Cooling Load

In the calculation of the cooling load for an air conditioned space, the problem usually reduces to determining the quantity of inside air that must be withdrawn and the condition to which it must be brought by cooling, separating and possibly reheating so that return of the conditioned air will have the net effect of removing given amounts of energy and water from the air conditioned space.

Let m denote the weight of dry air withdrawn per hour. With it will be withdrawn *energy* of amount mh_1 Btu per hour and *water* of amount mW_1 pounds per hour, where h_1 and W_1 denote enthalpy and humidity ratio, respectively, of inside air. The weight of dry air returned per hour will be the same as that withdrawn but with it must be returned a smaller amount of *energy*, mh Btu per hour, and a smaller quantity of *water*, mW pounds per hour, where h and W denote enthalpy and humidity ratio of conditioned air.

With this understanding, the requirements of the cooling load problem are,

$$mh = mh_1 - \Delta Q$$
$$mW = mW - \Delta W$$

where ΔQ and ΔW are the *given* amounts of energy and water, respectively, to be removed. Eliminating m from these two equations,

$$\frac{h - h_1}{W - W_1} = \frac{\Delta Q}{\Delta W}$$

which says that all possible states for the conditioned air lie on a straight line, on the Mollier Chart, which passes through the state point of the inside air with a slope determined by the ratio of the quantity of energy to be removed to the quantity of water to be removed. This straight line is called the *condition line* for the given problem. The border scale facilitates the graphical solution of this problem.

In practice the point at which the condition line crosses the saturation curve may dictate an excessive number of air changes for the particular space to be conditioned. If so it might be necessary to cool to a lower temperature; but if the requirements of the problem are to be exactly met both as regards the removal of water and the removal of energy, the mixture returned to the conditioned space must contain a certain amount of liquid. In other words, its state point must lie on the condition line; otherwise excessive dehumidification will result.

Example 19. In order to maintain a condition of 80 F dry-bulb, 67 F wet-bulb in a certain store, it is found necessary to remove 115,060 Btu of energy per hour and 15.97 lb of water per hour. Analyze the problem.

Solution. The state point of the inside air is easily located on the Mollier Chart. Through it draw a line having the slope 115,060 ÷ 15.97 = 7205 Btu per pound *water* as determined from the border scale. This line crosses the saturation curve at 58.02 F. Hence a possible conditioning process is to cool some of the inside air to 58.02 F, separate the liquid thus formed, and return the resulting saturated mixture to the store.

The thermodynamic properties entering the calculation are:

	Inside Air	*After Cooling*	*After Separating*
t	80.0 F	58.02 F	58.02 F
W	0.01115	0.01115	0.01027
h	31.41	25.09	25.07

The weight of dry air to be withdrawn is 115,060 ÷ (31.41 − 25.07) = 18,130 lb per hour.

Adiabatic Saturation

Any case of adiabatic mixing in which the resulting mixture is saturated may properly be called *adiabatic saturation*. For example, if enough water at 352 F be sprayed into dry air at 80 F to produce a saturated mixture, the resulting enthalpy will be $h_s = 19.19 + (W_s - 0)\ 324$; and since h_s and W_s are functions of the same temperature, this temperature is determined by the equation to be 53.0 F. Thus, adiabatic saturation of dry air at 80 F by injecting liquid water at 352 F results in a temperature of 53.0 F when saturation is reached.

But in practice, much more is usually read into the term adiabatic saturation, it being generally understood that saturation is to be produced by injecting liquid water at such a temperature as will *coincide* with that at which the saturation curve is reached. *With this understanding it may be said that thermodynamic wet-bulb temperature is the*

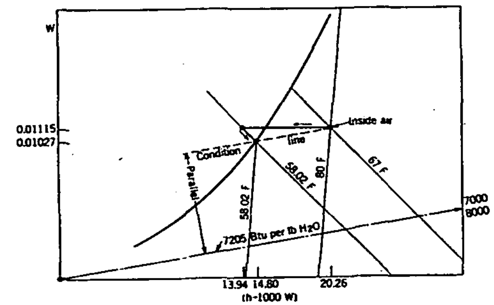

Fig. 8. Diagram Illustrating Example 19

result of adiabatic saturation. Thus, if liquid water at 48.26 F instead of 352 F be injected into dry air at 80 F a saturated mixture at 48.26 F instead of 53.0 F will be produced. Therefore, 48.26 F is the thermodynamic wet-bulb temperature of dry air at 80 F.

It is possible to produce adiabatic saturation, interpreting the term literally, by mixing two air streams neither of which is itself saturated. In order for this to be possible, the straight line connecting the representative points on the Mollier diagram must cut the saturation curve twice.

PSYCHROMETRIC CHART

Many types of charts which give graphical solutions of the psychrometric equations, and other useful data, have been devised. One of these, the Revised Bulkeley Psychrometric Chart[4], will be found in the envelope attached to the inside back cover of this book. Detailed in-

[4]The original Bulkeley Psychrometric Chart was presented to the Society in 1926. (See A.S.H.V.E. Transactions, Vol. 32, 1926, p. 163). Single copy of the revised chart can be furnished at a cost of $ .25.