Climate change, increasing demands on water due to global urbanization and the legal obligations under the EUs Water Framework Directive are making the water sector an attractive place for technologies that can help reduce costs and contribute to reducing the effects of climate change. This article discusses the influential role AC drives can play in meeting these challenges.

WATERMANAGEMENT

CLIMATE CHANGE, THE WATER CYCLE AND AC DRIVES

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Water is crucial for the economy. Virtually every industry from agriculture, electric power and industrial manufacturing to beverage, clothing and tourism relies on it to grow and ultimately sustain their business.

Yet water is becoming scarcer globally and every indication is that it will become even more so in the future. Decreasing availability, declining quality, and growing demand for water are creating significant challenges to businesses and investors who have traditionally taken clean, reliable and inexpensive water for granted.

Climate change and water management

It is only during the last five years that the effect of weather patterns has started to filter down as to the likely impact on the water cycle. And already it is affecting the way water is managed. The more the water cycle is managed, the more energy intensive it becomes.

The more that is pumped the more energy is used. The more sewage removed, the more methane is generated.

As such some 4 to 6% of the world's greenhouse gases come from the water industry. These are figures that urgently need to be addressed through energy efficient pumping; low energy desalination and treatment; and sludge to energy and methane capture.

According to recent European Union estimates, pumps use more energy than any other type of industrial equipment, consuming some 160 TWh of electric power and accounting for 79 million metric tons of CO_2 emissions a year.

Water Framework Directive

The potential driver to make things happen is the European Union's Water Framework Directive (WFD). It is the most ambitious and far reaching European legislation, with some estimating it will cost up to 200 billion by 2027 to meet its proposals for all water, whether surface, groundworks or marine. Although it was developed long before the impact of climate change on the water cycle was fully understood, such is its far reaching demands that it is likely to be the stimulus for additional

capital spending on new technologies on a broad scale.

So armed with a serious need to meet the WFD, contribute to climate change and reduce the energy consumption throughout the water cycle, utilities are turning their attention to the ways of controlling their pump demands, which is leading them to discover the benefits of low voltage AC drives. According to recent European Union estimates, pumps use more energy than any other type of industrial equipment, consuming some 160 TWh of electric power and accounting for 79 million metric tons of CO_2 emissions a year.

The power of the AC drive

Do not underestimate the power of AC drives. Today they are more than just devices used to vary motor speed. AC drives allow more precise control of processes such as water distribution, aeration and chemical feed. Pressure in water distribution systems can be maintained to closer tolerances. Wastewater treatment plants can consistently maintain desired dissolved oxygen concentrations over a wide range of flow and biological loading conditions by using automated controls to link dissolved oxygen sensors to AC drives on the aeration blowers.

Not to mention the benefits of using AC drives on the many different pump applications used throughout the water and wastewater industry: dosing, mains distribution, pressure boosting, raw water, inflow and sludge as well as mixers, compressors, centrifuges, screw conveyors and fans. In fact, AC drives are used throughout the entire water and wastewater treatment process – from the moment the raw water enters the inflow pumping station to the time the effluent is discharged after final purification in the wastewater plant.

Replacing mechanical devices

Traditionally for applications where flow requirements vary, mechanical devices such as flow-restricting valves or moveable air vanes are often used to control flow. This is akin to driving a car at full throttle while using the brake to control speed. This process uses excessive energy and may create punishing conditions for the mechanical equipment involved. Rarely do the pumps and motors need to operate at constant speed or all the time. But it is surprising how many of them run at unnecessarily high speeds or with over-dimensioned motors, wasting vast amounts of electric power and consuming valuable carbon credits.

Lowering energy consumption

AC drives enable pumps to accommodate fluctuating demand, running pumps at lower speeds and drawing less energy while still meeting pumping needs. By equipping each pump motor with an AC drive, the speed and torque of the pump system are controlled with precision and energy consumption is kept to the minimum.

Energy savings from AC drives can be significant. Affinity laws for centrifugal pumps suggest that even a small reduction in motor speed will provide as much as 50 per cent in energy savings. An AC drive controlling a pump motor that usually runs less than full speed can substantially reduce energy consumption over a motor running at constant speed for the same period.

