

are the two enthalpies calculated. Conservation of energy requires that the difference between these two enthalpies be the quantity of heat removed, or refrigeration supplied, between the two sections. Therefore,

$$-AQ_B = 43,072 - 34,187 = 8,885 \text{ Btu/lb}_a$$

The initial volume is $13.980 + 0.50 \times 0.822 = 14.391 \text{ cu ft/lb}_a$. Since 20,000 cfm of air is to be processed, the total refrigeration required is

$$-AQ_B = 8,885 \times 20,000 \div 14,391 = 12,348 \text{ Btu per minute}$$

On the Mollier Diagram the process is represented by the horizontal line AB, Fig. 3, whose length is the quantity of refrigeration required per pound of dry air.

Adiabatic Mixing of Two Air Streams

A typical air conditioning process requiring special analysis is the adiabatic mixing of two air streams. Referring to Fig. 4, let m_1 , m_2 , m_3 denote the weights of dry air convected across sections F_1 , F_2 , F_3 , respectively, per minute. Then m_1W_1 , m_2W_2 , m_3W_3 and m_1h_1 , m_2h_2 , m_3h_3 will

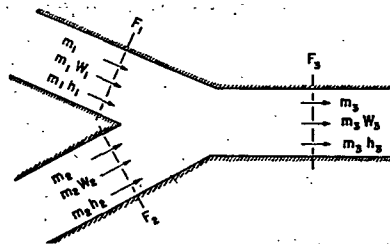


FIG. 4. ADIABATIC MIXING OF 2 AIR STREAMS

denote the weights of water and the quantities of energy similarly convected. If the mixing is adiabatic, it must be governed by the three equations,

$$\begin{aligned} m_1 + m_2 &= m_3 \\ m_1W_1 + m_2W_2 &= m_3W_3 \\ m_1h_1 + m_2h_2 &= m_3h_3 \end{aligned} \quad (8)$$

Elimination of m_3 gives,

$$\frac{h_2 - h_1}{h_3 - h_1} = \frac{W_2 - W_1}{W_3 - W_1} = \frac{m_1}{m_2} \quad (9)$$

according to which: *on the Mollier Diagram the state point of the resulting mixture lies on the straight line connecting the state points of the two streams being mixed and divides the line into two segments which are in the same ratio as are the weights of dry air in the two streams.*

Example 8. Outside Air at 0 F and 80 per cent saturation is to be mixed adiabatically with recirculated Inside Air at 70 F and 20 per cent saturation in the ratio of one pound of dry air in the former to seven in the latter. Find the temperature and degree of saturation of the resulting mixture.

Solution. The humidity ratio W_1 and the enthalpy h_1 of the resulting mixture must satisfy Equations 9, namely,

$$\frac{0.003164 - W_1}{W_1 - 0.000630} = \frac{20.270 - h_1}{h_1 - 0.668} = \frac{1}{7}$$

from which: $W_1 = 0.002847$, $h_1 = 17.820$. At the temperature of the resulting mixture, therefore,

$$h_a + 0.002847 h_{as}/W_s = 17.820$$

At 61 F the lefthand member of this equation has the value 17.750; at 62 F its value is 17.991; by interpolation the temperature of the resulting mixture is 61.29 F where the humidity ratio at saturation, also by interpolation, is 0.01161; hence the degree of saturation of the resulting mixture is

$$\mu = 0.002847 \div 0.01161 = 24.52 \text{ per cent}$$

On the Mollier Diagram, Fig. 5, a straight line is drawn between point 1 (0 F, 80 per cent) and point 2 (70 F, 20 per cent); then point 3 is located on the line one-eighth of the distance from point 2 to point 1. The temperature and degree of saturation at point 3 are read directly.

Adiabatic Mixing with Injected Water

Another typical air conditioning process is that of injecting water into an air stream to mix with it adiabatically. Let $W_2 - W_1$ denote the increase in humidity ratio of the air; this is obviously the quantity of water injected per pound of dry air; it follows that the quantity of energy injected per pound of dry air is $(W_2 - W_1)h_w$, where h_w denotes the specific enthalpy of the water as injected; if the process is adiabatic this produces an equal increase in the enthalpy of the air, namely, $h_2 - h_1$; therefore,

$$h_2 - h_1 = h_w(W_2 - W_1) \quad (10)$$

according to which: *the process of injecting water into an air stream to mix adiabatically with it is represented by a straight line on the Mollier Diagram whose direction is fixed by the specific enthalpy of the water as injected.* The protractor drawn on the Mollier Diagram provided with this book provides a convenient means for determining this direction.

Example 9. It is desired to increase the humidity ratio of air at 70 F dry-bulb, without changing its temperature. Under what conditions may water be injected in order to accomplish the desired result?

Solution. At 70 F the increase of enthalpy per unit increase of humidity ratio is $h_{as}/W_s = 17.27 \div 0.01582 = 1092 \text{ Btu per pound of water}$. This must be the specific enthalpy of the water added if the state point of the air is to be moved along the 70 F isotherm. Saturated steam at 668 F has this specific enthalpy¹.

On the Mollier Diagram, Fig. 6, it is seen that the 70 F isotherm is parallel to the line on the protractor for a specific enthalpy of 1092 Btu per pound.

Adiabatic Saturation

Any process by which the state point of moist air is moved to the saturation curve adiabatically may properly be called adiabatic saturation.

Example 10. Liquid water chilled to 35 F is evaporated into an air stream initially at 90 F and 50 per cent saturation. How much water must be evaporated to bring the air to saturation at what temperature?

Solution. The initial enthalpy of the air is $21.625 + 0.50 \times 34.31 = 38.780 \text{ Btu/lb}_a$; the initial humidity ratio is $0.50 \times 0.03118 = 0.01559 \text{ lb}_w/\text{lb}_a$; the specific enthalpy of the chilled water is 3.06 Btu/lb_w; therefore, the temperature at which the air reaches the saturation curve must be such that the enthalpy h_s and humidity ratio W_s at saturation satisfy the equation,

$$h_s - (W_s - 0.01559) \times 3.06 = 38.780$$

The solution is 75.19 F where the humidity ratio at saturation is 0.01894; consequently,