

These heaters operate on two broad principles. The *Direct Heaters* mix the products of combustion with the air which is to be blown into the dryer. The amount of mixture is determined by the temperature desired in the mixture. The *Indirect Heater* passes the products of combustion through an interchanger which avoids mixing these gases with the air. With either type heater, multiple type burners are used in order to obtain automatic temperature control without sacrificing good burner performance. The type of fuel used whether gas or oil depends on the locality and the important item of cost. The gas may be natural, manufactured as a by-product of coke, or derived from oil. High heater efficiencies are secured with the proper selection of the type of heater and careful arrangement of the heater in the drying circuit.

Vacuum Drying

It is sometimes advantageous to conduct the drying in a partial vacuum, in order to obtain rapid vaporization at comparatively low temperatures. This method is especially useful for materials which are sensitive to heat, such as valuable food products which must be dried rapidly at low temperatures in order to preserve flavors and prevent harmful organic changes. A vacuum as high as 28 in. of mercury is sometimes used where a very low boiling point is desired, but the usual range is from 12 to 20 in.

In vacuum drying, heat is supplied to the material either by contact with the heated walls or shelves of the container, which is the usual method, or by direct radiation, either from the walls or shelves or from special radiators. Some materials containing only 2 to 3 per cent moisture are first heated before being put in the vacuum chamber. When the vacuum is established, the heat already in the material vaporizes the moisture and becomes latent, thus drying and cooling the material at the same time.

The air within the vacuum container is so rarified as to reduce materially its value as an agent for transferring heat from walls or radiators to the material. The volume of air which must be circulated in a vacuum chamber in order to transfer a given amount of heat is increased several times as compared with air at atmospheric pressures, and the cost of creating a circulation sufficient to transfer any large portion of the heat required for rapid evaporation, is apt to be prohibitive. The evaporated moisture is removed by means of condensers in the vacuum line.

It should be clearly understood that a low temperature of product may not necessarily be secured in a vacuum dryer. If the material is very thin, is dried by radiant heat, and has a large amount of free water, then the temperature of evaporation for the constant rate period will correspond closely with the temperature of water vapor equal to the vacuum maintained. After the critical moisture content is reached, the temperature of the material is increased and approaches the temperature of the radiating or contact surface. With direct contact dryers, and especially with thick materials, the temperature is liable to be increased considerably over that corresponding to the vacuum. In these cases, much of the expected advantages of vacuum drying will be lost. (See later paragraphs on mechanism of drying, and dryer design.)

Adiabatic and Constant Temperature Drying

Air dryers are called *adiabatic* when the only source of heat for drying purposes is the heated air entering the dryer from the outside. When part or all of the heat required is applied by steam coils or other forms of radiation within the dryer itself, it is known as a *constant temperature dryer*. In adiabatic dryers, the temperature of the air decreases, as the drying proceeds, in direct proportion to the amount of heat consumed or made latent by evaporation. If this continued without new heated air being introduced, drying would slow down and finally stop.

The constant temperature dryer does not depend on the air to carry the heat and only enough air need be handled to remove the water evaporated. The great danger in the constant temperature dryer is that local zones in the dryer will vary widely in temperature, and hence, in humidity, while in the adiabatic dryer temperatures and humidities should be quite uniform in a properly designed dryer. In the adiabatic dryer there is ample opportunity to use the zone system whereby the temperature and humidity may be different in various zones. This is often desirable in a continuous dryer where the required condition at the different stages is other than that which would result if the air were allowed to vary in temperature and humidity due to the evaporation which has taken place in the preceding zone.

TYPES OF DRYER CONSTRUCTION

Drum Dryers are used for drying thick liquids or pastes. A steam heated cylinder, with its lower side immersed in a bath of the material, is revolved slowly. The film of material that forms on the hot surface of the drum dries rapidly and the resultant solid is scraped off by a fixed knife edge.

Cylinder or Can Dryers are designed for the continuous removal of moisture from material in the form of thin rolled sheets such as textiles, paper, and pulp products. Heat is transferred to the material by direct contact with a series of steam heated cylinders. In case the material shrinks on drying, as does paper, the drives must be arranged so that the speed of the drums is gradually less toward the dry end of the series. These dryers can be much improved as to speed and capacity by the application of jets of heated air to absorb the moisture as it leaves the material. This absorption of the vapor also prevents condensation on the ceiling and aids greatly in ventilating the dryer room.

Pan or Agitator Dryers are used for sludges, powders, or material in lump form and consist of a cylindrical metal shell. The material to be dried is placed in the bottom of the shell and is constantly shifted in position by means of agitators, either the shell or the agitators or both being in motion. Warm air, gas, or products of combustion, are passed over the material and additional heat is usually supplied from a steam heated jacket around the container, or by steam supplied to hollow stirring arms. Continuous agitation of the charge serves not only to expose new surfaces to contact with the air, but also to reduce the average distance from the interior to the surface of the solid and so to speed up the drying where the rate of liquid diffusion to the surface is the controlling factor.