

MODULE 6

HUMIDIFICATION AND AIR CONDITIONING

LECTURE NO. 2

6.12 *Adiabatic saturation temperature:*

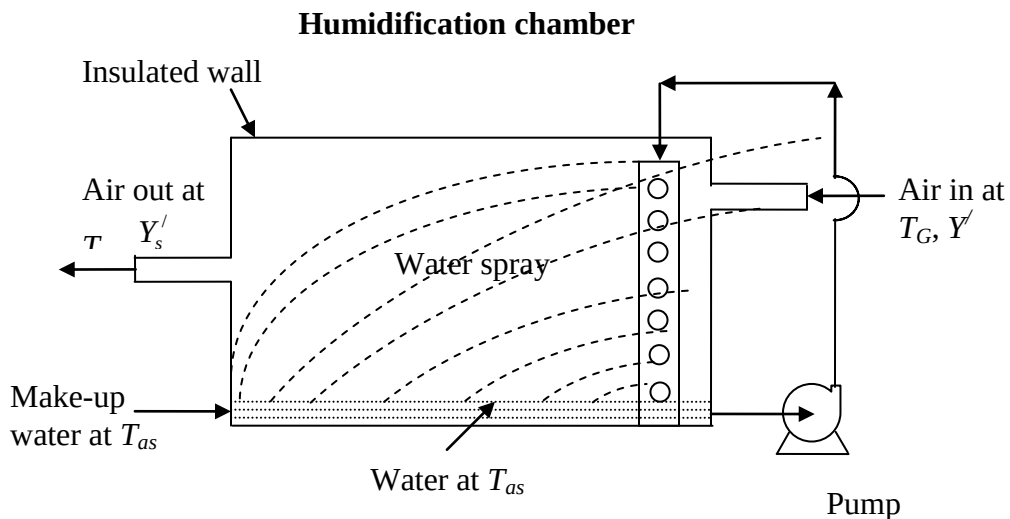


Figure 6.1: Schematic representation of adiabatic saturation of air

The schematic of the adiabatic saturation of air by water is shown in Figure 3.1. The air stream attains thermal equilibrium with water at temperature T_{as} and also gets saturated with water vapor at that temperature before it leaves. A small quantity of water at the temperature T_{as} is fed to the humidification chamber continuously in order to compensate for the vaporization loss of water. The chamber operates adiabatically, wall is well-insulated. The temperature T_{as} attained by air (same as water) is called “adiabatic saturation temperature, T_{as} ”.

$$\text{Enthalpy of inlet air, } H'_i = c_H(T_G - T_{as}) + \lambda_s Y'_i \quad (6.7)$$

$$\text{Enthalpy of exit air, } H'_o = c_H(T_{as} - T_{as}) + \lambda_s Y'_s = \lambda_s Y'_s \quad (6.8)$$

At steady state, $H'_i = H'_o$;

Hence,

$$c_H(T_G - T_{as}) + \lambda_s Y'_i = \lambda_s Y'_s \quad (6.9)$$

$$(T_G - T_{as}) = \frac{\lambda_s}{c_H}(Y'_s - Y'_i) \quad (6.10)$$

6.1.3 Wet bulb temperature

When evaporation of water occurs?

If the vapor pressure of water is higher than the partial pressure of water vapor in the ambient air, evaporation occurs. The latent heat for evaporation will be supplied by (i) surrounding air and (ii) water drop itself.

Now, consider a drop of water at the tip of thin wire. As temperature of water drop decreases with time, vapor pressure decreases causing a reduction in partial pressure driving force. Temperature driving force for heat transfer from ambient air to water increases. If sufficient time is allowed, a steady state temperature will be attained by drop. This is wet bulb temperature.

Factors that have influence on wet-bulb temperature

- (i) Dry bulb temperature of air T_G
- (ii) Humidity, Y'
- (iii) Air velocity
- (iv) Shape of the thermometer bulb

The combination of a dry-bulb and wet-bulb thermometer is called a “psychrometer”.

Determination of relationship between wet-bulb and dry-bulb temperature

$$\text{Heat flux, } q = h_G(T_G - T_w) \quad (6.11)$$

$$\text{Molar flux, } N_A = k_G(p_w - p_A) \quad (6.12)$$

Since, heat flux is sufficient to meet requirement of latent heat of vaporization at steady state.

$$\text{Hence, } h_G(T_G - T_w) = \lambda_w M_w k_G(p_w - p_A) = \lambda_w K'_Y(Y'_w - Y') \quad (6.13)$$

$$(T_G - T_w) = \frac{\lambda_w(Y'_w - Y')}{\left(\frac{h_G}{K'_Y}\right)} \quad (6.14)$$

$$\frac{h_G}{K'_Y} \approx c_H; \quad \frac{h_G}{c_H K'_Y} \approx 1 \rightarrow \text{Lewis relation}$$

For any system,

$$\frac{h_G}{K'_Y} = 1.231 Sc^{0.56} \text{ kJ/kg.K}$$

$$\text{Now Equation (6.14) becomes, } (T_G - T_w) = \frac{\lambda_w(Y'_w - Y')}{c_H} \quad (6.15)$$

Equations (6.10) and (6.15) are identical and $T_{as} = T_w$.

Adiabatic saturation temperature and wet-bulb temperature are nearly equal for air-water system.

$(T_G - T_w)$ is called wet-bulb depression.

