Plant Engineer

SOE IPlantE SOE BES

November/December 2009

Marine engineering technology set to take boiler control by storm

Boiler breakthrough

- Raising the bar on lifting and handling
- Synthetic and green-friendly lubricants
- Naval training: the secrets of success
- Process control valves: the inside story
- Heat recovery energising compressors
- Construction design and management

Boiler breakthrough

While innovative energy- and emissions-saving add-ons are gaining in popularity for steam-raising plant, technology trialled on marine boilers is tackling water treatment. Brian Tinham examines the final piece of the jigsaw

Converting conventional steam-raising plant into condensing boilers to improve heat recovery – even to the extent of rendering large boiler flues redundant – has been viable for some time. So also has condensate recovery, originally for boiler feedwater preheating, but latterly also harnessing otherwise wasted flash steam for indirect boiler reinjection. But what about water treatment?

The vast majority of sites still manage chemical dosing, either under open loop pump control or manually, with the traditional peripatetic boiler man doing his rounds. Getting any more sophisticated seems to have fallen between the cracks – and in a rather more worrying way than many seem to realise.

Why should we be concerned? After all, plant engineers know that the chemicals themselves are cheap. That's the point: precisely because dosing isn't expensive and water treatment appears to be under control, we give it little or no thought – even though we know that any inadequacy here is one of the fastest ways to kill any boiler (Plant Engineer, September/October, page 18). And even though SAFed advises that, on both tube and shell boilers, scale build-up alone is enough to cause efficiency losses, overheating and ultimately even catastrophic failure – usually of the furnace for a shell boiler (see BS 2486:1997 and SAFed PSG2, shortly to be replaced by guidance from SAFed and the Combustion Engineering Association).

Boiler chemistry

As Chris Reid, director of Controls 4 Steam, puts it: "Everyone assumes that, because their chemical treatment company has been in, analysed the boiler water and specified a chemical rate into the feed tank or feed line, all they need do is set the dosing pump and they're all right. But the fact is, even if they do their checks every shift [and how many do?], the boiler load moves all the time, so the feed tank temperature is constantly changing throughout the day."

That means your water treatment rate was only

Last piece of the jigsaw

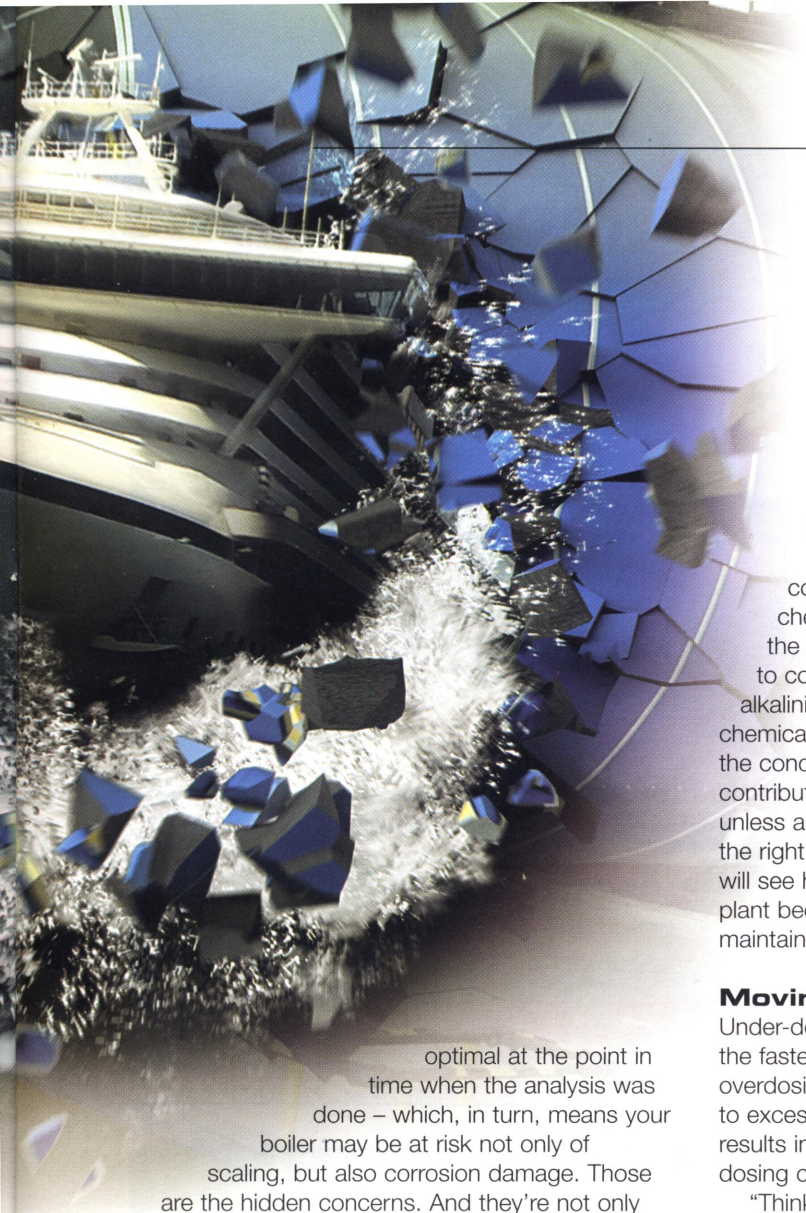
In operation, Aquanet's system monitors the feed conditions to each boiler, using an ultrasonic or mechanical hot water flowmeter on the feed line, as well as an oxygen or temperature probe to gauge or infer (respectively) dissolved oxygen.

