Types of dryers- and their respective application in food industry

1. Tray/Cabinet dryer

Tray dryers are used for batch drying of solid foods at small to moderate scale (say, 2000 to 20 000 kg per day). They are inexpensive and simple to construct. Tray dryers consist of a closed compartment in which are placed trays containing the food to be dried (Figure 1).

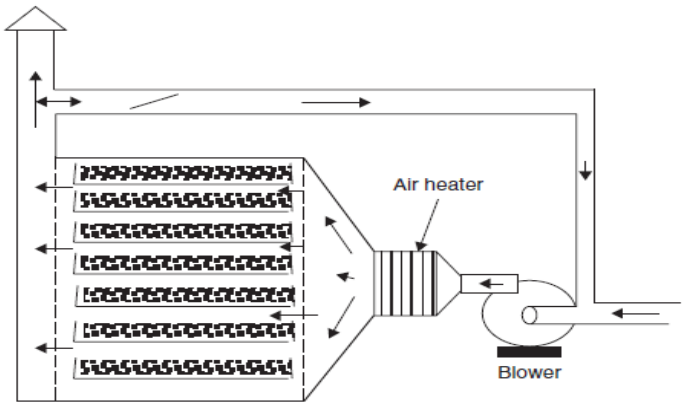


Figure 1. Tray/Cabinet dryer

The trays rest on shelves with adequate spacing between them. Heated dry air circulates between the shelves. Very often, tray bottoms are slatted or perforated, in order to provide some air flow also through the trays. The drying rate, hence the moisture content of the material, depends on its position on the tray. The material located closest to the entrance of dry air has the lowest moisture content. In order to secure more uniform drying, the direction of air flow may be reversed or the trays may be rotated periodically. The cabinet is usually equipped with movable baffles, adjusted so as to have uniform distribution of the drying air throughout the cabinet. Tray dryers are frequently found in rural installations where they are used for drying fruits (grapes, dates, apples), vegetables (onion, cabbage) and herbs (parsley, basil, mint, dill). Air inlet temperatures are usually in the range of 60–80°C. Air velocity is a few m/s and must be adjusted according to the size, shape and density of the food particles so as to avoid entrainment of dry particles with the wind. Depending on the product and the conditions, the duration of a batch is typically 2 to 10 hours. Most tray dryers feature means for adjustable recirculation of the air. The rate of recirculation is increased as drying progresses, when the air exiting the cabinet is warmer and less humid. Recirculation results in considerable saving in energy cost.

2. Tunnel dryer

Tunnel dryers consist of long tunnels through which trucks carrying stacks of trays travel with or against a stream of drying air (Figure 2). The material to be dried is evenly spread on the trays. Typical tray loading for wet vegetables is in the order of 10–30 kg per m^2. As one truck with wet material is introduced into the tunnel at one end, another truck, carrying dehydrated product, exit

at the other end. Depending on the size of the trucks and the tunnel, the trucks are moved manually or mechanically, e.g. with the help of chains. With respect to the relative direction of movement of the air and the trucks, tunnel dryers operate in co-current, countercurrent or mixed current fashion (Figure 3).

