CHAPTER 5

A necessary condition for functioning of a continuous thichener is that the rate at which solids settle through every zone must be at least fast enough to accommodate the solid being delivered to that level. In the upper part of the thichener, the slurry is quite dilute, and settling is quite rapid. In the bottom, the density and solids concentration are extremely high and settling velocity is low.

If solids entering any layer do not pass through at a rate equal to that of the arrival of solids into the layer, the layer will increase in thichness, and it will grow upward until solid ultimately appears in the overflow. This particular layer is called the rate-limiting layer.

Talmadge and Fitch method to determine the minimum area

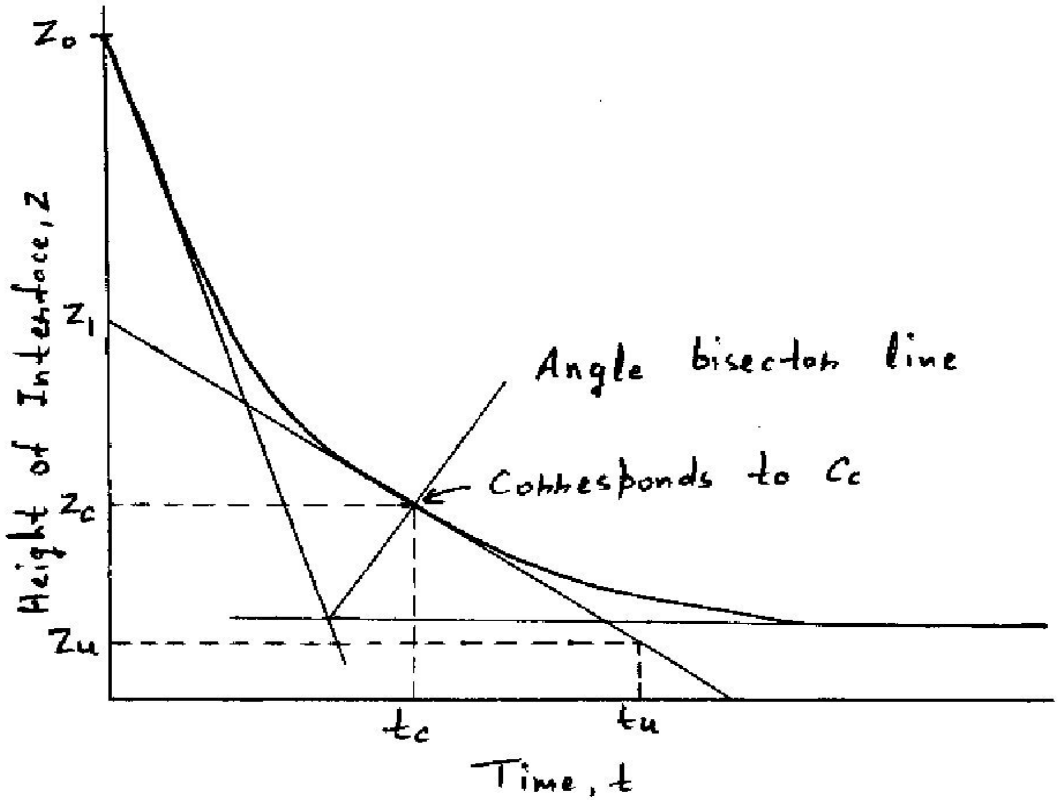
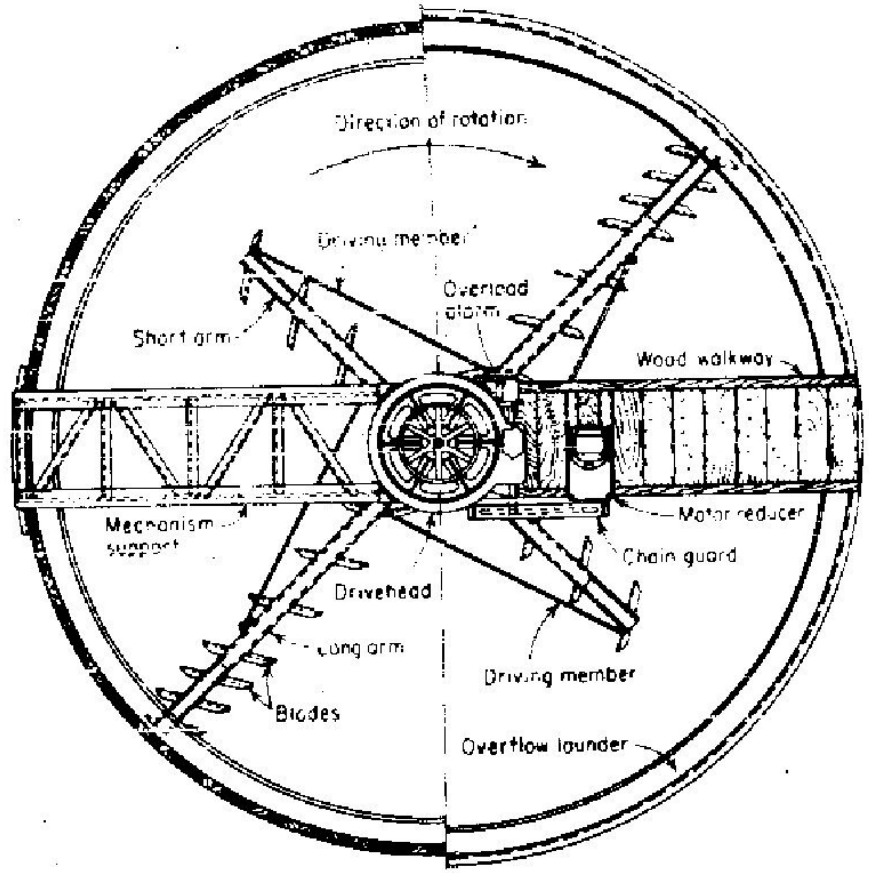


