Cutting pumping costs through motor efficiency

Running costs are never far away from the mind of the pump customer, but Geoff Brown of ABB argues that energy efficient motors and variable speed drives can increase the value and usefulness of pumpsets. As a result, vendors could increase their margins and save customers' running costs.

The electricity used for pumping represents a large cost for many companies. The issue is rising rapidly on the agenda as energy saving initiatives are being rolled out in many markets across Europe. Yet, suppliers are often missing out on opportunities to offer energy efficient pumpsets to their customers. By using energy efficient motors and variable speed drives when the opportunity arises, vendors can increase the value and usefulness of pumpsets, and may as a result be able to increase their margins while at the same time saving customers' running costs.

An efficient drive system is of great importance to the efficiency of the pumpset. An energy efficient motor can halve the losses inside the motor compared to a standard motor, typically raising efficiency by 3-5%. Because of the large numbers of motors used in industry and their long life cycles, efficiency differences of that order can produce large monetary savings over the course of the life cycle.

Energy efficient motors

The importance of energy efficiency to a motor's life cycle costs is often not well understood. It is startling to realise that an 11kW motor costing about £500, can consume over £50,000 worth of electricity over a 10 year operating life. Energy efficiency is far more significant to the bottom line than the purchase price. Even small differences in efficiency make big differences to a motor's life cycle costs.

There is a sound business case for motor efficiency. In a £100 million scheme in the water industry, typically £200,000 will be spent on motors — a relatively small part. However, these motors will account for 80% of the energy cost for a wastewater plant. If 3% of this energy can be saved, the savings will far outweigh any capital cost advantage that may be achieved by choosing the motors that cost least to purchase. The savings will be compounded by the long service life of many motors; it is not unusual to find motors still operating after 30 years of service.

For instance, a 250kW motor with 95% efficiency will save nearly £17,000 compared to one with 92% efficiency, assuming continuous duty, a tariff of £0.05 kWh and a 10-year service life. For a 90kW motor, the saving will be over £10,000. If the motors are running at less than full load - which normally is the case - the savings become even greater.

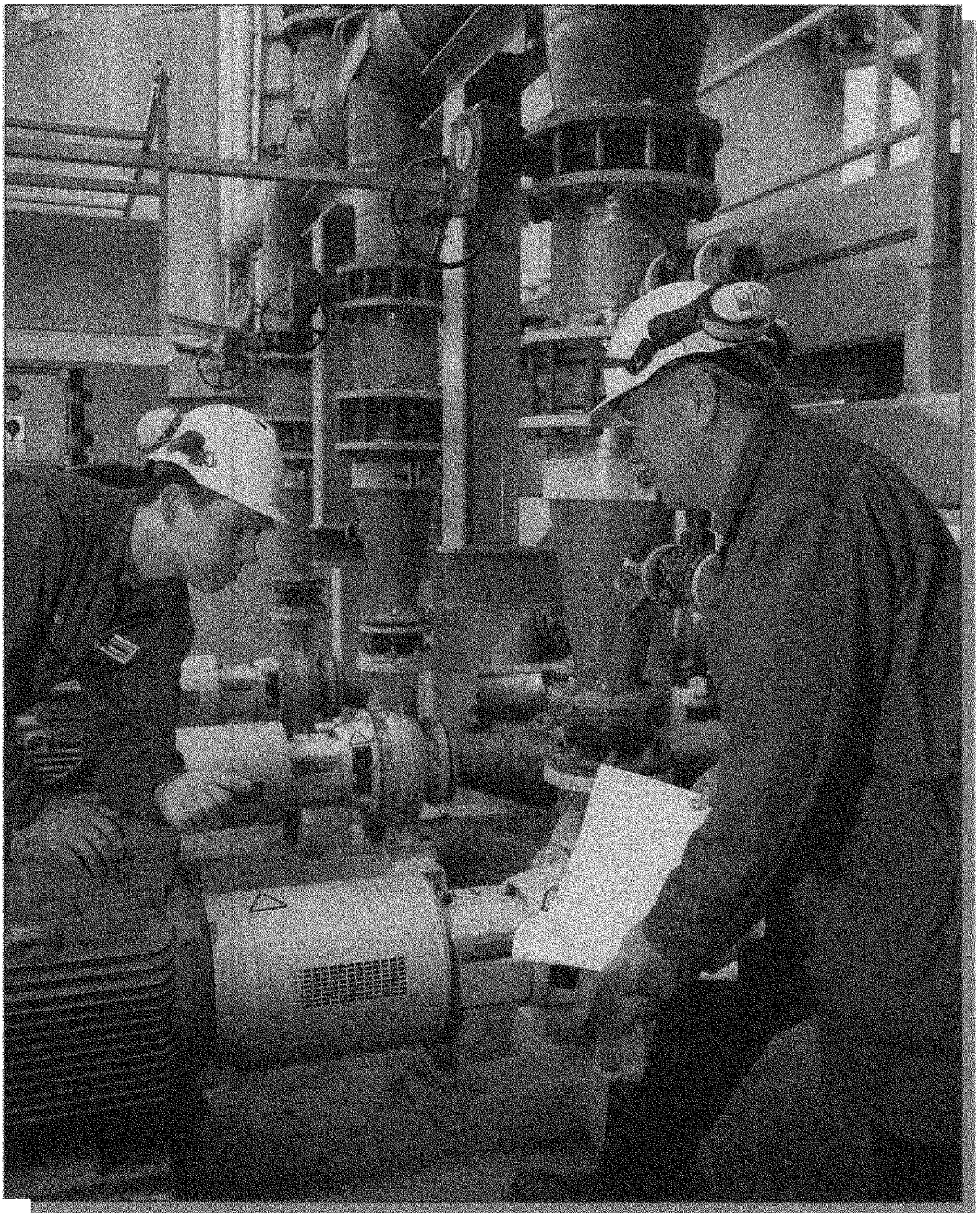
As an additional advantage, high efficiency motors also improve reliability. Their lower losses make them run cooler, extending the life of their components and reducing unplanned stoppages.