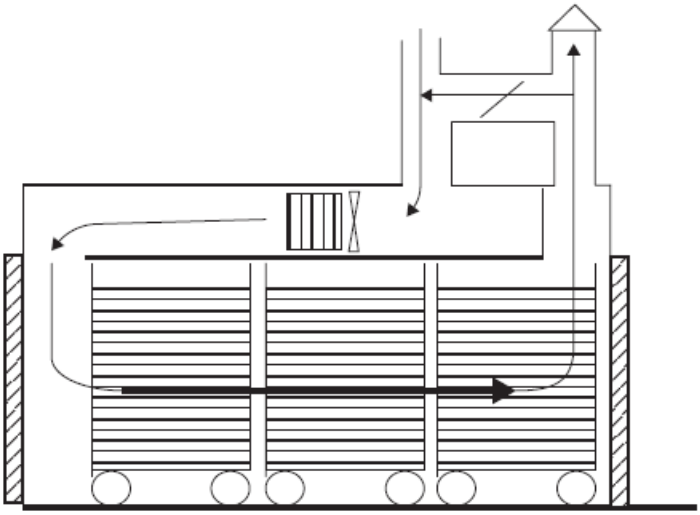


Figure 2. Short tunnel dryer

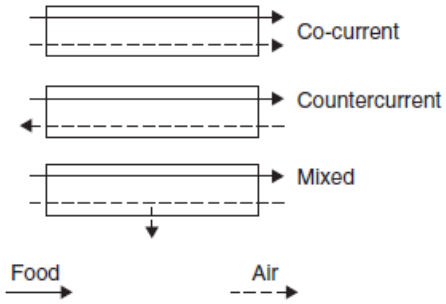


Figure 3. Flow patterns in tunnel dryers

In the case of the co-current tunnel, air with the highest temperature and lowest humidity meets the food with the highest humidity and lowest temperature. This provides the highest 'driving force ' for drying and therefore the most rapid rate of water transfer at the entrance to the tunnel. If the feed material is sufficiently humid, its temperature remains low despite the contact with hot air. The 'driving force', however, diminishes as the food travels towards the exit. The air at the exit end of the tunnel is the most humid and the coolest. Consequently, the final residual moisture content of the product may not be as low as desired. The contrary occurs in the case of countercurrent tunnels. The starting rate of drying is lower but it is possible to dehydrate the product to the lower final moisture content. The mixed flow, central exhaust tunnel

functions as two tunnels in series. Its first portion is co-current and provides the desired high initial drying rate. Its last portion is countercurrent and gives the desired finishing effect. Unlike cabinet drying, tunnel drying provides the possibility of exposing the product to a changing profile of external conditions. In addition to air temperature and humidity, it is possible to vary air velocity. In one model used for drying fruit, the tunnel is designed as two units in series, with a smallest cross-section, resulting in higher air velocity in the first unit (Figure 4).

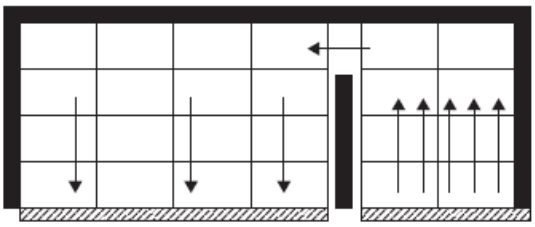


Figure 4. Flow patterns in tunnel dryers

Roller /Drum dryers

The basic principle of operation of the heated surface is the envelope of a rotating horizontal metal cylinder. The cylinder is heated by steam condensing inside, at a pressure in the range of 200 to 500 kPa bringing the temperature of the cylinder wall to 120‑155°C. The wet material is applied on the drum surface as a relatively thin layer by a variety of different methods to be described later. The dried product is removed from the drum with the help of a blade (Figure 5).

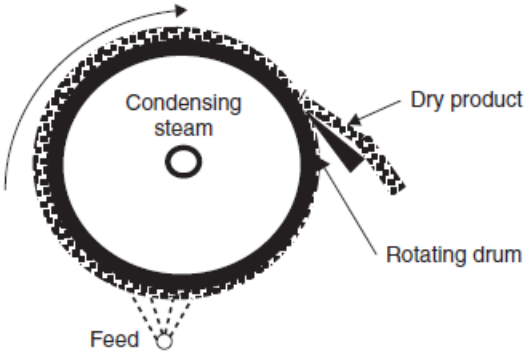
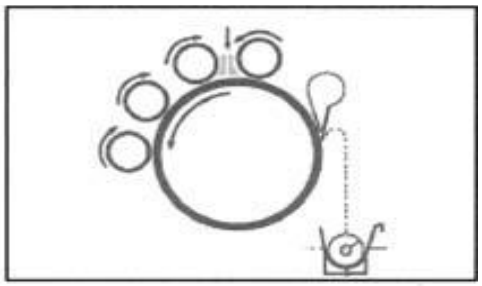


Figure 5. Drum dryer

The different types of drum dryers vary in the method used for applying the wet material on the surface of the drum. Drum dryers are classified into two types, namely, single drum and double-drum dryers. Double-drum dryers consist of two drums rotating in opposite directions, with a narrow, adjustable gap between the two. The so-called ‘twin’ drum dryer consists, in fact, of two independent co-rotating single drums sharing some of the accessory devices.