Figure : Determination of critical concentration

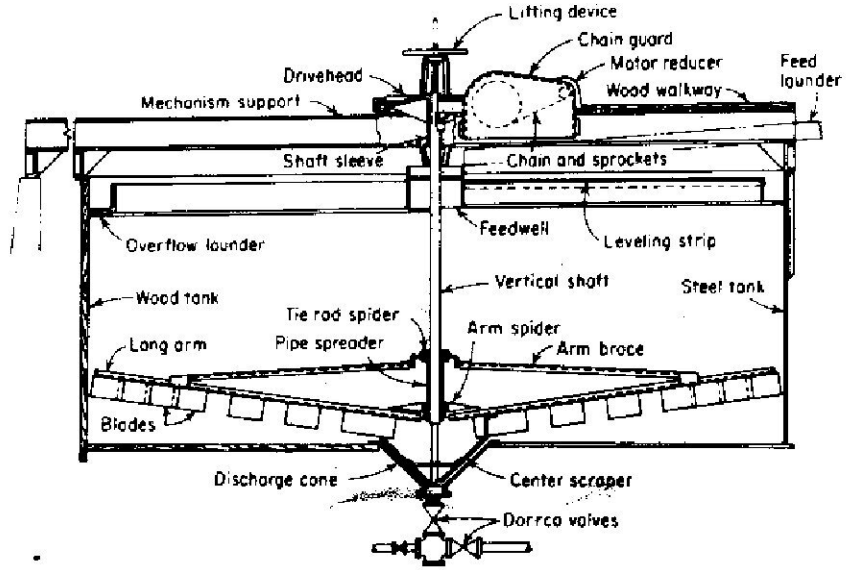
$$\text{Area } A = \frac{Q_o \cdot t_u}{z_o}$$

where Q_o = Feed volumetric flow rate

Equipment for Sedimentation; Thickeners.



