Saving Energy in Refrigeration Systems

Parasitic Loads

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This article is the seventh in a series exploring refrigeration and heat pump concepts without using jargon.

A parasite is an organism that derives some benefit from a host by modifying the host's behavior or bodily chemistry to gain some advantage. This is a more sophisticated meaning than our subject this month: for cooling systems a parasitic load is simply an additional demand on resources that could be smaller, or perhaps need not be there at all. They do not necessarily affect the rest of the system, and they may even help to make control systems more stable by adding a base load to an otherwise diminishing demand.

There are two types of parasitic loss: deliberate and inadvertent. Deliberate ones include the things we discussed last month such as fans and pumps. They are necessary for successful operation of the plant, but could perhaps be better managed so their impact on the total energy use of the system is reduced and performance is improved.

A common characteristic of deliberate parasitic loads is they remain constant when the main cooling demand is reduced. For example, the oil pump on a screw compressor may only be 5% of the main drive motor power, but as the compressor unloads that percentage increases. Likewise, in some chilled water systems total kWh consumption of the water pumps is more than the compressor motors on the chillers because the pumps run 24/7, even when the compressors are switched off. In these cases, there are significant benefits to be gained by reducing the liquid flow, for example, through the use of variable speed pumps. This applies to condenser pumps in water-cooled systems, too, and the savings can be very significant.

There are many methods for chilled water and condenser water flow control, but the heart of the problem lies with the configuration of the heat loads, not the water pumps. If a system has several heat loads, they all run all the time and they each have a modulating bypass valve to control the amount of cooling done; then the flow in the main cooling loop will be constant and variations in load will appear as changes in the temperature difference between cold water flowing to the load and warm water returning from it. When the cooling demand is low in all units, they will still draw the maximum flow, but will not make good use of it.

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You wait ages for a decent chiller control algorithm and then several come at once.

This is a bit like a bus company sending the maximum rush hour number of buses all through the day. It gives great service to the traveller at lunchtime but every bus is nearly empty, and it is clearly not a very efficient way to operate. The simplest way to avoid this problem is to reduce flow to each load when less cooling is required. This drops the flow rate within the cooling coil, but since the load is light and water is supplied at a constant temperature, this should not be a problem. It also changes the operating point for the pumps, so the water system design guys don't like it because they have to think a bit more, but the pump will be happy to find a new balance point further up the curve.

If the cooler needs to have a fixed flow, then the variable main flow can be achieved by recirculating water through the cooler until it warms up enough to be released back to the chiller. This requires the extra complication of a recirculating pump and three-port valve at the cooling load. The main chilled water pumps still have to run up and down the curve like mice on a clock.

Greater pump power savings can be achieved by reducing pump speed. If the speed is one-half then the power is one-eighth, but be careful because pressure capability is only one-quarter of what it was. Generally, speed control only operates between 70% and 90% of full load speed but the power savings are still very attractive.

Now the water system design guys really have to scratch their heads to make sure each cooling load gets its fair share of water under all conditions. If the loads are on different floors of the building, this can be tricky because convection in the rising headers can disrupt flow. In all cases, the real name of the game is to make sure the return water temperature coming back to the chillers is as warm as possible.

Inadvertent parasitic losses are easier to deal with. These are things like open windows when the air conditioning is on, fresh air dampers stuck wide open, computers left on all the time, and so on. In a refrigeration plant, leaks from the high-pressure side to the low-pressure side of the plant (which are like leaving an internal window open) fall into this category. To paraphrase a well known sportswear company, "Just don't do it!"

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