



## Lesson-2

### Construction and Operation of Evaporators

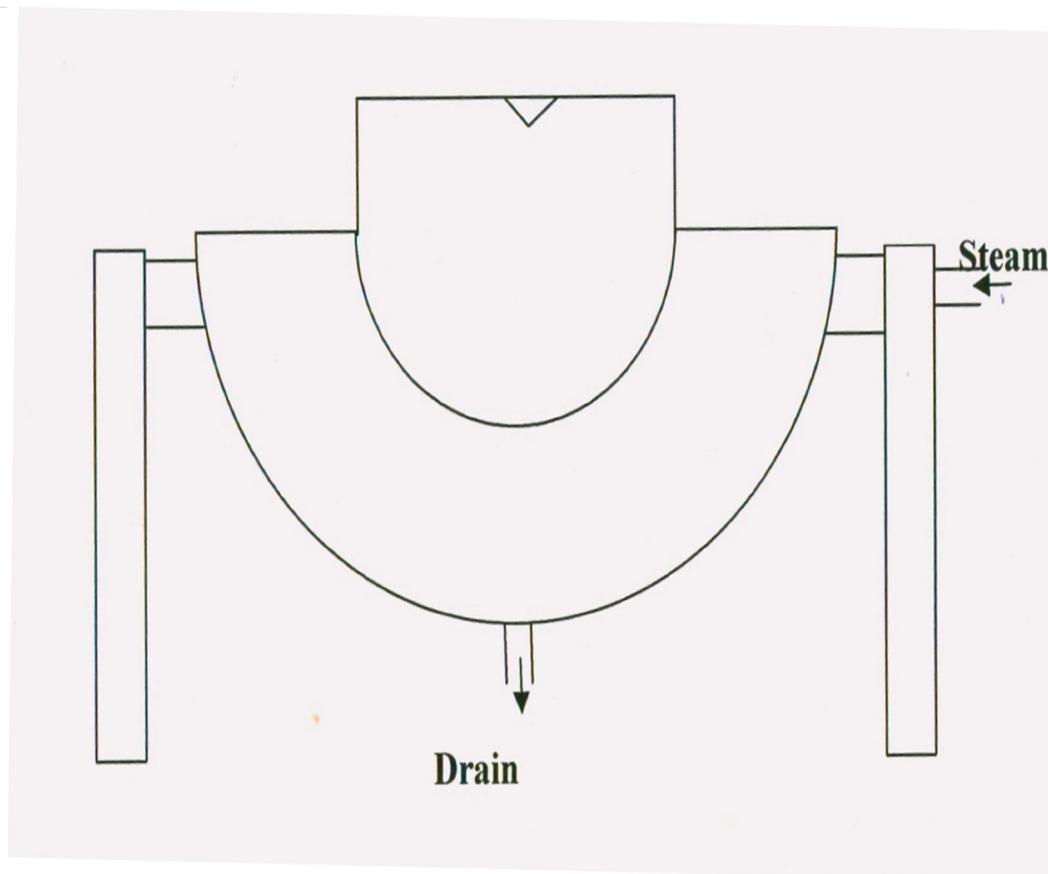
#### 2.1. INTRODUCTION

A number of evaporators of different design have been developed. The need of large scale operation and of improvement in quality has replaced the batch type evaporators. We shall discuss here the most important types of evaporators which are of interest to the dairy industry.

#### 2.2. EVAPORATOR SYSTEMS

Basically an evaporator system consists of a heat exchanger, supplying the sensible heat to raise the product to its boiling point and provide the latent heat of vaporization, a separator for the separation of vapour and concentrate, a condenser to remove the resultant vapour as condensate and a vacuum system as the process is carried out under reduced pressure. The heating medium is steam. For vacuum, barometric leg condenser, vacuum pump and steam ejector are generally used. The evaporators may employ natural or forced circulation of the product. In natural circulation units, circulation of the liquid is brought about by convective currents arising from the heating surface. In forced circulation evaporators, the increased velocity of the liquid over the heat transfer surface will bring about a marked increase in the liquid heat transfer coefficients. The circulation is achieved with the aid of an external circulating pump generally a centrifugal pump.

The simplest evaporator as shown in following figure, consists of an open pan and kettle in which liquid is boiled. The heat is supplied by condensation of steam in one side of a metal surface and the liquid material to be evaporated on the other side. Sometimes heating coils immersed in the liquid. In some cases the kettle is indirect fired. These evaporators are inexpensive and simple to operate, but the heat economy is poor. Paddles and/or scrapers are used to improve the economy and quality of the product.



**Fig-2.1: Evaporator System**

Based on the nature of the heat transfer surface, evaporators can be classified as:

- (1) Tubular surface with natural or forced circulation.
  - a. Horizontal tube evaporator
  - b. Vertical short tube evaporator
  - c. Falling film evaporator
  - d. Rising /Ascending / climbing film evaporator
- (2) Flat heating surface: plate evaporator
- (3) Stationary cylindrical surfaces with scraped surface evaporator.

### 2.3. TYPES OF EVAPORATORS

Evaporators used in food industry may also be classified in different ways as under.

1. Operating pressure – Vacuum and Atmospheric
2. Number of effects – Single effect and multiple effect
3. Type of convection – Natural convection and forced convection
4. Continuity of operation – Batch and continuous
5. Type of heat exchanger – Tube type, plate type, scraped surface etc.

