Steaming ahead

Engineering innovation has the propensity to change plant practice, and that applies to boilers and steam generators, too. But improvements can also be made by going back to plant engineering basics. Brian Tinham reports

For plant engineers who think of steam generating plant as established technology, probably not worth much investment, the following numbers will come as a surprise. Primary energy losses typically waste 40% of the energy input – with steam traps responsible for 10%, stack losses 18%, flash steam 5%, boiler blowdown 2% and insulation 5% – while secondary losses rack up a further 5%, in the form of standing losses (3%) and pipe leakage (2%).

As Grant Bailey, sales and marketing director at Thermal Energy International, puts it: "Of the money spent on producing steam each year, around 45% is lost, when up to 40% could be recovered." So, clearly, boilers and associated plant are worth some investigation and investment, in terms of both the equipment itself and its ancillaries, and revitalised maintenance – because this sheer scale of needless waste is simply unsustainable on both cost and greenhouse gas emissions grounds.

For Bailey, key areas worth immediate attention include auditing the steam trap population and converting industrial boilers into condensing plant to benefit from significant flue gas heat recovery – in line with TEI's main equipment offerings. However, he also suggests the following: reviewing fitness for purpose of the boiler itself; examining the pipework configuration for heat transfer and maintenance flaws; and reassessing the effectiveness of the boiler water treatment regime.

Spirax Sarco's technical and quality manager Paul Mayoh doesn't disagree, but adds that plant engineers also need to examine other aspects. He cites: adequacy of water level modulating controls on the feed side; potential for fuel efficiency improvements through pre-air heating, economisers and boiler feedwater pre-heating; and energy efficiency of the downstream water system or process plant, in terms of leaks and pipe insulation. And, for completeness, we ought also to recommend a plant survey, to guide priorities and projects likely to deliver fastest payback.

First things first, and steam traps (designed to discharge condensate and air, in order to maintain heat transfer, while preventing steam escape) are a relatively easy target, given that around 10% of mechanical types fail each year, resulting in substantial energy inefficiencies, particularly if they fail 'open'.

"The result is economic loss, directly via increased boiler plant costs and indirectly via decreased steam heat capacity," says TEI's Bailey.

While conceding that mechanical steam traps of various designs are extensively used, he suggests that plant engineers should look at his company's fixed orifice steam traps, which use the Venturi effect to drain condensate, instead of conventional valve mechanisms. "As these traps have no moving

Water treatment in the spotlight

Boiler water treatment has always been a black art, given the intractable trade-off between protecting the boiler and its ancillaries, and minimising TDS (total dissolved solids) to maximise energy efficiency and reduce blowdown frequency. But both the chemical additives themselves and the control systems providing automatic dosing have moved on, so this is worth some attention – particularly as Carbon Trust figures suggest that, on a boiler operating at a nominal 10barG, for every 1% saved in blowdown, there is a 0.2% saving in fuel and emissions.

The plain fact is that all steam boilers and generators require blowdowns to keep TDS within set concentration limits. However, traditional boiler water treatments, aimed at providing protection from scaling and corrosion by injecting phosphates and sulphates, also contribute to that TDS loading and have to be removed by increased blowdown frequency – so costing energy and reducing plant efficiency.

One solution is to prevent over-treatment by installing an automatic system that doses chemicals accurately in a closed loop, on-demand, rather than relying on open loop dosing, driven by the chemical treatment contractor's periodic analysis. Another is to revisit the treatment itself, which is where GEMchem comes in, with its 'filming amine' treatments, developed by Concord Chemise in France. These are claimed to deposit a monomolecular layer of protection on the entire boiler system, including the steam and condensate lines, with virtually no impact on TDS.

That makes a big difference: indeed GEMchem suggests that, if the make-up water is softened, users can expect a fuel saving of 3–4%. Grant Bailey, sales and marketing director at Thermal Energy International, also says that savings can be expected, in terms of both improved heat transfer at the heat exchanger surfaces and better boiler efficiency – at a rate of 1.5% for every millimetre of scale removed from the tubes.

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parts to wedge open or fail, they provide the ultimate in reliability, necessitating only minimal maintenance and requiring no spares, testing or monitoring equipment," insists Bailey.

If you're interested, the evidence in favour of fixed orifice traps is strong. Corus's Trostre steel plant in Llanelli, South Wales, for example, installed 18 Gem Venturi orifice steam traps as part of its energy conservation and CO_2 emissions programme – and now reckons it is saving £500 per week. Dr Darryl Lewis, energy operations manager at Corus, explains that its CAPL (continuous annealing process line) uses 600 tonnes a week of saturated steam at 8barG. He says the site initially installed one Gem trap, following trials on a line drainage trap that generated 60% savings. However, a subsequent survey by TEI revealed 25% of the traps failed closed and 17% open.

