Sun and solar drying, cabinet and bed drying.

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The early civilizations developed in the warmer and sunnier areas of the world, and sun drying was an obvious choice as a method of preserving food stuffs. It is worth recalling that sun drying is nature's way of preserving grains produced by plants during the growing season such that they are in a viable state for germination the following spring.

Objectives

1. Explain about sun, solar, tray and different types of bed dryer used in food processing.
2. To interpret food processing applications of these dryers.

The agricultural product drying method can be broadly classified into two,

1. Sun/solar drying
2. Artificial drying with mechanical means.

Sun drying

Sun drying is an age old method of drying for crop, grain, fruits, vegetables, fish etc. In India major portion of crops is left in the field and threshing yard for drying under sun.Grains are dried on the plant till proper moisture content is attained. This drying method is slow and takes about 2-3 weeks to attain proper drying. This is an improved method of drying, where crop is harvested at higher moisture content and is left in the field or on bunds of the field till it has dried to proper moisture content. Another improved method is to dry the harvested crops on the racks. Crop is bundled near the ears and hung on a rope exposing to the sun.

In further improved method of sun drying, the harvested crop at higher moisture content is threshed and the grains are spread on thefloor as thin layer. It is continuously stirred manually till it has attained the storage or processing moisture content.

Pros and cons of sun drying

The sun radiation is an electromagnetic waves and are associated with the following features

- Uncontrolled and nonuniform drying of grains results in cracks which further leads to less head rice yield during milling process.
- The drying process completely depends on the solar energy and hence this method will not suitable for all seasons.
- Highly impossible to control the process.
- This method of drying requires huge number of labours.
- Contamination from the environment and grain loss will be 1-2% due to birds, insects and rodent attack.
- Sun drying no fuel or other energy sources hence the cost of operation is low when comparing to the other artificial drying methods.
- The space requirement is high.

However sun drying is the cheapest method for food drying, in recent years the drying method is replaced by solar and other mechanical type of dryers.

In store drying

In store drying can also be called low temperature in bin drying. It may be used when grains are stored until milled. Weather conditions in tropical climates are less favourable for in store drying, due to high ambient temperatures and relative humidity. Two stages drying can produce good quality grain and preventing discolouration of high moisture grains and reduced cracking in the kernel.

Solar drying

Sun and solar drying, cabinet and bed drying.

Solar drying is an extension of sun drying. It can be a means of supplementing or replacing artificial dryers with consequential savings in fuels and costs. Solar drying provides higher air temperature and lower relative humidity than simple sun drying. It enhances the drying rates and lower final moisture content of dried products. As a result the risk of spoilage is reduced, in drying as well as in storage of dried grains. In many instance, solar drying is a best alternative method for drying foods. Though in some types of solar drying system requires a power source, considerable savings in energy costs is possible.

Two basic principles are inherent in the operation of solar dryers

1. The solar heating of air
2. The removal of moisture from the wet material by the heated air.

In recent years solar drying method is used widely in food processing sector. Solar drying is the most economic method when comparing to the other mechanical dryers. Solar dryer consists of three important components

1. Solar collector
2. Drying chamber
3. Air flow systems

In the drying chamber, trays are arranged to keep the food materials and sometimes the drying chamber is insulated to increase the efficiency of the drying process. Solar collector heats the air and then passed to the drying chamber. Natural convection or forced air convection system is followed. In forced convection method blowers are to circulate the air to enhance the drying process.

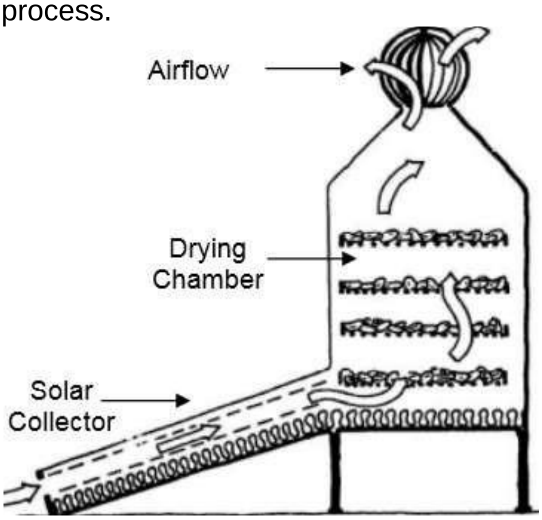

Fig.1. Solar drier components (Brace research Inst.)

