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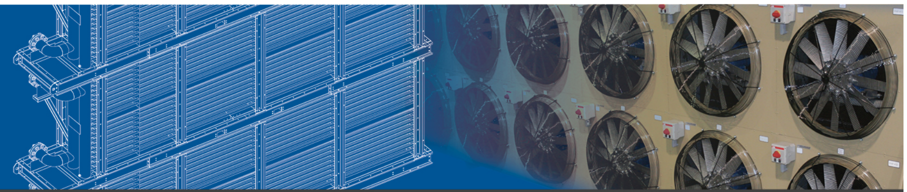
Manufacturing Inc.



Technical Bulletin

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BACK TO BASICS: USEFUL EQUATIONS WHEN SIZING COILS WITH COILPRO

Introduction

There are several equations that can be used in conjunction with the Colmac "CoilPRO" selection software program to speed the process of sizing coils. Following is a listing of several of these equations, a description of where they come from, and examples of how they are used.

Sensible Heating or Cooling

A definition of “sensible heat” is that heat which, when added or removed from a substance, results in a temperature change of that substance. If air or water is sensibly heated or cooled, the temperature (as measured by a thermometer) goes up or down. Heating air with a steam coil or a hot water coil is an example of sensibly heating air.

For sensible heating or cooling, the following equation holds true: **Q = M * Cp * Delta T**

Where:
- **Q** = The amount of heat transferred to or from the fluid (BTU/hr)
- **M** = Mass flow rate of the fluid (lb/hr)
- **Cp** = Specific heat of the fluid (BTU/lb-°F)
- **Delta T** = The change in temperature of the fluid (°F)

For air between 32° and 212° F, after converting the mass flow rate of air to standard cubic feet per minute (SCFM), and inputting the correct specific heat, the above equation becomes: **Qair = 1.085 * SCFM** * (**E**ntering **A**ir **T**emperature - **L**eaving **A**ir **T**emperature).

Note: Standard CFM can be calculated by multiplying the actual (measured) CFM by the ratio of the density of the actual air to the density of standard air (see equation below).

SCFM = ACFM * density of the actual air (lb/cu ft) / 0.075 (lb / cu ft)

The “air” version of the sensible heat equation can be used in several ways:

- If one knows the airflow, the entering air temperature (EAT) and the leaving air temperature (LAT); use the equation as stated above to calculate the amount of heat added to or taken from the air stream: **Qair = 1.085 * SCFM * (LAT - EAT)**

- If one knows the amount of heat required from a coil, the EAT and LAT; and want to calculate the amount of airflow required, the equation becomes: **SCFM = Q / 1.085 * (LAT - EAT)**

- If one knows the amount of heat required, the airflow, and the EAT, and want to calculate the required LAT, the correct equation is: **LAT = (Q / 1.085 * SCFM) + EAT**

For water, after doing the required conversions and inputting the correct specific heat, the sensible heat equation becomes: **Qwater = 500 * GPM** * (**L**eaving **W**ater **T**emperature - **E**ntering **W**ater **T**emperature).

As you can see, in the case of a hot water coil, where the air is heated and the water is cooled, the above equation will result in a negative Q. In a chilled water coil, the air is cooled and the water is heated, Q is positive. Keep in mind that a negative Qwater results in an equal, positive Qair (heating coil), and a positive Qwater results in a negative Qair (cooling coil).

This equation can be manipulated in the same way as the "air" version:

- If it is desired to calculate the amount of heat added to or taken from the water flowing through a coil, one must know the GPM, the LWT and EWT. Use the equation as stated above:

  Qwater = 500 * GPM (LWT - EWT)

Once again, keep in mind that the heat added to or taken from the water is equal to the heat taken from or added to the air stream. At times it is convenient to calculate the heat transferred to the air stream by doing calculations on the water side of the coil.

- If Q is known, and LWT and EWT are known, the GPM can be calculated as follows:

  GPM = Q / 500 * (LWT - EWT)
- If Q is known and the GPM is known, the required water "delta T" (LWT - EWT) can be calculated:

  Delta T (water) = Q / 500 * GPM

Sensible and Latent Cooling

The above equations for air do not apply to the majority of cooling coils (the equations for water apply to both heating and cooling coils). Air going through a typical cooling coil is not only sensibly cooled, latent cooling is also involved (although sensible cooling normally accounts for the majority of the cooling). Latent heat is defined as heat, that when added to or removed from a substance, results in a change of state with no change in temperature of that substance. The condensation we see on the fins of most cooling coils is a result of the latent heat that was removed from the air stream and resulted in the water vapor changing to a liquid state. To calculate the total heat removed from the air stream in a cooling coil, we must account for the sensible and latent heat. The term "Enthalpy" is used to describe the total heat of a substance. The enthalpy of a substance is the sum of the sensible heat and latent heat contained in that substance. It is expressed in BTU/lb and is normally designated by "H". For air, enthalpy is expressed in BTU/lb of dry air. Saturated air at -3° F has been assigned the value of 0 BTU/lb.

The equation for calculating the total heat added to or taken from a fluid flow is: **Q = M * Delta H**

Where:
Q = The amount of heat transferred to or from the fluid (BTU/hr)
M = Mass flow rate of the fluid (lb/hr)
Delta H = The change in enthalpy of the fluid (BTU/lb)

For air, the above equation becomes: **Qair = 4.5 * SCFM** * (**L**eaving **A**ir **E**nthalpy - **E**ntering **A**ir **E**nthalpy)

This equation can be manipulated several ways depending on what we know and what we want to calculate:

- If one knows the airflow, and the entering and leaving enthalpy, Q can be calculated as stated above:

  Qair = 4.5 * SCFM * (LAH - EAH)

- If one knows Q, and the entering and leaving enthalpy, SCFM can be calculated as follows:

  SCFM = Qair / 4.5 * (LAH - EAH)

- If one knows Q, the airflow and the entering enthalpy, the leaving enthalpy can be found by using this version of the equation:

  LAH = (Q / 4.5 * SCFM) + EAH

Conclusion

These equations can be very beneficial when used in conjunction with the Colmac CoilPRO selection software program. It is also important to have a basic understanding of the psychrometric chart when using these equations.

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