Hence the replacement programme: "I have been extremely pleased, both with the operation of the traps and the aftersales service provided by TEI's engineers", comments Lewis. "The site was the first steelworks in the UK to win a Carbon Trust standard accreditation, in recognition of our commitment to reducing energy and CO_2 emissions [and] the trap programme was an important element in achieving this." He also says that the current rate of savings indicates that payback will be within 30 weeks.

How many and where?

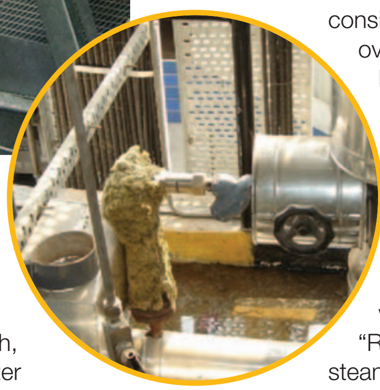
However, Bailey comments that it's not just about rooting out failed steam traps. "One of the issues we see is too few steam traps and not in the right locations," he explains. "As a rule of thumb, most plants need a trap every 30 metres to drain condensate effectively around the system. On pharmaceutical plants, it's more like every 10 metres, because they demand better quality, dryer steam to maintain process integrity and reduce the risk of condensate carryover."

There are exceptions: for example, good practice demands that, where pipework rises by more than one metre, a drain point, dirt pocket and steam trap should be installed at the bottom of the riser. The plumbing, too is important: if the main steam line is an eight inch pipe, installing a vertical half inch line for a steam trap is going to result in rapid failure, whatever the trap type, as dirt is deposited in the trap.

And Bailey also advises that steam traps should always be installed in front of pressure reducing valves, control valves, steam meters and the like. "Steam traps are relatively inexpensive, and people need to remember that they form the main barrier between the steam and condensate systems, preventing water hammer on both sides and maximising the efficiency of energy consumption... If the traps aren't adequate, then you're passing too much steam to the condensate system, which then goes to the receiver and is vented to atmosphere."

That said, other downstream problems are mostly caused by poor design and/or maintenance of the pipework itself. As Spirax's Mayoh points out: "You might have a wonderful boiler house, but, if it's putting steam into pipes that have failing insulation or are sited in flooding ducts, it will be costing you a fortune."

His advice: revisit your piping network and check the insulation, as well as the steam traps. Also, check the pipework configuration and look for areas where steam is being delivered from floor level, instead of via a swan neck from above the process: that is a surprisingly common mistake that leaves operators scratching their heads and



in Europe, but remain rare in the UK, whereas custom and practice favours low pressure or atmospheric tanks. "There is no good reason not to go for pressurised units," he observes, "and they allow you to recover more energy. Again, the higher the water temperature back to the boiler, the more responsive it can be and the greater the thermal energy it can deliver."

And on the subject of steam starvation, typically caused by demand exceeding supply in peak conditions, he also draws attention to another issue – traditional on/off feedwater level control.

"Modulating controls tend only to be specified on boilers generating five tonnes and above [of steam], but there is an argument for installing it on units generating only two tonnes. Bleeding in cold water reduces problems of suppressed steaming rates and lockout while the boiler runs through its cycle – and means the boiler can deliver a constant output, even with peak or batch type loads."

Similarly, he urges specifiers to consider the benefits of chest boilers over steam generators for plants likely to experience peaky steam demand, while also cautioning technicians to ensure that boiler set-up is correct. Specifically, he warns that the system must not be overstretched, because the risk is pulling boiler water out with the steam. And he adds: "Remember, various grades of steam are likely to be required for your production process and there are different methods for producing those. We'll have a definitive guide out pretty soon."

But, with all that checked, the big one for Mayoh remains condensate and, more importantly, flash recovery – particularly on high pressure steam systems – despite the difficulties. "When steam gives up its energy, it changes state back to water at line temperature. But passing that into the low

wondering why heat transfer isn't great and there are flooding issues. Unsurprisingly, payback on remedial work of this nature will almost always be very fast.

Returning to the boiler house, though, Mayoh suggests looking at the feedwater tank, hot well or de-aerator tank (depending on boiler feed configuration). You want the feedwater temperature to be as high as possible, to minimise oxygen carryover, and maximise boiler efficiency and responsiveness – but not so high that it causes cavitation at the feed pump, due to flashing. More on that later.

Incidentally, Mayoh also makes the case for pressurised de-aerators, which are quite common

Veolia treats boiler for maximum efficiency

Major boiler plants' chemical dosing regimes vary considerably. Take Veolia Environmental Services' Tyseley energy recovery plant, which incinerates 350,000 tonnes of Birmingham's non-recyclable rubbish each year and exports 25MW of electricity. The site has two 45bar 400°C water tube boilers, delivering 67 tonnes of steam per hour to high pressure turbines. It also has a 10bar waste heat shell boiler, fuelled by a clinical waste incinerator and supplying steam to a low pressure turbine.

