

FILTRATION

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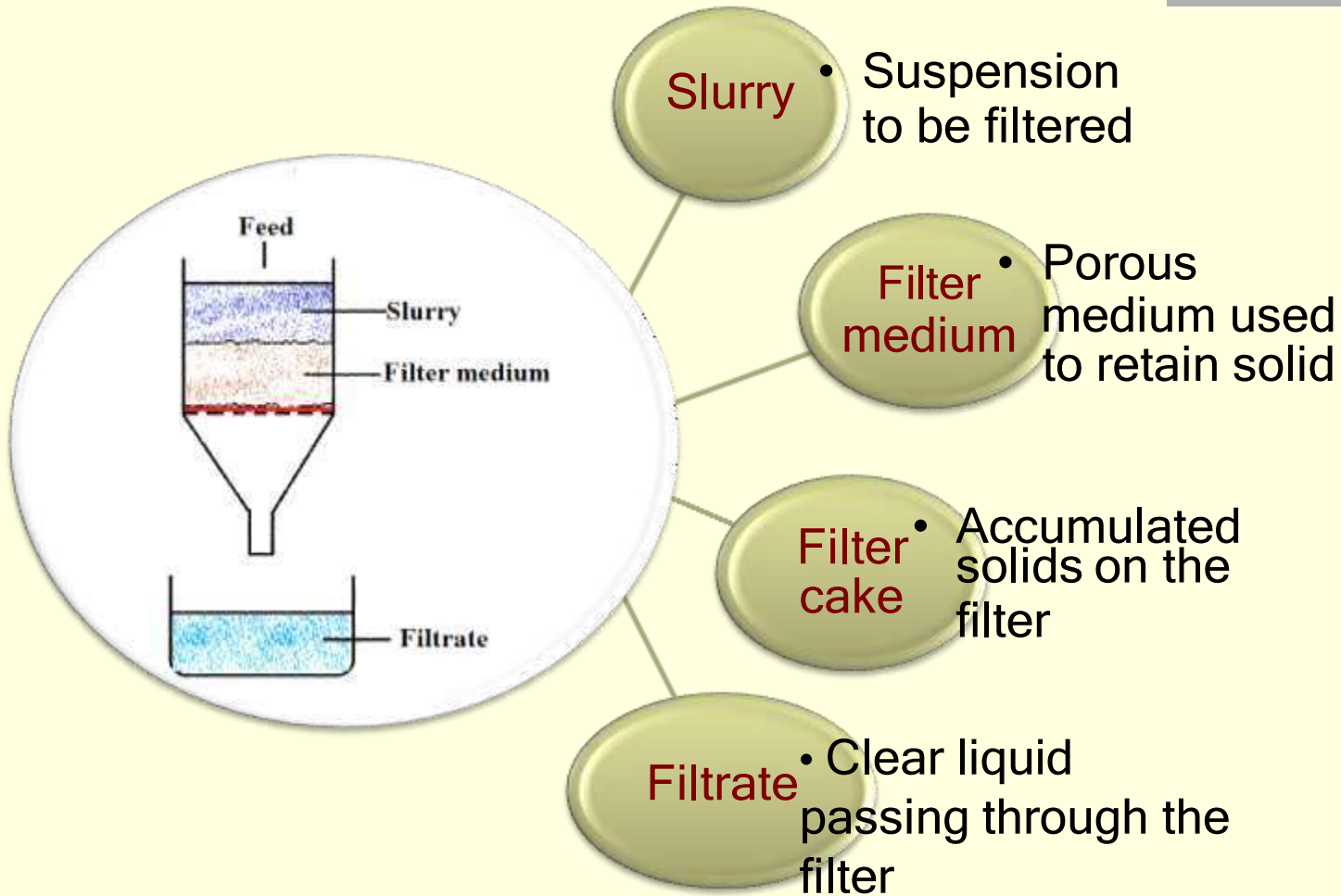
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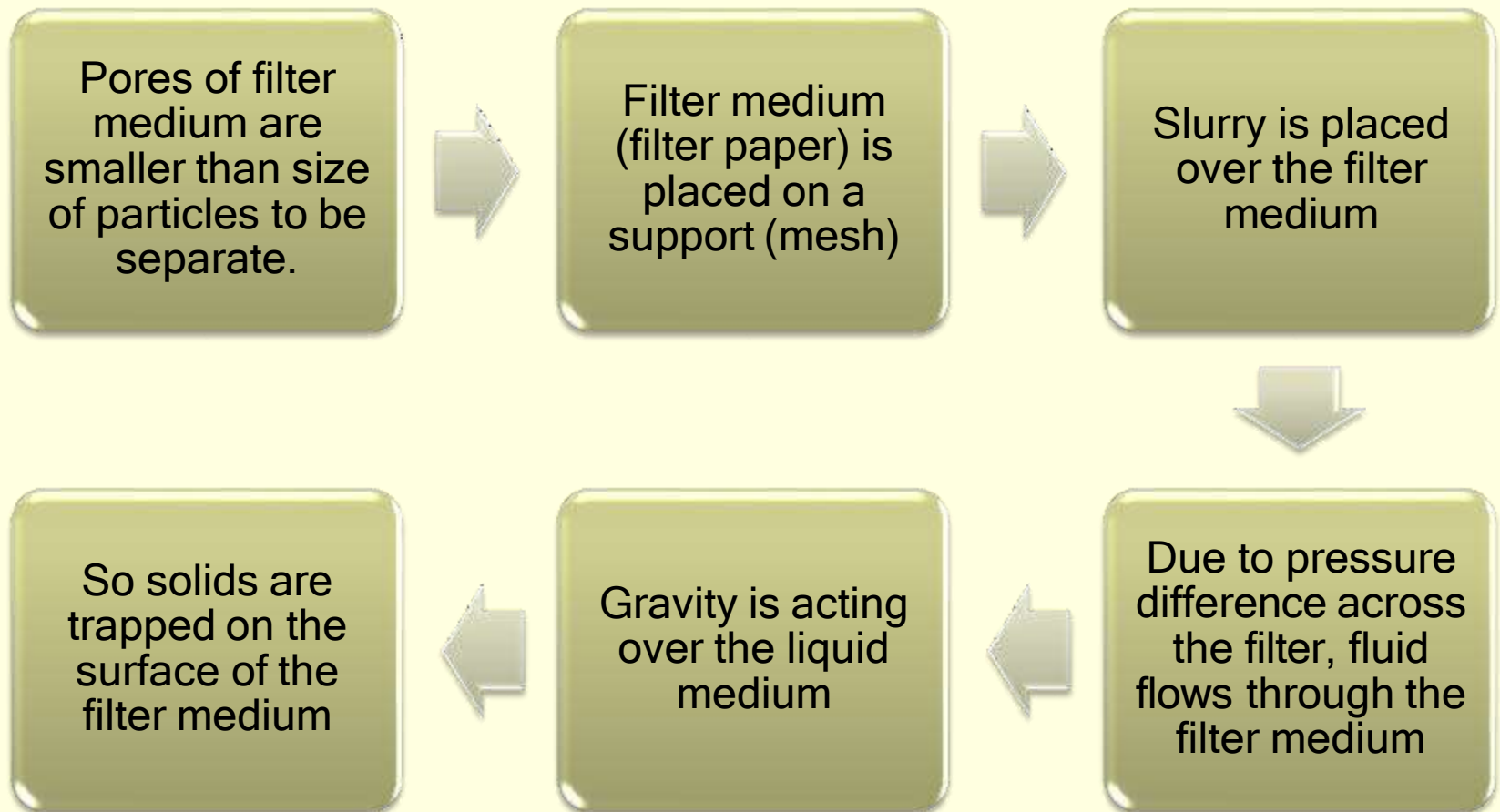
Definition