6.2 The Psychrometric chart construction and its use

Seven important quantities, namely, dry-bulb temperature, wet-bulb temperature, relative humidity, absolute humidity, dew point, enthalpy and specific volume, are all inter-related. The psychrometric chart characterizes this interdependence. If any two of these quantities are known, the other five quantities can be readily obtained from the Psychrometric chart. The Psychrometric chart can be obtained from the link: <http://en.wikipedia.org/wiki/Psychrometrics>.

The interdependency of these seven properties is presented in Figure 6.2. If T_G is the dry-bulb temperature of air and Y' is its humidity, its state is denoted by point 'a'. It falls on the constant humidity line, A%. The adiabatic saturation line through

'a' is 'ab'. 'c' point indicates its humidity, Y' . The adiabatic saturation temperature, T_{as} is obtained by drawing the vertical line through 'b'. For air-water system, wet-bulb temperature T_w is practically same as T_{as} . The humidity of the adiabatically saturated air is given by the point 'e'. The dew point T_d is given by the point 'd' that can be reached by moving horizontally from the point 'a' to 100% humidity line and then moving vertically down to the temperature axis. The humid volume of saturated air at T_G corresponds to the point 'f' and that of dry air at T_G is given by point 'g'. The point 'm' gives the humid volume if the humidity is Y' and it is reached by interpolation between 'g' and 'f'. Enthalpy of a sample of air can also be obtained from humidity chart.

How to use this chart?

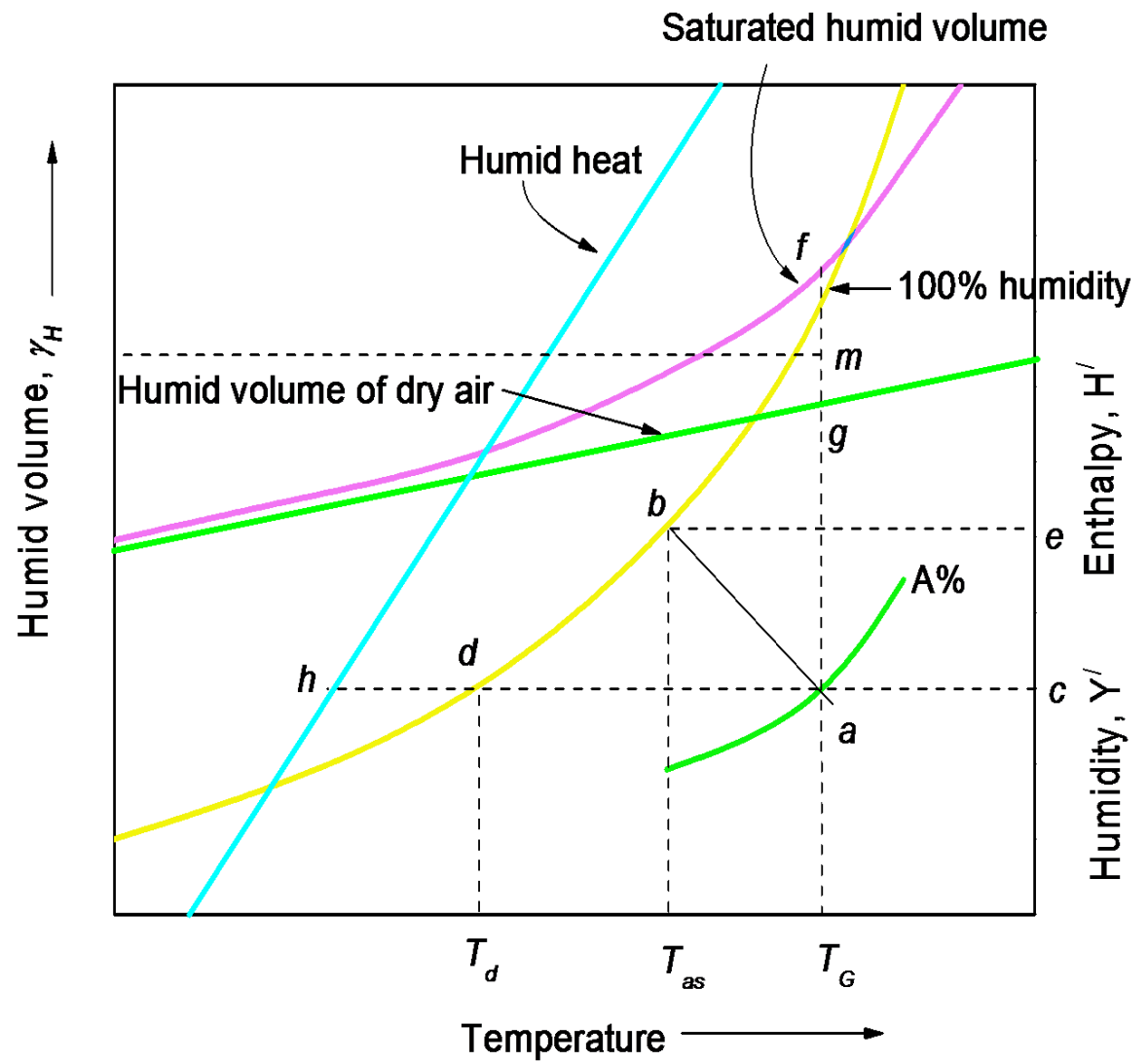


Figure 6.2: Determination of properties from the psychrometric chart.