#### (i) Horizontal Tube Evaporator

A simple unit, not used to a great extent on new installations, is the horizontal tube evaporator. Horizontal tubes from 2 to 3 cm diameter extended across the bottom of a cylindrical chamber from one to three meters in diameter and 2.5 to 4.5 meter high. Steam enters a chest on the end of the tubes, moves through the tubes and the condensate is removed from the chest at the opposite end. The vapour is removed from the top of the chamber and the product circulation is by natural circulation over the heating coil.

### **Fig- 2.2: Horizontal Tube Evaporator**

#### **(ii) Vertical Tube (short tube calandria) Evaporator:**

Tubes carrying the steam internally are placed vertically in the bottom of the cylindrical evaporator chamber. It is easier to clean the tubes in a vertical unit than in a horizontal tube evaporator, here also the product circulation is by natural convection. This type of unit is known as the Roberts evaporator in Europe and is the calandria evaporator in the United States.

### **Fig- 2.3: Vertical Tube (short tube calandria) Evaporator**

#### **(iii) Basket Type Evaporator:**

In a basket type evaporator the tubes may be placed in the shape of a ring or tubes. This unit provides an open space on the periphery so that the liquid may circulate more freely through the coils, with the liquid moving up through the coils as it is heated and the colder product moving down through the annulus around the basket.

### **Fig-2.4: Basket Type Evaporator**

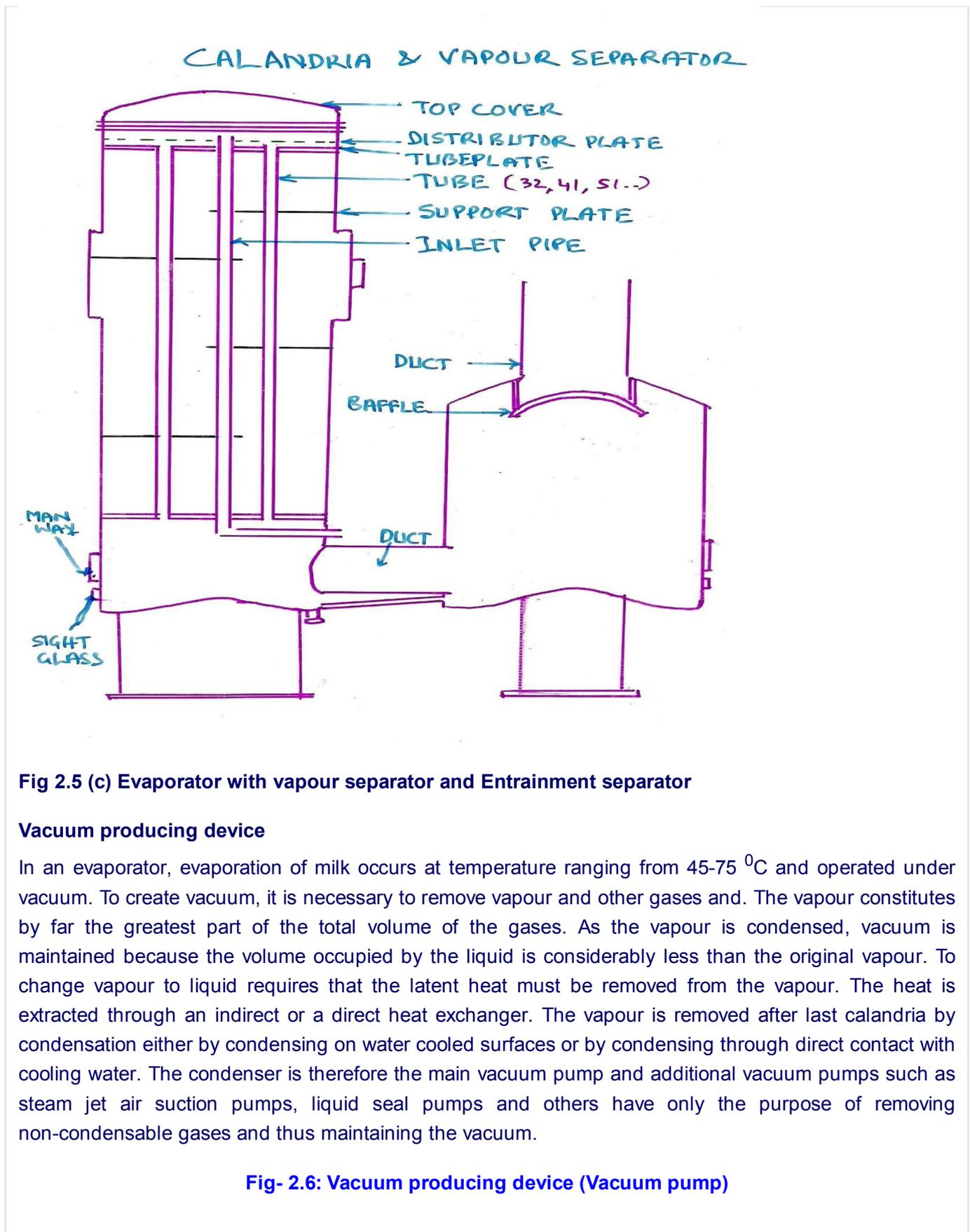
Components of evaporator system other than heat exchanger are as under :

#### **Vapour and Entrainment separators**

These are used in most evaporators to obtain vapours without product particles. Entrainment results wherever a vapour is generated from a liquid boiling vigorously. When this occurs the vapour carries with it varying quantities and sizes of liquid droplets. Separators provide a means for separating the vapour from the liquid with minimum liquid carry-over. Various mechanisms such as inverted U-tube, spiral, baffle, centrifugal type are adopted for such separation.

### **Fig- 2.5 (a):Entrainment separators**

### **Fig- 2.5 (b):Entrainment separators**



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