PLAN



SECTION ELEVATION

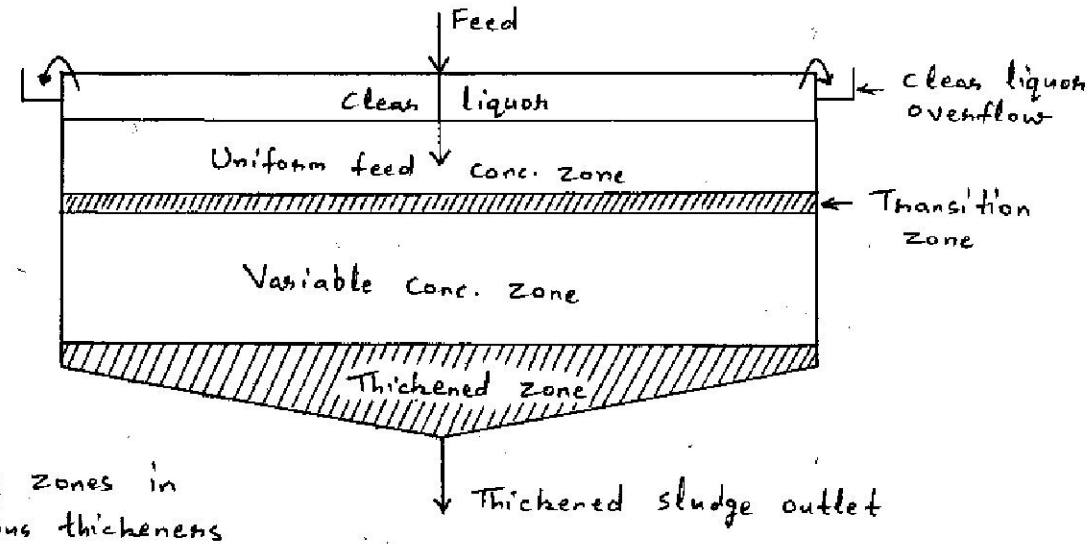


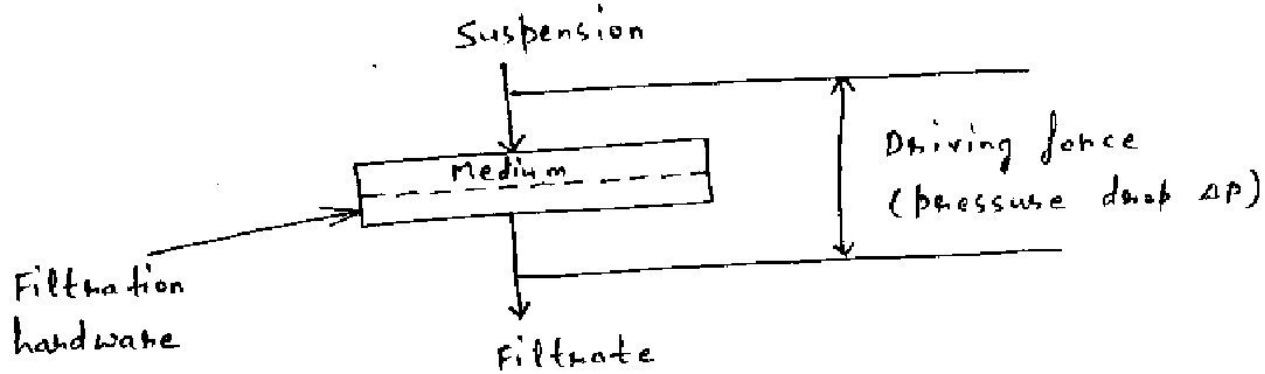
Figure : Settling zones in continuous thickeners

Thickeners are mechanical devices designed especially for continuously increasing the ratio of solid to liquid in a dilute suspension of finely sized particles by settling and decanting, producing a clear liquid and a thickened sludge as two separate products. Thickeners may be used before any ordinary filter in order to reduce filtering costs, but since both effluents are pumpable and consequently readily transported, thickeners are frequently used to wash leached solids and chemical precipitates free of adhering solution in a continuous multistage countercurrent arrangement.

The thin slurry of liquid and suspended solids enters a large settling tank through a feed well at the top center, in such a manner as to avoid mixing the slurry with the clear liquid at the top of the tank. The solids settle from the liquid which fills the tank, and the settled sludge is gently directed toward the discharge cone at the bottom by four sets of plow blades or rakes, revolving slowly to avoid disturbing the settled solid unduly. The sludge is pumped from the discharge cone by means of a diaphragm pump. The clear, supernatant liquid overflows into a launder built about the upper periphery of the tank. Thickeners are built in sizes ranging from 2 to 180 m in diameter, for handling granular as well as flocculent solids, and of varying detail design depending upon the size and service.

Filtration

Filtration may be defined as the separation of solids from liquids by passing a suspension through a permeable medium which retains the particles.



In order to obtain fluid flow through the filter medium, a pressure drop ΔP has to be applied across the medium, achieved by four types of driving forces:

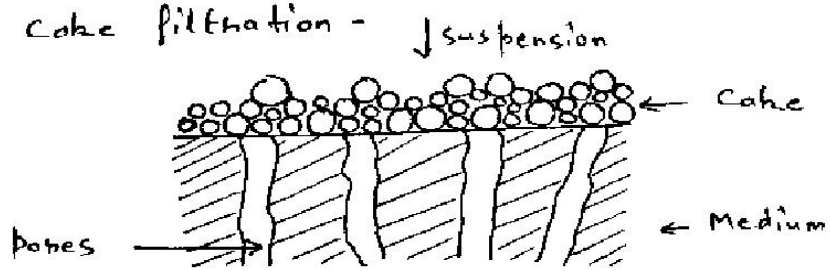
(1) Gravity
(2) Pressure
(3) Vaccum
(4) Centrifugal

