Variable Speed Drives: Reducing the cost of managing water treatment systems
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Water treatment in large commercial and industrial applications is an energy intensive process, contributing significantly to operating costs. Variable Speed Drives (VSDs) applied to these processes, particularly on pumps, present a clear solution for improving the energy efficiency of managing clean and waste water.

Variable Speed Drives (VSDs) are potentially the most underutilised tools for optimising the energy efficiency of pumps, motors, fans, compressed air systems and other electricity-driven equipment - a 20% cut in energy costs can represent the same bottom line benefit as an approximate 5% increase in sales, depending on the type of business.

Overview

Water treatment in the commercial and industrial sectors encompasses a wide range of operational applications, including:
- Adding heat to processes;
- Recovering heat from processes; and
- Treating or moving water for reuse for various purposes such as generating steam; heating, ventilation and air conditioning (HVAC); water heating, cleaning and irrigation.

Water treatment systems form an integral part of optimising the running of, amongst others:
- Commercial buildings;
- Hospitals;
- Universities;
- Hotels;
- Food and beverage plants;
- Data centres;
- Municipal buildings;
- Leisure facilities such as public pools; and
- Municipal sewage treatment facilities.

Variable Speed Drives can be used to improve the energy efficiency of electric motors and pumps at work in water treatment systems by matching the pressure and output speed or flow.
of equipment to the actual demand of specific applications. Improved control of speed and flow, according to requirements at different times of the day or for different processes, saves energy and contributes to lowering operating costs.

It is estimated that motors, of which 63% are used to drive fluid flow in pumps, fans and compressors, account for 72% of electricity usage in commercial buildings and industrial processes.

What is a VSD?

A VSD, also known as a Variable Frequency Drive (VFD) or adjustable speed drive, is a device that can adjust the frequency to regulate and adapt motor speed to match the actual demand required by the system or application it is driving, resulting in a reduction in energy consumption.

VSDs offer a high degree of motor control, accurately varying motor speed according to demand while also adjusting torque – all within the specifications of a particular manufacturer.

A basic VSD can be used for simple applications - such as to control a pump or a fan - where variable loads are required. It can also be interfaced with a transducer, such as a pressure or flow rate sensor, and programmed to maintain a particular setting.

More advanced VSDs can be used for precise speed and torque control in complex applications like materials forming and can be interfaced with a computing system to provide real time operating data on the status and performance of a motor.

Slowing down a pump from 100 to 80% can reduce motor energy use by up to 50%.

How do VSDs work?

All VSDs work on the same principle: they convert incoming electricity, which is at a fixed frequency and voltage, into variable frequency and voltage.

When a VSD starts a motor, it initially applies low frequency and voltage, typically 2Hz or less, which avoids the high starting current that occurs when a motor is started using a direct-on-line or star-delta starter method. The applied frequency and voltage are increased at a controlled rate to increase the speed of the motor (load) without excessive current being drawn.

Drives adjust the speed of electric motors to match the actual demand of the application, thereby reducing motor energy consumption by up to 20% to 50%.
How do VSDs save?

VSDs save energy because they prevent motors from using more electricity than required - many motors are oversized to cope with a maximum demand that rarely or never occurs.

When other control methods are used, such as valves, motors run at full speed and the flow of the output is mechanically restricted. This is wasteful, because the motor keeps running at its nominal speed regardless of demand. A pump, for instance, delivers maximum output and the excess is reduced at the valve where the surplus energy is wasted through friction.

A pump or fan running at half speed consumes only one eighth of the power compared to one running at full speed, which means a small increase in speed requires a lot more power.

VSDs deliver accurate control and less mechanical wear; reducing maintenance and extending the life expectancy of systems.

