The old ones are **the best ones**

Some of the older energy-saving techniques are still the best, and while newer variants may offer much, there are important limits, warns Dr Tom Shelley

Most worthwhile energy-saving techniques have been around for years, but, as increased energy prices, newer legislation and growing public awareness around emissions all force users to reconsider fuel consumption, many are now re-surfacing in subtly improved forms. However, while the growing market for green solutions is good, engineers need to reacquaint themselves with best technologies for different jobs – and beware of their limitations.

Those observations apply throughout plant operations. Whether your concern is compressed air generation, steam raising, hydraulic power, motive power, electrical power, space heating or cooling and conditioning, there's a range of methods and devices to cut costs and carbon footprint. The job today is sorting hype from reality.

Take variable speed drives (VSDs): retrofitting almost all kinds of pumps and compressors with inverters can bring striking energy improvements as a result of matching system requirements and better managing variable demand. Payback times of two years or less are frequently claimed – and with estimates of 75% of pump systems being oversized, many by more than 20%, it's not difficult to see why.

Traps for the unwary

Nevertheless, it's not all plain sailing. When retrofitting VSDs, care has to be taken in matching the electrical characteristics of motor and inverter to avoid premature failure. Mismatches can result in rough running, deterioration of motor insulation (especially on older motors) and induced voltages in the shafts of larger motors, potentially leading to circulating currents that can destroy bearings.

But while these problems – and solutions like filters on inverter outputs, common mode filters and insulated non-drive-end bearings – are well known, the same is not true of other issues. For example, varying the driven speed can also lead to vibration in pumps, support structures and associated piping, potentially causing mechanical resonances. The most common result is pressure pulsing, but excessive structural movement is also possible.

None of this would be picked up at fixed speeds, where vibration doesn't coincide with the driven equipment's natural frequencies. The solution is testing and/or modelling for resonance conditions using standard hydraulic calculations, frequency analysis, structural examinations and analysis.

However, there is yet another risk – and that is of the pump rotor encountering a lateral critical speed, which occurs when running speed excitation coincides with one of the rotor's natural frequencies. As inverter firm Deritend's general manager Mike Smith says: "The resulting rotor vibration may be acceptable or excessive, depending on damping mode. Variable speed vertical pumps are more likely than horizontal machines to suffer from this because the lower natural frequencies of these pumps are more likely to coincide with running speed."

All that said, when installed correctly, VSDs are good news and can do more than save energy. For

Show info

The Energy Event 2007 at the National Motorcycle Museum, Birmingham from 12 to 13 September, will provide guidance.

- Official sponsor is British Energy, with support from e.on, EDF Energy, Encore, Llumarlite, Space Airconditioning and Ingersoll Rand.
- Seminars will be run by the Energy Services and Technology Association, MEUC (Major Energy Users Council), Envirowise, the Chartered Institute of Building Service Engineers, British Compressed Air Society, Energy Information Centre and Encore.
- Speakers include the head of utility procurement for Proctor & Gamble, Bloomberg's W McKeever and A Bainbridge, director general of MEUC. More information from www.theenergyevent.co.uk .

Cutting losses in mobile plant hydraulics

The pressure is on to save energy wasted by pressure drop losses in mobile plant hydraulics. At a recent Bosch Rexroth Global Technology Summit in Germany, Bruno Hartmann, vice president sales International Mobile Hydraulics, said: "Looking 10 years ahead, a lot of our customers are talking about hydraulic systems without [throttling] valves."

Reiner Leipold-Büttner, who is responsible for engineering at Bosch Rexroth, described key energy-saving technologies as: Diesel Hydraulic Control (DHC), which can reduce consumption by 10%; Hydro mechanical Variable Transmission (HVT), which can save 25%; Hydrostatic Regenerative Brake system (HRB), 30%; and Pump controlled Linear Actuation (PLA), up to 40%.

In DHC, from Bosch's engine management systems, a single unit controls both the engine and hydraulic systems, running the engine optimally according to hydraulic load.

Hartmann described a related technique called Electrohydraulic Flow Matching (EFM) in which the pump is not controlled by a signal from the valve "but from a joystick, so as to bring about a synchronous actuation of pump and valve, producing a faster response and less energy consumption".

Meanwhile, HVT involves a vehicle transmission path being split between direct mechanical and parallel hydrostatic transmissions – the two paths being recombined by a planetary gearbox. Hartmann said: "It leads to a stepless ratio, high efficiency, active standstill and lower demands on the engine."

Finally, in HRB, braking is achieved by engaging a hydraulic pump to charge up a hydraulic reservoir whose energy is then released to boost the vehicle away from a standing start. It's an old idea with new software. Permo Drive in Australia offers similar technology. It is particularly applicable to vehicles that have to make frequent stops, such as refuse collectors and fork lift trucks.

example, changes to a production line as new products are brought on-line, or as shifts change, can also be accommodated by VSD-driven pumps accurately matching volumes of fluids, gases or powders to demand, resulting in better efficiency.

Beyond that, replacing inefficient mechanical throttling and choking allows operators to trim production to a better outflow, not just saving energy at the pump, but along the production line. Also, mechanical stress on pumps and powertrain components can be reduced, extending the life of the equipment and reducing maintenance costs.

Compressed air is among the top opportunities for energy saving from VSDs – the biggest single waste being air generated but not used, as fixed speed unloaded compressors still use 20% to 70% of full load power. CompAir and others are now offering audits of air systems, using data logging equipment on site to monitor the quantity and pattern of air usage to predict annual site demand and appropriate systems.

