Change is good

Variable speed pump technology can significantly cut operating costs in steam heating and process systems, says **Oliver Brigginshaw**

THE current economic climate, escalating energy prices and environmental concerns mean that steam plant operators in industry and public sectors alike are striving for new ways of cutting consumption and costs. New technologies that can reduce steam operating costs are being introduced to the market and an area that offers operators significant savings is improving the efficiency of condensate recovery.

Steam heating and process systems have changed little since the 1960s and many of the systems installed decades ago in process plants, large buildings and institutions such as hospitals and health centres are still operational. In fact, many of today's systems still follow the same principles. To improve efficiency, the majority of these collect condensate and return it into the system to recover its sensible heat. Clearly, the quicker the condensate is returned, the more sensible energy is recovered, thereby reducing operating costs.

Traditional systems rely on centrifugal pumps to return the condensate, but the volume of condensate varies according to the demands placed on the system. Given that frequent starting and stopping of direct on-line motors seriously reduces their service life, large condensate recovery units (CRUs) are needed to collect the condensate until the stored volume is sufficient to start the pumpsets and run them at a fixed speed for a period of time that is governed by the maximum number of motor starts per hour. With a limitation of ten motor starts per hour, the result is that the condensate has often lost much of its sensible energy by the time it is returned to the system.

affinity laws

The centrifugal pumps used in most systems are however robust and reliable. Their performance is also very predictable and governed by well-established affinity laws (see Figure 1). These state that:

- flowrate is proportional to speed;
- total head is proportional to speed squared;
- power is proportional to speed cubed; and
- net positive suction head (NPSH) is proportional to speed squared.

Clearly, for the condensate recovery system and therefore for the overall steam heating or process system to become more efficient it must have a pump that can be cycled on and off more frequently to return condensate to the system before it loses so much of its sensible heat. However, as the pump would be running more regularly, simply using a fixed speed pump would mean that the saving resulting from returning the condensate more quickly may be outweighed by an increased consumption in power, as the unit will only operate at maximum power. Varying loads of condensate might also mean that the pump would require other mechanical means of controlling flowrate, which are generally expensive and add additional frictional losses into the system.

variable speed efficiencies

This is where the affinity laws above can be used effectively. Power consumption reduces with speed cubed, which means that running a pump at 30 Hz (instead of the usual 50 Hz) results in a massive 78.5% drop in power consumption. If the speed of the pump can be varied to run at the minimum speed required to pump the condensate at the rate

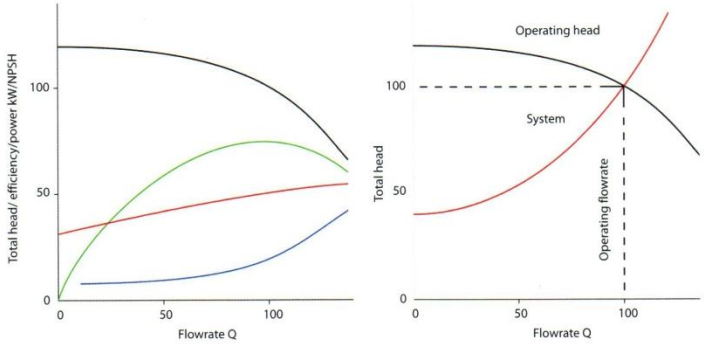
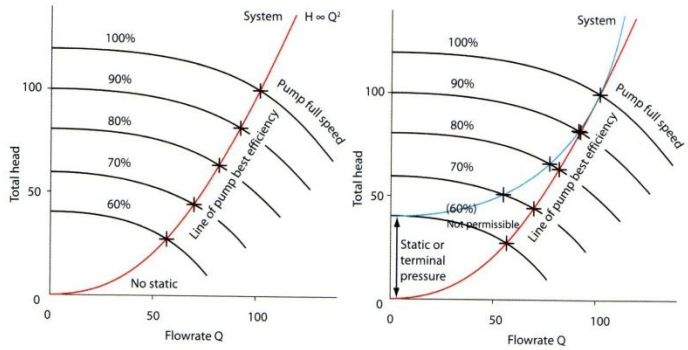


Figure 1 (l): Affinity laws Figure 2 (r): Combined characteristics



Figures 3 and 4 (l–r): Efficiencies of variable speed

that it is actually received, then there are significant benefits to be gained in both returning the condensate more quickly into the system and in reducing the overall power consumption of the pump.

