

## Chapter 11

### JUICE EXTRACTION AND FILTRATION

(Juice extraction method and equipment, Filtration, Plate and frame filter press, Shell and leaf filter)

#### JUICE EXTRACTION METHOD AND EQUIPMENT

The juice extraction from fruits and vegetables can be done by size reduction methods as crushing, chopping and comminuting. This is usually employed for fruits that are fully ripened and too soft for whole or diced or sliced packs.

The following points must be remembered in such situations.

- Crushing of products by chopping them into small pieces (0.025-0.075 inch) prior to heating speeds enzyme activity. Hence it is required to remove the air at the time of crushing and immediately after comminuting.
- Therefore, direct super heated steam introduction into the chopper or crusher is applied.
- Super heated steam aids in creating a partial vacuum. So superheated steam preferably under a vacuum will eliminate the air and aid immensely in creating a better consistency in the final product.

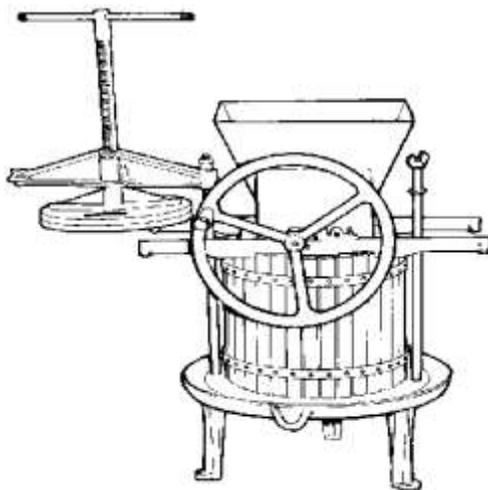
The equipment used for separation of the pulp is known as a pulper, where mainly the compression force is used. Basket press is a common equipment for taking out juice from soft fruits as oranges.



**Fig. 11.1 Hand operated pulp extractor**



**Fig. 11.2 Motor operated pulper**

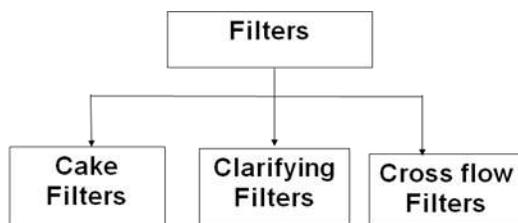


**Fig. 11.3 Basket press**

## **FILTRATION**

Filtration is the removal of solid particles from a fluid by passing the fluid through a filtering medium (or septum) on which the solids are deposited. The fluid may be a liquid or a gas. The feed is usually modified to increase the filtration rate (by heating, recrystallizing, or adding a filter aid). Because of enormous variety of materials to be filtered and the widely differing process conditions, many types of filters are used.

Filters can be classified broadly as cake filters, clarifying filters and cross flow filters.



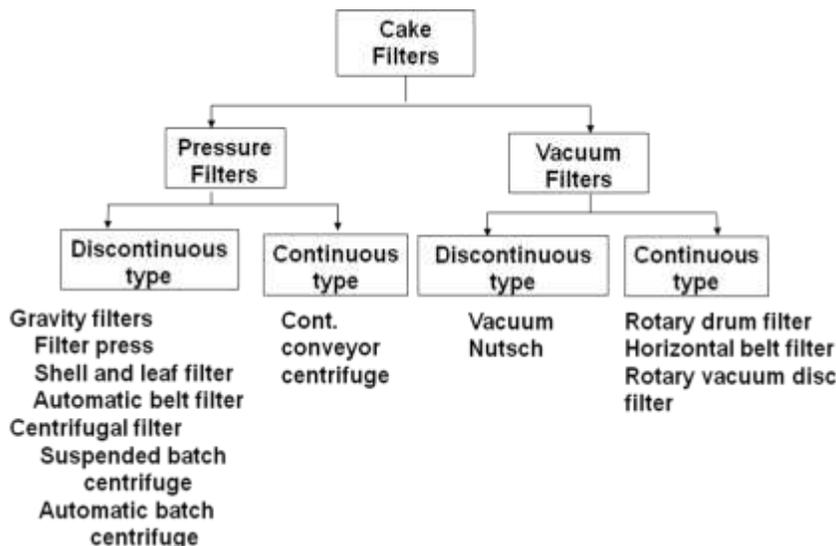
**Fig. 11.4 Classification of filters**

Cake filters separate large amounts of solids in the form of cake or crystals or sludge. Here the filter medium is relatively thin compared with that of a clarifying filter. At the start of the filtration, some solid particles enter the pores of the medium and are immobilized, but soon they begin to collect on the septum surface. After this initial period, the cake of solids does the filtration, not the septum. As the cake builds up to an appreciable thickness on the surface, it has to be removed periodically.

Further categorization of cake filters are shown in the Fig. 11.5. The filters may be continuous or discontinuous types depending on whether the discharge of filtered solids is steady or intermittent. During much of the operating cycle of a discontinuous filter, the flow of fluids through the device is continuous, but it must be interrupted periodically to permit discharging the accumulated solids. In a continuous filter, the discharge of both solids and fluids is not interrupted as long as the equipment is in operation.