To maximise boiler efficiency, Tyseley produces high purity deionised water on site, and adds chemicals to scavenge oxygen and optimise pH to prevent corrosion. However, the combination of two types of boiler, with common feed water and condensate systems, means that controlling the boiler water chemistry is a specialist job – in this case, handled by Elga Process Water.

To get it right, the organisation carried out a detailed site survey, with technical support from its boiler competence centre. That resulted in a recommendation for bespoke chemicals from Elga's Hydrex range, as well as a preventive maintenance regime.

Says Tyseley operations manager Andy Bullock: "Elga worked closely with us to achieve the appropriate boiler water quality, and we've been impressed with the technical support from the boiler team and their readiness to formulate bespoke chemicals for our system."

pressure return system causes some of it to flash back to steam – meaning a mix of states in the return side," he explains.

Hence, Spirax Sarco's FREME (flash recovery energy management equipment) system, which recovers the energy from flash steam and returns it to the boiler in a virtual closed loop. This system typically maximises energy recovery by preheating boiler water downstream of the feed pump (via a high temperature flash steam and condensate heat exchanger), eliminating problems of cavitation at the pump, otherwise caused when superheated steam injection takes the feedwater temperature too high.

Meanwhile, to achieve energy recovery where a condensate return run would be too long or inconvenient, most steam practitioners would recommend at least installing a process flash vessel to separate the steam and enable its re-use at slightly lower pressure, for example, for process preheating.

Flue gas heat recovery

But the other big aspect to consider is flue gas heat recovery. Products such as TEI's Flu-Ace stack economiser are claimed to recover "up to 100%" of heat normally lost, using a direct contact (gas/liquid) design that tackles both sensible and latent heat, even in widely varying operating conditions. Bailey explains that cold water travels from a spray nozzle against the rising hot flue gases via a stainless steel mesh, so recovering the energy and providing pre-heating. "A full payback is achieved, usually in less than two years with continuing savings being maintained throughout the unit's 20-year plus operating life," comments Bailey.

As for the future, Spirax Sarco, for one, is close to launching what it describes as super-insulated vacuum pipe, unveiled at the Institute of Healthcare Engineering and Estates Management exhibition in Manchester, back in May. "There was a lot of interest in the concept, which effectively seals the pipework in a jacketed arrangement, so that the outer wall is at ambient, while the inner wall is a steam temperature. The benefits, in terms of thermal transfer efficiency are obvious, but they might also mean fewer steam traps are required, because the condensing rate is reduced," says Mayoh.

He also refers to developments at the control end that will enable lower cost steam pressure control. "Plant engineers often ask us why boiler systems are sized to produce steam at 10 bar when they only use it at 4bar. And the reason is that distributing steam at high pressure results in better quality and drier steam. Also, you've got greater thermal mass in the boiler, which means better responsiveness, and you can distribute the medium in smaller pipework to the plant before reducing pressure at the point of use. That's why we're introducing a range of direct-acting, very robust control valves for steam applications, which we believe will make accurate pressure control more competitive." PE

Engineering innovation gets vertical lift-off at Fulton

Fifty years after introducing its vertical tubeless boiler, Fulton Boiler Works has launched the VMP (vertical multi-port), a new range of high output vertical boilers combining high output and efficiency with a small footprint and low maintenance.

The seven-model range of tubeless steam boilers includes Fulton's latest innovation – multi-port thick walled pipes, with removable, full-length turbulators that help to provide uniform heat transfer and speed-up boiler start time. Its Schedule 80 exhaust pipes also reduce maintenance by eliminating the need to replace worn or broken tubes.

The VMP range, which is also equipped with a Fulton designed and manufactured LoNOx burner that fires down the full length of the furnace, can be supplied for gas, oil or dual-fuel firing. Outputs range from 784 to 1,471kW, with a maximum fuel-to-steam operating efficiency of 85%.

Fulton sales and marketing manager Carl Knight says the VMP bridges the gap between the company's existing J Series vertical boilers and its horizontal RBC boilers, and is ideal for applications that need the high output of the RBC, but with a smaller footprint.

Incidentally, he also points to a new flue gas economiser for the firm's gas- and dual-fuel-fired horizontal RBC boilers, claimed to offer fuel savings up to 5%. The unit captures waste heat in flue gases, transferring it to the boiler feed water and raising its temperature from 85°C to 120°C on the positive side of the feed pump, to avoid cavitation problems.

And he points to a new modulating burner that uses linkageless burner management to operate two modulating actuators – one regulating gas flow and the other adjusting air for optimum combustion across the full boiler firing range. Initial results from a Cardiff University trial indicate significant reductions in gas consumption, with further savings being made on electricity. Thanks to the burners' modulation, the boiler is also more efficient, as steam pressure is kept at a more consistent rate.