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Topic: Introduction to Evaporator

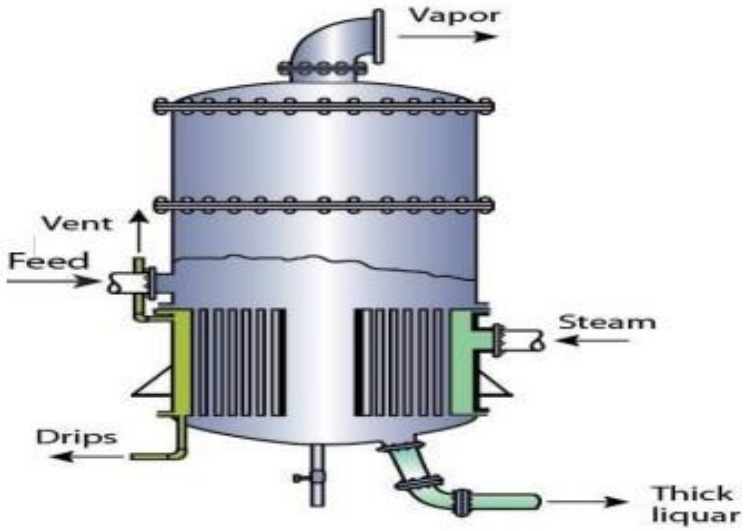
INTRODUCTION:

Evaporation is the removal of solvent as vapor from a solution. The aim is to concentrate a non-volatile solute, such as organic compounds, inorganic salts, acids or bases from a solvent. Common solutes are caustic soda, caustic potash, sodium sulfate, sodium chloride, phosphoric acid, and urea. The most common solvent in most of the evaporation systems is water. Evaporation is normally stopped before the solute starts to precipitate in the operation of an evaporator.

TYPE OF EVAPORATORS:

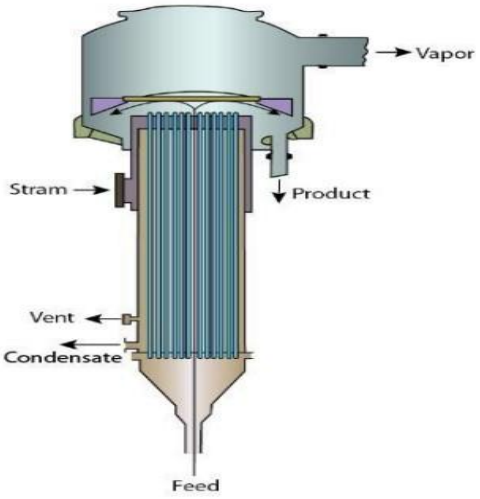
Short-Tube Vertical Evaporators

Short-tube vertical evaporators are the oldest but still widely used in sugar industry in evaporation of cane-sugar juice. These are also known as calandria evaporators. It became so common in process industry that this evaporator is sometimes known as standard evaporator. Short-tube vertical evaporators consist of a short tube bundle (about 4 to 10 ft in length) enclosed in a cylindrical shell. This is called calandria. The feed is introduced above the upper tube sheet and steam is introduced to the shell or steam chest of the calandria. The solution is heated and partly vaporized in the tubes. The central tube in a calandria is of longer diameter. Typically it's downcomer area is taken as 40 to 70% of the total cross sectional area of tubes. The circulation rate through the downcomer/downtake is many times the feed rate. The flow area of the downtake is normally approximately equal to the total tubular flow area.



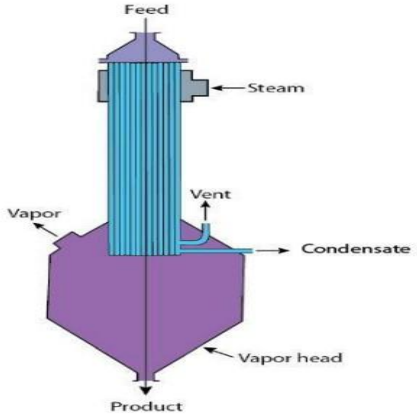
Long-Tube Vertical Evaporators

This is another most widely employed natural circulation evaporator because it is often the cheapest per unit of capacity. The long vertical tube bundle is fixed with a shell that extends into a larger diameter vapor chamber at the top. The long-tube vertical (LTV) evaporator consists of one pass shell and tube heat exchanger. In this type of evaporator, the liquid flows as a thin film on the walls of long (from 12 to 30 feet in length) and vertical heated tube. Both rising film and falling types are used. Tube length usually varies from 20 to 65 ft. The main advantage of this type of evaporators is higher heat transfer rate. The feed enters at the bottom and the liquid starts boiling at lower part of the tube. The LTV evaporators are commonly used in concentrating black liquors in the paper and pulp industries.



