Energy savings

SAVING ENERGY FROM ‘THE WIRE TO THE WATER’

LIKE THE OLD SONG ABOUT THE KNEE BONE CONNECTED TO THE THIGH BONE, EVERY ELECTRIC MOTOR IS CONNECTED TO MACHINERY. AND NO MATTER HOW CLEAN, COMPACT AND EFFICIENT THE MOTOR, WHAT IT’S CONNECTED TO MAY NOT BE.

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As a result, alongside increasing efficiency in electric motors, a new whole-system efficiency approach is now emerging, best known by its pumping sector description of ‘wire to water’.

Laying down the law

Legislation is forcing increases in industrial electric motor efficiency. Under the EU MEPS (Minimum Efficiency Performance Standard) scheme, from 1st January 2015, newly manufactured 7.5kW and above IE2 rated motors must have Variable Speed Drive (VSD) control, and uncontrolled motors must have a minimum IE3 rating.

With IE3 at the upper limit of induction motor efficiency, manufacturers are anticipating IE4 and above with various new technologies.

A popular option is motors using high powered “rare earth” magnets, but the raw materials’ cost makes this technology expensive. Various attempts at lower cost solutions have been developed, for example, the notable launch of the Synchronous Reluctance Motor from ABB, which in common with the permanent magnet motors, requires a dedicated VSD to operate it. Brazilian manufacturer, WEG have an already proven premium efficiency motor which meets the criteria for IE4. This American market ‘NEMA’ specification motor uses a conventional design, so does not require any specialised VSD for operation.

Driving savings

No other technology can deliver the energy savings made possible by reducing the running speed of motor-driven equipment than VSDs. So development of this inherently efficient technology has focused on ease of use and performance.

However, in the UK market, the Carbon Trust Energy Technology List – itemising specific technology eligible for Enhanced Capital Allowances – now places more stringent requirements on VSD technology. The Fenner QD series of VSDs retained its status on the list thanks to its Energy Optimiser function within its general purpose controllers.

Electrical Regulations amendments for limiting harmonic distortion have also pushed VSD development towards mitigation of distortion, but most filtering solutions increase the losses in the drive. As an alternative, the Fenner QD:HVAC will soon introduce film capacitor technology, addressing the cause rather than the symptoms of distortion, with a slight increase in efficiency to boot.

The right gear

The equipment coupled to a motor’s shaft varies widely. Many systems employ a belt drive to transmit power from one shaft to another. Advances in V-belt and wedge belt technology have led to a five-fold increase in the power a single belt can transmit, and reducing the number of belts required naturally increases a drive’s efficiency.

Synchronous belt drives are even more efficient, but not always the most suitable – if noise is a concern, for example. The drives’ efficiency depends on correct installation, with particular reference to pulley alignment, belt tensioning, and the condition of the pulley grooves.

Gearboxes are often employed to convert the motor shaft’s high speed into more usable high torque, lower speed motion. Worm gears have been favoured for their compact size, and low initial cost, but this is negated by the high running cost compared to the equivalent helical gear train.

Of course, for any mechanical system, correct shaft alignment is key for achieving the potential efficiency. Misaligned shafts will increase bearing loads and fatigue stresses within the machine – not just using more energy, but also reducing service life.

Exceptions to the rule

Centrifugal pumps and fans are a unique equipment category, because their output is not uniformly related to shaft speed. Instead, fluid pressure and shaft torque vary with shaft speed.

The ‘cubed law’ states an approximate cube relationship between shaft speed and power requirement, which is true for fans and for pumps which do not have to lift the fluid very high. Conversely, for a pumping system moving water to a height, the reduction in pressure eventually becomes a problem when there is not enough pressure to lift the water, so no flow. A simple test is to compare the pumps’ nameplate pressure with the actual pressure required. If there is excess pressure, large savings can be made, but where the two parameters are close, a speed reduction will soon result in no flow.

Adjusting pump and fan speeds to match output to demand – especially where demand changes – is a great way to save energy. It is often implemented using sensors and automatic control, which is now a standard feature in most VSDs.

‘Wire to Water’ efficiency

This measure of system efficiency can be expressed in many ways, depending on the process. For example, a water pumping station would be measured by the cost of moving a volume of water (kilowatts per mega-litre per day).

However, looking purely at whole-system efficiency is not always a fair representation. After all, businesses pay for energy used, not for efficiency. For example, where a pump system has a 20% higher flow than required, assuming that there is adequate pressure, it would be valid to reduce the pump speed. Even if we account for additional losses by introducing a VSD, and perhaps a pump efficiency reduction at the new operating point, it would still use less energy and therefore cost less. This is where absorbed power is dominant.

Numeric notes

Overall system efficiency is the numeric product of the component efficiencies. That is, each component’s efficiency must be multiplied together. This can create a surprisingly low overall efficiency, as shown below:

VSD (98%) *
Motor (88%) *
Gearbox (95%) *
Pump (85%) =

69.6% SYSTEM EFFICIENCY