Fiber saturation point is the moisture content of cellular materials (wood, etc.) at which the cell walls are completely saturated while the cavities are liquid-free. It may be defined as the equilibrium moisture content as the humidity of the surrounding atmosphere approaches saturation.

Free moisture content is that liquid content which is removable at a given temperature and humidity. Free moisture may include both bound and unbound moisture.

The funicular state is that condition in drying a porous body when capillary suction causes air to be sucked into the pores.

Humidity denotes the amount of water vapor actually present in a gas, and is generally expressed as weight of vapor per unit weight of any gas.

A hygroscopic material is one that may contain bound moisture.

Initial moisture distribution refers to the moisture distribution throughout a solid when drying begins.

Internal diffusion. Diffusion is a single-phase phenomenon; internal diffusion must therefore occur as solid through solid, liquid through liquid, or gas through gas. Internal diffusion occurs when the moving phase obeys the fundamental laws of diffusion.

The moisture content of a solid is usually expressed as moisture quantity per unit weight of volume of the dry or wet solid. A weight (dry or wet) basis is preferred.

Moisture gradient refers to the internal distribution of water in a solid at a given moment in the drying process, the nature of which depends on the characteristics of the solid involved.

A non-hygroscopic material is one that can contain no bound moisture.

Pendular state is that state of a liquid in a porous solid when a continuous film of liquid no longer exists around and between discrete particles and, therefore, flow by capillarity cannot occur. This state succeeds the funicular state.

Unaccomplished moisture change refers to the ratio of the free moisture present at any time to that initially present.

Unbound moisture in a hygroscopic material is that moisture in excess of the equilibrium moisture content corresponding to saturation humidity. All water in a non-hygroscopic material is unbound water.

Wet basis expresses the moisture in a material as a percentage of the weight of the *wet* solid. This basis is less satisfactory than the dry-weight basis on which the percentage change of moisture is constant for all moisture contents. Fig. 1 shows the relationship between the *dry-* and *wet-weight* bases, and indicates that when the *wet-weight* basis is used to express moisture content, a 2 or 3 percent change at high moisture content (above 70 percent) actually represents a 15 to 20 percent change in evaporative load. An evaporative increase of this amount might well increase the load above the capacity of a dryer.

MECHANISM OF DRYING[1]

When a solid dries, two fundamental processes are involved: (1) the transfer of heat to evaporate the liquid, and (2) the transfer of mass as vapor and internal liquid. These two processes occur simultaneously, and the factors governing the rate of each process determine the rate of drying.

In any commercial drying problem, a principal objective is to supply the required heat in the most efficient manner. Consequently, heat transfer may occur by convection, conduction, or radiation, or by any combination of these mechanisms. The various types of industrial dryers may be shown to differ fundamentally with respect to the method used for transferring heat to the solid. In general, heat must flow first to the outer surface of the solid and then into the interior. An important exception is drying with high frequency electrical currents where heat is *generated within the solid*, producing a higher temperature at the interior than at the surface, and consequently, causing heat to flow from inside the solid to the outer surfaces.

Mass transfer in drying occurs as liquid or vapor flow, or both, within the solid, and as vapor flow from the external wet surfaces. The nature of liquid concentration gradients in solids during drying depends on the mechanism of internal liquid flow, and this mechanism, in turn, depends to a large extent upon the physical and chemical characteristics of the solid being dried.

Internal vs. External Conditions

A study of how a solid dries may be based on the *internal* mechanism of liquid flow, or on the effect of the *external conditions* of temperature, humidity, air flow, state of subdivision, etc., on the drying rate of the solid. The former procedure involves a fundamental study of the liquid flow conditions within a solid during drying. The latter procedure, although less fundamental, is more generally used because the effects are easier to establish and the results have greater immediate application in dryer design and operation.

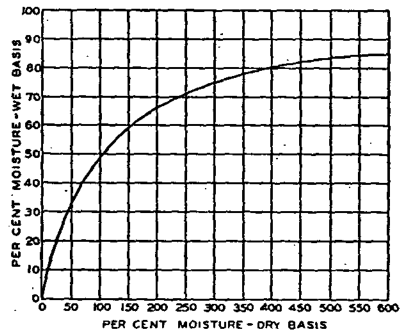

Fig. 1. Relation between Wet-Weight and Dry-Weight Bases

Internal Mechanism of Liquid Flow. Internal liquid flow may occur by several mechanisms, depending on the structure of the solid. Several mechanisms of flow are as follows:

1. *Diffusion* in continuous, homogeneous solids.
2. *Capillary flow* in granular and porous solids.
3. Flow caused by *shrinkage* and *pressure* gradients.
4. Flow caused by a *vaporization-condensation* sequence.
5. Flow caused by *gravity*.
6. Flow caused by an electrical potential, *electro-osmosis*.
7. Flow caused by temperature gradients, *thermal diffusion*.

Although more than one of these mechanisms of flow may be effective at one time, only one predominates as a rule at a given time in a solid during drying. However, a different mechanism may predominate at a different time in the cycle. The mechanism of moisture flow is usually established experimentally from a study of moisture gradients.

External Variables. The principal external variables involved in any drying problem are: *temperature, humidity, air flow, state of subdivision* of the solid, *agitation* of the solid, *method of supporting the solid,* and the *contact* between hot surfaces and wet solid. All these variables do not necessarily occur simultaneously in one problem.