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Water & wastewater

World's thirst for desalination plants

In 2018, Cape Town, South Africa, came close to running out of water and several global cities could face a similar threat. However, desalination plants with reverse osmosis technology could avert such disasters, as variable speed drives and high-efficiency motors are proving to be beneficial.

Desalination is the well-established process of removing salt from seawater and turning it into potable water. There are two methods, one which uses thermal technology and the other, which is fast growing in popularity, uses membrane filtration, also known as reverse osmosis (RO).

In reverse osmosis desalination, seawater is forced through a semi-permeable membrane by adding pressure in a continuous flow condition, thereby removing salt and other impurities. It is a popular desalination method due to its independence from power plants, scalability and general cost-effectiveness.

However, RO desalination plants consume a considerable amount of energy during the processes of extracting the seawater, pre-treating, filtration, and post-treatment. The filtration process relies on high-pressure pumping and often requires booster pumps to move the seawater through the filters at the right pressure, creating an energy-intensive environment. Electrical energy is estimated to account for up to 50% of a desalination plant's running costs.

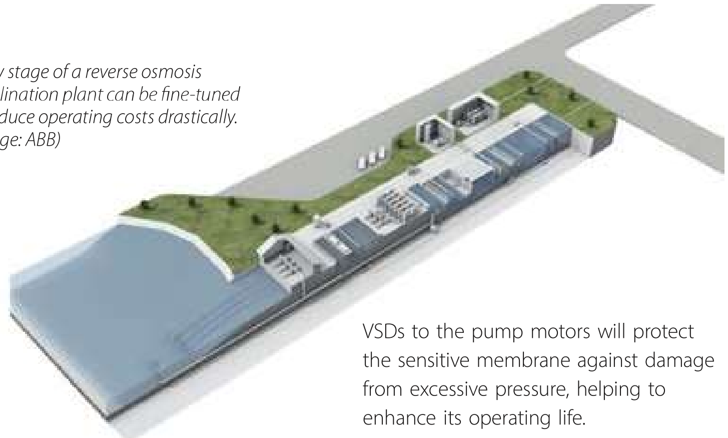
Driving costs

The capital expenditure (CAPEX) for the construction of seawater reverse osmosis desalination plants has fallen substantially over the past decade. This is related mainly to their increased scale. Where a capacity to produce up to 150,000 m^3/day of water was once typical, the current trend is to build plants up to four to six times larger. There are two main factors driving this upscaling.

First, there have been significant improvements in filtration technology that make very large-scale production feasible. Second, there is a growing realisation that larger plants are generally more cost-effective to build. For example, capital costs per m^3/day of a 600,000 m^3/day plant are about 20% lower than a 150,000 m^3/day plant.

Higher capacity plants offer better energy efficiency. However, they are equipped with large numbers of centrifugal pumps of various capacities, requiring flow control and consuming more than 90% of all the energy used by the plant. This is where variable speed drives (VSDs) play a vital role by controlling the precise flow rate of these pumps to enable substantial energy savings, typically up to 60%. VSDs also reduce the electrical stress on the motors and mechanical stress on pumps and associated equipment by providing soft and smooth start and stop features. These factors significantly enhance the life of the equipment and lower maintenance costs.

Desalination plants typically operate in areas where water supplies are already scarce. (Image: Shutterstock)



Every stage of a reverse osmosis desalination plant can be fine-tuned to reduce operating costs drastically. (Image: ABB)

Every stage of reverse osmosis desalination can be fine-tuned to drastically reduce operating costs. If we examine each stage of the desalination process, it is clear where there could be improvements with VFDs and high efficiency motors.

Seawater intake stage: The first stage, the seawater intake, uses centrifugal and submersible pumps to raise the seawater to the level of the facility. Seawater pumps are typically high-volume, low-speed vertical pumps. To prolong the life of these pumps and to match the quantity of seawater entering the plant to the required process, they are equipped with VSDs. Also, these pumps need soft starting (to reduce water hammering during start and stop) which is an inbuilt function of VSDs. In addition, these seawater pumps and associated equipment need to be designed to withstand a harsh corrosive environment to ensure reliable performance.

Pre-treatment stage: In the pre-treatment stage, water is filtered to remove inorganic suspended solids, sand, oil, clays, bacteria and dissolved organic matters. A coagulant is added to bind colloids, which are then removed in a flocculation tank. These processes require a combination of mixers, pumps and aerators; the last two are large energy consumers. With the new generation of low-voltage IEC motors, operators can achieve IE4 efficiency levels. The motors are designed for harsh environments and offer a high degree of protection against ingress of water or solids.

Filtration process: The filtration process, where the water and salt solution are separated, requires a booster and high-pressure pumps to push the seawater through the membrane. Fitting VSDs to the pump motors will protect the sensitive membrane against damage from excessive pressure, helping to enhance its operating life.

Clean-in-place (CIP): Pollutants that accumulate on the surface of the RO membrane can adversely affect performance, which leads to the fourth process, clean-in-place (CIP). CIP pumping operations apply low-pressure flushing in combination with chemical cleaning and disinfection to maintain optimal productivity. Dedicated VSDs for CIP can be applied to maintain the correct pressure, flow velocity, and solution composition levels in each stage of the cleaning cycle.

Post treatment: Post-treatment, the penultimate step in the RO process, is where the water is chlorinated to remove any remaining contaminants to make the water potable. Pumps are used to control the dosing since excess dosing can be costly, while underdosing can compromise water quality. A package comprising a synchronous reluctance motor (SynRM) with VSDs offers more precise process control and better efficiency, even at partial loads.

Storage and distribution: The final step is storage and distribution. Treated water is conveyed to a pump station ready for distribution. To guarantee safe water quality, positive pressure must be maintained and controlled to avoid contamination. With a VSD, the motor speed can be adjusted to achieve the desired pump pressure or desired output flow.

Electricity accounts for around 50% of the operational costs of a desalination plant, so energy efficiency and life cycle cost optimisation are critical challenges.

Lifecycle optimisation

The growing use of VSDs, particularly intelligent VSDs for pump control, represents a major departure from the standard operating practice of using control valves to vary fluid flow. With its low energy usage and low maintenance outlay, the total lifecycle cost of a VSD-controlled high-efficiency pumping system can be significantly less than using traditional pump technology.

New developments in Cloud technology, such as the ABB Ability Condition Monitoring service for the complete 'wire to water' powertrain, enables full transparency on key parameters for VSDs, motors, mounted bearings and pumps. Data gathered from VSDs' built-in sensors and loggers, together with that from smart sensors on motors, bearings and pumps, can be aggregated, stored and further accessed via the Cloud. This data gives operators a complete overview of the condition of their equipment, providing a sound basis for the implementation of predictive maintenance regimes that maximise plant availability.

Technology in action

Algeria has one of the world's largest seawater RO desalination plants, providing 500,000 m^3/day. The solution includes 33 medium voltage VSDs that reduce plant electrical losses from the benchmark target of 5% to only 3%. Compared with accepted industry standards, this is a vast improvement. Also, the VSDs speed up the long plant start-up process after shutdowns, reducing the length of plant downtime.

Overall, the future of RO seawater desalination looks promising, and by lowering production costs with smart technology, potable water is becoming more affordable and more available. ●

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