

be provided to prevent stagnation. The velocity of the air passing over the surface to be dried determines the rate at which the moisture-laden air is swept away. The more rapidly this moist air can be removed the more rapidly can evaporation occur. It has been demonstrated that this drying rate is a function of the 0.8 power of the velocity. Air directed perpendicularly to the drying surface exhibits the greatest efficiency in dispersing the *dead air* film. The limiting factors in air velocity are the power requirements to remove the air and the danger of blowing away the lighter particles of material.

Fig. 7 indicates the effect of changes in air velocity for the same material previously considered.

Miscellaneous Items

Many other factors affect the rate of drying curve such as size and shape of pieces, thickness of layer, type of tray or other support, mode of

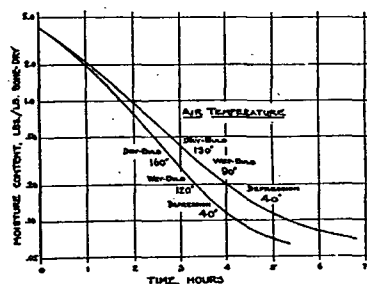


FIG. 5. DRYING CURVES AT DIFFERENT TEMPERATURE LEVELS

Russet potato, blanched $\frac{1}{2}$ -in. strips, wood-slat tray, load 1.5 lb per square foot, cross-circulation, air velocity 500 fpm.

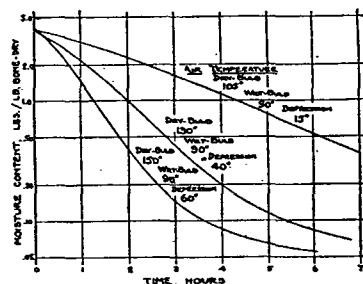


FIG. 6. DRYING CURVES AT DIFFERENT WET-BULB DEPRESSIONS

Russet potato, blanched $\frac{1}{2}$ -in. strips, wood-slat tray, load 1.5 lb per square foot, cross-circulation, air velocity 500 fpm.

exposure to air stream, and relative amounts of heat received by radiation, conduction and convection. Fig. 8, for example, illustrates the effect of changes in layer thickness.

DRYING METHODS AND EQUIPMENT

Drying systems are sometimes classified according to the method of heat transfer that is employed since the entire problem of drying resolves itself into individual problems of heat transfer and the thermodynamics of air and water vapor. The methods of heat transfer are radiation, conduction and convection. Many types of dryers have been built on these principles for different purposes.

Drying systems can also be classified according to the method of product handling—thus batch operation, semi-continuous and continuous.

Radiant Drying

Sun drying, the oldest form known to man, is still practiced where the material is amenable to such treatment, where the necessary time can be allowed, and where there is little danger of rain or atmospheric pollution.

In artificial systems radiating surfaces, heated by steam, electricity or other means, afford a good method of heat distribution and control. Ra-

Drying Systems

diant heating sets up convection currents, and in low-temperature dryers only about one-third to one-half of the total heat for evaporation is actually supplied to the material by radiation. At high temperatures the radiation output increases rapidly, according to the *fourth-power law*. The total radiation may be computed by the equations and tables given in Chapter 5. In general, fins and irregular surfaces do not increase radiation, hence the area to be used in calculations is the area of a smooth-surface envelope enclosing the radiating elements.

A certain amount of air circulation is required through a radiant dryer, in order to carry off the vapor.

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.

Electric heating by induction and dielectric means, as described in Chapter 30, is applicable to the drying of certain materials.

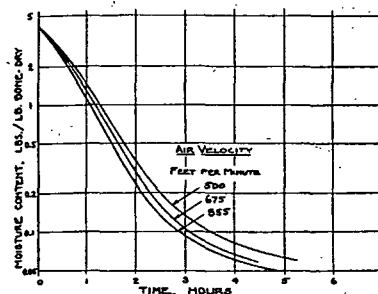


FIG. 7. DRYING CURVES AT DIFFERENT AIR VELOCITIES

Russet potato, blanched $\frac{1}{2}$ -in. strips, wood-slat tray, load 1.5 lb per square foot, cross-circulation, air temperature 150 F, wet-bulb temperature 90 F.

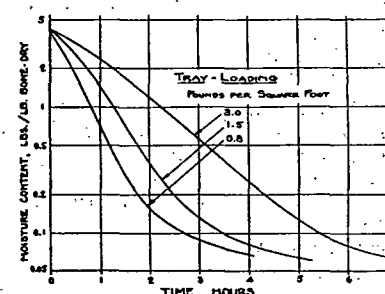


FIG. 8. DRYING CURVES AT DIFFERENT DENSITIES OF LOADING ON TRAYS

Russet potato, blanched $\frac{1}{2}$ -in. strips, wood-slat tray, cross-circulation, air velocity 500 fpm, air temperature 150 F, wet-bulb temperature 90 F.

Conduction Drying

Drying rolls or drums, Fig. 9⁴, 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.

Greatest resistance to heat transfer occurs on the air side of the material being dried. The rate of heat transfer from the surface of the heated material to the air, and hence the rate of drying, may be increased by: (a) forced convection or air circulation and (b) vacuum operation to lower the boiling point of the liquid being evaporated.

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 con-