UNIT OPERATION (I)

Department of Chemical and Petroleum Industries Engineering
Fourth Year
AL-Mustaqbal University Collage

Lecture **(3)**
Drying (3)

Drying Equipment:

The dryer system presented on the following factors:

a) Temperature and pressure in the dryer,

(b) The method of heating,

(c) The means by which moist material is transported through the dryer,

(d) Any mechanical aids aimed at improving drying,

(e) The method by which the air is circulated,

(f) The way in which the moist material is supported,

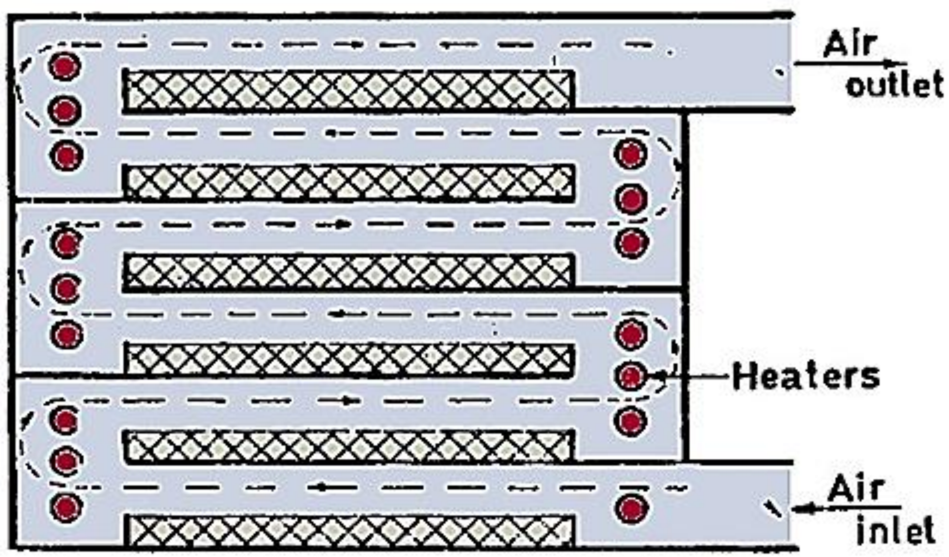
(g) The heating medium, and

(h) The nature of the wet feed and the way it is introduced into the dryer.

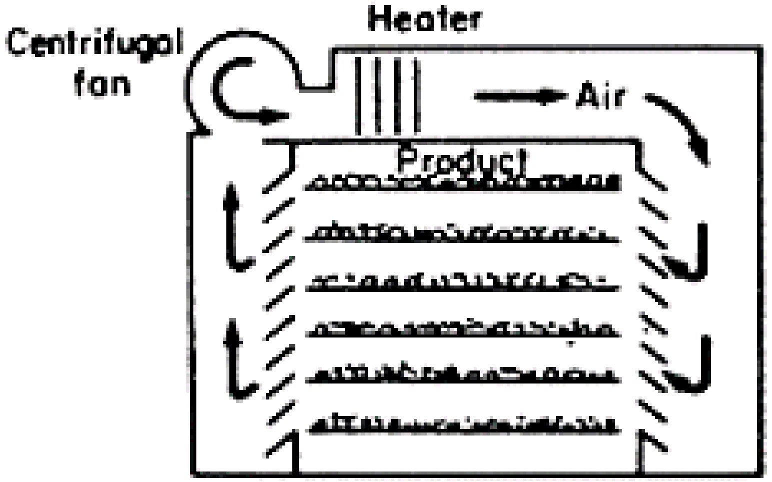
The choice of dryer based on whether batch or continuous operation, the nature of material, whether heating by contact with solid surface or directly by convection and radiation is preferred.

1. Tray or Shelf Dryer:

Tray or shelf dryer are commonly used for granular materials and for individual articles. The material is placed on a series of trays which may be heated from below by steam coils and drying is carried out by the circulation of air over the material.