VSDs and water treatment systems

Cutting the cost of pumping

A pump converts mechanical energy into pressure, which is imparted into a fluid and creates flow – VSDs are the ideal technology for improving the energy efficiency of pumps. Many existing pump and fan systems are based on throttling arrangements: The motor is driven at full speed and the flow of liquid or air is regulated by dampers, valves or vanes. Throttling output this way wastes energy. VSDs can increase systems’ efficiency by adjusting the motor speed to the correct operational point and eliminating the need for throttling.
• A small reduction in speed can make a big difference in energy consumption. A pump running at half speed consumes only 25% as much energy as a unit running at full speed. Because many pump systems run at less than full capacity for much of the time, VSDs can produce huge savings.

If a 100kW pump is throttled by 50%, the investment in a VSD can have a payback of only six months of continuous operation.

VSD control is used in pump applications where the flow is matched either to volume and/or pressure. The pump adjusts its revolutions to a given set point via a regulating loop. Adjusting the flow or pressure to actual demand reduces power consumption. Pumps offering ideal opportunities for energy savings with VSDs include:

• Chilled water circulating pumps.
• Circulating pumps for water heating systems.
• Geothermal heat pump systems.
• Pool pumps.

Installers frequently oversize pumps and piping because it is difficult to predict exactly what the demand will be once the system is in operation. Oversized pumps draw unnecessary power to feed a demand that is “not there”, with the excess capacity normally throttled by a valve. VSDs, which can be seen as design compensators, can reduce pump speed to match actual demand.
Preventing energy wastage by HVAC systems
At least half of the electricity consumed by commercial and industrial buildings is used to circulate air and water. Too often these systems are run at full power, irrespective of need, resulting in energy waste. In the case of HVAC systems, VSDs can regulate air and water flow, avoiding wasteful pumping and heating or cooling of water.

When air conditioning or ventilation systems require less cooling or heating than the maximum load for which they are sized, VSDs allow the equipment to operate at a lower speed, using less power. VSDs can be installed at various points in the HVAC-cycle to improve energy efficiency, including:

- Ventilation fans
- Chillers
- Cooling towers
- Cooling coils
- Heating coils

There is a broad range of Variable Speed Drives available specifically engineered for air conditioning and ventilation applications. These can be integrated into a variety of building management systems (BMS) to optimise efficiencies.

Improving the energy efficiency of boilers

The benefits of VSD control in boilers include:

- Reducing energy consumption;
- Eliminating the need for a separate motor starter;
- Improving fan control; and
- Extending equipment life.
VSDs are particularly effective when operating conditions call for frequent low load periods. By adding a VSD to the system and controlling the fan motor speed, energy is saved. Moreover, by restricting the excess air rate in line with actual demand, stack losses are minimised.

**The advantages of VSDs go beyond energy efficiency - they:**

- Enable precise control over applications and help to control pressure, flow and temperature;
- Allow for soft starting, which can reduce stress on motors and bearings and, therefore, extend equipment life;
- Enable more frequent starting and help to reduce motor overheating;
- Help to improve the power factor;
- Allow for the rapid adjustment of speed, torque and power to provide better control in high-speed applications;
- Deliver meaningful intelligence on the status and performance of motors when interfaced with computers or wider process control systems;
- Avoid penalties for exceeding supplied kVA; and
- Can run more than one motor at a time if the load on the motors is equal – in fact, up to 6 fans with the same load can be controlled by one VSD.

When linked by remote control, VSDs can be used to switch off motors or lower the speed of fan or pump motors to decrease the air or water flow rate during Eskom’s peak hours of demand for electricity.