Solar collector (absorber) is a dark coloured box made up of a radiant energy transmitting material made of glass or fibre glass and energy absorbing material such as metal. The radiation falls on the surface of the transparent cover and dark colour promote the absorption of solar radiation in to the absorbing plate. The air gets heated when passing through the plate then hot air is used as a source to dry the material in the drying chamber.

Sun and solar drying, cabinet and bed drying.

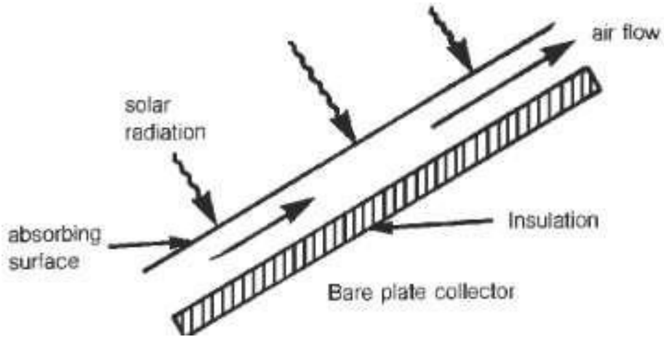

Fig.2 Solar collector

19.4.1 Classifications of solar dryer

Direct dryers with natural convection and with combined collector and drying chamber.

The solar collector is made by spreading burnt rice husk on level ground. It is covered with plastic sheet on a inclined bamboo framework. The drying chamber is a shallow wooden base with either perforated metal or bamboo matting. The drying chamber has removable panels at the back. It is provided with a chimney to provide a column of warm air for increasing the draught or the flow of air. The dryer is successfully used to dry paddy in monsoon.

Direct dryer with natural convection and with separate collector and drying chamber.

The most popular variation of this type of dryer is solar cabinet dryer. This consists of a rectangular cabinet preferably insulated and covered with roof of glass or clear plastic. Holes are made through the base and upper parts of the cabinet. Perforated drying trays are positioned within the cabinet. The insolation passes through the roof and is absorbed on the black end interior surfaces which are then heated and warm the air within the cabinet. The warmed air rises by natural convection and passes out of the upper holes. Fresh air in the meantime enters through the base holes.

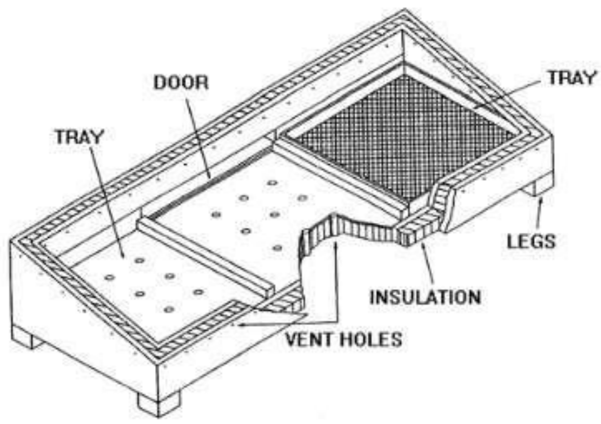

Fig.3 Solar dryer

The length of the cabinet should be three times the width to minimize the shading effect of the sides. The angle of the roof should be such as to maximize the amount of insolation received. The global latitudes and time of year decides the angle of roof.

Indirect dryer with forced convection and with separate collector and drying chamber.

In this type, the roof of the dyer is commonly used as solar collector. The warm air from the roof section is sucked by a blower and delivered to the lower plenum chamber under the drying bin. The warm air is ventilated through the products kept in drying racks or chamber and it leaves the room through north facing roof.

Applications

Solar dryer is mostly applicable in agricultural crops and dehydration of fruits and vegetable products. Specific products like mango, banana, apple, tomato, chillies *etc.,* solar dryer is highly suitable.

Mechanical dryers

To overcome disadvantages in natural and solar dryers, mechanical dryers are introduced where it is possible to fix preferred temperature with minimum contamination. Tray dryer, tunnel dryer, conveyor type of dryers and bed dryers are discussed in this chapter.