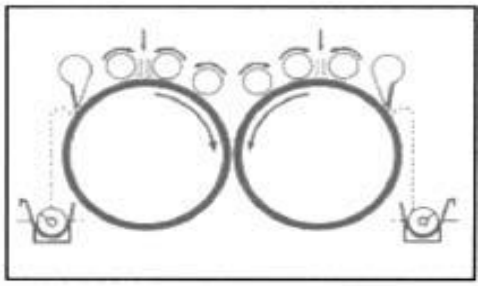
SINGLE DRUM DRYER WITH APPLICATOR ROLLS

The wet product is applied to the drum by means of applicator rolls. According to the number of the applicator rolls used the layer formed on the drying drum is thicker or thinner. This arrangement is suitable for the processing of pulpy or pasty products.
Typical applications are: Cereal based breakfast foods, Babyfood products, Pre-gelatinized starches, Fruit pulp and pastes, Potato flakes.



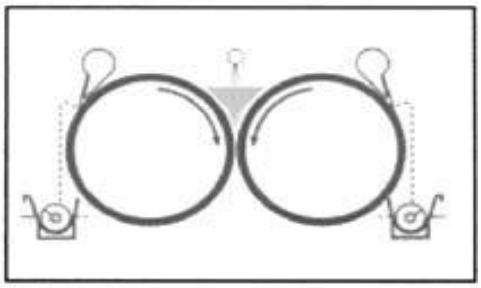
DOUBLE-DRUM DRYER WITH FEED ROLLS

This is a special 'Hybrid' system used to impart certain physical properties, particularly density, to specific products
Principle applications are: Cereal based breakfast foods, Baby food products, Fruit pulp and pastes.



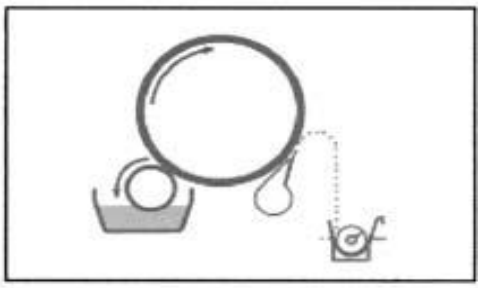
TWIN CYLINDER DRYER WITH NIP FEED

The material to be dried is pumped, either directly or through spray nozzles, into the nip formed between two drying drums. This is the oldest and simplest form of drum dryer. The thickness of the product film may be varied by adjustment of the gap between the drying drums or cylinders.
Typical applications are: Drying of Yeast, Milk products, Detergents, Dyestuff manufacture.



SINGLE DRUM DRYER WITH APPLICATOR ROLL

This is a more specialized type of drying, for example in the Chemical Industry. The applicator roll is located underneath the drum dryer and dips into the product. A liquid film is then transferred to the drying drum.
Typical applications are: Animal based glue, Gelatine, Pesticides.



DIP FEED DRUM DRYER

One of the most basic forms of the drum dryer, where a film of the product to be dried is picked up on the surface of the dryer drum as it rotates through a feed tray mounted below. The feed tray may be cooled or fitted with a recirculation system to prevent overheating or settling out of product from suspension.
Typical applications are: Drying of cereals, Spent Yeast.

