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Date: April 13, 2010

The main energy consumers in a water-cooled air conditioning system are the chiller, recirculating pumps, tower fans, and air handler fans.

Chiller efficiency is important because it reflects the amount of energy required to produce a ton of refrigeration. It is typically measured in KW/Ton
and is a function of the chiller design, operating conditions, and heat transfer efficiency. Effective water treatment helps optimize chiller efficiency and minimize energy costs by keeping the evaporator and condenser heat exchange surfaces clean and corrosion free.

Compressor, Condenser & Head Pressure
The function of the chiller is to transfer the heat "collected" from the building by the chilled water system to the cooling tower, where it is then discharged back into the atmosphere.
The compressor provides the driving force for the refrigeration cycle and is the primary consumer of electricity in a chiller. The compressor functions to increase the refrigerant temperature and pressure. Anything that increases the workload on the compressor will increase energy consumption.

In the condenser, heat is transferred from the hot refrigerant gas to the cooling water, which causes the refrigerant gas to cool and liquefy. The temperature of the condensed refrigerant has a corresponding vapor pressure called the condensing pressure or condenser head pressure.

The compressor is designed to work at a certain condensing pressure for a given load. The term "high head pressure" refers to condenser pressure that is higher than it should be for a specific load condition.

Condenser Fouling & Energy Costs
Deposition (fouling) on the condenser tubes reduces transfer, increases the condenser head pressure, and results in higher energy costs.

Reduced heat transfer in the condenser causes the compressor to work harder, increasing the refrigerant condensing temperature and pressure in
order to transfer the same amount of heat to the cooling water. Each additional 1 oF in refrigerant temperature requires the compressor to consume 1.5% more energy. If the deposit thickness is great enough, condenser head pressure will exceed the chiller limits and the chiller will shutdown.

Some deposits are more insulating than others and thus have a greater impact on the head pressure and energy requirements. For example, calcium carbonate scale deposits transfer heat up to 4 times better than biofilm deposits (slime). As a result, slime increases head pressure and energy requirements and will shut down a chiller much faster than "normal" scale. Condenser deposits can be a mixture of slime, scale, corrosion by-
products, and suspended solids scrubbed from the air.

The following table shows the potential economic impact of scale deposits on a 500 ton chiller running at full load, 24 hours per day. Actual increased energy use depends on compressor type, actual operating head pressure, and percent operating load.

For the same thickness, the increased cost associated with a biofilm deposit can be significantly greater than with scale, depending on the actual scale composition. It becomes clear that good microbiological control is vital for efficient chiller operation.

Deposit Thickness, inches	Fouling Factor	% Efficiency Loss	Increased Annual Electrical Cost Scale Deposit
0	0.0000	0	$ 0
0.01	0.0008	9	$ 19,790
0.02	0.0017	18	$ 39,580
0.03	0.0025	27	$ 59,365
0.04	0.0033	36	$ 79,155
0.05	0.0042	45	$ 98,945

Condenser Deposit Thickness vs. Increased Electricity Cost
Based on electricity cost of $0.07 per KWH, a chiller efficiency of 0.65 KW/Ton, a power factor of 0.91. Scale assumed to have thermal conductivity
of 1.0 BTU/(hr)(SqFt)(F o)

Other Factors Influencing Head Pressure
Besides waterside fouling, there are 3 other conditions which can cause high head pressure:

1. Non-condensable gases (i.e. air) in the refrigerant
2. Low condenser water flow rate
3. Condenser inlet water temperature too high

In diagnosing a high head pressure condition, all of these factors should be investigated as possible causes.

Evaporator Fouling
Fouling in the evaporator tubes will also increase energy costs. Fouled evaporator tubes can cause a drop in refrigerant evaporating pressure that
reduces its density. As a result, the compressor must pump the gas to a higher pressure to remove an equivalent amount of heat from the chilled water. Again, the compressor must work harder, which increase energy requirements.

Fouling of 0.001 Increases Energy Consumption by 10%
Based on $0.07 per kWH electricity cost and Power Factor of $ 0.91 on a Efficient Chiller at 40% load = $ 0.25 kW/Ton
Based on $0.07 per kWH electricity cost and Power Factor of $ 0.91 on a Efficient Chiller at 100% load = $ 0.57 kW/Ton

An Example of a 500 Ton Chiller operating at 100% for 2000 hours a season, which if you averaged a seasonal load this is fairly common and fouling often exceeds 0.0042.
When making ICE for thermal storage units you can modify the hours and still reach the same costs.

Fouling of	Reduction in Chiller Efficiency	kW/Ton/100% load	Wasted Energy/Ton/Season	500 Ton
0.0008	9%	0.62	$100.00	$ 50,000.00
0.0017	18%	0.672	$204.00	$102,000.00
0.0025	27%	0.724	$308.00	$154,000.00
0.0033	36%	0.775	$410.00	$205,000.00

As you can see side stream filtration down to 100 micron filtration can save real energy dollars on chiller efficiency.

______________________ Tower Basin & Condenser Tube Cleaning Cost

______________________ Cooling Water Chemical Treatment Cost / Filtering out Solids reduces Bioside Cost by 20%

______________________ Condenser Efficiency x Tonage x kW/Ton x 2000 hours/season (Clean vs. Fouled)

______________________ Make Up Water Savings keeping TSS counts down

Every system will be different as electrical cost and labor rates vary by locality and chemical cost can vary by design, the efficiency of the chillers will always be ***affected*** by solids and fouling. The more efficient you can run the chiller at off peak times will reduce your energy cost and carbon footprint on society.

Suggestions

A wide variety of filtration technologies are employed in cooling tower applications. Though all are helpful, choosing carefully can save money and headaches in the long run. Most cooling towers have large screens to filter out big debris such as leaves and twigs. However, straining out debris is just a start – it can still leave several pounds of sediment per ton of cooling water in the system.

Hydrocyclones, which use centrifugal force to separate heavy particles from the water stream, are popular in cooling tower applications. Though they are extremely effective at removing sediments with high specific gravity, hydrocyclones are markedly less effective at separating out lighter particles. In many cases, that can be a significant shortcoming.

On the other hand, sand media filters are highly effective at removing very small particles, whether hard or deformable. The technology has been in use since the early 1800s, and has proven itself widely. However, sand media filters have a very large footprint, and back flushing them requires an interruption in the filtering process as well as a great deal of clean water.

Bag or cartridge filters are highly effective, but replacing cartridges or bags demands a significant amount of labor and can represent a large amount of solid waste to be disposed of. Prompt maintenance is a must. As they do their jobs, cartridges or bags can create a significant pressure drop on the system, increasing from an insignificant 0.14 bar (2 psi) with a new cartridge to as high as 2 bar (30 psi) when the cartridge is dirty. Also, as one customer pointed out about the combination hydrocyclone/bag filter he eventually traded out for an automatic self-cleaning screen filter, “it did a good job, but when that bag was full, it wasn’t doing anything – we were just spinning the pump”.

Automatic self-cleaning screen filters are highly effective, compact, and nearly maintenance-free. When the pressure differential between the inside and outside of the screen reaches 0.5 bar (7 psi), a valve opens, creating an outlet at atmospheric pressure. The differential between the 7 psi internal pressure and atmospheric pressure draws water and filter cake through an array of small focused back flush nozzles and out of the system. The nozzles spiral around the screen, cleaning it completely without interrupting filtration.