PLANT LIFE EXTENSION

Keeping condensers clean

The humble condenser is among the biggest contributors to a steam power plant's efficiency. But although a clean condenser can provide great economic benefit, a dirty one can raise plant heat rate, resulting in large losses of generation revenue and/or unnecessarily high fuel bills. Conventional methods for cleaning fouled tubes range from chemicals to scrapers to brushes and hydro-blasters. This article compares the available options and describes how one power station cleaned up its act.

By Ken Wicker

There's a relatively easy way to make a steam plant more efficient and reliable: keep the tubes of its condenser (s) clean. According to George Saxon, Jr., VP of international sales and marketing for Conco Systems Inc. (Verona, Pa.)—a company whose specialty is cleaning and maintaining condenser tubes—"There are two major problems that result from dirty tubes. The first is reduced heat transfer and the second is under-deposit corrosion."

Saxon explains that anything that impedes the flow of water through condenser tubing is nearly always detrimental to heat transfer. When the efficiency of this process falls, so does condenser vacuum and, with it, the efficiency of steam turbine operation. "In severe cases," he explains, "poor vacuum conditions in the condenser can reduce generating capacity by more than 50%." Dirty condenser tubes do more than just increase the amount of fuel a plant needs to produce a certain output. They also foster corrosion, which can lead to outages and cost considerable time, money, and effort to repair.

The extent to which a condenser fouls depends on the quality of the plant's makeup and cooling water. Condenser tubes can become clogged with deposits of soft organics or hard minerals like iron, manganese, or calcium carbonate (calcite). Identifying the contaminant(s) at work is the first step in determining the best cleanup method to use.

The importance of avoiding corrosion cannot be overstated. According to Andy Howell—a chemist in Xcel Energy's Colorado operations who works closely with companies like Conco Systems to identify tube foulants and corrosion mechanisms at the utility's plants—"If corroded condenser tubes end up leaking cooling water contaminants into the condensate, major damage to boiler tubing and steam turbine materials is often the result."

Foul play

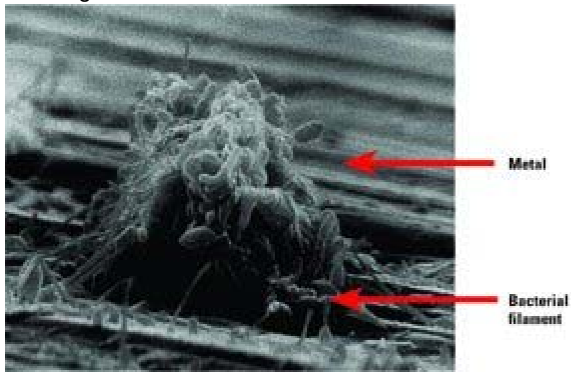
Condenser fouling can take different forms, depending on the source and type of contaminant. Among the most prevalent are:

- Deposition of fine-particulate materials such as silt, coal dust, or algae on tube surfaces.
- Scaling (crystallization fouling). This occurs when the concentration of contaminants in cooling water exceeds the saturation point, at which point the contaminants precipitate on tube surfaces (Figure 1).

  1. It's the pits. Pitting is common in damaged condenser tubes and can be very detrimental to heat transfer. Manganese, silica, and calcium carbonate scale have been reported causing capacity reductions of 20 to 25 MW. Courtesy: Andy Howell
- Microbiological fouling by bacteria naturally occurring in water. As the bacteria attach to the base metal o

tube surfaces (Figure 2), they form a thin film of slime that grows and traps other particulates, further reducing heat transfer.



2. Hungry critters. Bacterial attack of tubes' base metal is a problem that can be just as serious as nonbacterial pitting or deposition. Courtesy: Conco Systems Inc.

- Macrofouling of tubes by debris or organic or inorganic substances such as rocks, wood, trash, or small marine animals.
- Copper-oxide fouling of copper-alloy condenser tubes.

Howell explains that, although there is usually more than one cause of fouling, one mechanism typically dominates. If not addressed, the problem will likely increase over time. So once any type of fouling is detected, it's important to assess whether it has caused any damage, and the extent of that damage.