Pressure filters are usually discontinuous; vacuum filters are usually continuous. Pressure filters can be either gravity filters or centrifugal filters depending on whether a pump or blower or centrifugal force is used to develop pressure on the upstream side. In vacuum filters the vacuum is maintained on the downstream side.

The clarifying filters remove small amounts of solids to produce a clean gas or sparkling clear liquid such as beverages. These are also known as deep bed filters, because the particles of solids are trapped inside the filter medium and usually no layer of solid can be seen on surface of the medium. The examples are cartridge filter and ultra filter.



**Fig. 11.5 Classification of cake filters**

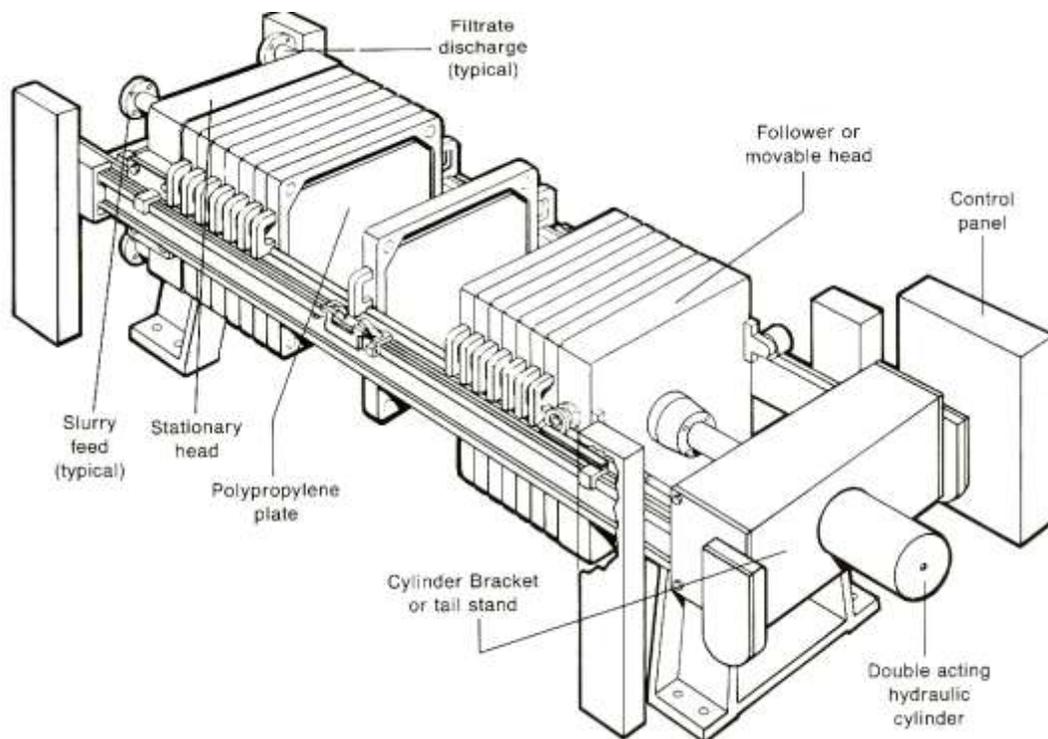
In case of cross flow filters, the feed suspension flows under pressure at a fairly high velocity across the filter medium. A thin layer of solids may form on the surface of the medium, but the high velocity keeps the layer from building up.

## Plate and frame filter press

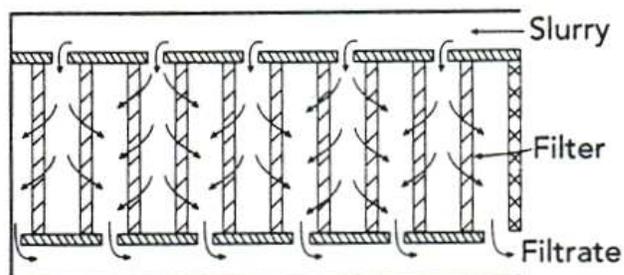
The characteristic features are as follows.