Filtration Mechanism

(1) Cake filtration

(2) Deep bed filtration

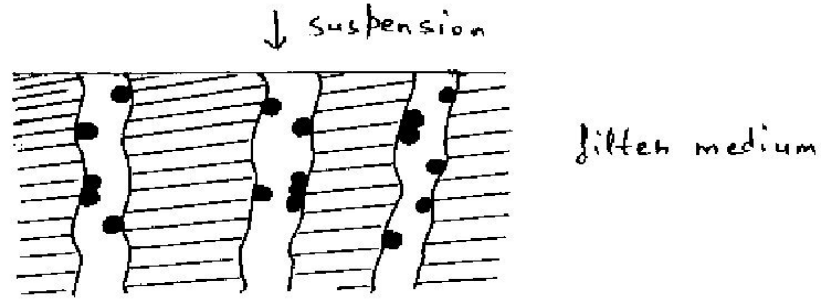
1. Cake filtration -



Cake filtration, in which the solids are deposited in the form of cake on the up-stream side of a relatively thin filter medium. The filter cake thus formed functions as a medium for the filtration of subsequent (following) input suspension. The filter medium has a relatively low pressure drop.

- high concentration of solids, above 1% by volume.

2. Deep bed filtration -

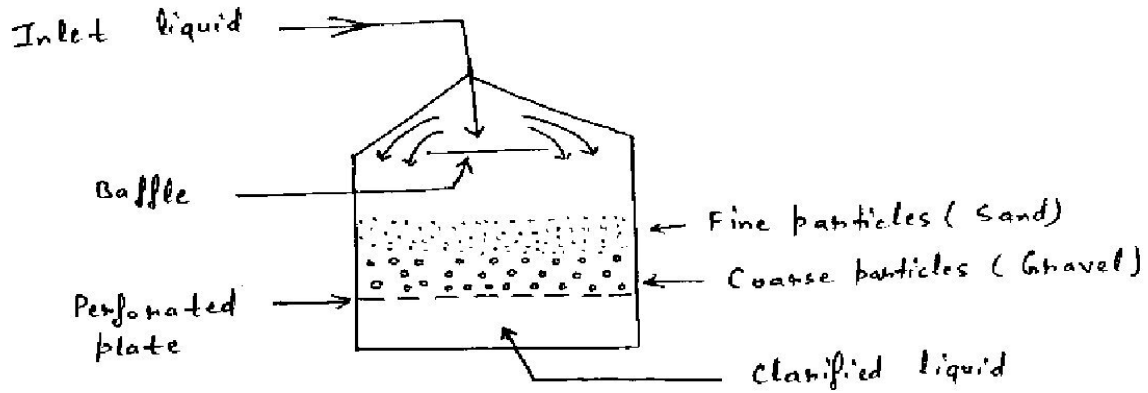


Permeate - To pass through the holes.

Deep bed filtration, in which the particle deposition takes place inside the medium and cake deposition on the surface is undesirable. In this type the particles are smaller than the medium openings, hence they proceed through long pores where they are collected and attached to the medium.
Used with very dilute suspension of fine particles, less than 0.1 % by volume.

Filtration equipments

1. Bed Filter (mechanism - deep bed filtration)
(driving force - gravity)



The simplest type of filter is the bed filter. This type is useful mainly in cases where relatively small amounts of solids are to be removed from large amounts of water. Often the bottom layer is composed of coarse pieces of gravel resting on a perforated plate. Above the gravel is fine sand, which acts as the actual filter medium. Water is introduced at the top onto a baffle which spreads the water out. The clarified liquid is drawn out at the bottom.

The filtration continues until the precipitate of filtered particles has clogged the sand so that the flow rate drops. Then the flow is stopped and the water introduced in the reverse direction so that it flows upward, backwashing the bed and carrying the precipitated solid away. This apparatus is used only on precipitates that do not adhere strongly to the sand and can be easily removed by backwashing. Open tank filters are used in filtering municipal water supplies. It can produce filtrates containing only 5 mg/l or less of suspended matter.

Rate of filtration : 100 - 300 gallon / ft^2 - hr.

Media range : 0.4 - 2.5 mm. and can be graded in various layers (dual media or multimedia)

Thickness of the layers : 0.6 - 1 m. (2 ft - 3.3 ft.)

