

Filtration

Filtration

- Filtration is a mechanical or physical process used to separate solids from liquids or gases by passing the mixture through a medium that allows only the fluid to pass while retaining the solid particles.

Objectives of Filtration

- Clarification:** To remove suspended solids from liquids or gases, making them clear.
- Concentration:** To separate and collect solids from fluids, concentrating the solid particles.
- Purification:** To remove impurities or contaminants from liquids or gases.
- Product Recovery:** To recover valuable solid materials from liquid suspensions.
- Protection:** To protect downstream equipment from damage or contamination by solid particles.

Applications of Filtration

- Water Treatment:** Removing particulate matter, pathogens, and chemical contaminants from water.
- Food and Beverage Industry:** Clarifying liquids such as wine, beer, and juices; removing impurities from cooking oils.
- Pharmaceuticals:** Sterilizing solutions by removing bacteria and other microorganisms.
- Chemical Processing:** Purifying chemical solutions and recovering catalysts.
- Environmental Engineering:** Air filtration to remove pollutants; wastewater treatment.
- Industrial Processes:** Oil filtration in machinery, filtration in mining operations, etc.

Mechanism

- Filtration is the process of separating solid particles from a liquid or gas by passing the mixture through a medium (filter) that allows the fluid to pass but retains the solid particles.
- The main mechanisms of filtration include:
 - Surface Filtration:** Particles are retained on the surface of the filter medium.
 - Depth Filtration:** Particles are trapped within the filter medium.
 - Cake Filtration:** A layer of filtered particles (filter cake) builds up on the filter medium, enhancing filtration over time.

Factors Influencing Filtration

1. **Particle Size and Distribution:** Larger particles are generally easier to filter, while a wide size distribution can complicate the process.
2. **Filter Medium Properties:** Pore size, surface area, and material of the filter medium affect the efficiency and type of filtration.
3. **Flow Rate:** Higher flow rates can lead to lower filtration efficiency as particles may pass through the filter medium.
4. **Viscosity of the Fluid:** Higher viscosity fluids are harder to filter.
5. **Temperature:** Temperature can affect fluid viscosity and the properties of the filter medium.
6. **Pressure Drop:** The difference in pressure across the filter medium influences the filtration rate.
7. **Solid Concentration:** Higher solid concentrations can lead to faster clogging of the filter medium.

Theories of filtration

1. Poiseuille's Equation

- Poiseuille's equation describes the laminar flow of a fluid through a cylindrical pipe, often applied to describe the flow through the pores of a filter medium.

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

Where:

- Q = flow rate
- r = radius of the pore
- ΔP = pressure drop across the filter
- η = viscosity of the fluid
- L = length of the pore

2. Darcy's Equation

- Darcy's equation describes the flow of a fluid through a porous medium, useful for understanding filtration through filter cakes and media.

$$Q = \frac{k A \Delta P}{\eta L}$$

Where:

- Q = flow rate
- k = permeability of the medium

- A = cross-sectional area
- ΔP = pressure drop across the medium
- η = viscosity of the fluid
- L = thickness of the medium

3. Carman-Kozeny Equation

- The Carman-Kozeny equation is an extension of Darcy's law that takes into account the characteristics of the filter cake, such as particle size and porosity.

$$\frac{\Delta P}{L} = \frac{180\eta(1 - \epsilon)^2}{d_p^2 \epsilon^3} \cdot v$$

Where:

- ΔP = pressure drop
- L = thickness of the filter cake
- η = viscosity of the fluid
- ϵ = porosity of the cake
- d_p = diameter of the particles
- v = superficial velocity of the fluid

Filter aids & filter medias

Filter Aids

Definition:

- Filter aids are inert, porous materials added to fluids or used as a precoat on filters to enhance filtration.
- They prevent clogging, improve flow rate, and enhance filtrate clarity.

