

line at a constant horizontal distance from the saturation curve. It should be understood that the line 1-A-2-3 is not intended to represent the path of the condition of the air as it passes through the coil from row to row. It is simply the path traced by the exit air conditions as the surface temperature is gradually reduced with other conditions remaining constant².

In the process of dehumidification, since heat is being transferred to the coil surface by two different mechanisms, (convection and condensation), it is evident that an over-all coefficient of heat transfer cannot be determined by the same method used for heating and for dry cooling coils. However, if it is assumed that the sensible heat transfer of a dehumidifying coil is unaffected by the presence of moisture on its surface, Equation 5 may be obtained to express this part of the heat transfer in terms of the external film coefficient and the surface temperature.

$$q_s = h_a \times A \times N \times (MTD_s) \quad (5)$$

where

q_s = sensible heat transferred, Btu per (hour) (square foot of coil face area).

t_1 = dry-bulb temperature of air entering coil, Fahrenheit degrees.

t_2 = dry-bulb temperature of air leaving coil, Fahrenheit degrees.

t_a = average temperature of coil external surface, Fahrenheit degrees.

MTD_s = logarithmic mean temperature difference between air and coil surface =

$$\frac{t_1 - t_2}{\log_e \frac{t_1 - t_a}{t_2 - t_a}}$$

If Equation 5 is combined with another equation expressing sensible heat transfer in terms of mass velocity and temperature difference, the variables may be arranged in the following form (which is useful for the solution of dehumidification problems and for the determination of h_a from test data):

$$\frac{h_a AN(t_1 - t_2)}{\log_e \frac{t_1 - t_a}{t_2 - t_a}} = 0.243G(t_1 - t_2)$$

or,

$$\frac{h_a AN}{0.243G} = \log_e \frac{t_1 - t_a}{t_2 - t_a} \quad (6)$$

where

0.243 = specific heat of humid air, Btu per (pound) (Fahrenheit degree).

G = air mass velocity, pounds per (hour) (square foot of coil face area).

An examination of Fig. 1 will reveal that when t_a is at the dew-point of the entering air:

$$\frac{t_1 - t_a}{t_a - t_2} = \frac{t_1 - t_{dpt}}{t_a - t_{dpt}}$$

and when t_a is below the dew-point:

$$\frac{t_1 - t_a}{t_2 - t_a} = \frac{t_1 - t_{dpt}}{t_2 - t_{dpt}}$$

Therefore, Equation 6 may be written in its most useful form as:

$$\frac{h_a AN}{0.243G} = \log_e \frac{t_1 - t_{dpt}}{t_2 - t_{dpt}} = \log_e \frac{t_1 - t_a}{t_2 - t_a} \quad (7)$$

where

t_a = minimum dry-bulb possible without dehumidification, Fahrenheit degrees.

t_{dpt} = dew-point of air entering coil, Fahrenheit degrees.

t_{dpt} = dew-point of air leaving coil, Fahrenheit degrees.

This equation may be used to establish a line as A-2-3 for a given coil if h_a is known for the coil, or it may be used to determine h_a from test data for the purpose of rating coils. The use of this equation for coil selection is illustrated in Example 1 at the end of the chapter. Equation 7 is also important as a means of determining the external film coefficient.

External Film Coefficient

While formulas have been developed expressing the film coefficient h_a for air passing parallel to a plane surface, they cannot be used directly for fins on tubes because of air turbulence and because of the temperature gradient prevalent from the edge of a fin to its center. It is therefore necessary to make tests to evaluate the combined term ηh_a . The term, ηh_a , will be written merely h_a in this discussion as there is no necessity for separately evaluating η and because values of h_a are usually applied only to the particular coils for which tests are made.

The air side coefficient, h_a , of a coil of particular dimensions is an exponential function of the mass velocity of the air:

$$h_a = Z G^n \quad (8)$$

where

h_a = film coefficient of heat transfer, Btu per (hour) (square foot external surface) (Fahrenheit degree mean temperature difference between air and average surface temperature).

G = air mass velocity, pounds per (hour) (square foot of coil face area).

Z and n = constants which depend upon both air turbulence and surface arrangement.

Evaluation of constants Z and n may be accomplished through the use of test data in Equation 7 which gives values of h_a directly from the results of any wet coil test. If h_a , calculated in this manner, is plotted against values of G which prevailed during the tests a straight line should result on logarithmic coordinates. The slope of this line is the value of n . The value of Z may then be determined by direct substitution in Equation 8.

For finned coils of different designs, values of Z and n are extremely variable, depending on the particular design and arrangement of the coil surface. Therefore, it is desirable that these constants be determined directly from test data for each type of coil surface.

Internal Film Coefficient

The internal film coefficient, h_i , which appears in Equation 3, is evaluated in various ways, depending upon the nature of the fluid, and whether the fluid is changing state.

When evaporating refrigerants are used in tubes, the temperature of the