1. Filter efficiency depends on particle size, density and shape.
2. Small particles give higher efficiencies, and angular grains are better than spherical.

3. Higher flow velocities give lower efficiencies.
4. Filtration is more efficient at higher water temperatures, principally due to lower viscosity.
5. Downflow is more efficient than upflow for gravity-dominated transport mechanisms.

2. Plate-and-Frame filter press
(Driving force - pressure)

Many suspensions of solids in liquids are difficult to separate by gravitational, centrifugal or vaccum techniques due to their slow settling characteristics, poor filtrability, or high solids contents. Under these conditions large separating areas may prove necessary and this, together with a relatively high driving force, can be provided by pressure filtration equipment. The driving force for filtration is fluid pressure generated by pumping.

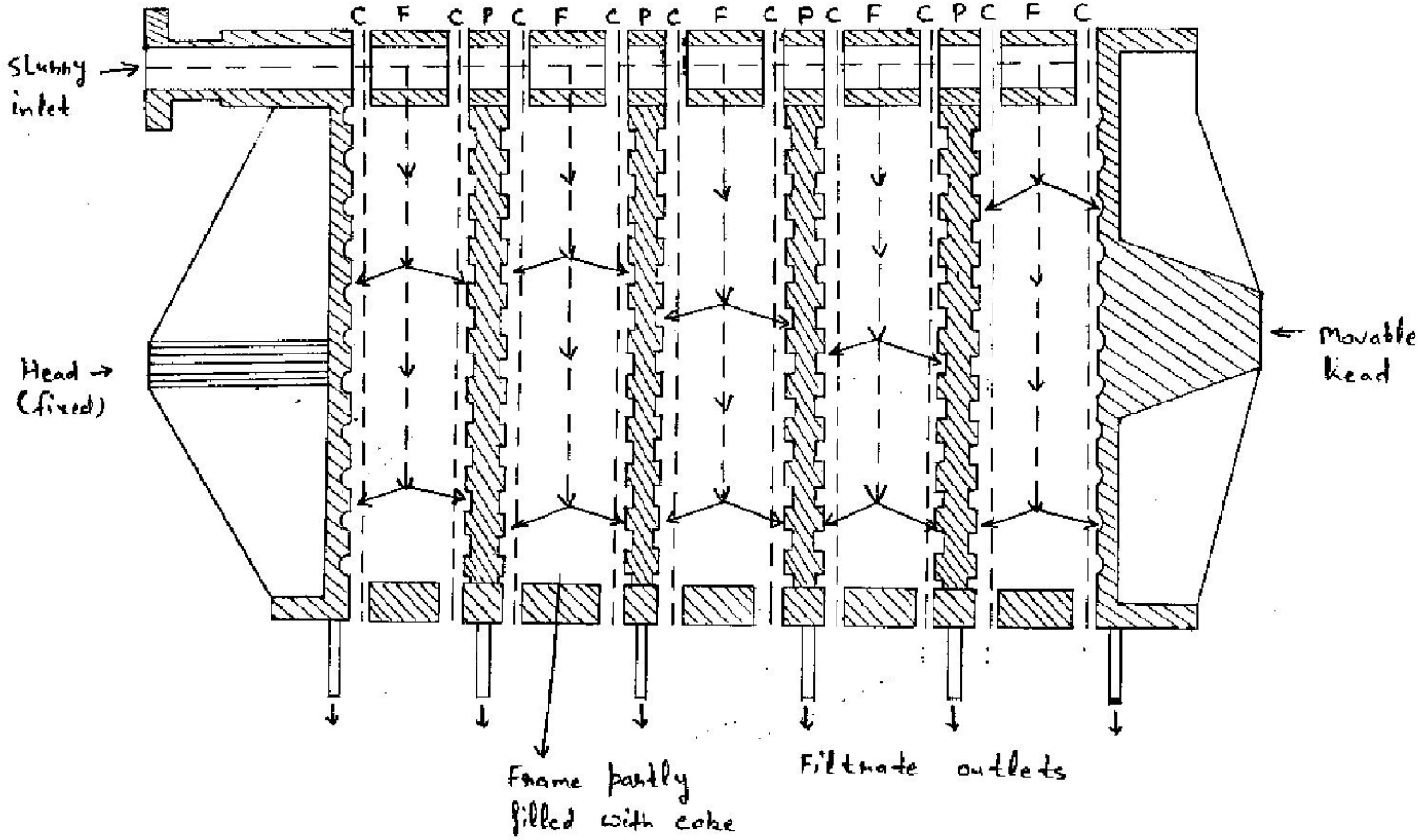


Fig: Schematic diagram of plate-and-frame filter press

C = Filter cloth

F = Frame

P = Plate

A filter press contains a set of plates designed to provide a series of chambers/compartments in which solids may collect. The plates are covered with filter cloth on both sides. Slurry is admitted to each of the chamber under pressure; Liquor passes through the filter medium (cloth) and out from discharge, leaving a wet cake of solids behind.