Motor efficiency schemes

In many markets, incentives are now being introduced to increase the use of energy efficient motors. The most stringent rules exist in the United States and Canada, where the legislation requires motors, whether locally manufactured or imported, to meet certain efficiency standards.

The European Commission has taken a slightly softer approach. It has agreed a scheme with CEMEP, the European Committee of Manufacturers of Electrical Machines and Power Electronics, which is a forum for motor manufacturers, to label two and four pole motors, ranging from 1.1 to 90kW output, according to efficiency. This way, anyone buying a motor can easily make a choice for energy efficiency. EFF1 is the highest efficiency class. These motors are traditionally referred to as "premium efficiency" and are not normally available off the shelf, however ABB recently became the first manufacturer to introduce a full range of stock motors in EFF1. EFF2 are the motors normally referred to as 'high efficiency' and EFF3 to what has traditionally been 'standard motors'. However, these days, EFF2 is becoming the norm and the manufacturers in CEMEP have agreed to phase out their EFF3 motors by 2002 and to have a full range of EFF1 motors by 2003.

Energy saving schemes are also being launched by national governments. For instance in the UK, the Climate Change Levy is now adding 10-15% to electricity bills in industry. To further encourage users to change to energy efficient technology, the UK



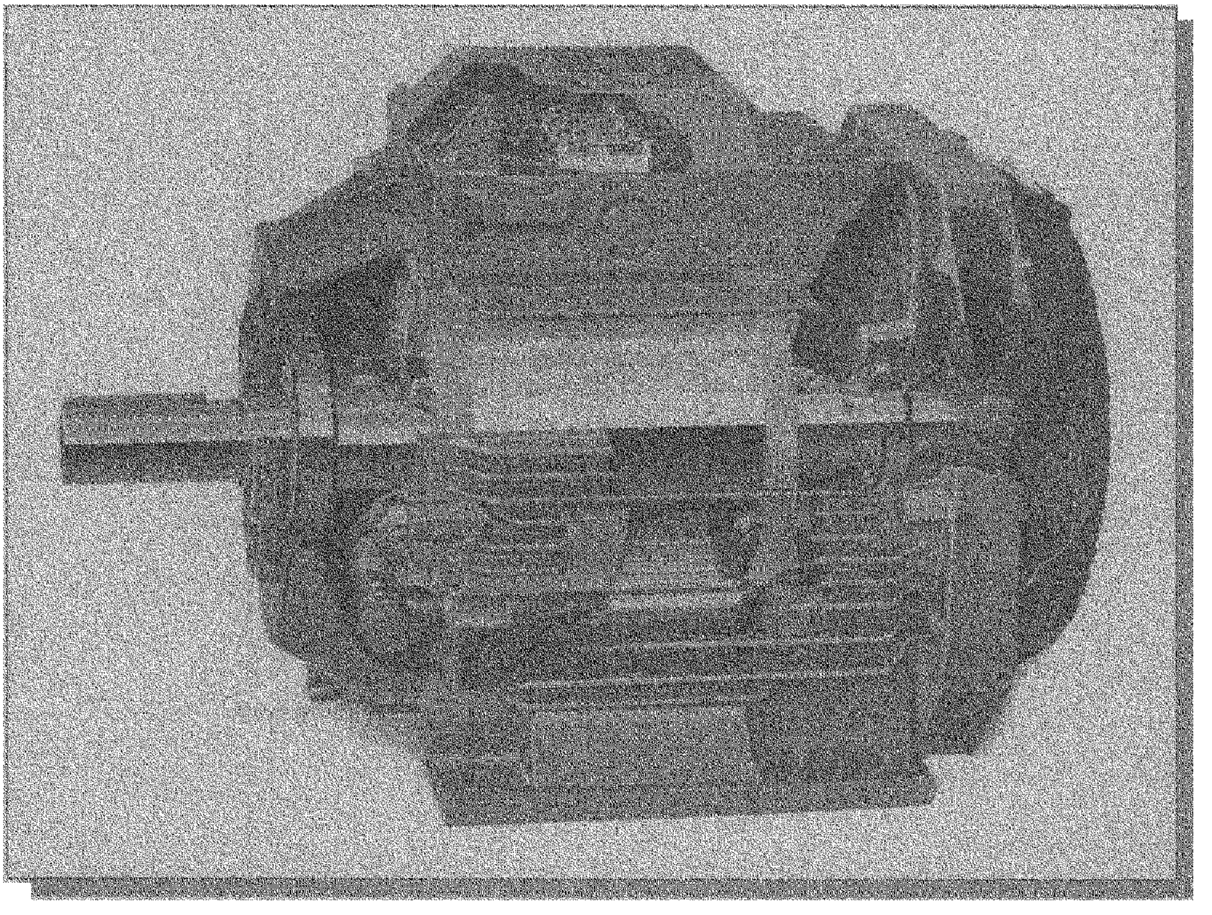
Variable speed drives can dramatically reduce energy consumption in pump systems. Savings in excess of 50% are not unusual

government is giving enhanced capital allowances for certain types of equipment, among these EFF1 motors and variable speed drives, enabling users to offset the full purchase cost against corporation tax in the year of purchase.

As the CEMEP scheme only covers two and four pole motors up to 90kW, another scheme, WIMES, is used to quantify energy efficiency for six and eight pole motors and for motors in larger sizes for the purposes of the Climate Change Levy.