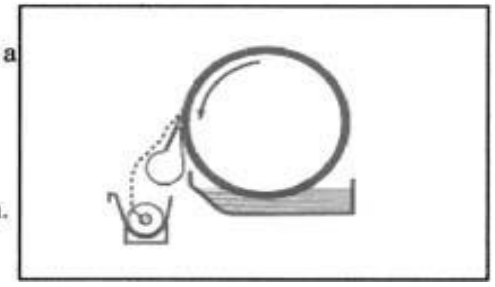


Figure 6. Drum drying feeding methods.

The simplest method of application is dip feeding. The drum is partially immersed in the feed fluid contained in a tray. A film of fluid adheres to the immersed segment of the drum. Fresh material is continuously supplied to the tray. Because the mass of material in the tray is heated by the drum, this method is less suitable for heat sensitive products. In the double-drum dryer with nip feed, the feed fluid is introduced into the pool formed between the two drums. The thickness of the adhering film is controlled by adjusting the gap. This type of feeding is used with less viscous materials, such as milk and other dairy products. Applicator rolls are used for spreading viscous liquids, purees and pastes on the drum surface. Single drum dryers with applicator rolls are extensively used in the production of instant mashed potato. Multiple applications, resulting in thicker layers, are made possible by mounting a number of applicator rolls on the drum periphery (Figure 6). Application rolls are also useful for pressing the film upon the drum, to restore good contact and to reduce porosity. Removal of the water vapors from the vicinity of the drums is essential in order to prevent moisture adsorption by the dry product. To this end, drum dryer installations are usually equipped with venting hoods of adequate size.

Fluidized bed dryer

In fluidized bed dryers, hot and dry air is used both for fluidization and for drying. Fluidized bed drying can be applied to particulate, non-sticky foods with particle size within the range of 0.05 to 10 mm depending on the density. Fluidized bed drying can be in batches or continuous (Figure 7). Due to the efficient heat and mass transfer, the product is dried rapidly. Sticking and product accumulation in continuous dryers is largely prevented by vibrating the fluid bed. Fluidized bed dryers are also used for powder agglomeration and coating.

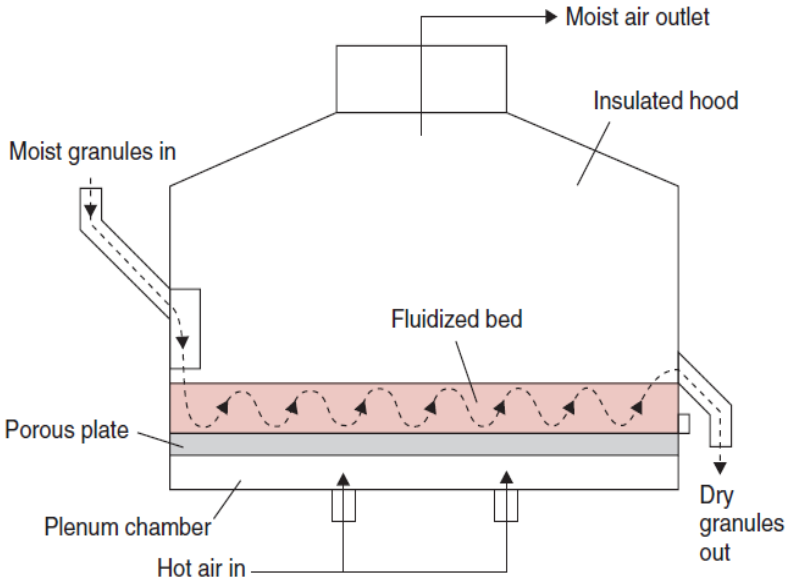


Figure 7. Fluidized bed dryer

Vacuum shelf dryer

Vacuum shelf dryer consist of hollow shelves in a vacuum chamber (Figure 8). Food is placed in thin layers on flat metal trays that have good contact with the shelves. A partial vacuum is drawn in the chamber and steam or hot water is passed through the shelves to dry the food. Rapid drying and limited heat damage to the food make both methods suitable for heat-sensitive foods. However, care is necessary to prevent the dried food from burning onto trays in vacuum shelf dryers, and shrinkage reduces the contact between the food and heated surfaces in both types of equipment. They have relatively high capital and operating costs and low production rates.