Common Types:

1. **Diatomaceous Earth** – Fossil-based, highly porous, used for fine filtration.
2. **Perlite** – Expanded volcanic glass, lightweight and inert.
3. **Cellulose** – Fibrous, supports cake structure, often blended with other aids.
4. **Activated Carbon** – Adsorbs dissolved impurities, used for decolorization and odor removal.

Filter Media

Definition:

- The filter medium is the barrier through which the fluid passes, retaining solids and allowing liquid or gas to flow through.

Types of Filter Media:

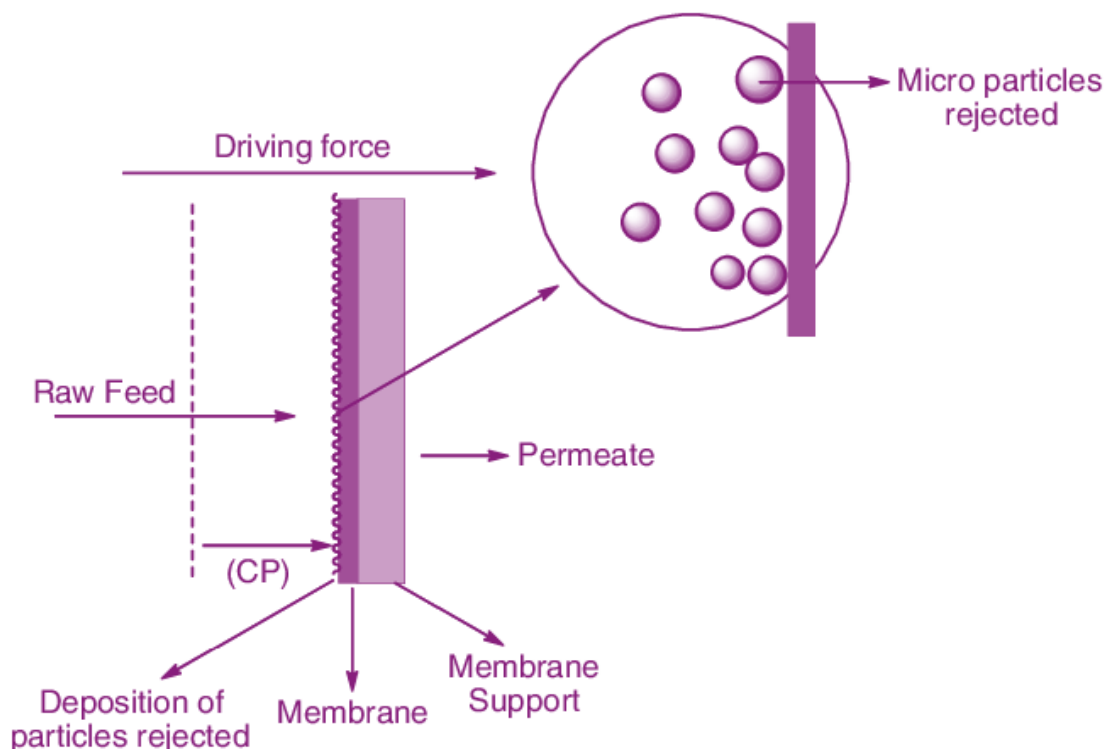
1. **Cloth Filters** – Woven fabric (cotton, nylon); used in bulk and industrial processes.
2. **Paper Filters** – Cellulose-based, disposable, used in labs and simple filtrations.
3. **Membrane Filters** – Precise pore sizes (micro to nano), used for sterile and fine filtration.
4. **Sand Filters** – Graded layers of sand; used in water treatment.
5. **Ceramic Filters** – Chemically and thermally resistant; used in hot or corrosive environments.
6. **Metal Filters** – Woven or sintered metal; reusable in high-pressure and high-temperature systems.

Membrane Filters

Principle

- Membrane filters operate on the principle of selective permeability, allowing certain molecules or particles to pass through while retaining others.
- They use a thin, semi-permeable membrane for filtration.

Construction



1. **Membrane:** Made from materials like cellulose acetate, polyamide, or polysulfone.



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