Tray dryer

Tray dryers are used in domestic and industrial applications due to its simple and economic design.Tray dryer consists of a stack of trays arranged inside the insulated chamber where the hot air is circulated. The trays may or may not have perforated bottom. Perforated trays are used when the plenum chamber is at the bottom of the drying chamber. The heater is provided to heat the air stream and blower increases the preferred velocity of the air. If the heated air is coming from the sides of drying chamber, the tray may not have perforated bottom. The gap between the group of trays permits air ventilation. Vent is provided at the top of the dryer to release the moisture air. Uniform distribution of air flow over the trays is maintained in tray dryers. Tray dryers are generally used for drying of vegetables and similar semi perishables and the products are kept in thin layers in the trays. Drying time varies from 10-60 hours.

Fig.4 Tray dryer

Bin type finished dryers are sometimes used for the final drying and equilibrium of some dried vegetables, although often with large modern conveyor dryers they are no longer needed. They are essentially large vertical cylindrical bins with perforated bottoms through which a constant stream of warm air is blown.

Tunnel dryer

This is similar to the tray dryer. When the group of trays are stationary, that system is called a tray dryer but when a group of trays are moving in a tunnel, that system becomes a tunnel dryer. The flow of heated air in a tunnel dryer may be co current or counter current.

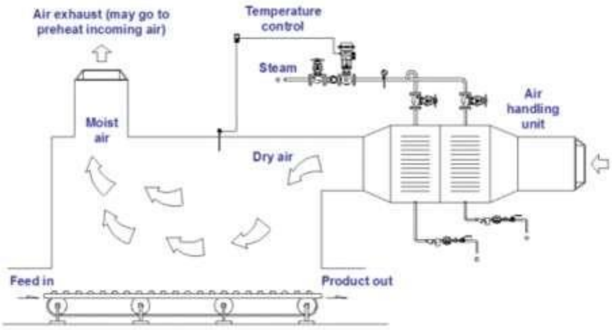

Fig. 5 Tunnel dryer

Tunnel dryer is a direct continuous type and large scale. In tunnel dryer the food materials to be dried are kept in the air heated tunnel. The material is entered at one end and dried materials are collected at exit end of the tunnel dryer.Tunnel dryers possess all advantages of tray dryers. In addition, they have a semi continuous operation. This type of dryer is very popular for drying vegetables and fruits. As compared to a tray dryer, the investment costs are higher.

The wet materials are loaded in trays that are stacked on trolleys. The trolleys are introduced periodically into one end of the tunnel and remove at the other end. A typical tunnel dryer can be operated in co current or counter current flow of air and trolleys. Two stage dryers are also used featuring a short co current stage followed by longer counter current stage. In cross flow designs the drying air moves at right angles to the path of the trays of food. Basic modelling principles for this type of drying are similar to that of a cabinet dryer. The drying times are similar to those in cabinet tray drying while the air flow rate is linked to the total number of trays. The dimensions of the tunnel are calculated based on the necessary drying throughput, necessary drying time and the dimensions and capacity of a single trolley.

Conveyor type dryers

Fully continuous drying operation is achieved in conveyor, belt or band dryer. This type of dryer is also very popular in vegetable processing industry. The wet product formed or placed in a bed of different thickness is carried through a tunnel on perforated (mesh, slotted or louvered) conveyors. Heated air is directed up or down through the conveyor and the layer of the product. Usually up in the early drying stages and down towards the dry product exit, or directed across the material surface for product in thin layers on a non-perforated band. Some models consist of two or more conveyors in a series. Also, either co current or counter current configurations can be used. Such dryers are limited to foods that form a porous bed (cut, granulated or naturally particulate foods). For vegetable drying, multiple conveyor dryers (up to 5), one above the other can be used. The wet product is introduced onto the top conveyor and progress downwards from one conveyor to the next. Air circulation is usually a combination of cross flow and through flow. A final drying step for some vegetables is provided often in this type of dryer. Gradually the conveyor dryers are replacing drying trays in tunnels for vegetable pieces such as carrot, onion and potatoes. Infrared, microwave or radio frequency energy is sometimes additionally supplied to the product conveyed through the dryer. The drying unit may operate under vacuum or atmospheric conditions.