### Construction and operation

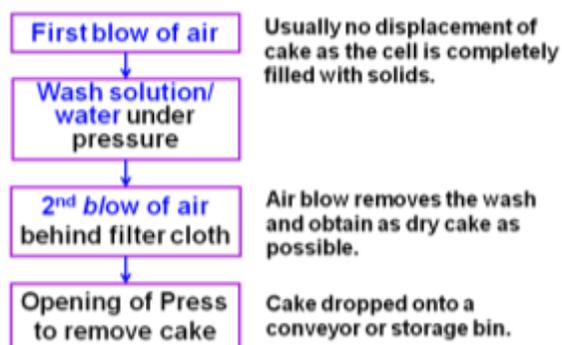
- It consists of plates and frames arranged alternatively and supported on a pair of rails. The plates have ribbed surfaces and the hollow frames are separated from the plates by filter clothes, i.e. the set of plates are designed to provide a series of chambers in which solids are collected.
- The plates may be square or circular, vertical or horizontal, and may be 6 to 50 mm thick. Usually square plates are used and the size may be 0.15 m to 2 m on a side. In many cases, the compartments for solids are formed by recesses in the faces of molded polypropylene plates.
- The press is closed by means of a hand screw or a hydraulic press.
- The feed channel is formed by a hole in each plate and frame, these holes registering together. Slurry enters through this channel running length wise through one corner of the assembly.
- In each frame there is an opening from this channel that admits feed into the frame and at the bottom of each plate there is an outlet for the filtrate. Liquor passes through the cloth, down grooves or corrugations in each faces, and out of the press.
- During filtration, the solids quickly form a thick cake at low pressure (1.5-3.2 kg/cm<sup>2</sup> gauge pressure) on the cloth covered faces of the plates.
- The filtration is continued until the frames are completely filled, i.e. when the filtrate ceases to flow from the drain cock at the bottom. This is known as solid filling or the press is said to be jammed.
- Filling may be followed by blowing of air to expel solution before wash is applied. At that time no displacement of cake occurs as the cell is completely filled with solids.
- Then washing is carried out by admitting wash solution or water under pressure behind the filter cloth of each alternate plate.
- An air blow may be given again to remove the wash and obtain as dry cake as possible.
- The press is then opened, cake removed and dropped onto a conveyor or storage bin. Slurry is admitted to each compartment under pressure; liquor passes through the canvas and out a discharge pipe, leaving the wet cake of solids behind.



**Fig. 11.6 Plate and frame filter press**



**Fig. 11.7 Flow pattern in a Plate and frame filter press**



**Fig. 11.8 Removal of solid filling in a plate and frame filter press**

### Salient features

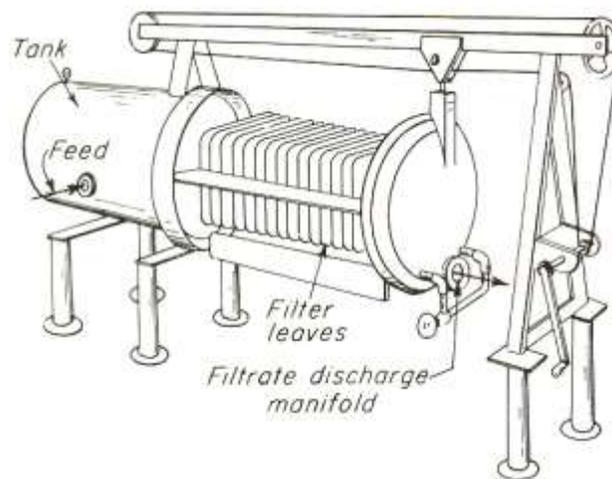
- It involves low capital cost, high flexibility for different types of products, and can be easily maintained.
- The dryness of the cake is one major advantage with the plate and frame press.
- The disadvantage associated with this system is the intermittent operation since the presses must be taken away and cleaned by hand at the end of each cycle.

**Application:** This is widely used for production of apple juice and cider, other juices, and filtration of oil.

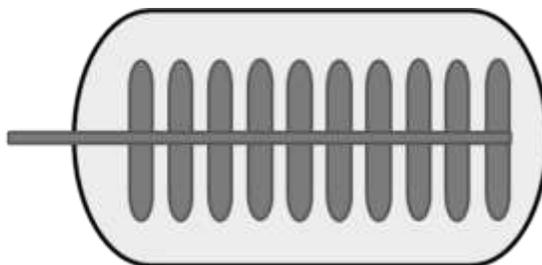
### Shell and leaf filter

#### Construction and operation

- It consists of a set of vertical mesh leaves held on a retractable tract.
- The leaves are coated in filter medium and supported on a hollow frame which forms the outlet channel for the filtrate.
- The leaves are stacked vertically or horizontally inside a pressure vessel.
- During operation, the leaves are inside the closed tank; feed enters through the side of the tank; feed liquor is pumped into the shell at a pressure of approx.  $400 \times 10^3$  Pa. and filtrate passes through the leaves into a discharge manifold.
- The cake is blown or washed from the leaves after completion of the filtration operation.
- In some designs the set of leaves rotate at 1-2 rev/min to improve the uniformity of cake build up.



**Fig. 11.9 Shell and leaf filter**



**Fig. 11.10 Leaves arranged in the shell**

### **Salient features**

- It involves higher cost than the plate filters.

### **Application**

The shell and leaf filter is widely used for filtration involving the filter aids. Besides, the shell and leaf filter is used under following conditions:

- For filtration under higher pressures than are possible in a plate and frame filter.
- To economize on labor.
- When more effective washing of the cake is necessary.

Besides there are also other common types of filters as automatic belt filter, suspended batch centrifuges, automatic batch centrifuges, continuous filtering centrifuges, rotary drum filter, horizontal belt filter and clarifying filters, etc. which have been explained in the '*Manual of Food Engineering Equipment*' by the same author.

## **CHECK YOUR PROGRESS**

- 1) Explain the working principles of different types of commercial juicers.
- 2) Explain the working principle of a plate and frame filter press with suitable sketches.
- 3) Explain the working principle of a shell and leaf filter with suitable sketches.