many materials produce better results if dried quickly at comparatively high temperatures than if dried more slowly at lower temperatures.

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 proportion 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.

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 supplied 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. Thus the drying rate and the capacity of the air to absorb moisture decline steadily until drying stops entirely or fresh heated air is introduced.

Constant temperature dryers can supply heat by internal recirculation from the radiators to the material and can thus continue the drying operation at maximum speed with little or no change in the air of the dryer, provided that surplus moisture can be disposed of by ventilation or condensation. This advantage is offset, however, in drying some types of material, by the fact that local overheating of the material is liable to occur in some parts of the dryer, due to the transfer of heat from the radiators to the material by direct radiation. In adiabatic dryers, on the other hand, temperatures in different parts of the dryer are usually quite uniform, particularly the wet-bulb temperature, which makes this method especially adapted to the drying of such materials as gelatine which are sensitive to heat when wet and relatively insensitive when dry.

TYPES OF DRYER CONSTRUCTION

Mechanical Contact Dryers

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.

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. Hot air or gas is 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.

Rotary dryers are suited particularly to the continuous drying of granular, crystalline, or lumpy material which does not tend to ball or stick together. They consist of a revolving cylindrical shell into which the fresh material is fed at one end and from which the dry material is removed at the other end. Lifting plates usually extend from end to end of the inside of the cylinder, parallel to its axis, projecting radially toward the center. Hot air or products of combustion are blown through the shell, either parallel or counter current to the direction of movement of the material. The rotation of the cylinder continually elevates the material and drops or throws it through the current of hot gas or air, the inclination of the shell moving the charge forward at any desired speed. To furnish additional heat to the material by contact, the cylinder is often provided with a steam jacket or with steam coils inside the cylinder. In drying material which is not injured by high temperatures, the outside of the shell may be fired directly and the products of combustion then led through the dryer in contact with the material.

Air Current Dryers

Spray dryers are used for the drying of thick liquids, including any product in solution, suspension or emulsion, such as milk and rubber latex. The liquid is usually first condensed to from 35 to 50 per cent solid content and is then atomized in the form of a fine spray at the top of a lofty chamber, falling through a current of heated air or furnace gases, the dried powder accumulating at the bottom of the chamber. The air can be heated to a considerably higher temperature than would be used for the same material in a contact dryer and the drying is practically instantaneous. The spraying may be done by atomizing nozzles,