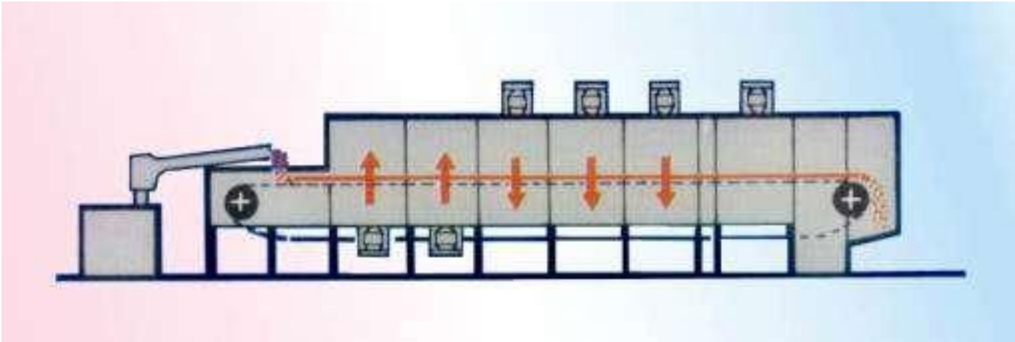

Fig.6 Single conveyor dryer

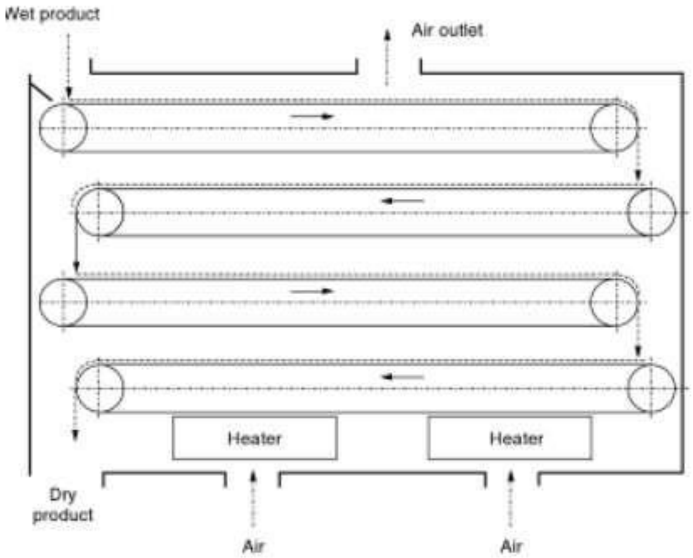

Fig.7 Diagram of multiple conveyor dryer

Bed dryers

Deep bed dryers

Deep bed drying is generally practiced for on farm drying of grains. In this system of drying, all grains in the dryer are not exposed to the same conditions of drying. The grains are placed on a false perforated floor that is raised to a certain height above the ground. The space below this floor acts as an air plenum chamber. Natural air or hot air is blown through the bed above it.

The air flow through the grain mass in the bed carries the moisture. The moisture transfer from the grain to the outgoing air takes place in a finite depth or zone, which is also termed drying front. This drying front moves upward in the bed in the direction of air movement. To avoid mould growth at the upper layer of the bed, this drying front should move quickly. Considering the large pressure drop and, consequently, the higher energy consumption for air flow across the bed, the volumetric air flow rate per unit volume of the grain is kept to a minimum level that would be just sufficient to prevent the spoilage of grains in the bed.

Fluidized bed dryers

The hot air at certain velocity is passed towards the upward direction through a bed of food material. The air stream expands and become agitated and suspended to form a fluidized bed. This is called “fluidization”. More vigorous type of fluidization occurs at very high air velocities is called sprouting. Turbulence take place in the bed makes very efficient contact between hot air stream and solid food particles and results in uniform mixing and high heat transfer rate. In this type of drying process thermal efficiency is high.

