

Fig. 6 Drum Dryer?

Radiant heat from infra-red lamps has been accepted by certain industries as practicable for their specific problems. An example of successful application is found in the drying of lacquers.

Conduction Drying

Drying rolls or drums, Fig. 6,⁷ flat surfaces, open kettles, and immersion heaters are examples of the direct-contact method. Intimate contact of the material with the heating surface is important, and in some cases agitation is desirable to increase the uniformity of heating or to prevent overheating.

A rather interesting method of conduction drying was put into practical use during the war for the drying of blood plasma, and has since been expanded to other fields such as the preservation of bacteria and other micro-organisms. This has come to be known as freeze drying or drying by sublimation. The material to be dried is first frozen and then placed in a high vacuum chamber connected to extremely low temperature condensers. The water is removed by vaporizing from the solid directly to the gas without ever becoming liquid.

Convection Drying (Direct Dryers)

A typical convection dryer is composed of an air-conditioning system, a material handling system, and the dryer housing. In normal practice it is desirable to recirculate as much as 95 percent of the air, from the standpoint of heat economy. There is an optimum point for the percentage of recirculation, depending on the temperature and evaporation rate.

A limited amount of convection drying takes place in almost any dryer such as those described in the preceding paragraphs. However, to be classified as a convection dryer the principal source of heat is the heated air or other gases circulated in the dryer. There are a number of mechanical

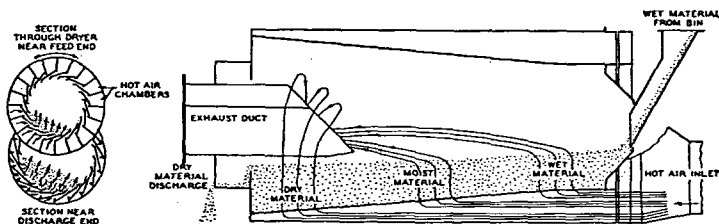


Fig. 7 Cross Section and Longitudinal Section Through Circulation Dryer?

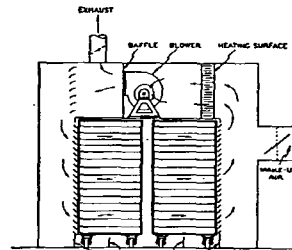


Fig. 8 Compartment Dryer, Showing Trucks, with Air Circulation?

means of accomplishing this circulation of air or gases, each of which has some particular virtue. Brief descriptions of some important types of convection dryers follow:

Rotary Dryers. These dryers are cylindrical drums which cascade the material being dried through the air stream. (See Fig. 7.) The dryers may be heated directly or indirectly, and the air circulation may be parallel or counterflow. A variation is the rotating-louver type dryer, which introduces the air beneath the flights thus securing very intimate contact.

Cabinet and Compartment Dryers. These are generally considered batch dryers wherein each charge is dried to completion before removal. A wide range includes trays from the heated loft with only natural convection, and usually poor and non-uniform drying, to the self-contained units with forced draft and properly designed baffles which give positive results. It is also possible to evacuate some of the systems for low temperature drying of delicate or hygroscopic materials. These dryers are usually loaded with material spread in trays to increase the exposed surface. The trays are loaded directly into the dryer or may be stacked on trucks which are wheeled in. Fig. 8 shows a dryer of this type which can be used to dry water-saturated products. When these dryers are designed to dry products saturated with a solvent, they must be designed with special features to guard against the formation of explosive vapors. (See Fig. 9.)

Basically, safety is accomplished by first exhausting 100 percent of the air circulated during the initial drying period or any subsequent portion of the drying cycle when the solvent is being evaporated at a high rate. Generally, this occurs only during the beginning of the drying cycle. Later, at the end of the purge cycle the air may be recirculated and heat gradually

Industrial Drying Systems

applied. The amount of air circulated, the length of each cycle, and the rate of applying heat to prevent the circulated air from ever reaching an explosive concentration must be determined in the laboratory dryer for each product and the information obtained extrapolated to the full sized production model. Recirculating air as soon as practicable in the drying cycle is particularly advantageous for economy where costly dehumidified air is used.

