Coil Capacity And Efficiency

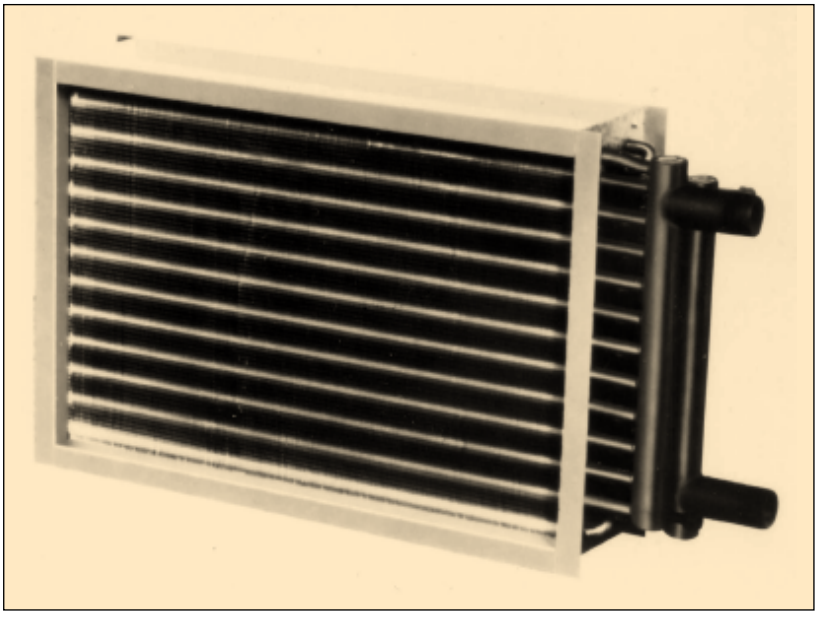
Understand the basics of finned tube coils and maximize coil capacity and efficiency.

BY MATTHEW JACOBS, MULTITHERM

Finned-tube coils are found in many process heating systems and many times are the first major component to show symptoms of improper upstream filtration. In a dirty atmosphere, they can actually cause many systematic problems, including pump, compressor and fan failures.

Finned-tube coils (sometimes known as heat transfer coils) have two important parts that convey heat transfer. The first is the tubes, which also are called the "primary surface." The second is the finned surface, which also is known as the "secondary surface." Both are ultra-important to creating the designed heat transfer with balanced air- and water-side resistance.

The tubes do a lot of the work via a transfer of energy between what is going through the tubes and what is on the outside. (As we all know, there is no such thing as "cold" — only the absence of heat — but for purposes of clarity, I'll use the word cold to describe the lower temperature stream.) In heat transfer coils, the transfer goes from the hottest to coldest of the two streams. In a chilled water coil, the air temperature is higher than the water temperature; therefore, heat is removed from the air and given to the water. In a hot water heating coil or thermal liquid coil, the liquid is a higher temperature than the air; thus, the water or thermal liquid gives its BTU/hr capacity to the air.



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The fins on a coil accomplish two major functions. First, they straighten the air out as it comes in contact with the entering-air side of the coil. Normal process fans tend to distribute air through a unit in a spiral pattern. The fins straighten this wavy air and allow the air a more uniform path across the primary surface. Second, they actually do some heat transfer of their own. The heat transfer is taken from the tube to the fin, thus raising the overall capacity of the coil. This is the reason the fins are called a secondary heat transfer surface.

Basics of Coil Selection. Coil selection is now done primarily by computer, but many do not understand the dynamics of coil selection. Proper selection is predicated upon meeting three major requirements:

- Heat transfer (BTU/hr load).
- Fluid pressure drop.
- Air pressure drop.

There is a unique balance that is required by the selector — you cannot meet one or two of these requirements and be way off on the other(s).

Take an example where a coil is selected and meets both the heat transfer load and water-side pressure drop requirements but is high on the air-side pressure drop. In this example, the fan that has been selected to move the air is based on amount of air against a

required total static resistance (pressure). If the coil resistance is too high, the fan will produce less air and the capacity of the system is then reduced as well.

It is very important for all owners and designers of process equipment to understand that the selection of coils almost never carries a significant service factor in capacity. This means that system changes during the life of the coil can dramatically change the efficiency and capacity of any system.

SYSTEM CHANGES THAT CAUSE COIL INEFFICIENCY

A multitude of system changes can affect heating and cooling coils. Among them are:

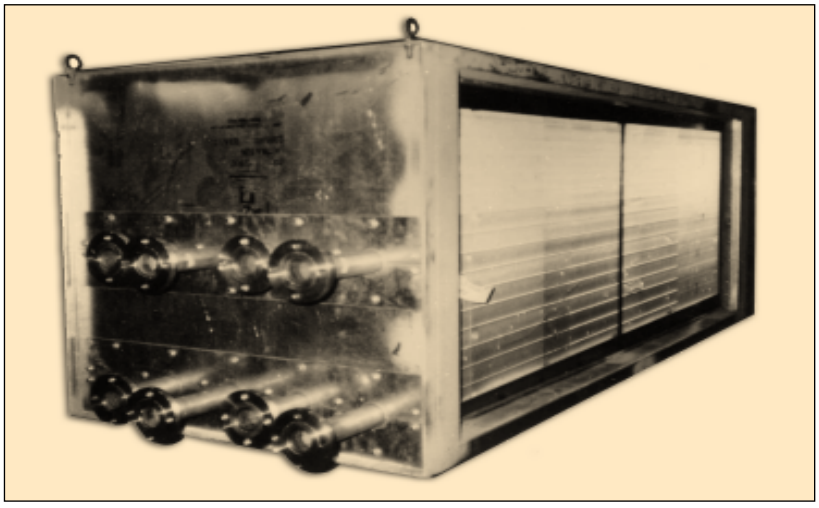
- The fluid temperatures that are supplied to the unit are higher or lower than what was specified.
- The air temperatures that are supplied to the unit are higher or lower than what was specified.
- The fluid volume that is supplied to the unit is higher or lower than what was specified.
- The air volume that is supplied to the unit is higher or lower than what was specified.

