rapidly at the high temperatures which are obtained in dry kilns even with high relative humidities than under conditions that obtain at normal atmospheric conditions. Practical operation of dry rooms would seem to show that diffusion of moisture is also facilitated by keeping the material in a rather moist hygroscopic state.

Curve II on Fig. 6 shows the relative rate of evaporation of hygroscopic moisture in cotton compared with the rate of evaporation with free moisture. It is interesting to note what happens at moisture contents less than that corresponding to the vapor pressure of the air. At a moisture content of 3.7 parts per hundred, the vapor pressure of the moisture in the material and the temperature are the same as that of the air and the rate of evaporation is zero. At moisture contents of material below this point, the rate of evaporation becomes negative, i.e., there is absorption of moisture. For example, the rate of absorption with material containing two parts of moisture is exactly as rapid as the drying which occurs when the material contains 6.3 parts of moisture. The temperature of the material, however, will be higher than the dry bulb temperature of the air. In this particular case it would be 118 deg., while with 6.3 parts of moisture content the temperature of the material would be 82 deg. These relations may easily be worked out for any known material and any hygroscopic condition.

The rate of evaporation, of course, will vary with the velocity exactly as it does with the free moisture surface, except where the diffusion of moisture is slower than the normal rate of evaporation. When this point is reached, increased air velocities will be of slight advantage.

The formulae by which the temperature of material and the rate of evaporation in a dry material may be calculated are as follows:—

$$t - t_m = \frac{(me_m - e)}{C'}$$

where t = the temperature of the air;

t_m = the temperature of the material;

m = the per cent of vapor pressure corresponding to the temperature and to the per cent of moisture in the material;

e_m = the vapor pressure corresponding to the saturation at the temperature t_m;

me_m = therefore, the vapor pressure of the moisture in the material in the process of evaporation;

C' = the psychrometric coefficient and is determined as follows:

$$C' = \frac{P - e'}{2920 - \dfrac{69500}{80 + t_p - t'} + 0.054\,(t - t')}$$

The relative rate of evaporation or of absorption compared with that of a free water surface is:

$$\frac{me_m - e}{e' - e} = \frac{t - t_m}{t - t'}$$

Many hygroscopic materials are very easily injured in drying, as for example, hard wood, ceramic ware, macaroni, paper, leather, etc. It has been usual to avoid injury by slow drying, but this is not at all necessary, neither is it at all effective. Material can be injured in slow drying if the moisture conditions are not right and it is much more apt to be injured by slow drying at low temperatures without regulation than by rapid drying under properly regulated conditions.

There are two especially critical stages in the drying of all such products. The first stage is in the removal of the free moisture and a proportion of the hygroscopic moisture. This should be done at high humidities which will keep the materials pliable and prevent cracking, checking, warping or brittleness.

The next critical point in the drying is the point at which normal regain of moisture content is to be secured at the end of the process of drying. Many processes of drying injure the product by the removal of moisture far beyond the point which occurs under normal atmospheric conditions. Another point is that materials do not exhibit the proper elasticity, flexibility, appearance, etc., when dried to an excessive degree. In many cases the manufacturer loses considerable in the market value of his product owing to the fact that he is selling it at a weight which is below normal owing to the excessive removal of moisture.

It has been found possible to determine and control automatically the moisture content of hygroscopic materials to a remarkable degree of accuracy in the final stages of drying and conditioning and also to secure a perfectly uniform distribution of moisture throughout all parts of the product, which is also usually essential.

SUMMARY

It has been shown that:—

1. The psychrometric wet bulb temperature and temperature of evaporation are substantially identical.