This is where Howell's 20 years of experience with tube analysis comes into play. His examinations of tubes and foulants in the laboratory identify the source and impact of the problem. Once those have been determined, he hires a company like Conco Systems to clean house. Conco's experts can determine whether the foulant can be removed by a simple condenser back-flush or whether the unit needs to be taken off-line so the tubes of its condenser can be more thoroughly cleaned by mechanical scrapers.

Mechanical or chemical?

According to Saxon, there are several different ways to keep a condenser from getting fouled in the first place. Mechanical methods include installing screens to prevent debris from reaching the condenser, using settling ponds and/or clarifiers to remove large particulates and dissolved contaminants, and putting in filters to remove fine particulates. Some utilities report having had success with an on-line method: sending soft objects such as sponge balls through condenser tubes to wipe them clean.

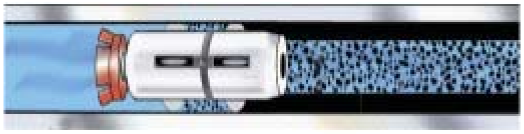
Howell explains that if mechanical measures don't do the trick, a plant can use any of several chemicals that have proven able to control condenser fouling while a plant remains on-line. Among them are acids and bases (for pH control), scale inhibitors, dispersants, biocides, and corrosion inhibitors.

Last resort

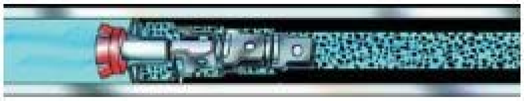
If a condenser is fouled badly enough to justify taking its turbine off-line, another menu of mechanical and chemical options is available to the plant manager. Regarding the latter, Saxon explains that calcium carbonate deposits on condenser tube surfaces can be removed by a solvent such as hydrochloric acid and that hydrofluoric acid works equally well on silicon-based scale. There are, however, four downsides to using chemicals to clean condenser tubes: the high cost of the treatment process, the safety concerns of chemical handling, the possibility of incomplete foulant removal, and the high cost of disposing of the chemical waste produced.

If chemical cleaning isn't appealing or doesn't work, a plant manager can choose from among several mechanical-cleaning approaches. Blasting water at 8,000 to 40,000 psi through condenser tubes, for example, is one technique that has proven effective at many plants. But Saxon warns that this method used at ultrahigh pressures presents risks when removing contaminants from softer copper alloys, possibly creating another problem. As mentioned earlier, another approach is to send sponge balls (or balls made of a more-abrasive material) through the tubes. For really tough problems, such as debris lodged in tubes, a brute-force approach—using a flexible fiberglass rod akin to a plumber's snake to ram the debris free—may be the only option.

Last but certainly not least on the list of mechanical cleaning options is using a scraper powered by pressurized water (see box). Over the years, this method has become more effective as cleaning specialists have sized scrapers to match the inner diameter of tubes, allowing them to be cleaned right down to the base metal.



5. Who ya gonna call? The Cal-Buster tube cleaner from Conco Systems Inc. contains carbide blades that score calcite scale—much as a glass cutter cuts glass. Courtesy: Conco Systems Inc.



6. Suction, please. Conco's C3S tube cleaner follows up on the work of the Cal-Buster by removing scored scale, leaving the inside of tubes shiny and clean. Courtesy: Conco Systems Inc.

An example of this kind of scraper is Conco Systems' "Cal-Buster" tube cleaner (Figure 5). Mounted on its Teflor body are several rotary carbide cutters. Because the cutters are placed at different angles, the tool can fully cover the interior of the condenser tube into which it is inserted. A plastic disk propels the Cal-Buster through the tube and fractures the eggshell-like crystalline form of calcium carbonate. Once the Cal-Buster has done its job, a heavier-duty device such as the Conco C3S tube cleaner (Figure 6) is used to remove the dislodged calcite, leaving the inner tube surface free of corrosion-causing deposits and scale.