Notice that in each of these examples, the actual operating conditions vary from that which the coil was designed for. Because coils do not carry a significant service factor, if the process conditions are appreciably different from those for which the coil was designed, process inefficiencies will result.

Fluid Temperature Variations. If the actual fluid temperatures are higher or lower than those specified when the coil was designed, heat transfer is reduced. For example, suppose a process coil system is designed to heat air from 95°F (35°C) to 350°F (177°C), and it is selected based on 400°F (204°C) entering thermal liquid supplied to the coil's tube side. Based on this process data, the coil selected is 6 rows, 12 fins per inch. However, suppose the actual fluid temperature is 380°F (193°C). This reduced fluid temperature may reduce BTU/hr capacity by as much as 15 percent and lower the leaving air temperature significantly. This happens all of the time based on inferior insulation, faulty valves and other circulating characteristics.

Fluid Volume Variations. Fluid volume deficiency causes BTU/hr problems as well. Pumps are sized just like fans: They produce a volume of water or thermal liquid vs. a known maximum resistance. When that resistance is more than what was specified, then the pump produces less volume, and the coil is trying to produce BTU/hr with less flow (gal/min).

Air Volume Variations. Air volume that is not as specified is very much a symptom of too much resistance in the system. Certainly, there can be design problems from the outset, but many systems build up extra resistance because of air-side fouling. Coils are easily loaded with dirt, particles and bacteria because of their density. This increase in pressure reduces airflow and is a major contributor to decreases in overall system efficiency.



When looking at a coil, it is apparent that the space between fins and around tubes is limited.

COIL FOULING DECREASES EFFICIENCY

Air-side fouling can cause a small decrease in efficiency early on, and if it is allowed to accumulate, efficiency can be cut in half (BTU/hr output). Dirt, debris and scale act like insulators in the system. (In addition, they negatively affect efforts to meet air volume requirements.) Insulating foreign material decreases efficiency because the two streams (water, steam or refrigerant inside the tubes; and air or gas on the fin side) cannot transfer heat as well. Just this dynamic can cause a 5 percent to 10 percent decrease in efficiency, and in extremely dirty situations, a 20 percent to 25 percent decrease in efficiency is possible.

Foreign material also has a huge effect on airflow volume because the material does not allow a coil to pass the airflow from the entering side to leaving side. When looking at a coil, it is apparent that the space between fins and around tubes is limited. Actually, that is a good thing, because you want the air to be in contact with the primary and secondary surfaces as much as possible. However, if fouled, the very nature of the coil's design can cause airflow restrictions and eventually airflow volume decrease.

Many mechanics and process systems operators deal with fouled coils by just adjusting the fan drives, speeding up everything so that the system can supply the design airflow (cfm). While effective in the short term, this approach is costly because the mechanical brake horsepower (BHP) goes up, and this hits the owner right in the pocketbook. Also, an operator can only speed up his drive for so long before he reaches the limit on motor horsepower and cannot adjust any further. At this point, the airflow amount will start to decrease, and so will the overall cooling or heating capacity of system.

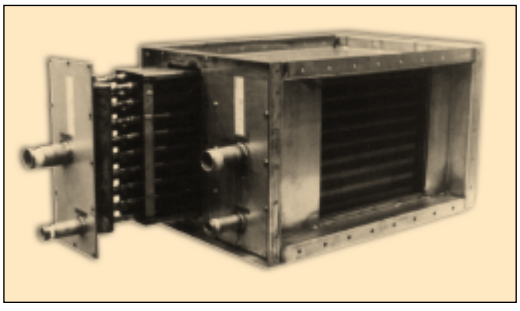
SYSTEM PROBLEMS RELATED TO AIR-SIDE FOULING

There are many system problems that can be traced back to fouled coils, but here are a few:

- The equipment must run longer to meet the design conditions. As a result, maintenance, emergency breakdowns and replacements are more prevalent.
- Operating and service personnel must spend more time with equipment to set and reset controls to allow the system to run somewhat according to design.
- With thermal fluid liquid systems, fouled coils can cause control, valve and pump issues.
- With steam systems, valve cycling is possible, leading to condensate corrosion and inefficiency.

WHAT ABOUT CLEANING THE COIL?

Understanding some basic principles will help ensure that when you clean your coils, it is done correctly. The most important part of cleaning a coil is knowing the type of product used and at what pressure. You must understand that some coils have very thin fin surfaces, and high pressure cleaning may clean the coil but close off the fin surface by bending the outer edges.



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Also, once the coil is cleaned, make sure that the cleaning agent is removed completely. I have seen hundreds of coils destroyed by corrosion caused by cleaning agents.

Clean your coils on a regular basis, and never let airborne particles find their way into the internal rows of any coil. You have a chance to clean a multi-row coil if the material is still on the outside area of a coil, but you won't have much success if the material has moved more than two rows into the center of the coil.

And remember, prevention is worth its weight in gold. Why deal with fouled, inefficient coils when you can remove these foreign agents before they ever arrive at the surfaces? High quality filtration may seem like a huge expense, but it is pennies on the dollar in comparison to the costs of downstream contamination. **PH**

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