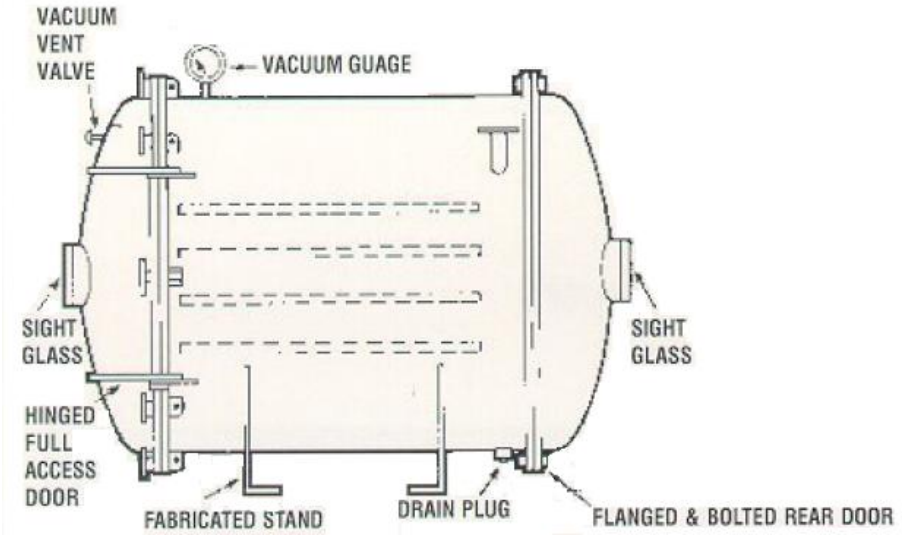


Figure 8. Vacuum shelf dryer

Spray dryer

Spray dryers are used for drying liquid solutions and suspensions, with the objective of producing light, porous powders. Spray drying is the accepted method for the production of milk and whey powders, coffee creamers, cheese powder, dehydrated yeast extract, instant coffee and tea, isolated soybean protein, enzymes, maltodextrin, egg powder and many other products in powder form. Spray drying is also one of the methods used for micro-encapsulation.

The liquid is dispersed (atomized) as a spray of fine droplets into very hot air inside a large chamber (Figure 9). Because of their small size and the high temperature of the air, the droplets are dried in a matter of seconds and transformed into particles of solid powder. At the exit from the chamber, the solid particles are separated from the humid air. A spray dryer system consists of the following elements:

- An air heater
- A device for forming the spray (atomizer)
- A pump for feeding the liquid to the atomizer

- A drying chamber
- Solid–gas separators (cyclones)
- Fans for moving the air through the system

