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CUSTOMER NEWSLETTER

Reducing Cooling Tower Operating Costs

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A midwestern industrial plant had a problem. The plant had a cooling tower that supplies cooling water to air compressors, oil coolers, air dryers, and various process equipment. The local city water and sewer rates were increasing significantly and their molybdate-based chemical treatment costs were skyrocketing as molybdate costs had risen nearly 1,000% lately! In an effort to cut operating costs, the plant looked for ways to decrease their cooling tower makeup water, sewer, and chemical requirements. Various ideas were investigated such as:

- Improved blowdown controller
- Fixing leaks
- Acid feed
- Soft water makeup
- Blended city/soft water makeup
- Water treatment chemistry
- Recycled wastewater

Cooling Tower Basics

Once-through cooling allows water to be used once for cooling before it is discharged. Cooling towers allow the same water to be used repeatedly for cooling before it is discharged. What limits the number of times the same water can be used is solubility of various dissolved ions in the water. When concentrated high enough, some dissolved ions will become insoluble and start forming scale in the system. Typically, calcium carbonate is the first species to cause scale.

For example, for a cooling tower system with a temperature change of 10°F and running at 3 cycles of concentration (cycles), one pound of makeup water gets used an average of **145 times** before it is discharged via blowdown. That is much more efficient that 1 pound of water only being used once in once-through cooling.

As a yearly average, approximately 75% of the cooling action in a cooling tower results from evaporation, while 25% is transferred to the air through sensible heat.

Case Study

The original operating characteristics for the midwestern industrial plant being discussed are listed in Table 1. Calcium carbonate scaling potential was the limiting factor for how many cycles the cooling tower could run.

Improved Blowdown Controller

It was known that the cooling tower blowdown controller was old and unreliable. Sometimes it would blow the system down too much and other times not enough. Blowing down too much wastes water and chemical. Not blowing down enough could lead to scale formation in the cooling tower.

A review of the system parameters in Table 1 shows the system was only running at an Langelier Saturation Index (LSI) of 1.8 and cycles of 3. The LSI is a measure of calcium carbonate scale forming tendencies. The higher and more positive the number, the more likely calcium carbonate scale will form. Typical

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cooling tower chemistries can control an LSI of 2.5. This means the cooling tower could really run at 4.6 cycles if the controller would control the conductivity properly. The plant replaced the blowdown controller with a new one. Even though the controller was working correctly, the cycles only increased to 3.6. There must have been a leak in the system wasting more water than what was required for blowdown to maintain the cooling tower at 4.6 cycles.

Table 1: Original Cooling Tower Operating Characteristics

Parameter	Value
Recirculation rate	10,000 gpm
Temperature change	10°F
Current cycles of concentrate	3
Makeup rate	113 gpm
Evaporation rate	75 gpm
Blowdown rate	38 gpm
Current LSI	1.8
Makeup calcium hardness	75 ppm
Makeup M-alkalinity	85 ppm
Makeup conductivity	550 μmhos
Hottest heat exchanger skin temperature	140°F
City Water	$2.25/1,000 gal
Sewer	$5.00/1,000 gal

Fixing Leaks

Blowdown is used to control the cycles of concentration (or conductivity) of a cooling tower system. If a leak is bigger than the required blowdown, it will be impossible to maintain the proper cycles or conductivity. The plant traced the cooling piping and found a valve had been opened to the drain. When the valve was closed, the cooling tower was able to be controlled at 4.6 cycles.

Acid Feed

Lowering the pH of the system would increase the solubility of the calcium carbonate and allow more cycles to be run. Because of safety considerations, the plant decided not to use acid feed.

Water Treatment Chemistry

For various reasons, molybdate prices are going through the roof. Chemical treatment products that contain molybdate cost more as a result. There are numerous non-molybdate cooling tower products that can be used. Also, while in the past the highest LSI that could be run was 2.5, new polymers on the market allow the system to run at an LSI of 3.0. This would allow the cooling tower to run at 6.4 cycles and save water, sewer and chemicals.

Soft Water Makeup

One way to avoid calcium carbonate scale is to remove the calcium itself. Using a water softener to remove the calcium and magnesium from the makeup water would allow the system to run at much higher cycles. Once the calcium is removed, the limiting factor becomes the chlorides in the water (<3,000 ppm). Running the calculations shows that 56.6 cycles of concentration could theoretically be obtained! However, cooling towers are never tight enough to run anywhere near this level due to drift, windage, short circuiting, and process leaks. Typically the highest practical cycles of concentration obtained in a cooling tower is 12 to 17 cycles.

Blended City/Soft Water Makeup

There are operating costs associated with running a water softener such as salt costs and regeneration water costs.

Table 2: Cooling Tower Savings Comparison

Cost Cutting Measure	Annual Water/Sewer Savings ($/year)	Annual Chemical Savings ($/year)	Total Annual Savings per Scenario ($/year)
Improved Blowdown Controller	$33,580	$9,140	**$42,720**
Fixing Leaks[1]	$65,090	$17,720	**$82,810**
Acid Feed[2]	$91,130	$20,710	**$111,840**
New Water Treatment Chemistry[2]	$90,230	$30,810	**$121,040**
Soft water Makeup[2]	$111,590	$35,390	**$146,980**
Blended City/Soft Water Makeup[2, 3]	$75,180	$22,150	**$97,330**
Recycled Wastewater[2, 4]	$70,440	$19,690	**$90,130**

Notes: Each cost cutting measure is independent and not additive.

1. **Assumes new blowdown controller installed.**
2. **Assumes new blowdown controller installed and leaks fixed.**
3. **50% soft/city water blend**
4. **RO concentrated supplies 25% of the total makeup.**

Perhaps a blend of soft water and city water would allow the cycles to be increased enough to save money but not be offset by the softener operational costs. The plant compared the savings of 100% soft water to a blend and found the 100% soft water program to show more savings.

Recycled Wastewater

Some wastewaters are of sufficiently high quality to use as cooling tower makeup without any extra treatment. Reverse osmosis (RO) concentrate can be a good source of makeup if the water is softened prior to the RO. The plant did have an RO nearby for boiler makeup and process water. The concentrate from the RO was going to the drain, but could easily be collected in a tank to use as cooling tower makeup.

RO concentrate is typically high in alkalinity, so it is important to either degasify the water or only mix it with soft water to avoid scale.

Conclusions

Table 2 shows the results of the midwestern industrial plant's evaluation of their options to save money in the operation of their cooling tower. As you can see in this particular case study, the savings are significant. The plant ended up installing a new blowdown controller, fixing the leak, and using 100% soft water makeup with a non-molybdate chemical treatment for a total savings of $146,980/year. They plan to use RO reject in the future for an addition $9,500/year savings.

Savings will vary depending system parameters and makeup water quality. Your Water Management Specialist should be able to calculate any savings for you.

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