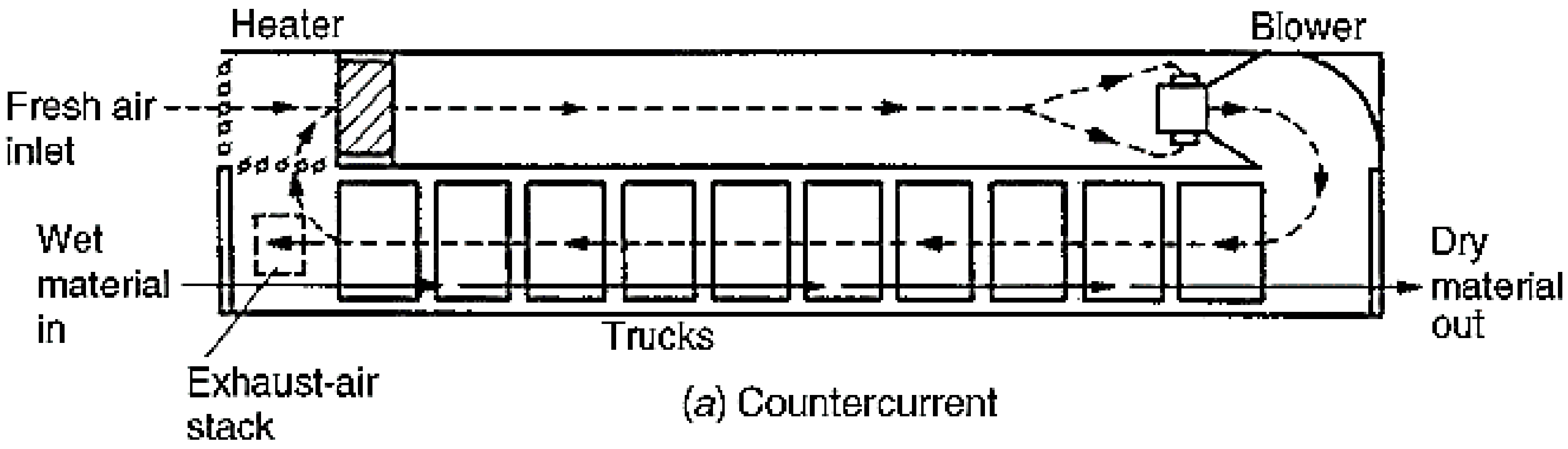
Directed-circulation tray drier



TRAY DRYER

2. Tunnel Dryer:

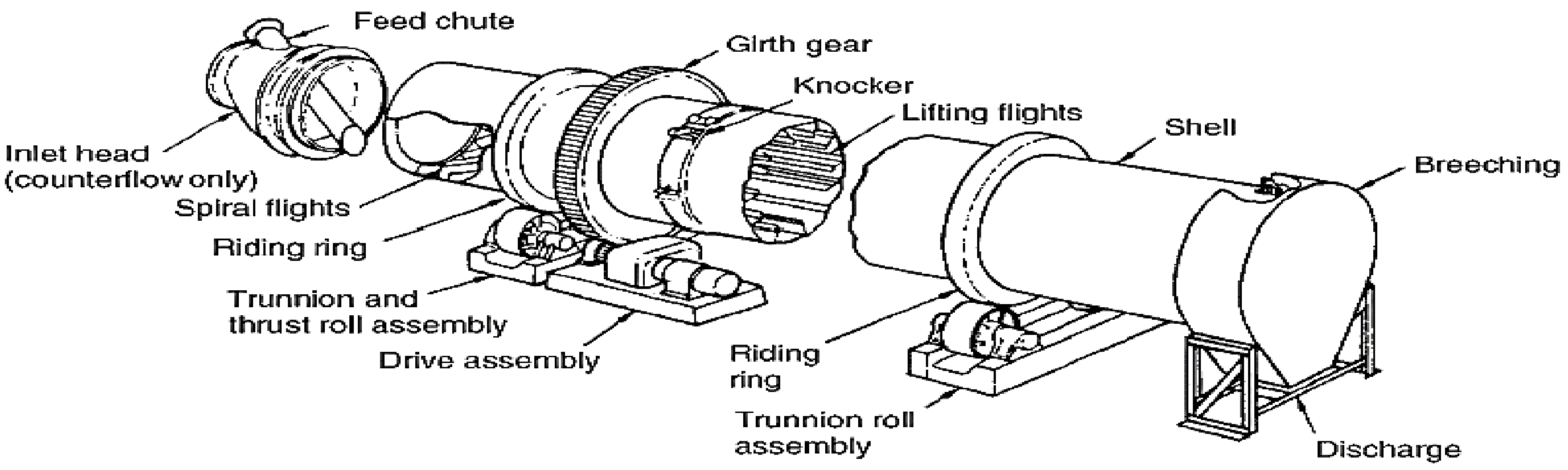
In tunnel dryers, a series of trays or trolleys is moved slowly through a long tunnel, which may or may not be heated, and drying takes place in a current of warm air.