For an 18 kW motor running 23 hours per day (2 hours at 100% speed; 8 hours at 75%; 8 hours at 67%; and 5 hours at 50%) an AC drive can reduce energy use by 45%. At 0.10 per kilowatt hour, this saves over 5,000 annually. Because this benefit varies depending on system variables such as pump size, load profile, amount of static head and friction, it is important to calculate benefits for each application before specifying an AC drive.

Many water utilities are saving energy using AC drive systems. For example, one of the major needs facing desalination plants is to minimize energy consumption and operating costs. Australia's Gold Coast desalination project is using ABB motors and drives on its first and second-pass reverse osmosis pumps, as well as on the energy recovery device (ERD) booster pumps to control intake, booster, filter backwash and potable water pumps, ranging from 250 to 900 kW. The motors have an energy efficiency of 97% and are saving hundreds of thousands of euro's in running costs, as well as saving many tonnes of carbon dioxide gas from being released into the environment.

Meanwhile, at least £80,000 (€86,000) in electricity costs over a 20-year life span is being saved using ABB AC drives at West of Scotland Water's waste water pumping station. The wet well is monitored with ultrasonic level instrumentation, generating a speed reference signal, which is fed to an ABB industrial drive. This increases or decreases the pump speed to give optimum energy efficiency, replacing simple on/off control of the motors. "Indications are that the electricity consumption has been reduced by 48% compared to the same period in

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the previous year. I estimate that 44% of the savings can be put down to maintenance and 56% to the drives," says Charles McCaig, electrical design engineer at West of Scotland Water's Planning & Capital Procurement Department

Reducing maintenance costs

But it is not just in energy saving where AC drives offer benefits. Manufacturers have been working closely with water utilities and original equipment manufacturers (OEMs) to explore ways in which drives can help improve every stage of the water and wastewater cycle. While energy saving remains the number one reason for installing a drive, it is in the operation and maintenance of pumps where drives can also make a big impression.

Eliminating water hammer and preventing leakage

AC drives reduce mechanical stress on pipes, pumps, valves and other key equipment, and diminish the likelihood of water hammer by enabling the flow rate to be increased gradually and safely. Water hammer occurs when the flow of water in a pipe is stopped suddenly, causing a shock wave to ripple through the water and impact on the structure of the pipes, leading to damage. Over time, this can result in burst pipes, causing possible injury to operators. Using an AC drive allows demand to be smoothed out, reducing the sudden stops and starts that lead to water hammer.

This is precisely what happened at the Fourth Water Plant in Xinxiang in China's Henan Province where variable water pressure and inconsistent water discharge problems was putting at risk water quality while cracking pipelines. Each of the five 400 kW/10 kV pumps was started direct-on-line at full water pressure. Residual water in the pipeline was propelled at high pressure causing water hammer and the risk of damage to pipelines.

Single-speed drives start motors abruptly, subjecting the motor to high torque and current surges up to 10 times the full-load current. In contrast, AC drives offer a "soft start" capability, gradually ramping up a motor to operating speed. This lessens mechanical and electrical stress on the motor system and can reduce maintenance and repair costs and extend motor life.

Stress on the electrical system is mitigated by starting the pump motor softly and with considerably lower peak current than direct-on-line starting. And drives lower the risk of cavitation by monitoring the pressure of the incoming pipeline.

So at the Fourth Water Plant, five industrial drives were installed to provide a soft start for the pump motors, smoothing demand and reducing the stops and starts that cause water hammer. As the water pressure changes, the drives guarantee constant pressure by adjusting the pumped water discharge through prompt, closed loop control of the water pumps' motors, using the drive's inbuilt PID controller. Each drive is saving around 500,000 RMB (€50,000) a year. In addition, the drives reduce the frequency of pump on/off cycles, extend the equipment's life and lower the noise level at motor start and stop.

The benefit of soft-start was also experienced at Howden Water Treatment Works in Scotland. Consisting of a borehole pumping station as well as the treatment works itself, the site was facing extreme water turbulence in the pipework, so-called water hammer. AC drives were installed to control it.

The soft start capabilities of the drives are also critical to the application, helping the facility meet the electricity utility's regulations on motor starts. To reduce the current at start-up, these must not exceed 68 A at 11,000 V and each motor must be started separately, with a two second minimum time between starts.