Slurry enters at one end of the assembly from a pump under a pressure of 3 - 10 atm. It passes through a channel running lengthwise through one corner of the assembly. Auxiliary channels carry slurry from the main inlet channel in to each frame. Here the solids are deposited on the frame-side faces of the filter cloth. Liquor passes through the cloth, down grooves in the plate faces, and out of the press.

Filtration is continued until liquor no longer flows out the discharge or the filtration pressure suddenly rises. These occur when the frames are full of solid and no more slurry can enter. The press is then said to be jammed.

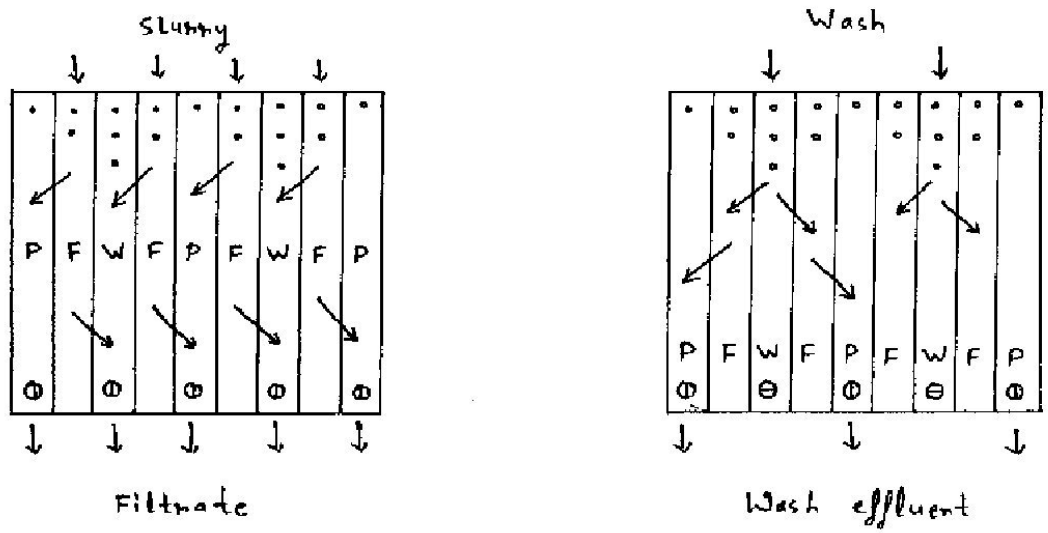
(1) Now the frames and plates are separated and the cake removed.

Then the filter press is reassembled and the cycle is repeated.

or

(2) If the cake is to be washed, the cake is left in the frames and thorough washing is performed. In filter press, a separate channel is provided for the wash water inlet. The wash water enters the inlet, which has openings behind the filter clothes at every other plate of the filter press. The wash water then flows through the filter cloth, through the entire cake, through the filter cloth at the other side of the frames, and out the discharge channel.

There are two kinds of plates: those having ducts (a tube or pipe) to admit wash water behind the filter cloth alternating with those without such ducts.



P = Plate F = Frame W = Washing plate

plates are usually square in shape.

Size range : 150 mm square - 1830 mm square
Upper limit is generally about 1220 mm square.

Plate material : Rubber or PVC - coated steel or wood. Timber used may be resin coated otherwise it will tend to absorb large quantities of moisture causing it to swell.

Usually, screw or hydraulic rams are used to close the press by pushing the plates and frames together against a fixed end plate. Closing pressures are adjusted to minimize edge filtration (leakages from the edges of the filter cloths) while minimizing cloth degradation at the gasket surface.

3. Leaf Filter

(Driving force - pressure)

The main disadvantage with plate and frame filter press is that it is not economical for handling large quantities of sludge or for efficient washing with a small amount of wash water. The leaf filter was developed for large volumes of slurry and more efficient washing.

