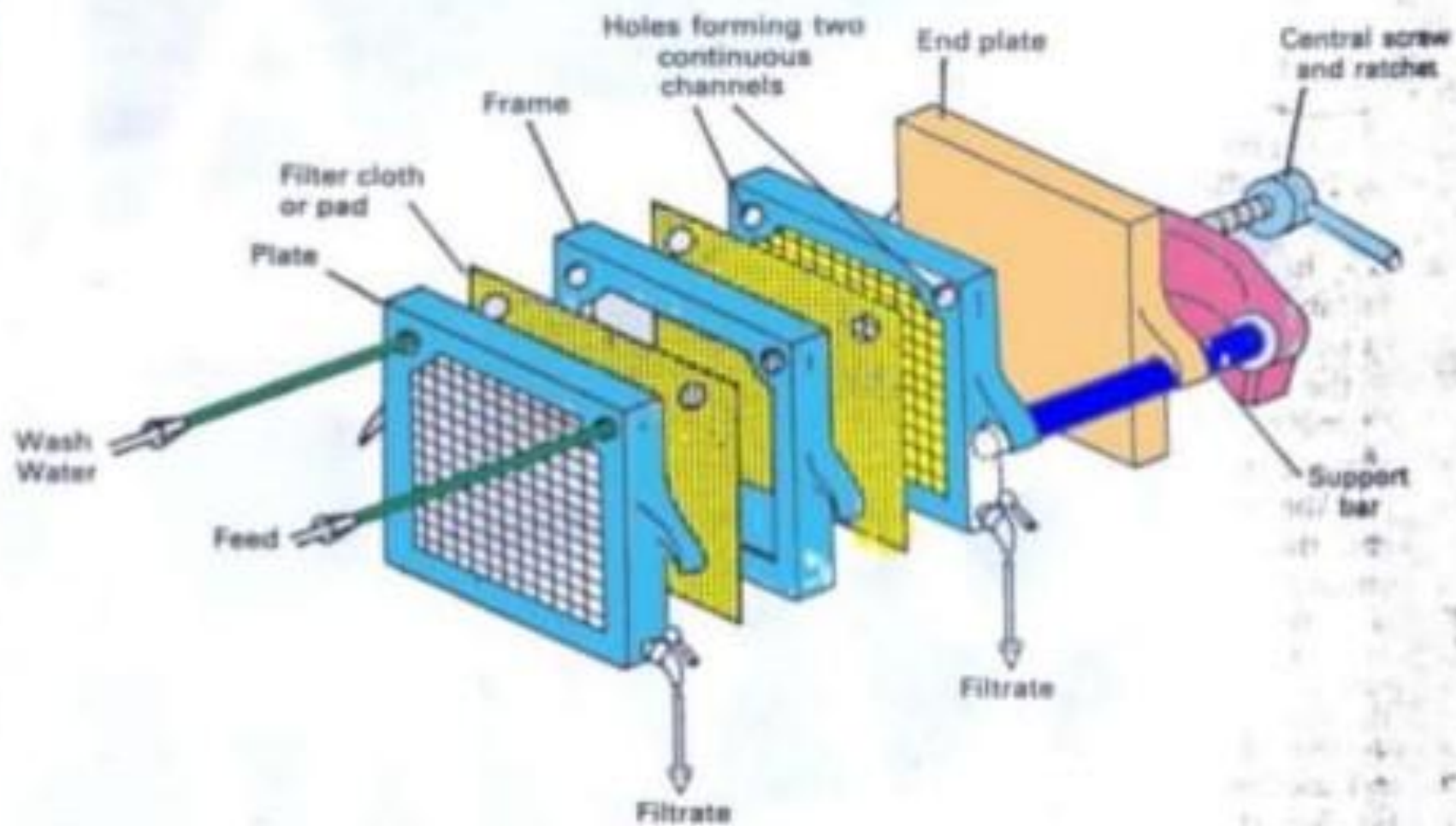


Fig. 31.5 Filter press. Assembly of plates and frames

Working

- 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

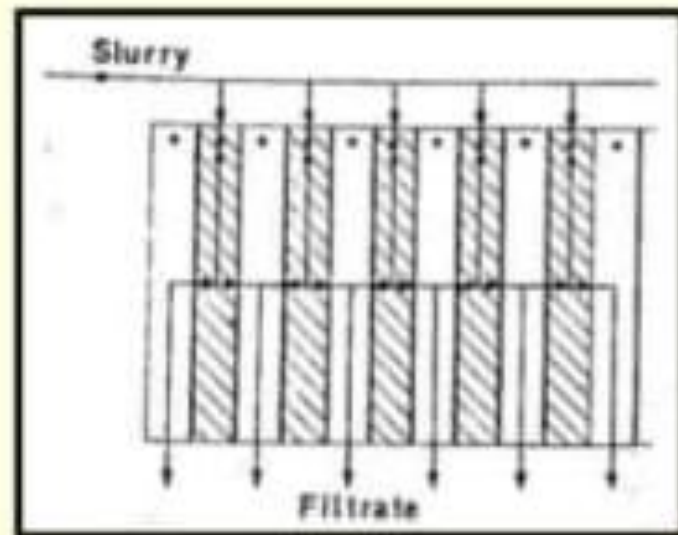
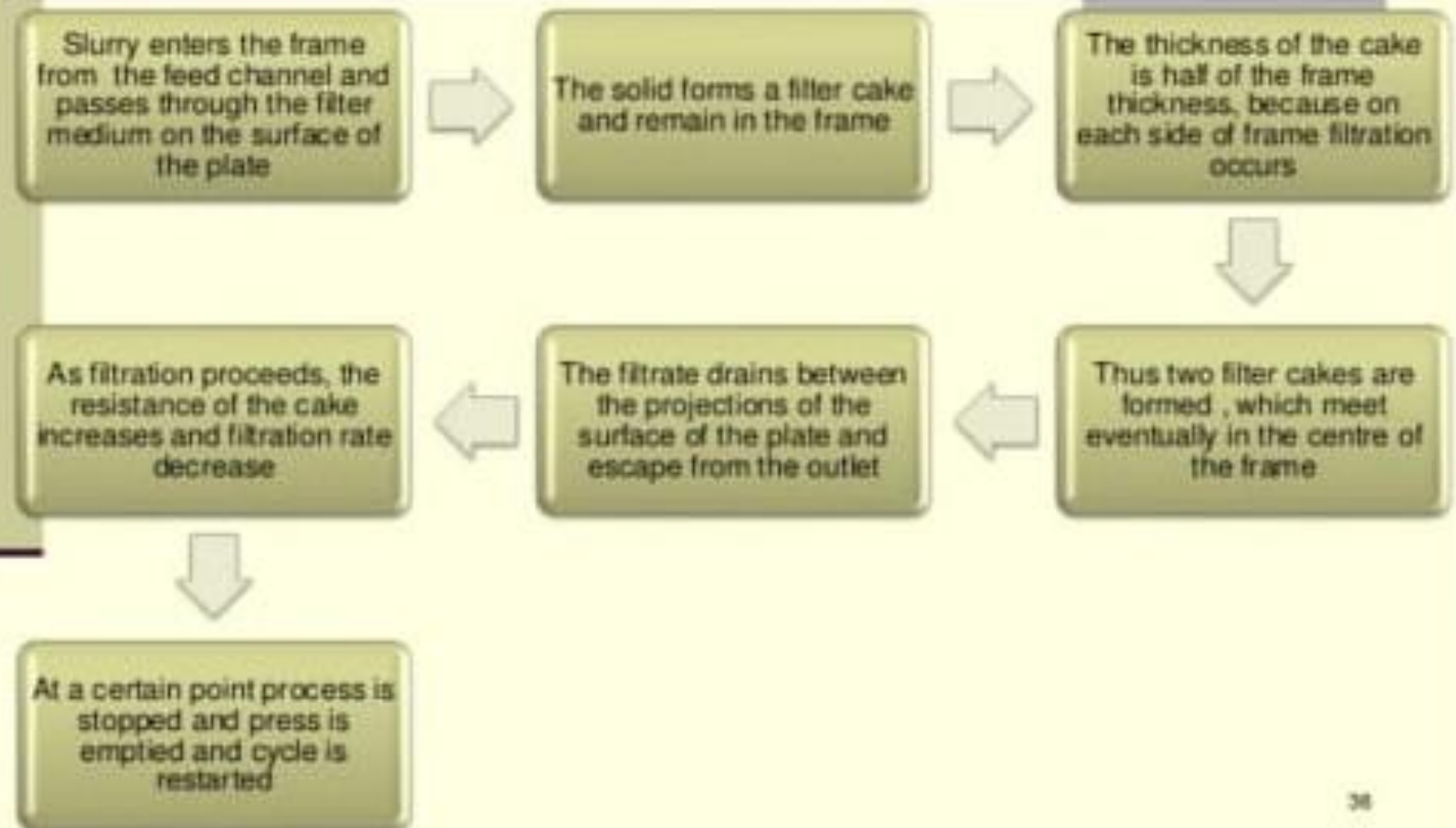


Plate and frame filter press, principle of filtration operation

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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.

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 become completely filled with washing cake.
- This helps not only in emptying the frames but also helps in washing the cake correctly.

ALL THE BEST

THANK YOU

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