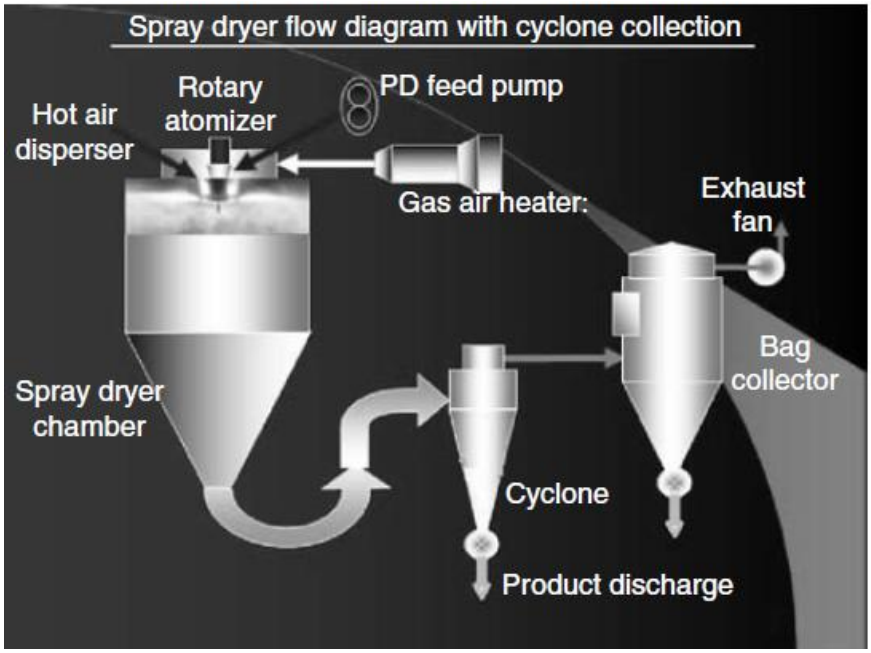


Figure 9. Spray dryer.

Freeze dryer

Freeze-drying is accomplished by reducing the product temperature so that most of the product moisture is in a solid state, and by decreasing the pressure around the product, sublimation of ice can be achieved. When product quality is an important factor for consumer acceptance, freeze-drying provides an alternative approach for moisture removal.

The heat- and mass-transfer processes during freeze-drying are unique. Depending on the configuration of the drying system (Figure 10), heat transfer can occur through a frozen product layer or through a dry product layer. Obviously, heat transfer through the frozen layer will be rapid and not rate-limiting. Heat transfer through the dry product layer will be at a slow rate due to the low thermal conductivity of the highly porous structure in a vacuum. In both situations, the mass transfer will occur in the dry product layer. The diffusion of water vapor would be expected to be the rate-limiting process because of the low rates of molecular diffusion in a vacuum.

The advantages of the freeze-drying process are superior product quality resulting from low temperature during sublimation and the maintenance of product structure. These advantages are balanced against the energy-intensive aspects of the product freezing and vacuum requirements.

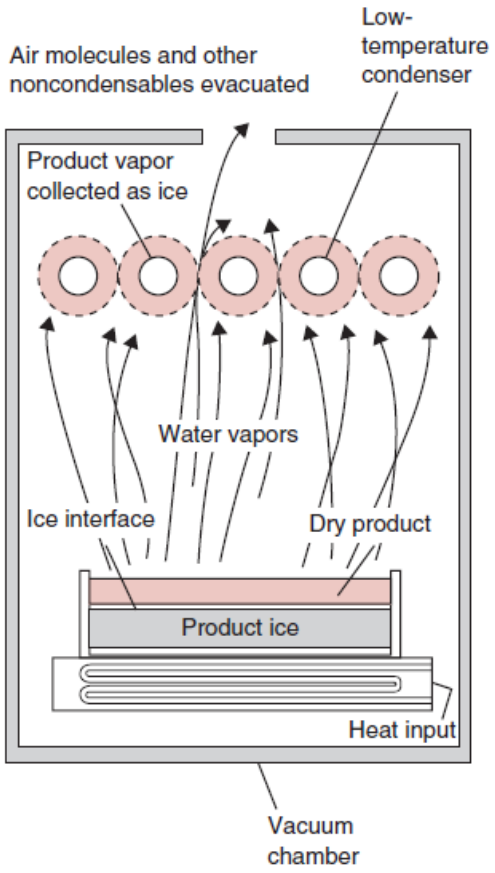


Figure 10. Freeze dryer

Freeze-drying is used to dry high-value foods that have delicate aromas or textures. Examples include coffee, mushrooms, herbs and spices, strawberries and raspberries, fruit juices, meats, seafoods or vegetables. Freeze drying is also used to produce complete meals for hikers and campers, military rations or space flights. Newer products include freeze-dried droplets of cream, yoghurt and creme fraiche for use in breakfast cereals, confectionery and as a topping for desserts. Freeze drying is also used to prepare active enzymes (e.g. for cheesemaking) and microbial cultures for long-term storage prior to inoculum generation.