Fixed speed pumps have fixed characteristics and so unless the system is manipulated in some way they will only operate where the pump curve intersects the system curve (see Figure 2). Centrifugal pumps are also generally a fixed geometry and so they have a best efficiency flowrate when the fluid flow pattern best matches the vane angles and passages. It can be seen from Figures 3 and 4 that the efficiency obtained by varying the pump speed changes dependent on the type of system – more or less static with less or more friction. Pump/system matching can be accurately modelled though using the affinity laws and so the pump/system interaction can be computer modelled, and system behaviour and economics can be predicted for a range of conditions.

Centrifugal pumps are ideal to control via their speed because their performance is so predictable. Combining a standard centrifugal pumpset with an inverter to replace the motor control panel and a process control sensor/sender with an electronic output compatible with the inverter delivers a reliable and robust system capable of being set up to the best simulated operating regime, and changeable to suit changing conditions.

The benefits from such a system can be enormous and we have developed a range of CRUs and control systems that take advantage of up-to-date variable speed technology. The pump units incorporate a soft-start control that both extends the service life of the pumpset and allows it to be operated much more efficiently than previously. The speed of the pump can be adjusted between 10–50 Hz depending on the level of condensate to be returned, and the actual system curve. The saving in electricity alone for these new units can be shown to be over £1000/y per unit.

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compact design, hotter returned condensate

As the condensate is being returned much more continuously, a smaller CRU can be designed which means that new units are very compact, thereby reducing manufactured cost. In the case of the Amarinth range of CRUs, the new design also allowed the number of units to be rationalised from 59 models to just eight, minimising stock holding and improving delivery, all of which feeds through to lower costs for the units.

Most importantly though, the condensate is returned on average 10°C hotter delivering significant savings in re-heating costs. This alone can amount to a saving of as much as £10,000/y in a typical system.

reduced capital and maintenance costs

Energy saving is not the only benefit here. An important consideration when building new plant or upgrading existing equipment is one of space. The new compact design of CRUs means that smaller plant room is required, providing further capital cost savings. With many of the new units destined to be retrofitted to replace existing ones, the compact design will also enable it to fit through a standard doorway so it's relatively easy to get them into the plant room which in many cases is in the basement and hard to access.

With skilled labour costs rising, ongoing maintenance is also coming under increasing scrutiny. Through the adoption of modern design practices the maintenance costs for the new CRUs can be reduced and tasks de-skilled. The 'rotating assembly' (basically the back half of the pump) in the new units can be easily and quickly removed and replaced. If a problem occurs the replacement can be undertaken by a low-skilled maintenance engineer in just 20 minutes.

The ability to quickly change the pumps also has the benefit of reducing the requirement for costly two-pump CRUs with all of their associated switch gear and valves. The UK's National Health Service for example has for years specified two-pump CRUs, one pump on duty and the other for stand-by in case of any problems. With such a quick replacement of the pump unit, the CRU could now be specified as a much more cost effective and efficient single pump unit and all that is required is for the operator to hold a spare rotating assembly on the shelf in their stores. Even the seals only take 90 minutes to replace from start to finish.

quick return on investment

The combination of energy savings, lower cost of manufacture and reduced maintenance over traditional units means that operators will get a return on any investment in just 6–9 months when installing compact CRUs utilising variable speed technology. The units are also designed with future upgrades in mind, for example the addition of building management systems where any controls and/or alarms can be monitored centrally, or the addition of duplex pump units.

With little end in sight to the regular rises in energy prices and with such a quick return on investment possible from the new variable speed CRUs, replacing ageing units would seem sensible, instead of spending money on repairs to extend the service life of an inefficient existing system. For new installations, the decision is simple; install the best and most economic CRUs available. **tce**