IMPROVING EFFICIENCY THROUGH SYSTEM-BASED CHANGES

photo: ITT Flygt

Almost half of all energy consumed by pumps is through systems installed in domestic and commercial buildings. Leading on from the UK government's new targets to reduce energy consumption, John Veness, a consultant with the BPMA, explains how system-based changes could dramatically improve the energy-efficiency of closed and open loop pump systems used in HVAC and pressure boosting applications.

Pump systems consume 13% of all UK electrical energy. Independent studies have identified the potential to save over a million tons of carbon emissions a year through the better design and operation of pumping systems. This has led to the UK government setting targets to reduce consumption by 6 TWh/a by 2020.

Over the past four years, the British Pump Manufacturers Association (BPMA) has adopted a proactive position with regard to the reduction of energy consumption in pumps and systems. The BPMA has been working with Future Energy Solutions (now AEA Environmental) to develop the pump system element of the UK government's Market Transformation Programme.

Some 49% of the energy consumed by pumps is in systems installed in domestic, commercial and public buildings. It is not surprising therefore that this sector is receiving a lot of attention both from pump owners but also from pump suppliers, system designers and installers. Whilst there is some potential to improve pump design it is recognized that this would yield only on average about 4% saving in energy consumption. System-based measures, where over 50% savings could be made, offer therefore the greatest potential.

Closed and open loop

There are two types of pump system, closed and open loop. In closed loop systems, liquid is circulated around a path with common starting and end points with a required head generally dictated by the friction loss resulting from pipe-work and fittings. HVAC systems typically are an example of a closed loop.

In open loop systems, liquid is generally conveyed from one point to another and along with frictional resistance, there is the need to provide additional pressure to overcome elevation or tank pressurization needs. Pressure boosting applications typically are an example of a open loop.

One of the most common factors resulting in energy inefficient pump systems is the incorrect selection of pipe work diameter. The situation is often exacerbated by bad plant layout and the consequential inefficient routing of pipe runs. These elements can increase frictional resistance, necessitating a selection of larger pumps to push liquid to the required service.

The initial capital cost of the pipe work and associated fittings will always be a major issue but nowadays, when energy costs are increasingly important, the higher capital cost of pipework and fittings can quickly be repaid and lower velocities can reduce the erosive wear, extending system life.

Pumps are generally designed with relatively small branch sizes and high liquid terminal velocities. This is to minimize the cost of production and to meet dimensional standards. This often leads to the wrong but common practice of matching pipework to branch size, which often leads to the resultant system frictional resistances being too high. The recommended velocity in pipework is 1.5 to 2.0 m/s for delivery pipework and 0.75 to 1.25 m/s for suction pipework, and if pipework is selected using this simple liquid velocity criteria, it will be possible to use increasers/decreasers on the pump branches to join to correctly selected pipe work and lower frictional heads, and low head pumps, using less energy will be sufficient.

Having carefully designed the pump system, it is critical to select a pump that is matched to it. Pumps in buildings are generally made of a simple centrifugal design. These pumps have been refined over the years and major manufacturers have developed high efficiency designs. Europump for example has developed a guide to the attainable efficiency of water pumps which can be used for the evaluation of pumps during the selection and procurement process. Whatever the pump selected, it will have been designed for a specific flow and pressure and will attain its maximum efficiency at that design point – its best efficiency point (BEP). If the pump is operated away from its BEP it will be increasingly inefficient and may suffer mechanical damage or reduced operating life. It is important therefore to select a pump to operate close to its BEP.

There are many pump applications within buildings. Water supply pressure boosting and fire protection are open systems, while heating, ventilation and air conditioning systems are generally closed loop.

Closed loop heating & HVAC systems bring with them significant opportunities for savings to be made. These systems require a wide range of flowrates to cope with seasonal, temperature control and different zone requirements. In these systems the pressure required from the pump is mainly determined by the friction loss within the system. The pressure required varies closely with the square of the flowrate and therefore a small change in flow results in a large reduction in required pressure.

Control is usually provided by the use of throttling and balance valves or on/off control, all of which are inefficient and waste energy. While throttling reduces the flow, the motor is still running at full speed and works even harder as it has to work against a restriction. By reducing the speed of the motor a variable speed drive can ensure that no more energy than necessary is used to achieve the required flow. A centrifugal pump running at half speed consumes only one-eighth of the energy compared to one running at full speed. This is because the torque needed to run a pump is the square of the volume.


