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Improve Power Plant Efficiency with Water Treatment

By Axel Bokiba, December 4, 2018

Disinfection, pH adjustment are ways to facilitate greater water reuse.

There is a reason thermoelectric (coal, nuclear or natural gas) power plants are located near rivers, lakes or oceans. It is because they need tremendous quantities of water to generate power.

More than 90 percent of electricity generated globally comes from thermoelectric plants. These plants boil water by burning a fossil fuel (or using a nuclear reaction) to create steam that spins turbines. Steam must be cooled back into water before it can be reused to produce more electricity. Colder and cleaner water cools steam more effectively and allows for more efficient electricity generation.

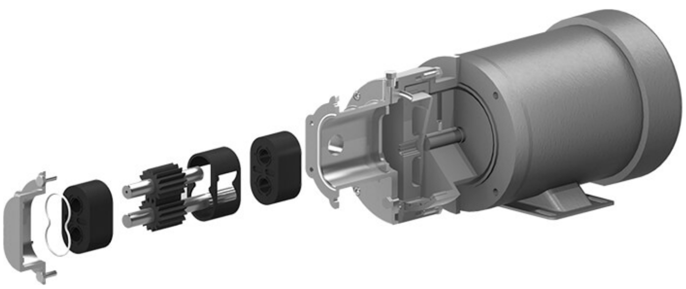

Image 1. Access to the pump's inner workings simplifies maintenance. (Images courtesy of Pulsafeeder)

Legacy coal-fired plants, relying on once-through cooling processes, need about 30,000 gallons of water for every megawatt of electricity produced, and nuclear plants need even more. Modern natural gas combined cycle (NGCC) plants can produce the same megawatt of electricity with 5 percent as much water (which is still about 1,500 gallons per megawatt).

Water quality is almost as important as quantity when it comes to plant efficiency. The turbidity of incoming water can vary depending on storms or man-made interactions, so incoming plant water must be treated before it can be used.

A number of water treatment applications are performed in power plants to remove sludge and sedimentation, dissolve suspended organic material, adjust pH levels and disinfect water by killing disease-causing microorganisms. These applications include:

Disinfection. This is accomplished by dosing chemicals such as sodium hypochlorite (bleach), or hydrogen peroxide (at concentrations as high as 30 percent), which kills bacteria by oxidizing molecules in the cells of the germs. These harsh chemicals have been used for more than 100 years but are still prone to causing problems for pumps by off-gassing, which can entrap air in a pump and prevent it from maintaining prime. To address this issue, metering pumps must be able to pass the gas bubbles through the pump head in a manner that prevents any loss of prime due to off-gassing.

pH Adjustment. 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.

Legionella. One of the primary goals for water treatment applications (particularly in cooling towers) is to prevent the growth of legionella, which is a ubiquitous organism that can appear in almost all sources of water. Numerous studies have found cases of legionella in up to 60 percent of all cooling towers around the globe, and the organism has shown the ability to resist standard chemical treatments.

Preventing legionella is best accomplished through a combination of disinfection and pH control treatments. One halogen that works effectively is Bromine, if it can be delivered at a higher pH level (8.5 to 9). By using metering pumps to dose additional volumes of caustics to raise alkalinity, a sweet spot can be created for Bromine to effectively kill legionella.

Flocculation. At the end of a plant cycle, all of the water used must be treated prior to disposal. Many plants use flocculation basins, where additional chemicals and polymers 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 facility before water is discharged into the environment.

Requirements for Metering Pumps Used in Power Plants

The criteria for selecting metering pumps typically includes flow rates, pressures and corrosion resistance (depending on what chemicals are pumped). Although plant operators and the engineering, procurement and construction (EPC) firms that serve them have multiple options for pumping infrastructure, the most popular choices usually involve diaphragm or rotary gear pumps.

In plants where American Petroleum Institute (API) requirements must be adhered to,

Image 2. Gear pumps are available in different materials to handle a wide range of chemicals.

diaphragm pumps are the preferred choice. Diaphragm pumps can also deliver +/- 0.5 percent accuracy, which is often required in chemical manufacturing processes or in refineries.

But when it comes to water treatment applications in power plants, API standards (and the costs that come with meeting them) are usually not required. Accuracy levels of +/- 2 percent are generally acceptable for water treatment applications. In these cases, rotary gear pumps can provide the functionality needed at a fraction of the cost of hydraulically actuated diaphragm pumps. Rotary gear pumps also provide the following capabilities:

Flexibility to accommodate flow and pressure requirements. The flow rates required for water treatment applications in power plants typically range from a few liters per hour (l/hour) to approximately 100 l/hour. Most water treatment processes are low pressure applications, ranging from less than 10 Bar, up to about 40 Bar. Gear pump lines feature numerous models that can accommodate any flow range, connection size and pressure requirements within these ranges.

Construction materials. Rotary gear pumps are available in different materials, including polyvinylidene fluoride (PVDF) or 316-SS, to provide corrosion resistance against a wide range of acids, caustics, polymers, flocculants, resins, solvents and scale inhibitors that are needed for the treatment processes.

Safety. Because exposure to chemicals such as chlorine gas can cause respiratory issues for employees, great care should be taken to ensure that leaks do not occur when dosing hazardous chemicals. Sealless gear pumps offer fewer points of failure because there are no leak points for harsh chemicals to damage the pump or the surrounding equipment.

Streamlined maintenance. The simpler the design is, the easier a pump is to maintain. With just a few moving parts, a rotary gear pump's front pull-out design facilitates easy access to the inner workings. This enables the pump to be repaired in place with one tool.

This reduces downtime and eliminates the need to move the equipment to a repair shop, which in some plants can require separate personnel. Spare parts kits are readily available and include everything needed to return the pump to as-new condition. This gives plant operators greater flexibility to schedule maintenance between shifts, or whenever it is least disruptive to do so.

Smaller footprint. Rotary gear pumps are compact in nature, and they do not require as many ancillary items as diaphragm pumps (such as pulsation dampeners), so the overall size of the equipment package can be reduced.

Longevity and reliability. Chemicals such as sodium hypochlorite tend to off-gas when they come in contact with metal surfaces. But nonmetallic gear pumps feature a simple design that helps prevent off-gassing, which minimizes disruptions and helps to maximize uptime for water treatment operations.

Accuracy. When used as a metering pump, rotary gear pumps can provide +/- 2 percent metering accuracy, and accuracies of 1 percent or better are achievable with a closed loop control system. This level of control is well within the range needed for pH and disinfection applications at power plants.

Better Water Treatment & Water Reuse Increase Plant Efficiencies

On a global scale, much has improved in power generation over the last 50 years. Legacy coal-fired plants that previously wasted massive quantities of water via once-through cooling processes are increasingly repowered around the globe by modern NGCC technologies that use far less water.

Water treatment processes are also evolving, as water experts refine best practices and pump manufacturers deliver more efficient pumps. Better water treatment leads to increased water reuse, which is particularly helpful for power plants in landlocked areas that have fewer choices for incoming water.

Effective water treatment also provides the added benefit of inhibiting scaling and corrosion, which protects pumping and piping infrastructure while ensuring continuous plant uptime.

The effective management of water and wastewater investments can save power plants 1 to 2 percent annually, which adds up to millions of dollars each year. While these benefits may never equal the financial advantages of once-through cooling processes, they do enable power plants to use significantly less water.

This puts operators on a more flexible path to address potential changes in regulations. It makes them better environmental stewards. And it puts them on a path to more predictable and sustainable operations.

Image 3. Thermoelectric power plants require tremendous quantities of water to produce electricity.

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