MOISTURE CONTENT CALCULATIONS

Moisture content is usually expressed as a percentage of the original combined weight of the material and its contained water. Thus, if the moisture content were 20 per cent, the dry material would weigh 80 per cent of the total weight. In drying some types of material, notably lumber, it is customary to use the "bone-dry" or water-free weight of the material as the divisor (100 per cent), the weight of the water being calculated as a percentage of this dry weight.

Regain is practically always expressed by the latter method, as a percentage of the water-free weight of the material.

Moisture Transfusion and Gradient

The rapidity with which evaporation can be carried on at the surface of a material depends upon the *rate of transfusion* or movement of water from the interior to the surface. This is particularly important with thick, bulky, solid substances such as clay and lumber in which the rate of transfusion is slow and which shrink with loss of moisture. In drying material of this kind, the rate of evaporation must be retarded by the use of high humidities in order to prevent too rapid drying and shrinkage of the surface, with consequent case-hardening rupture or distortion of the material. At the same time, internal transfusion must be stimulated by the use of as a high a temperature as the material will stand. At any given temperature, the rate of transfusion varies inversely as the thickness of the material, therefore the minimum time for drying varies approximately as the square of the thickness of the material. See *low temperature drying* for a discussion of case-hardening.

What is known as the *moisture gradient*, between the moisture content at the center of the material and the moisture content close to the surface, is determined by the rate of evaporation at the surface and the rate of transfusion from the center outward. In drying hygroscopic or colloidal materials, good drying practice ordinarily requires that this gradient be held within a narrow range in order to avoid case-hardening or damage due to rapid shrinkage of the surface of the material.

With every material having hygroscopic properties, a point of *equilibrium* is reached at any given temperature between the vapor pressure of the moisture in the air and the vapor pressure of the moisture in the material. In rapid artificial drying at high temperatures, an extremely low moisture content is often produced in the material which is below its natural *equilibrium moisture content* (E. M. C.) in ordinary air. The percentage of moisture that it re-absorbs from the air is sometimes called the *regain*. It varies with the relative humidity of the air and decreases to some extent as the temperature increases.

High Temperature Drying

In what is known as *high temperature drying*, temperatures range from 212 to 1000 deg. fahr. or more. Since these temperatures are above the boiling point, all of the water in the material will vaporize quickly at atmospheric pressures and the humidity of the air becomes of minor importance.

Within the critical limits, many materials produce better results if dried quickly at maximum temperatures than if dried more slowly at lower temperatures. It is important to remove products of oxidation as well as explosive or inflammable gases as quickly as possible, by means of ample circulation. Agitator fans within the dryer are often used in high temperature work to create the necessary velocity for close contact without moving an excessive volume of air. In drying with temperatures above the boiling point, it makes little difference whether the superheated vehicle is gas, air or steam. Static electricity which sometimes accumulates with hot dry air and makes powders and fabrics difficult to handle, may often be controlled with a small steam spray. Many materials dried at high temperatures are soft when removed from the dryer and must be hardened in air that is warm enough and dry enough to prevent sweating and moulding.

Low Temperature Drying

Air processing at temperatures below 200 deg. fahr., involves control of both the temperature and the relative humidity of the air, as well as the velocity and uniformity of circulation. Regulation is governed so that evaporation from the surface is allowed to proceed only as fast as moisture transfuses from the interior of the material, after allowing a safe moisture gradient to be set up.

In the early stages, when the material contains a considerable amount of free water, a relative humidity of between 80 and 90 per cent is usually called for, with a comparatively low temperature in the case of materials of cellular structure which are liable to collapse if allowed to become too hot when still very moist. At these high humidities, a rapid and uniform circulation is essential to secure uniform drying and the housing of the dryer must be well insulated in order to prevent condensation on the material and on the inner surfaces of the dryer, particularly the ceiling and air ducts.

As the drying proceeds, successive changes in the moisture content and condition of the thicker and more exacting materials call for gradual increases in temperature and decreases in humidity until the final stage is reached. This is usually a somewhat lower moisture content than equilibrium under conditions of use, to allow for enough regain to balance the moisture remaining in the interior and surface to a uniform condition. For every temperature there is a certain humidity which will dry the material to a certain point and then stop. It is usually undesirable to allow the drying to proceed much beyond the equilibrium point of the material in use, as over-drying is liable to produce undesirable physical changes in the material, and such over-drying also unnecessarily prolongs the time and increases the cost of the operation.

Uncontrolled humidity is also liable to cause excessively rapid drying of the surface of the material in the early stages. This produces a condition known as "case-hardening," the material being encased in a dry layer which it is difficult for the interior moisture to work through. In this way the drying operation is retarded and may, in some cases, be entirely stopped and replaced by a baking operation. Another harmful result in materials subject to shrinkage, such as wood and clay, is that the case-hardened surface is dried and stiffened or "set" in an expanded