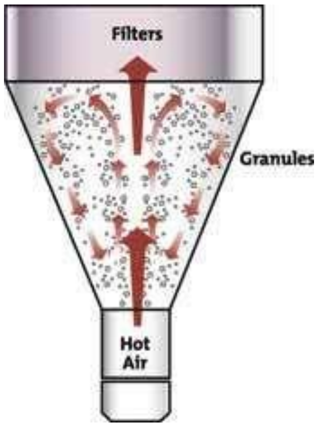

Fig.8 Fluidized be system

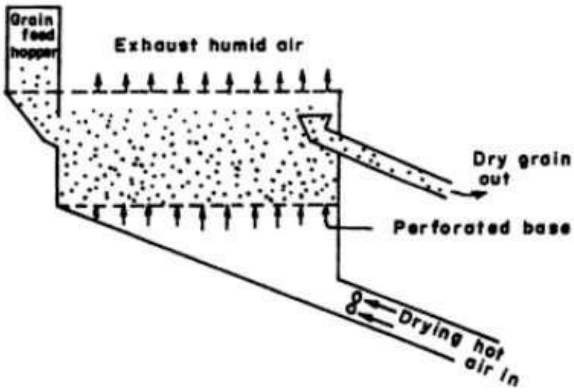

Fig.9 Schematic diagram of fluidized bed grain drying system

Sprout bed dryer

The sprout bed dryer is a specific design of fluidised bed dryer is also called as vortex bed dryers. Larger size coarse solids can be handled in this type of dryers. Grain particle diameter of more than 5 mm is highly suitable for these dryers. A high velocity air is allowed to enter through a centrally located nozzle in conical base, vertical chamber. The zone of fast moving particles at the centre creates a sprout, and the granular materials move downward at a slower rate surrounding the central spout. Thus, the downward moving grains generally receive the countercurrent moving air at the annular zone. The initial drying takes place at a higher rate in the central spout, but the later drying in the annular bed is relatively mild.

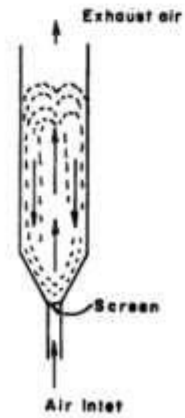

Fig.10 Schematic diagram of spouted bed

Plug flow fluidized beds

If the length to width ratio of the fluidized bed is superior to about 4, it is no longer well mixed, but the solids flow continuously. A plug flow fluidized bed may be a simple straight channel 1 or 2 meter wide and upto 20 m in length. The greater the length to width ratio is, the more uniform the residence time distribution.

Vibro fluid bed

Vibro fluidized beds are used to handle cohesive, sticky or fragile materials, or those with a wide size distribution, especially oversize particles. In vibro fluidised beds, the gas distributor is vibrated mechanically allowing movement of the coarse or cohesive particles while the gas velocity used for fluidization is low to avoid excessive elutriation of fine particles. With significantly lower upward velocity of air required compared to static fluidized beds, vibro fluidized beds are interesting from the economical point of view. But the bed depth is lower (0.3m) than in static beds (about 1m), requiring large equipment.

Pulsed fluid bed

The technique of drying of granular materials while keeping them in suspended state by continuous flow of air has been conventionally used widely in drying fruits and vegetables. In the pulsed fluid bed drying technique, the conventional fluid bed drying system is modified so that pulsation of the gas flow takes place thereby causing high frequency vibrations within the bed of product particles. This technique is reported to be effective in overcoming defluidization, particularly in the case of cohesive particles. Further, pulsation is expected to reduce channelling of particles and to affect easier fluidization of an irregular shaped particle. The requirement of saving energy is achieved by saving 30% to 50% of the air requirement for fluidization, because air for fluidization in drying application consumes energy not only for its circulation but also for supplying it at elevated temperature. Additionally, dryers operating with pulsed fluid bed technique require a smaller size. With the pulsed fluid bed drying, energy savings is achieved without affecting the production yield due to the lower drying air requirement.

Multistage fluidized bed

In many applications two or more fluidized beds with different functions are used in stages. For example, a well mixed unit followed by a plug flow one allows wet and sticky materials to be handled. In some cases, the distributor is constructed so that both sections are part of the same bed.

Desiccated air drying

The ambient air is passed through a desiccated medium or source. The desiccator absorbs moisture from the air, as a result, the relative humidity of air is reduced and at the same time there is an increase in its temperature. When such air comes in contact with wet food materials, transfer of moisture from food to drying air takes place. The drying action occurs due to convective heat transfer.

Summary

- Natural sun drying is a traditional drying process used for crops and grains.
- Solar drying is advanced method of sun drying which is energy economic method of drying applicable for almost all fruits and vegetables.
- Mechanical drying methods such as tray dryer, tunnel dryer and bed dryers advanced type of dryers which overcome the limitations of natural drying methods.
- Different types of fludized bed dryers are applicable for food materials. In this type of drying, uniform mixing of products and better heat and mass transfer rate is possible.