Special safety features must be designed into the dryer to safeguard against failure of any part of the drying cycles. Factory Mutual Insurance Co. Bulletin No. 14.15 *Industrial Ovens and Dryers* is one source of information which can be used as a guide to design of these safety features. Some of these features are as follows:

1. Each compartment must have a separate supply and exhaust fan and an explosion relief panel.
2. The exhaust fan should be selected so that the blade tip speed will be 5000 fpm if a forward inclined blade is used, 6800 fpm for a radial-tip blade, and 7500 fpm for a backward inclined blade. These tip speeds will produce excessively high static pressures at the fan which will assure fairly constant air exhaust volumes under varying external conditions such as negative pressure within the building or downdrafts in the exhaust stacks.
3. An air-flow failure switch located in the exhaust duct shall shut off both the exhaust fan and the supply fan, as well as the heating coil and also sound an alarm bell in the event of failure of air pressure in the exhaust duct.
4. An air-flow failure switch in the air supply system shall shut off the supply fan and the heating coil and also sound an alarm bell in the event of loss of air pressure in the supply system.
5. A high-temperature limit controller in the supply duct shall shut off the heat to the heating coil and sound an alarm in the event of over-ride of air supply temperatures.
6. An electric interlock on the dryer door shall cause the system to repeat the drying cycle if the door is opened beyond a set point. This control is set to permit the door to be opened far enough for a man to enter for product inspection but not far enough to permit a truck to enter.

Tunnel Dryers. Tunnel dryers are a modification of the compartment dryer, and as a rule are continuous or semi-continuous in operation. Heated air or combustion gas is usually circulated by means of fans, although a few natural draft units are still in use. The material is handled on trays

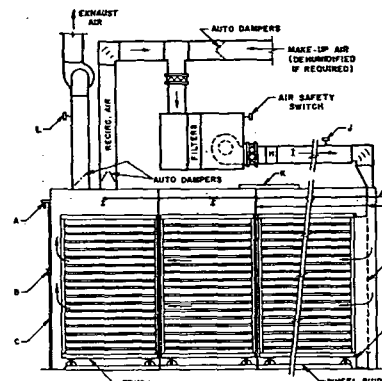


Fig. 9 Explosion Proof Truck Dryer Showing Air Circulation and Safety Features

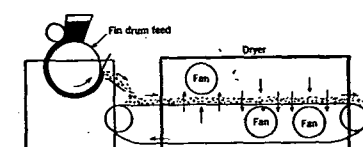


Fig. 10 Section of Continuous Dryer, Blow-Through Type

or racks on trucks, and moves through the dryer either intermittently or continuously. The air flow may be parallel, counterflow, or a combination of the two, obtained by center exhaust. Further, the air flow may be across the surface of the trays or up or down through the bed, or in any combination of directions. By reheating the air in this type of dryer or recirculating it, a high degree of saturation is achieved before exhausting the air. This reduces the waste of sensible heat.

A variation of this type dryer is the strictly continuous type having one or more mesh belts which travel through the dryer carrying the product, such as Fig. 10. Innumerable combinations of temperature, humidity, air direction, and velocity are possible. The labor requirement is low on such a dryer, as it can be loaded and unloaded mechanically. There is the disadvantage of hot air leaks at the entrance and exit, although these can be minimized by means of baffles or inclined ends where the material enters and leaves from the bottom.

Spray Dryers. Spray dryers have been used successfully in the production of dried milk, coffee, soaps, detergents, and other products. Because of the uniformity of the dried product (in the form of small beads) and the short drying time (5 to 15 sec), this method of drying has become increasingly important. When the product to be dried is a liquid or slurry the spray dryer is applicable, and is capable of relatively high production rates.

Essentially, spray drying involves the atomization of a liquid feed in a hot gas drying medium. The spray may be produced by a two-fluid nozzle, a high pressure nozzle, or a rotating disk. Inlet gas temperatures may range from 200 to 1400 F, with special materials of construction required for the latter temperature. Since the thermal efficiency increases with the inlet gas temperature, high inlet temperatures are desirable. Even heat-sensitive products may be dried at elevated temperatures because of the extremely short drying time. The hot gas flow may be either concurrent or counter-current to the falling droplets. The dried particles settle out by gravity. Fines in the exhaust air are collected in cyclone separators or bag filters. Fig. 11 shows a typical arrangement of a spray drying system.

The bulk physical properties of the dried product, such as

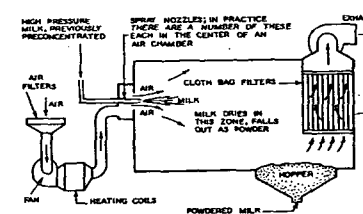


Fig. 11 Spray Dryer of the Pressure-Spray Rotary Type?