(*a*) Countercurrent

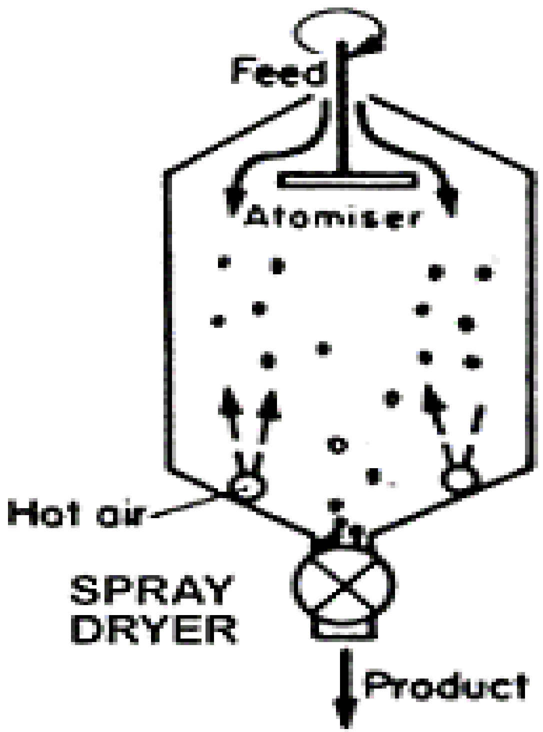
3. Rotary Dryers:

It consists of a relatively long cylindrical shell mounted on rollers and driven at a low speed. The shell is supported at a small angle to the horizontal so that material fed in at the higher end will travel through the dryer under gravity, and hot gases or air used as the drying medium are fed in either co-current flow or countercurrent flow.



4. Spray Dryer:

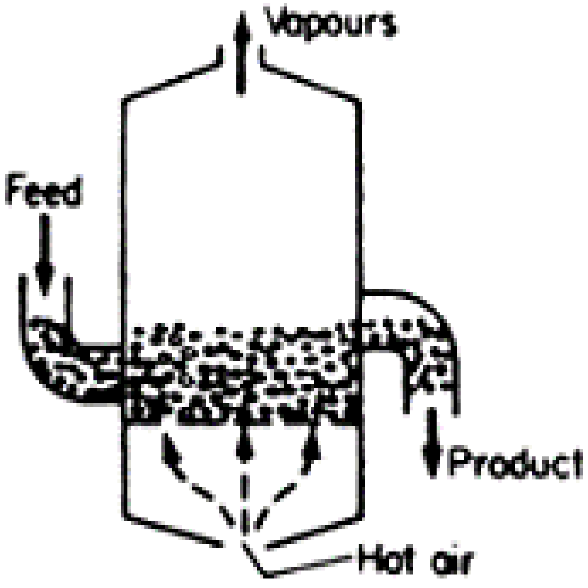
Water may be evaporated from a solution or a suspension of solid particles by spraying the mixture into a vessel through which a current of hot gases is passed. In this way, a large interfacial area is produced and consequently a high rate of evaporation is obtained. The performance of a spray dryer system is critically dependent on the drop size produced by the atomizer; is a device which causes liquid to be disintegrated into drops lying within a specified size range, and which controls their spatial distribution.



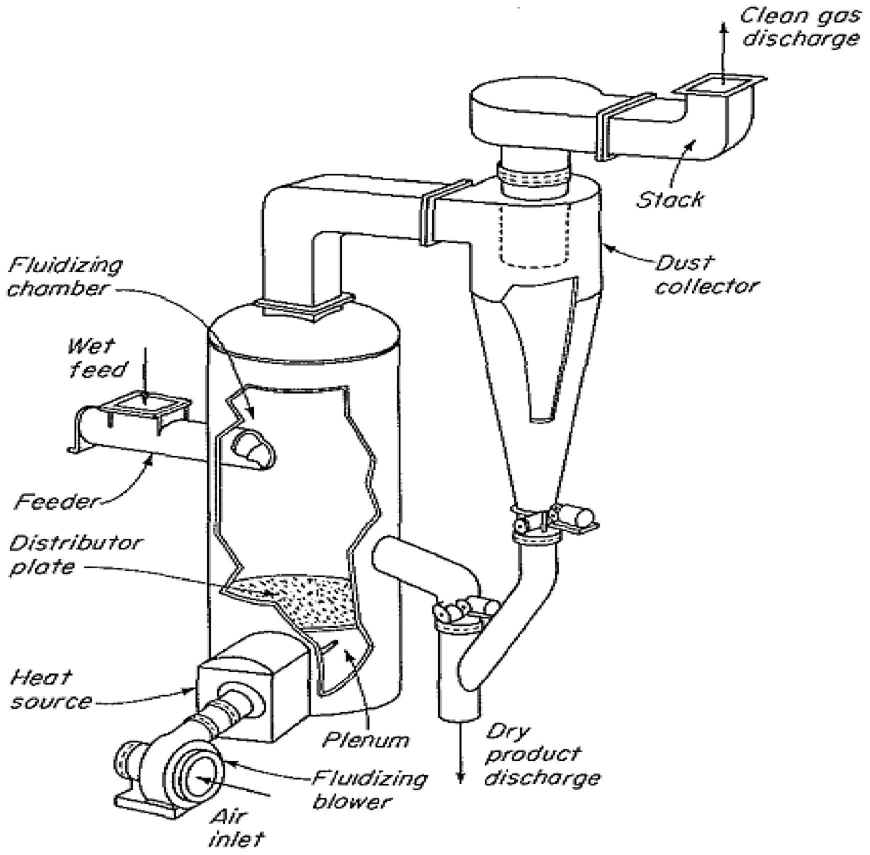
5. Fluid-bed dryer:

The particles are fluidized by air or gas in a boiling-bed unit, as shown in Figure below.

In a fluidized bed dryer, the food material is maintained suspended against gravity in an upward-flowing air stream. There may also be a horizontal air flow helping to convey the food through the dryer. Heat is transferred from the air to the food material, mostly by convection.

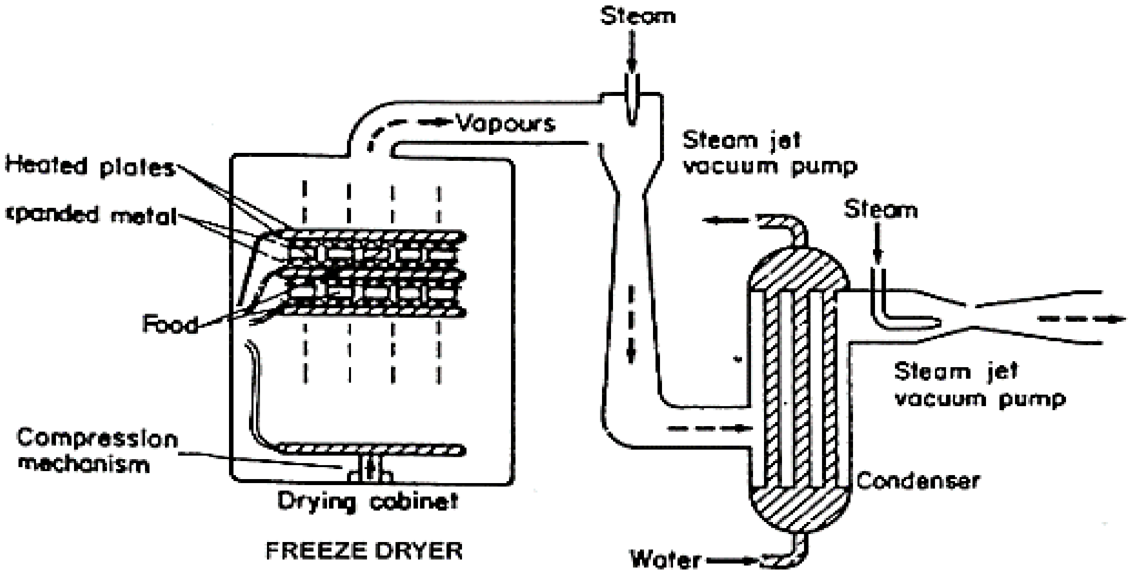


FLUIDIZED BED DRYER



6. Freeze drying:

In this process, the material is first frozen and then dried by sublimation in a very high vacuum, 10–40 N/m^2, at a temperature of 240–260 K. During the sublimation of the ice, a dry surface layer is left. The great attraction of this technique is that it does not harm heat- sensitive materials, and it is suitable for the drying of penicillin and other biological materials. Freeze drying allows for greater flavor retention and less vitamin loss of a product than any other drying method.



Roller or Drum Dryers **Pneumatic Dryers** **Trough Dryers** **Bin Dryers** **Belt Dryers** **Vacuum Dryers**

Ex:

An aqueous solution of cholesterol oxidase is freeze dried in a tray dryer. The frozen solution on the trays is 1.0 cm thick. The sublimation of water is 2950 kJ/kg, the thermal conductivity of the frozen solution is 0.16 W/m.^{o}C, and the operating temperature difference is 30^{o}C. What will be the required drying time in order to be thickness of the frozen solution equal to zero?

Solution:

The time required for complete drying:

$$t = \frac{1}{2}\left(\frac{\rho_o \lambda\, l^2}{k(T_o - T_z)}\right)$$

l = thickness of frozen solution

k = thermal conductivity of frozen solution

T_o = temp at the bottom of the tray

T_z = temp at the wet-dry interface

ρ_o = density of water

λ = heat of sublimation

$$t = \frac{1}{2}\left(\frac{1000 \times 2950 \times (0.01)^2}{0.16(30)} \frac{1000J}{1kJ} \frac{1hr}{3600s}\right) = 8.5\text{ hr}$$