Second, it monitors pH, dissolved oxygen and total dissolved solids in the boiler (the latter for blowdown control) by automatically sampling and passing the water across pH, DO and conductivity probes, via a plate cooler. And third, it reads the pH of the condensate return line.

Based on its findings, the system adjusts all the chemical dosing pumps on-demand against a computer model developed over the last 15 years. It controls boiler water alkalinity, the oxygen scavenger pump and condensate treatment.

"Sometimes we also put a flowmeter on the make-up line, if it's not possible to measure hardness, so we can dose for control at that point," says Les Emptage, technical director of Aquanet. "A lot depends on the site. We look at the feed tank design – for example, what's the maximum feed water temperature before there's a risk of feed pump cavitation. We also look at the quantities, the pressure and load on the boiler, and also the size of the dosing pumps."

"It's the final piece of the jigsaw," says Emptage. "It's the difference between preventing corrosion by accurately dosing oxygen treatment, based on requirement, rather than continuously second guessing the feed tank temperature."



optimal at the point in time when the analysis was done – which, in turn, means your boiler may be at risk not only of scaling, but also corrosion damage. Those are the hidden concerns. And they're not only about excessive operational costs, in terms of pounds per kg/hr of steam due to poor heat transfer, but also (and arguably even more importantly) premature boiler ageing and very expensive repairs. In short, you're operating that boiler with a very, very false sense of security.

Is this too fine a point of detail? Absolutely not, says Les Emptage, technical director of Aquanet International, which has been at the forefront of developing the next generation of closed-loop, on-demand automatic boiler feedwater controls. Emptage takes us back to basics.

"Water coming into the feed tank contains dissolved gases and solids, so chemicals are added to prevent damage to the boiler. Those include an oxygen scavenger to combat the effects of dissolved oxygen, alkalinity builder to keep the chemistry correct, chemicals to prevent scaling and others to protect the condensate system. Some of these also contributed to the dissolved oxygen level and, unless all are dosed in the right proportions and at the right points in the system, the boiler installation will see heat transfer efficiency falling off and the plant becoming more costly to operate and maintain."

Pointers

- Industrial boilers can easily be converted to condensing boilers
- Condensate recovery now extends to flash steam heat boiler reinjection
- Boiler conditions change, so water treatment should be on multi-parameter closed loop control
- Failure to do so leads to, at best, poor thermal transfer; at worst, corrosion and premature failure
- Costs can typically be £11,000 for unnecessary re-tubing in three years

Moving target

Under-dosing oxygen control, for example, is one of the fastest routes to corrosion damage, whereas overdosing increases dissolved solids – which leads to excessive blowdowns, to avoid carry-over, and results in inefficient operation. Yet, in terms of dosing control, a boiler is always a moving target.