- 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.

Terms used in filtration



Process of 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

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.

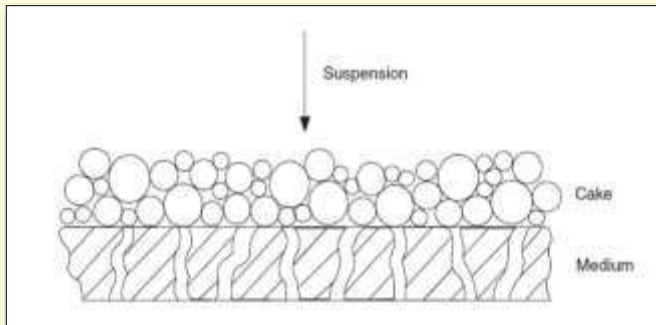
Attractive forces

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

Types of filtration

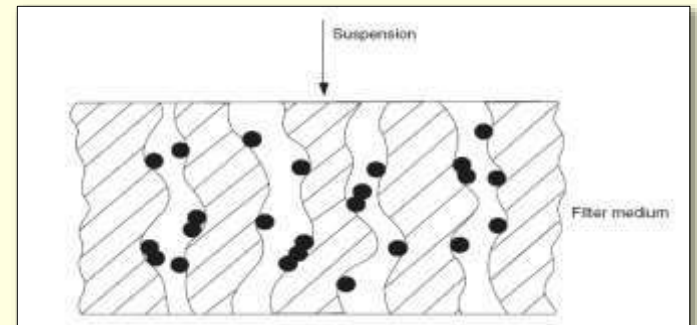
■ Surface/ screen filtration

- 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.