Flow calculation

As can be seen, water hammer and pressure build up lead to pipe fractures and consequently leakage. Another feature now built into drives is flow calculation. This function provides the drive with a flow meter routine that enables the pumped volume to be monitored by the AC drive, without any additional components. This is a useful feature in systems where data about the total flow during a specific time period is needed. Severe variations in flow can indicate leakage problems.

Pressure and flow control

Using AC drives to control pressure and flow reduces the electrical energy requirements. A pressure boosting station, for example, feeds water directly into the distribution system and seeks to maintain a constant pressure in the

pipes. With smooth AC drive control there are no pressure shocks causing noise, erosion or leakage in the pipeline. Parallel drives enable the system to run with 100% redundancy. If a defect occurs in one of the pumps, motors or drives, the others will continue the operation without any interruption. Pump stations are sometimes located remotely and service activities might take some time. With redundancy, the pump station operation is trouble-free with minimized downtime.

The running time of the pumps can be stabilized with the pump priority function (see earlier) to ensure that the wear and tear of all pumps is the same.

Where several parallel pumps are operated together and the required flow rate is variable, a function called multi-pump control maintains stable process conditions optimizing the speed and number of the pumps needed. This function provides the most energy efficient way to operate parallel pumps.

Avoiding pump impellor ragging

Another issue affecting maintenance teams is the jamming or ragging of pump impellors. This occurs when debris within the waste water being taken into the treatment works clogs the pumps. Normally this is an expensive repair, whereby the pump is lifted from its position using a crane, whereupon a maintenance team manually clean the rags from the impellors. The pump is reassembled and lowered back in-situ.

To overcome this, ABB developed an anti-jam routine, now built within one of its AC drives. This enables the drive to perform preventive maintenance on the pump. When triggered the pump runs at high speed through a number of user-defined cleaning cycles to prevent the build-up of particles

Severn Trent Water (STW) in the UK is one of the early adopters of this technology, saving up to 2,700 a week on pump maintenance. The company installed four submersible foul pumps at its Worcester Water Treatment Works, pumping raw sewage from a new foul well.

STW experienced a number of blockages in the foul pumps, caused by rags sticking to the impeller. ABB suggested the installation of its anti-jam software. Taking minutes to complete, the cleaning cycle removes the debris from around the pump volute, preventing it from entering the pump and blocking it when the pump ramps up from zero to its nominal operating speed.

Following installation, STW has not experienced a single blockage of the foul pumps.

Reducing harmonic distortion

Because of the switching technology used by drives, they can sometimes produce harmonic distortion - adversely affecting power quality,

and subsequently, other electrical machinery. However, manufacturers have developed many solutions to correct this problem.

ABB, for example, has developed a range of low harmonic drives that produce exceptionally low harmonic content in the drive input. It achieves this by way of an active rectifier, along with the motor control method, direct torque control (DTC) and the use of a low pass filter, giving a total current distortion of less than 50%. The electrical system is also more reliable, due to avoiding external harmonic filters. Expensive multi-winding transformers are also unnecessary.

Forty such drives were used M/S Torishima Pump Mfg Co. for use in a variety of water pumping stations and refurbishment projects in Qatar. The projects are seeing the capacity of a number of pumping stations increased, resulting in pump sizes being changed and other pumps added.

Intelligent pump control

Because of the many and varied challenges the water industry faces within pump control, AC drive manufacturers are developing drives that are packed with all the functions that can single handedly meet these challenges. The idea of application-specific drives is something which research organization, IMS, has identified as a growing trend. With such drives the user can reduce the total cost through shorter start-up times, lower integration costs and improve machine productivity.

ABB, for instance, has developed a version of its industrial drive that is loaded with intelligent functions that meet the demanding needs of squared torque pump control, for single and multi-pump systems. All these pumps have specific requirements from level control through to multi-pump and priority pump control, and all of which can be solved using the latest software now available. The drives' pump-specific functions decrease the lifecycle cost of the pumping systems, helping to save time and money, boost energy efficiency and reduce carbon dioxide emissions.

Conclusion

Nearly half of all readily available renewable supplies of water have already been abstracted for human use. So the world is currently running on empty. A report by the Ceres/Pacific Institute concludes that climate change will exacerbate these water risks, especially as the world population grows by 50 million a year. The more the water cycle is managed, the more energy intensive pumping is utilized. So the role for energy-saving technologies like AC drives appears secure. << *(photos: ABB)*

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