Water treatment and cooling applications for power plants

Ninety-percent of electricity generated in the U.S comes from thermoelectric plants that are powered by coal, nuclear or natural gas. These plants require tremendous volumes of water, which is boiled to create steam that spins turbines. The heat used to boil water comes from burning a fossil fuel or from a nuclear reaction. Once steam passes through a turbine, it has to be cooled back into water before it can be reused to produce more electricity. Colder (and cleaner) water cools steam more effectively and allows more efficient electricity generation.

By Andrew Freeman, Vice President - Global Sales, Pulsafeeder

There are three primary methods to cool water in power plants:

- Once-through systems take water from nearby rivers, lakes or oceans and circulate it through pipes to absorb heat from the steam in condensers. Once used, water is discharged back to its local source. About 30 percent of the legacy power plants on the east coast of the US still use this inefficient process. They were built several decades ago when it was possible (and inexpensive) to build plants near abundant water sources. However, most of the plants built since the 1980s leverage a more efficient cooling system that causes fewer disruptions to local ecosystems.
- Closed loop, wet-recirculating systems reuse cooling water in repeated cycles rather than immediately discharging it. These systems use cooling towers to expose water to ambient air. Some of the water evaporates; the rest is sent back to the plant's condenser. These systems only withdraw water to replace what's lost through evaporation – but in total, they end up consuming a higher percentage of incoming water and discharging less of it. About 60 percent of all power plants in the US (and almost every plant built on the west coast) feature wet-recirculating systems.
- Dry-cooling systems use air instead of water to cool steam in turbines. These systems can decrease water requirements by as much as 90 percent, but they require more fuel per unit of electricity. Most plants that use this system run on natural gas. Despite the name, dry-cooling systems still require water for system maintenance, cleaning and boiler blowdown.

How much water do power plants need?

Power plants that rely on once-through cooling systems waste a lot of water (which is why they aren't built anymore). Coal-fired plants need about 30,000 gallons of water for every megawatt of electricity produced. Nuclear plants need twice as much water. In both types of plants, only about 1 percent of this water is consumed, while the remaining 99 percent must be treated before disposal.

Plants that use recirculating cooling systems require far less water. Coal-fired plants can make a megawatt of electricity with about 1,200 gallons, while nuclear plants with recirculating systems need about 2,600 gallons per megawatt.

In either case, it takes a lot of water to make electricity - perhaps too much water. The cost of water and its increasing value/scarcity around the globe are driving momentum towards natural gas powered plants that can leverage dry-cooling processes. This is why almost all of the new power plants being built in China, India, Africa and other parts of the developing world are standardizing on natural gas combined-cycle (NGCC) techniques.

For more than 30 years, the state of California has been on the leading edge of building and maintaining natural gas powered plants, as most of the state's plants switched from coal to gas in the 1980s. The lessons learned are being adopted by the 50 or so remaining coal plants on the east coast of the US, through the "repowering" and modernization process of replacing coal boilers with gas-fired turbines.

NGCC systems can increase a plant's efficiency by up to 40 percent over coal fired plants. They help plant owners reduce costs, specifically maintenance costs, as newer systems are easier to work on. And the switch to natural gas brings other savings because feed stocks are abundant, less expensive and easier to transport via pipelines.

How natural gas power plants operate:

The natural gas combined-cycle power plant uses a gas combustion turbine to generate electricity, and it also uses waste heat to make steam, which then generates additional electricity in a steam turbine. Because the first stage (the gas combustion turbine) has no steam to condense, it doesn't require cooling. As a result, the combined process requires only 25 percent as much water to generate the same megawatt of electricity as a coal fired plant.

Even though natural gas plants use less water, they still need to treat water, because there's a direct correlation between the quality of the water and the efficiency of the plant.

The quality and the turbidity of a plant's incoming water can vary significantly, depending on storms or other man-made interactions. A number of pretreatment activities must be performed, such as removing sludge & sedimentation; dissolving suspended organic material; adjusting pH levels; and disinfecting water by killing disease-causing micro-organisms.

These applications are administered by injecting chemicals with metering pumps.

Disinfection - is accomplished by dosing specific quantities of high-concentration sodium hypochlorite (bleach). When sodium hypochlorite comes in contact with bacteria, it oxidizes molecules in the cells of the germs and kills them. Even though this simple but harsh chemical has been used for more than a hundred years, it is prone to causing problems for pumps by "off-gassing." To solve this issue, the pumps used to deliver it must be able to pass the gas bubbles through without locking or clogging the pump.

Natural gas combined-cycle power plants require much less water to produce a megawatt of electricity than coal or nuclear plants. Image courtesy of Pulsafeeder.

pH adjustment: power plants operate best when the pH of the water is as close to neutral (7) as possible. Specific volumes of acids are administered to alkaline feed-water (pH higher than 7) to adjust the pH, while similar volumes of caustics are dosed to acidic feed-water (pH lower than 7) to raise its alkalinity.

Boiler feed-water must be treated to avoid scale and corrosion that could damage or impede the boiler's performance. Boilers and other plant equipment are protected by metering pumps that dose precise volumes of polymers and corrosion inhibitors.

At the end of a plant cycle, the process water must be treated prior to disposal. Many plants use flocculation basins, where additional chemicals are dosed via metering pumps to aggregate precipitated particles, making them easier to filter out. Additional rounds of disinfection and pH adjustment are typically rendered by the plant's wastewater plant before water is discharged into the environment.

Because most plants run 24x7 operations, water treatment must be done in a manner that prevents unplanned downtime. As such, the metering pumps used must be highly reliable and be able to run on a continuous basis, and maintenance plays a key role.

Reliable pump operation:

Plant operators need a durable pump technology that is able to dose a precise volume of water treatment chemical, while maintaining a high level of operational reliability. This is one reason why hydraulic diaphragm metering pumps are preferred for a majority of water treatment applications in power plants. The pump's ability to survive system upset conditions helps keep the overall plant infrastructure operating reliably, all while dosing the exact amount of chemical needed to keep operations running efficiently.

Space in any plant is valuable, so operators prefer pumps with small footprints. Today, trends continue to shift away from horizontally laid infrastructure, because vertical configurations are more spatially available, less susceptible to flooding and easier to work on.

Pulsafeeder's PulsaPro Series: Hydraulic diaphragm metering pumps are preferred for a majority of water treatment applications in power plants. Image courtesy of Pulsafeeder.

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Extracting further efficiencies:

On a macro level, the power industry is gaining efficiencies by moving away from coal and shifting to more economical inputs like natural gas. This shift helps the environment in numerous ways – perhaps most significantly by minimizing water requirements.

On a micro level, plant operators continue to seek more efficient and cost effective methods to treat the water they use and to protect and maintain the plant equipment. These goals are being accomplished by the adoption of hydraulic diaphragm metering pumps that are durable, energy-efficient, easy to maintain and offer the maximum level of reliability, which helps to ensure continuous plant uptime.

About the Author

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