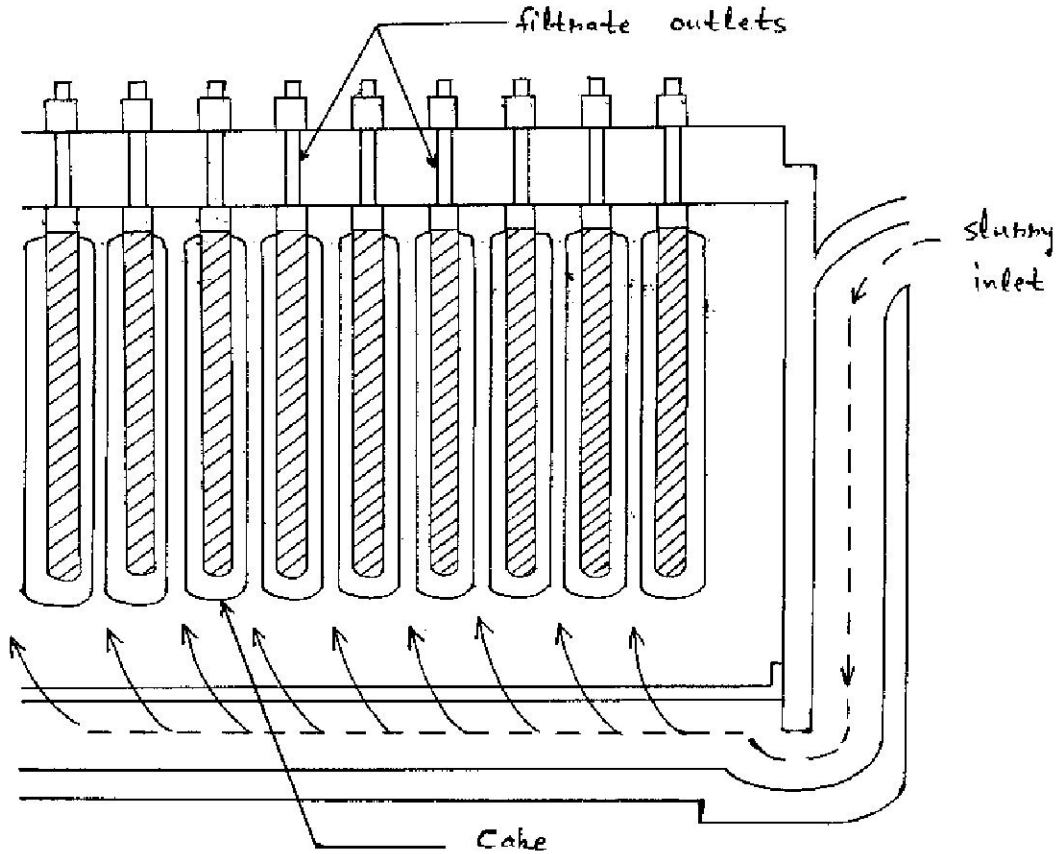


Figure : Leaf filter

Leaf is a hollow wire framework covered by a sack of filter cloth. A number of these leaves are hung in parallel in a closed tank. The slurry enters the tank and is forced under pressure through the filter cloth, where

Sack - बोरा, जवाला

the cake deposits on the outside of the filter cloth. The filtrate flows inside the hollow framework and out a header. The wash liquid follows the same path as the slurry. Hence, the washing is more efficient than the through washing in plate-and-frame filter presses. Sometimes, air is blown in the reverse direction into the leaves to help in dislodging the cake. If the solids are not wanted, water jets can be used to simply wash away the cakes without opening the filter.

4. Continuous rotary filter

(Driving force - Vaccum)