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The most efficient way of controlling flow within these types of systems is with electrical variable speed control. Reducing the speed of the pump reduces both flow and pressure and a 30% reduction in flow can lead to a 60% reduction in energy. Variable speed drives may be simply fitted to existing motors without the need to change system pipework, although of course throttling valves should be fixed fully open.

Upgrading motors

When considering retrofitting a variable speed drive, it may also be worth considering upgrading to a high efficiency motor. These can save 3–5% of their running cost. A 90 kW high efficiency motor could cost £1,200 more to buy than the standard model, but will save £12,000 during a ten-year service life.

In the example of a hotel air conditioning system, the original system was designed with a large single pump controlled by a wasteful bypass system. The single pump was replaced by three pumps with variable frequency drives. An investment of £11780 resulted in a 57,000 kWh/year energy saving, which equated to £4569/year. Moreover, the use of three pumps resulted in maintenance savings of £800 a year, giving a payback of 2.2 years.

In pressure boosting open loop systems, vertical multistage pumps are preferred, because the hydraulic efficiency is generally better than, say, end suction at pump flows less than 50 m3/hr and much better at less than 20 m3/hr – all of which results in smaller motors saving on power consumption. If high efficiency EFF1 motors are used instead of EFF2 this also saves on consumption – although running hours dictate how much in kWh.

In HVAC building systems, variable volume demand often encourages splitting the pumps up into duty/assist/assist/standby – for example in a four pump set where maximum demand is shared by any three from the four pumps. This brings each pump motor size down when lower demand is being met, compared to old pump sets with only duty/standby operation and oversized pumps operating at inefficient points on their fixed speed curve. If the flow variation for most of the time is substantial, such as 2, 3 or 4 to 1, and the system curve is flat, it makes sense to use more than one pump to reach maximum flow. A sequence control system will start up the pumps (depending on actual demand) and will also bring about automatic cyclic changeover of the pumps to achieve equal running times and spread wear to increase overall system reliability.

In pressure boosting systems, variable speed pumps at constant pressure can further reduce the power consumption when compared to fixed speed pumps, because they better match the pressure requirement and work at option speed and power consumption. In pressure controlled systems, it is important to shut off pumps immediately when the demand stops. For booster pump sets this must happen independently of varying incoming pressure and therefore with varying pump head at zero flow. Operating pumps at zero flow wastes energy and can cause high temperatures to develop within the pump, resulting in damage and premature failure.

Pumps either use integral frequency inverters or external frequency inverters, and multipump systems can use a single variable frequency drive to control one pump in combination with fixed speed pumps. If users specify approved Energy Technology List products (motors & drives), end users in the UK can claim Enhanced Capital Allowance from the country's Inland Revenue tax incentives. It is estimated that £74 million of savings have already been made by using variable speed drives and high efficiency motors.

High efficiency systems

Pump manufacturers have combined improvements in pump design, variable speed control and high efficiency motor technology to create the circulators now available to the building services industry. Since its introduction in 1995, domestic appliance energy labelling has grown, with more products being added every year. Domestic circulators have now joined this scheme on a voluntary basis. A number of manufacturers, who between them account for approximately 80% of the domestic circulator sales in Europe , have committed to add the energy label to all their relevant product packaging. Although these new design circulators were initially targeted at the domestic market, they are also available with the same beneficial features up to 4 kW, bringing them into a number of applications in public and commercial buildings. Continued development will see these high efficiency designs increasing in size to cover all of the major applications within the building sector which will make them an important contributor to the reduction of the energy footprint of a building.

Finally, its important to remember that the simplest way to save pump system energy is to switch the pump off! The BPMA is continuing to improve member awareness of the opportunities of reducing pump system energy consumption. It has already led the development of three Energy Savings Guides for Europump which are used worldwide. These cover life cycle cost analysis, system design and variable speed pumping and are available from the BPMA bookshop. In 2005 BPMA members financially supported the commissioning of an 'options for action' report by environmental consultancy Sustain which led in 2006 to the formation of a focused BPMA Energy Group created to develop the BPMA's Better Pumping Practices Programme and turn its strategy into deliverables. This also led to the setting up of a pump energy specific website at www.bpma-energy.org.uk as a resource to help users to buy and operate more efficient pumps and systems. <<

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