

Radiant Heat

Radiant heat can at best supply only a portion of the total heat of vaporization. About one-third to one-half of the heat given off by a radiating surface passes through the air to the object which is to be dried without materially raising the temperature of the intervening air. The remaining portion of the heat from the radiator warms the air by convection and produces warm air currents which in turn transfer their heat to the material. A given amount of heat can be supplied to the material by means of heated air currents with only one-third to one-tenth as much radiating surface as would be required if this same quantity of heat were to be transferred by direct radiation. Direct radiation is, therefore, only an incidental source of heat in most dryers, except in the drying of certain kinds of material where the advantages of radiant heat will offset the higher first cost of the equipment. In vacuum dryers radiant heat is particularly useful in the drying of some bulky solids, owing to the difficulty of transferring heat to the material by means of rarified air currents at extremely low pressures.

Continuous and Intermittent Operation

Dryers may be operated continuously or intermittently. In the continuous type, the material is fed in at one end of the dryer and discharged at the other end when dry. The movement may be either a steady flow, or may consist of the periodic or progressive removal of a minor portion of the charge at one end of the dryer and the admission of a like portion at the other end, at more or less regular intervals. Dryers of the intermittent type, often called charge or batch dryers, are filled at the start with the material to be dried and are emptied again when the drying is completed, after which the process is repeated. The material in charge dryers is usually stationary but is sometimes shifted in position periodically or kept in continuous motion within the dryer for greater uniformity and speed of drying.

With constant rates of flow of air and material, continuous dryers are usually simple to control and can be fitted advantageously into the train of manufacturing operations with minimum loss of time and requirements for storage and handling. Charge dryers, on the other hand, permit the use of complicated schedules of temperature and humidity which would be difficult to attain with continuous operation; and they have the important advantages of simplicity and low first cost, making them particularly adapted to small installations and experimental work.

Temperature and humidity conditions in a charge dryer should be substantially uniform throughout the dryer, in order to produce uniform drying throughout the charge and prevent injury to the material. These conditions may remain uniform throughout the drying cycle or may be changed periodically as the drying progresses. In continuous or progressive dryers, the drying conditions usually vary from one end of the dryer to the other, either to suit the varying requirements of the different stages of drying or because of different rates of evaporation at different positions in the dryer.

With some materials, such as clay and other plastic material, the usual requirements are for the entering material to encounter the air at the

lowest temperature and highest humidity. As the material dries, it gradually moves forward to higher temperatures and lower humidities and encounters the highest temperature and lowest humidity just before leaving the dryer. This lends itself very nicely to a tunnel dryer with the air movement opposite to the travel of the material as the air cools and picks up moisture, producing the exact effect desired.

Other material, like lumber, requires a high temperature and high humidity at the beginning, and lower temperature and humidity at the end. Such a condition requires very special handling of the air in a continuous dryer, and it is here that a batch dryer is of advantage. The material stands still and the entire dryer can be kept at any desired temperature and humidity, which can be changed at will at any interval of time. In batch dryers it is almost always necessary to recirculate a considerable proportion of the air to conserve the heat and to prevent the air from being too dry. A continuous dryer, on the other hand, often does not require recirculation as the air has been in contact with the material for a longer time, and the increasing humidity and lower temperature encounters material in various stages of drying. This question of recirculation is more fully dealt with later under *Control of the Drying Operation*.

Low and High Temperature Drying

The division line between what is known as low temperature drying and high temperature drying is, roughly speaking the boiling point of water under ordinary atmospheric conditions. In high temperature drying, the temperatures range from 212 to 1000 F or more. Under these conditions, all of the water in the material will vaporize quickly and the humidity of the air becomes of minor importance. High temperature drying, is usually faster and more economical of heat than low temperature drying, but often cannot be used because many materials, particularly foods and other organic substances, are injured or destroyed by temperatures above the boiling point. For such materials low temperature drying is required, the drying being produced by supplying enough heat to the material, and surrounding it with a sufficiently low humidity so as to produce a higher vapor pressure within the material at its surface than is present in the air surrounding it. As long as this difference in vapor pressure is maintained, the drying will proceed until completed.

In drying with temperatures above the boiling point, the choice of means of heating the air becomes more difficult. Exhaust steam at low pressures becomes useless. High pressure steam may be used in coils, either in separate banks near the fans, or as direct radiation. By this means, air may be heated to about 340 F. This does not mean, however, that the dryer will be as high as that. Above these temperatures, hot oil may be circulated in the coils. Occasionally electric heat is used, and in some cases superheated steam has been admitted to dryers requiring high temperatures. The most widely accepted method, however, is to employ oil fired or gas fired air heaters which are now standard equipment in many industries, even when lower temperatures are required. This avoids putting drying loads (which often fluctuate widely) on the boiler plant. They also have the advantage of being independent for isolated locations.