- A smart VSD with a built-in Programmable Logic Controller (PLC) can do sequence starting and sequence stopping and, therefore, replace a number of devices.
• Before installing one, make sure that the system to be controlled is efficient and correctly sized for its application; only opt for a VSD if it is the correct electro-technical solution.
• VSDs must be correctly installed to operate optimally and achieve the intended energy savings – always select an expert installer who can back up his/her product and who understands the operating profile of your processes.
• Once installed, VSDs must be correctly programmed to deliver the intended energy savings - setting incorrect parameters results in poor control and energy wastage.
• Like all electrical equipment, VSDs are susceptible to damage from humidity and inadequate cooling and need to operate within specified temperature and humidity parameters. (Select the correct IP-rated VSD for your particular environment).
• Ventilation and/or air gaps must be provided (according to the manufacturer’s specifications) to prevent overheating; VSDs should be located near the motor in suitably ventilated enclosures or remotely in a suitably protected area.
• VSDs are dust sensitive; an appropriate dust filter needs to be installed when operating in dusty conditions - filters must be cleaned regularly to avoid overheating. (Select the correct IP-rated VSD for your particular environment).
• Full energy saving gains will be achieved when harmonic filter protections and components are properly installed and tested.
• Regular maintenance of VSDs – and associated motors – is essential to maintain energy savings. VSDs can become inefficient over time if they aren’t adequately maintained, especially in demanding environments with heavy loads.
• Preventive maintenance is always less expensive than correcting faults and having unanticipated breakdowns - opt for a maintenance contract with a reputable supplier to ensure that VSDs are kept in optimal condition.

VSDs deliver accurate control and less mechanical wear; reducing maintenance and extending the life expectancy of systems.
Important to know

• Some older motor designs may not have enough electrical insulation in their windings to withstand the high voltages that can occur with VSDs - they must be checked to determine whether they are suitable for VSD controls.

• In some applications, mainly in 90kW motors and higher - or where high switching frequencies are used - there is a risk of stray electrical currents being induced in motors, which can damage bearings.

• VSDs can increase harmonics in the electricity supply, which disturb the sine curve of the alternating current and cause motors to run warmer than what they are designed for, reducing their life expectancy. Harmonics can also decrease the life expectancy of computers and negatively influence the operation and accuracy of electronic measuring devices. The appropriate harmonic filters and chokes must, therefore, be installed along with the VSD to filter out the harmonics and protect your equipment.

• Motors operating under VSD control tend to run a little warmer than motors directly connected to the electricity supply; alternative methods of cooling may be required. The threshold for additional cooling will depend on the installation - in some applications motors may be de-rated to ensure adequate cooling. The reason for that is that an electric motor is equipped with a fan to cool it down. If the speed is lowered to below the specifications of the manufacturer, overheating may occur and additional fans or ventilation might be required. (If the motor runs at half the speed, forced cooling must be installed to prevent it from overheating.)

• If you have a power factor correction capacitor installed, remove it before installing a VSD.
Investing in the correct VSDs for your system or process and regularly maintaining motor drives will save you downtime and money and ensure optimal energy efficiency.

**Safety considerations**

- VSDs contain Electrostatic Discharge (ESD) sensitive parts and assemblies.
- Static control precautions are required when installing, testing, servicing or repairing VSDs.
- Component damage may result if ESD procedures are not followed - allow VSD capacitors to discharge for approximately five minutes before starting with work or an inspection.
- The enclosure housing for the VSD must be large enough to allow sufficient ventilation.
- **Earthing is critical:** both the motor and the drive must be earthed according to installation guidelines.
Eskom’s Energy Advisors

Eskom’s national Advisory Service can help locate VSD suppliers. The team can also advise business on:

- Reducing energy usage
- Doing walk-through energy assessments to identify energy usage patterns, energy needs, areas of energy wastage and energy saving opportunities
- Improving the energy efficiency of operations and electrical systems and processes
- Prioritising maintenance as an important contributor to reducing energy usage
- Finding SANAS approved energy savings Measurement & Verification Authorities.

Advisors also help identify funding opportunities for energy efficiency projects.

Call 08600 37566, leave your name and number and an Eskom Energy Advisor will contact you.

Alternatively, ask for a specific advisor to contact you or email an enquiry to AdvisoryService@eskom.co.za.

Visit www.eskom.co.za/idm for more information.

Credits:

- www.carbontrust.com
- http://www.schneider-electric.com
- Fanie Steyn, technical paper - Energy savings on motor-driven systems (Johannesburg, South Africa, 2012)
- http://www.advantageengineering.com
- http://new.abb.com
- https://www.trendcontrols.com
- http://www.ijirset.com