Version 3.03 of WIMES — the Water Industry Mechanical and Electrical Specification — is a recently introduced standard for low voltage a.c. motors in the UK water industry, which aims to minimise the cost of motor ownership, from specification to maintenance and energy consumption. The standard has been drafted by a working group with members from leading water companies, co-ordinated by UK industry body The Pump Centre.

Initially established to lower the costs across the industry by providing a common standard, it also specifies minimum standards for factors that impact on the bottom line, such as energy efficiency, corrosion resistance and build quality.



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Variable speed drives

In variable speed operation, a variable speed drive can produce even greater savings – savings in excess of 50% are not unusual. But all too often in pump systems, control is still performed with throttling valves. Though such arrangements may seem cost effective at first, they are energy wasting as well as noisy. Running a motor at full speed while throttling the output has the same effect as driving a car with one foot on the accelerator and the other on the brake; a part of the produced output immediately goes to waste. An estimated 65% of industrial energy is used by electric motors, and some 20% of this is lost by wasteful throttling mechanisms. This indicates that in the right applications, variable speed drives can make a huge difference.

In particular, variable speed drives can dramatically reduce energy consumption in pump systems. A pump running at half speed consumes only one-eighth of the energy compared to one running at full speed. Or, put differently: the power required to run a pump is proportional to the cube of the speed. This means that if 100% flow requires full power, 75% requires (0.75)3=42% of full power, and 50% flow requires (0.5)3=12.5% of the power.

As even a small reduction of the speed can make a big difference on the energy consumption, and as many pump systems run at less than full capacity a lot of the time, a variable speed drive can make huge savings.

A variable speed drive can also make it possible to stop a motor completely when it is not required as soft start/stop is one of the built-in features included in the drive.