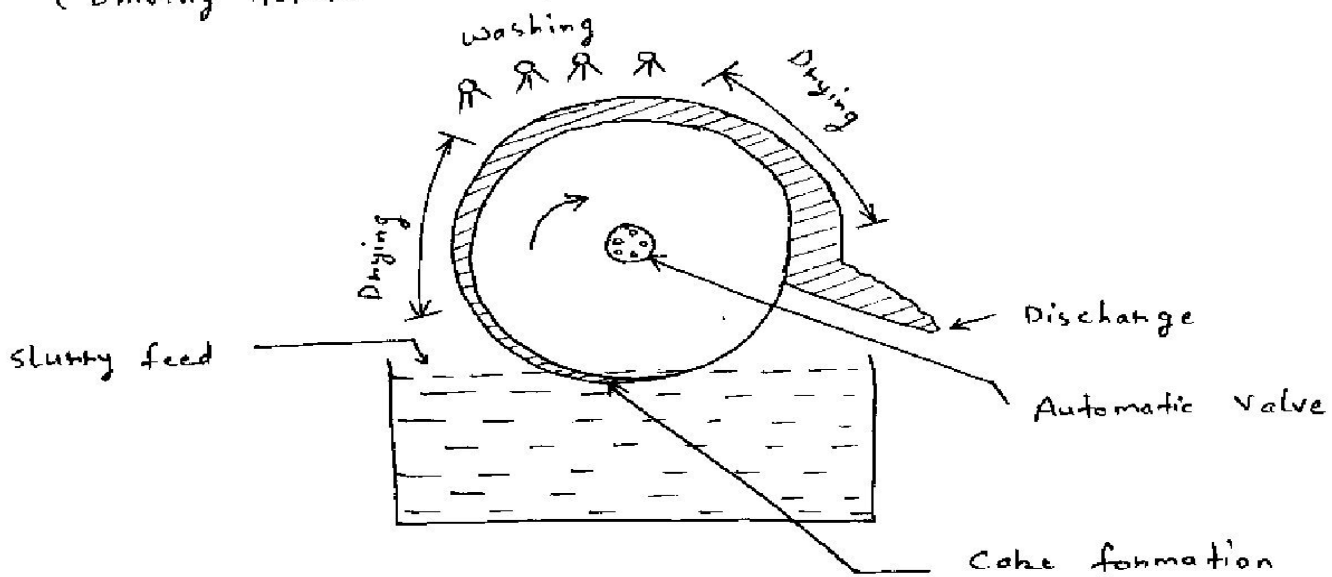


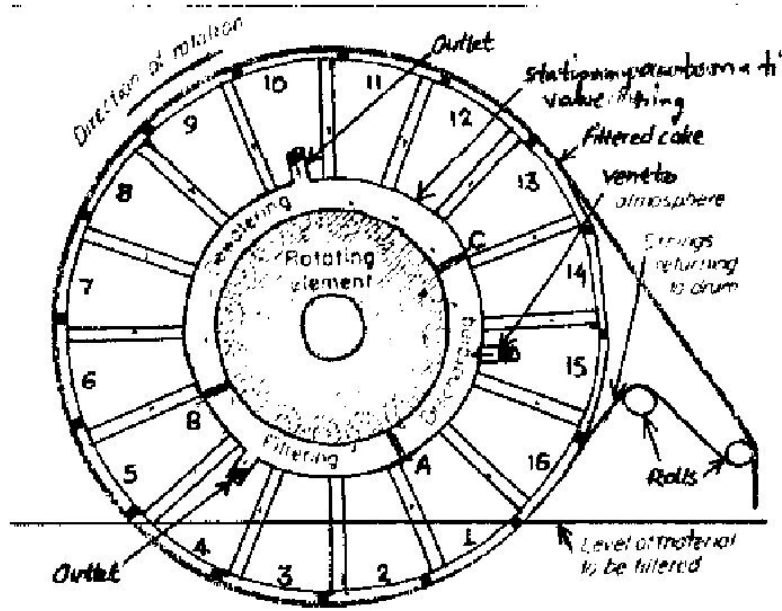
Figure : Schematic of continuous rotary-drum filter.

The Plate- and- Frame and Leaf filters suffer from the disadvantage of batch type process. The continuous rotary vaccum filter filters, washes, and discharge the cake in a continuous repeating sequence. The drum is covered with a suitable filtering medium. The drum rotates and an automatic valve in the center serves to activate the filtering, drying, washing and cake discharge functions in the cycle. The filtrate leaves through the axle of the filter. The automatic valve provides separate outlets for the filtrate and the wash liquid.

Section 1-4 : filtenation

Section 5-12 : Dewatering

Section 13 : Discharging the cake



Section 14-16 : ready to start a new cycle.

Factors affecting the rate of filtration

1. The drop in pressure from the feed to the far side of the filter medium.
2. The area of the filtering surface.
3. The viscosity of the filtrate.
4. The resistance of the filter cake.
5. The resistance of the filter medium and initial layers of cake.

Filter media :

The choice of filter media is the single most important factor that determines the satisfactory operation of a filter.

The primary characteristics of a good filter are :

1. It should prevent the slippage of fine suspended particles to the filtrate.
2. Minimum resistance to the rate of filtration ensuring high rate of production.
3. Enough strength to withstand filtration pressure.

THANKS