Jeremy Sykes, managing director of CompAir, says that, in his experience, the exercise shows variable speed compressors saving in excess of 25% in energy and operational costs. He concedes that companies inevitably need to buy equipment, but points to financial incentives like Enhanced Capital Allowances (ECA) and interest-free loans under the Carbon Trust's energy efficiency programme. "With the work being done by BCAS [British Compressed Air Society], the Carbon Trust and others, we are finding more companies wanting to take a proactive approach by reviewing performance," he observes.

Proving the point, fastenings manufacturer Henrob says it realised a 16% drop in energy costs over just three months by installing a Boge SF 100-2 frequency controlled screw compressor, powering pneumatics at its Deeside plant. This company used Compressor Care (N Wales) to review its site equipment and found its fixed speed compressor was operating unloaded for 30% of its duty cycle.

Says John Aldridge, Henrob operations manager: "They proposed a Boge SF 100-2 frequency controlled compressor as the main provider, with the existing Boge S 75 fixed speed compressor becoming the back-up." Henrob bought its equipment with a Carbon Trust loan and Aldridge says: "We expect to see a £6,000 pa saving."

But it's not just about compressed air. For example, just 48 inverters and a Eurotherm Model 2500 electronic controller are enabling Fenland

Replacing mechanical throttling and choking with variable speed drives allows operators to trim production to a better outflow, not just saving energy at the pump, but along the whole production line

Laundries to save £10,000 per year by controlling the power supplied to 96 fans used to maintain positive air pressure in its clean room area. At the end of each working day, the controller automatically selects night-time pressure, ensuring that power consumption is minimised during non-operational periods.

Steam raising

Then again, steam-raising boilers at a new energy centre for Heinz's factory at Kitt Green in Wigan are now 14% more efficient as a result of closely matching burner output to demand using VSDs – and it has reduced NO_x emissions.

The site produces more than 1.3 billion cans of food every year, and consumes more than 100 tonnes of steam per hour both for space heating and sterilising. Each of its four boilers is equipped with two Hamworthy gas-fired burners, and all eight fans now supply air under ABB 55kW VSD control – varying the quantity of air injected according to whether higher or lower flames are required.

Barry Aspey, environmental compliance manager for Heinz, says: "We have a six-day-a-week operation and, although steam demand stays reasonably flat, it does ramp up slowly over a period of 36 hours and down over 24 hours. Variable speed drives are more responsive than mechanical dampers, which tend to introduce a time lag when demand changes."

There are, of course, other energy-saving opportunities for boilers beyond inverters. Walsall-based Maxsys' Fuel+ (Plant Engineer, September 06, page 19), apparently produces a cleaner, more efficient burn by applying a controlled magnetic field to the burner fuel. Designed for installation in vertical or horizontal fuel pipes, it has no moving parts and needs no electrical supply – and Maxsys promises "a 5% energy saving or your money back."

Synthetic fibres manufacturer Toray Textiles Europe installed the system and says it achieved that figure. "We found that Fuel+ offered maximum return when demand was high, which is something that suits our operations at Mansfield," says Mike Fisher, engineering manager. "Overall, it has provided us with a significant improvement in energy use. Another advantage is that it helps reduce the amount of CO_2 emitted. During a 20-day period, 12,400m^3 less gas was consumed than would have been expected if Fuel+ had not been installed."

More conventionally, another useful way to improve boiler efficiency is to condition the feed water to prevent build-up of scale. Chemical water softening was routinely used in the days of steam locomotives, but Hydropath claims that the Cathay Murni Garment Factory in Indonesia recently reduced its fuel consumption by 66% by applying its Hydroflow system, which uses electric current.

The fact that passing electric current through water prevents lime scale by precipitating lime as small particles within its bulk, rather than on hot surfaces, is well known and confirmed by C-Tech Innovation in Capenhurst, which has its roots in the old Electricity Council Research Centre.

Its approach to energy saving with fluids is to pass electric current directly and use ohmic heating to avoid the possibility of, for example, food being burned onto the inside of externally heated vessels. The technique also avoids all the heat transfer losses associated with boiling water to generate steam before using steam to heat food. Applied to water, the organisation says its solution greatly reduces, and in some cases eliminates, the formation of scale in water heating units, even in hard water areas.

Meanwhile, back at Hydropath, its Hydroflow uses a ferrite ring round the water pipe. A 200kHz diminishing signal with random wait periods is applied to a coil, and the water and pipe then act as the secondary coil of what becomes a transformer, resulting in current flow.

The factory in Indonesia previously used chemical water softening, blow down for 20 seconds at the end of each day, and shut the whole system down annually for chemical descaling. It still does the daily blow down, but no longer needs water softening. It reports no scale and no efficiency losses. PE

Combustion Plant Directive puts pressure on industry

Industry needs to ramp up its efforts to meet the requirements of the EU Large Combustion Plant Directive (LCPD), due for implementation in 2008, which will have a substantial impact on allowed emissions and thus energy.

Revised in 2001, LCPD aims to reduce acidification, ground level ozone and particles throughout Europe by controlling emissions of sulphur dioxide (SO2), oxides of nitrogen (NOx) and dust from combustion plants exceeding 50MW. And it's worth noting that Defra regards multi-unit power plant discharging waste gases through a common stack as single units.

Plants opened since 1987 are required to meet emission limit values (ELVs) given in the LCPD, while older plants can operate within each EU member state's National Emissions Reduction Plan (NERP). This is being set by looking at an annual national level of emissions calculated by applying the ELV approach on the basis of average actual operating hours, fuel used and thermal input during the five years between 1995 and 2000.

A 'cap and trade' trading scheme is being developed by the Environment Agency as an aid to meeting the requirements of the LCPD and NERP, but the most effective, hassle-free and cost-efficient way of meeting obligations lies in reducing emissions and energy consumption.

Retrofitting pumps with variable speed drives can reduce energy costs substantially, but beware of the potential for electrical and mechanical problems