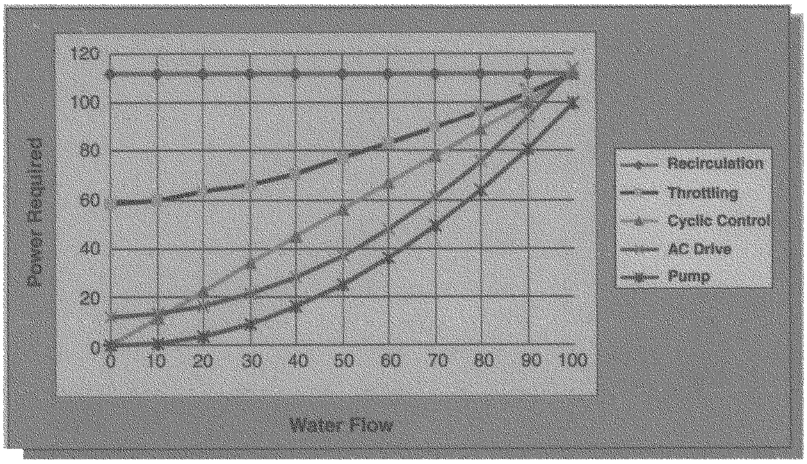
Regulating the motor speed has the added benefit of easily increasing output without extra investment, as speed increases of 5-20% is no problem with an AC variable speed drive.

By matching the performance of the motor to the needs of the process, variable speed drives can give major savings, compared to the wasteful practice of running the motor at full speed against a restriction to modulate output.

Mechanical control systems add complexity

The simple control method offered by a bypass valve may present a seemingly attractive alternative but has several drawbacks. The optimal process capacity, which gives the best quality of the process, is very difficult to achieve with simple control. An increase in production capacity usually requires reconstruction of the whole process and each direct on-line start-up brings a risk of electrical and mechanical damage.

But the main disadvantage is that the method is very energy consuming. Take the example of a simple heat exchanger cooling system with a flow



The above chart shows that variable speed drives give major savings compared with mechanical control methods

of 25 litres per second and a head of 58 metres. With this system, process water is cooled to a pre-set temperature through a plate heat exchanger by regulating the amount of chilled water.

If the temperature of the process water rises above the pre-set temperature, a three way control valve restricts the flow of chilled water in the by-pass loop, increasing the amount that goes through the heat exchanger. The shaft power required is calculated by multiplying the flow with the head, and dividing this with the pump efficiency, let's say 70,5%.

This gives a power requirement of 20.2kW. With a variable speed drive, the same effect can be achieved by slowing the pump speed, reducing the flow from 25 litres per second to 15, which decreases the head from 58 metres to 27 metres and also improves the pump efficiency to 71.8%. This gives a power requirement of 5.5kW, a saving of 73% compared to by-passing.

Using the example of the heat exchanger above, a throttling valve could also be used to reduce the flow from 25 litres per second to 15. This would however increase the system head from 58 to 71 metres, reducing pump efficiency to 66.5%. The shaft power required in this example would be 15,7 kW; using a variable speed drive would save 65% of the power required for throttling.

Efficient district heating

German company Stadtwerke Strausberg operates the district heating in the town of Strausberg 30km east of Berlin. Its 86MW power plant produces 190,000MWh of heating energy, distributed through a 32km distribution network with seven substations, to most official buildings and 50% of the private households in the town. The company decided to upgrade its control system, which was using throttling valves, to one with variable speed drives.

Using the throttling valves to reduce flow increased the head, making the system less efficient as the pump worked harder to overcome the extra head. Temperature changes were too large and fast, and high pressure through the control valves caused loss and noise.

The system is now equipped with variable speed drives, and works on the principle of keeping constant pressure in the network. When temperatures drop, the thermostat valves open, causing the pressure to fall and decreasing the pressure transmitter output signal. This increases the pump speed and the higher flow rate increases the water pressure until a control loop balance is reached.

The annual pumping energy consumption was about 550MWh using throttling valves, but that was reduced to 230 MWh when variable speed controlled pumps were used throughout the year. The payback period of the variable speed control system was about twelve months.

Recently introduced drive technologies, such as DTC (Direct Torque Control) give even better energy savings as well as more accurate speed and torque control across a wider speed range. Increased energy saving can be achieved with ABB's DTC-based drives compared to standard AC drives on pump, fan and other centrifugal applications, as the drive's Flux Optimisation feature reduces the energy drawn by the motor.

But above all, lower energy consumption means that less energy needs to be generated to run the motors, thereby reducing emissions of CO2 and other pollutants to the atmosphere. Such environmental benefits can be part of an environmental management plan by companies seeking certification to ISO 14001. ■

WEB LINKS

www.environment.detr.gov.uk/climatechange - offers information about the Climate Change Levy in the UK

www.unfccc.de - general information on climate change and the Kyoto agreement

http://iamest.jrc.it/projects/eem/eurodeem.htm - about the European scheme for labelling of energy efficient motors (CEMEP)

www.pumpcentre.com/wimes.htm - about the UK Water Industry Mechanical & Electrical Specifications

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