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

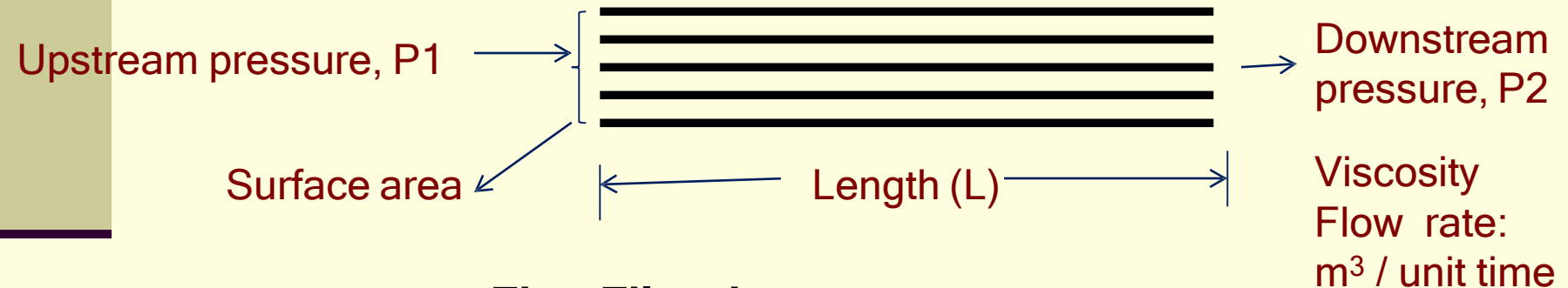


Fig.: Filtration process parameters.

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

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

Poiseuille's Equation

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

- Poiseuille's Equation is-

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

- 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

- 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.

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:

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

- 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.

Continue....

- 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

- 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,

s = porosity of cake (bed)

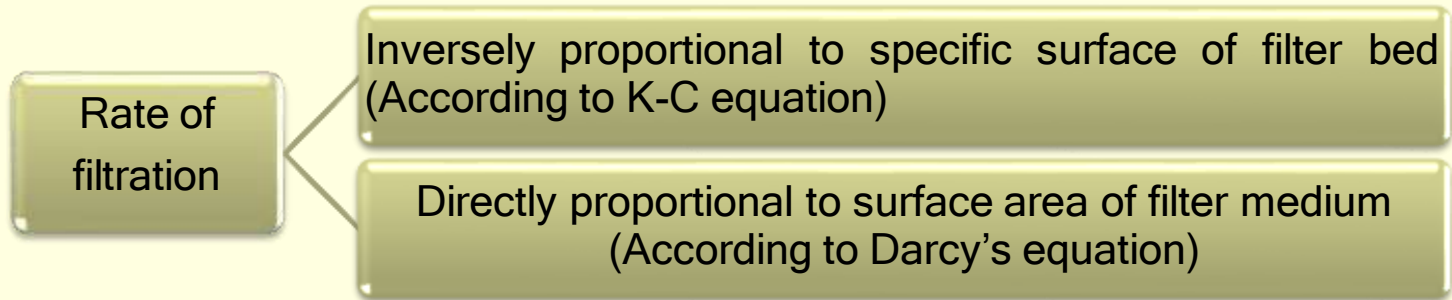
S = specific surface area of particles comprising the cake m^2 / m^3

K = Kozeny constant (usually taken as 5)

Other terms are same as previous equations.

Factors influencing filtration

1. Surface area of filter medium



Factors influencing filtration

- 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.

2. Pressure drop across the filter medium

- According to K-C equation the rate of filtration is directly proportional to the overall pressure drop across both the filter medium and filter cake.

3. Thickness of Filter Cake

4. Pore size of filter media

5. Porosity of filter cake

6. Viscosity of filtrate

- According to K-C equation rate of filtration is **inversely proportional to the viscosity of the fluid**.
- Reason behind this is an increase in the viscosity of the filtrate will increase the resistance of flow.
- This problem can be overcome by two methods:
 - The rate of filtration may be increased by raising the temperature of the liquid, which lowers its viscosity. However, it is not practicable if thermolabile materials are involved or if the filtrate is volatile.
 - Dilution is another alternative but the rate must be doubled.



Thank you!