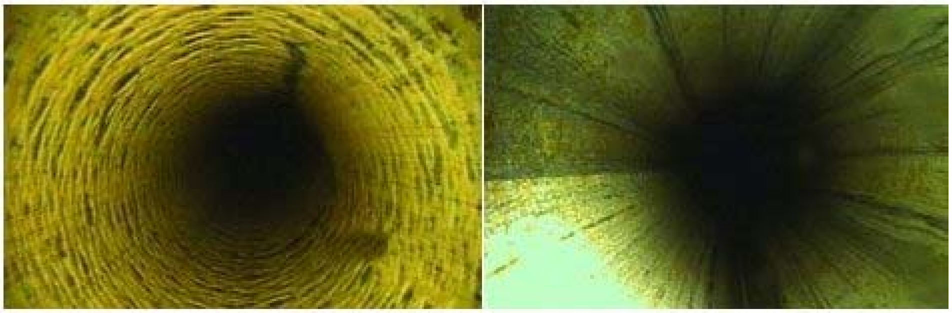
—Andy Howell of Xcel Energy and George Saxon, Jr. of Conco Systems Inc. provided much of the information in this article.

Unclogging a condenser's arteries

Omaha Public Power District's 600-MW North Omaha Power Station has five coal-fired units ranging in size from 75 MW to 200 MW. The makeup and cooling water of all five units comes from the Missouri River. As part of an upgrade in the 1970s, North Omaha Station replaced the copper tubes of all five condensers with stainless steel tubes to improve reliability. According to plant manager Jon Hansen, routine mechanical and/or hydro-blast cleanings have been performed over the years to keep the tube surfaces clean and free from deposits. In light of this practice, Hansen found himself puzzled when instruments began indicating a significant loss of vacuum in the condensers of Units 3 and 4 a few winters ago.

As it turned out, cooler winter river temperatures were masking inefficiencies in the two condensers. Hansen says the effect became clear when the condensers' performance worsened with rising river temperatures in the spring and bottomed out in the summer. During one outage inspection, the source of the problem—calcium carbonate scale—became evident. Laboratory tests indicated that some deposits weighed as much as 184 grams and had a density of almost 25 grams/square foot. The tests also revealed there was now a 0.010-inch-thick deposit of scale (on average) on the 50,000 tubes of the two condensers, reducing their inner diameter fron 0.944 inches to 0.925 inches.

To get rid of the scale, plant management called Conco Systems Inc. After examining samples of the deposits, Conco's technicians arrived with an arsenal of Cal-Busters and C3S tube cleaners. The technicians opened up the water boxes of Units 3 and 4, exposing the condenser tubes. They then shot the two tube-cleaning tools, one after another, down each tube at up to 20 ft/sec, propelled by water at 300 psi.



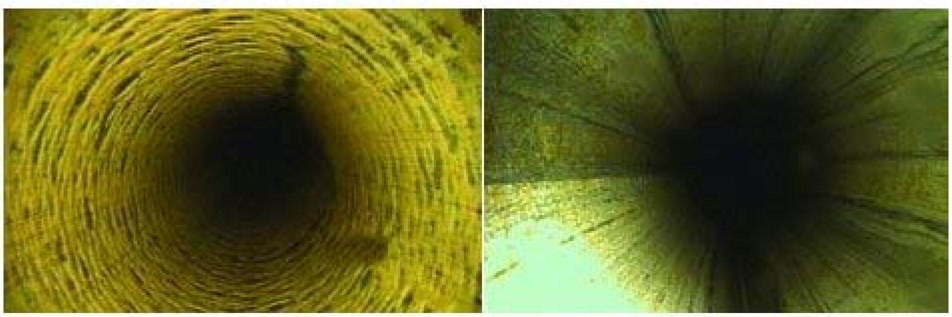
3. Before and after. At left is a close-up of calcium carbonate scale. At right is the same surface after the scale was removed. Courtesy: Conco Systems Inc.

4. Ready for pickup. Piles of calcium carbonate scoured from North Omaha Power Station's five condensers await removal. Courtesy: Conco Systems Inc.

Parameter	Unit 3	Unit 4
Apparent cleanliness (before cleaning)	34%	37%
Apparent cleanliness (after cleaning)	93%	90%
Improvement in heat rate (Btu/kWh)	602.1	395.6
Annual savings[a]	**$258,400**	**$212,500**

Note: a. Assuming a 0.7 plant capacity factor and the prevailing average market price of coal.

Cleanliness and heat-rate improvements at North Omaha Power Station following calcite removal



4. Before and after. At left is a close-up of calcium carbonate scale. At right is the same surface after the scale was removed. Courtesy: Conco Systems Inc.