Falling Film Evaporators

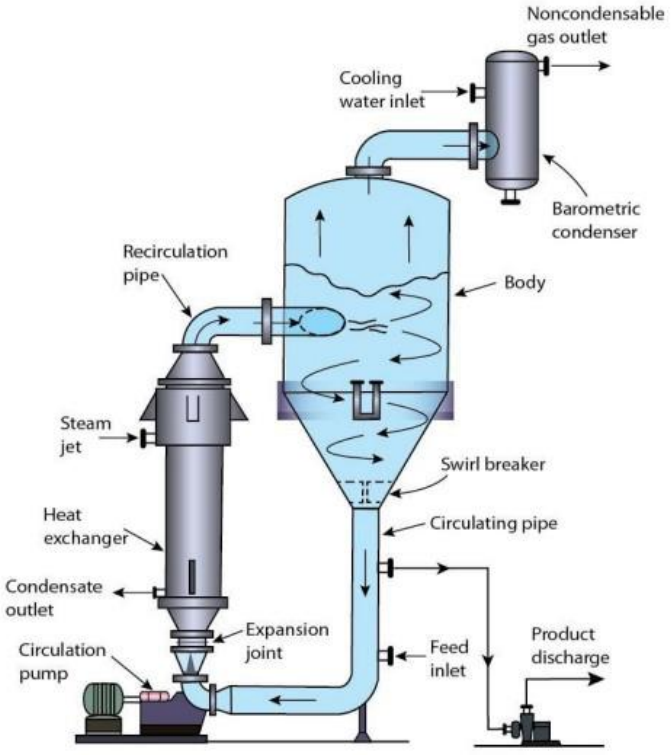
In a falling film evaporator, the liquid is fed at the top of the tubes in a vertical tube bundle. The liquid is allowed to flow down through the inner wall of the tubes as a film. As the liquid travels down the tubes the solvent vaporizes and the concentration gradually increases. Vapor and liquid are usually separated at the bottom of the tubes and the thick liquor is taken out. Evaporator liquid is recirculated through the tubes by a pump below the vapor-liquid separator. The distribution of liquid in the inner wall of the tubes greatly affects the performance of this type of evaporator. The falling film evaporator is largely used for concentration of fruit juices and heat sensitive materials because of the low holdup time. The device is suitable for scale-forming solutions as boiling occur on the surface of the film.



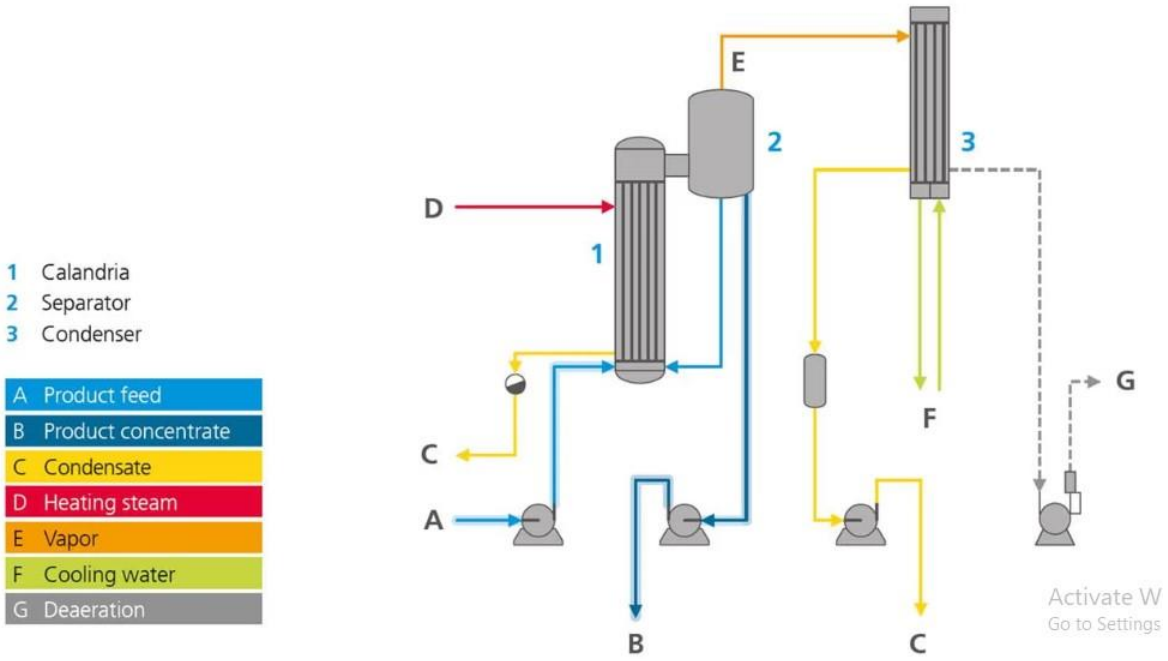
Forced Circulation Evaporators

Forced circulation evaporators are usually more costly than natural circulation evaporators. However the natural circulation evaporators are not suitable under some situations such as: - highly viscous solutions due to low heat transfer coefficient - solution containing suspended particles and for heat sensitive materials All these problems may be overcome when the liquid is circulated at high velocity through the heat exchanger tubes to enhance the heat transfer rate and inhibit particle deposition. Any evaporator that uses pump to ensure higher circulation velocity is called a forced circulation evaporator. The main components of a forced circulation evaporator are a tubular shell and tube heat exchanger (either horizontal or vertical), a flash chamber (separator) mounted above the heat exchanger and a circulating pump.

The solution is heated in the heat exchanger without boiling and the superheated solution flashes off (partially evaporated) at a lower pressure are reduced in the flash chamber. The pump pumps feed and liquor from the flash chamber and forces it through the heat exchanger tubes back to the flash chamber. Forced circulation evaporator is commonly used for concentration of caustic and brine solutions and also in evaporation of corrosive solution.



Natural Circulation Evaporator



The liquid is fed to the bottom of the heating tubes. Due to the external heating of the tubes the liquid film on the inside walls of the tubes starts to boil and evaporates partially.

As a result of the upward movement of the vapors produced, the liquid is also transported upwards – according to the thermosiphon or rising film principle. After the separation from the vapors it flows back into the evaporator through a circulation pipe, ensuring stable and uniform circulation.

The larger the temperature difference between the heating chamber and the boiling chamber, the greater the intensity of evaporation and, consequently, the liquid circulation and heat transfer rates.

Where the boiling chamber of the circulation evaporator is divided into several separate chambers, each one equipped with its own liquid circulation system, the heating surface required for high final concentrations can be considerably reduced compared to an undivided system.

The final concentration is only reached in the last chamber. In other chambers, the heat transfer is considerably higher due to the lower viscosities and boiling point elevations.