"Think about the feed water tank, which is usually on level control. As water is taken out of the system, its level drops and make-up water is brought in. You could be looking at 2–3,000kg of cold water infill at 12°C, so the temperature drops and the dissolved oxygen content rises. Suddenly, you're feeding more dissolved oxygen to the boiler

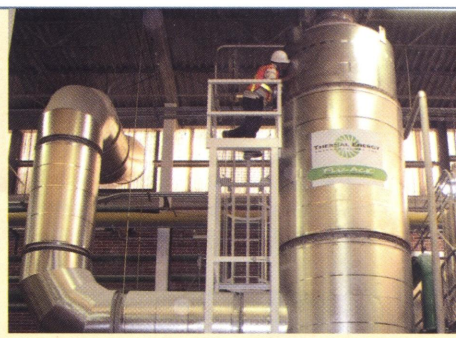
Converting flue gases into free heat

It's been possible to convert industrial boilers that burn natural gas or light fuel oil into condensing boilers for some time. Indeed, in the US there are hundreds of examples. In the UK, however, such projects have been less popular – apart from on well-heeled institutional plants. But, as fuel costs rise and the environment remains high on the agenda, that's changing.

And no wonder. As Sam Mawby, technical director at Gardner Energy Management, points out, his organisation's Flu-Ace recovers up to 90% of heat otherwise lost, while also reducing carbon emissions and energy bills by up to 20%, NO_x and SO_2 emissions by 20% and 90% respectively, and particulates by 50%. What's more, it renders large boiler flues practically redundant, and it's virtually maintenance-free and can deliver ROI in just 18 months.

"When you burn hydrocarbons, you get CO_2 and steam on the wrong side of the stack. So we install an adjacent condensing heat recovery system, which drops the flue gas temperature below the dew point and extracts energy through a heat transfer bed," explains Mawby. And it is very simple. The retrofit involves tapping into the existing flue and passing the gas through a short tower, equipped with a direct contact spray system. The shower passes over a heat exchanger at the base of the unit, recovering both sensible and latent heat, while flue gas flow is maintained via a variable speed, induced draft fan at the tower outlet. The latter automatically maintains optimum flue gas static setpoint and prevents interference with upstream processes, via a pressure transducer.

Several skid-mounted sizes are available, and all assembly, ducting and installation work is normally completed on site before tapping into the flue line(s), which Mawby reckons is less than a morning's work. Interestingly, several boilers and exhaust flues can be accommodated with a single retrofit. As for the output, hot water at up to 63°C accumulates in the tower's receiver, where it is treated before being used for boiler water makeup, CIP (cleaning in place) or any other hot water service. Mawby makes the point that the unit can also be coupled with an economiser to preheat the boiler feedwater after the feed pump. Surprisingly, though, only nine such units have been installed in the UK.



Skid-mounted flue gas heat recovery plant is routinely recovering 90% of wasted energy

than you should, because your dosing pump is just ticking away, assuming 1mg/l, when now it's more like 4mg/l. Then that oxygen hits the boiler and two things happen. First, it gobbles up any reserve of oxygen scavenger [due to earlier over-treatment], but then it attacks the metal surfaces and you get pitting."

How much pitting? Well, that depends but, he comments, with his company's plant model (www.aquanetint.com/model/boilermodelsetup.exe) he shows how a 5,000kg/hr steam boiler operating at 3,000kg/hr load can easily be under-dosed to the tune of 19kg of oxygen over a year.

Deep corrosion

"That results in 30kg of lost iron, which won't be stripped evenly off the boiler surfaces, because they're protected. Instead, you get electrolytic cells set up on the metal surface, causing deep localised corrosion. So the operator won't notice for a couple of years, but then in year three, probably during inspection or the annual thorough examination, he'll find he's in for expensive repairs."

How much? For a 5,000kg/hr boiler costing typically £44,500, re-tubing to repair typical damage runs out at about £11,000. On top of that, you need to factor in boiler hire costs and any lost production. And it's a similar story with under-dosing condensate treatment, which causes damage at stressed areas, such as screw threads, joints and seams, leading to leaking pipework.

Suddenly, an automatic system that doses accurately on-demand looks rather more attractive, doesn't it? Equally, the stock accountants' answer – that the increasing annual cost of a boiler is quantified and well known, so why invest in more sophisticated automation – looks less persuasive.

Aquanet's systems have seen most action in the marine sector, where the cost of chemical treatments is higher and the ramifications of failure more obviously critical. Big names include Cunard's Queen Mary, Queen Victoria and the Queen Elizabeth, due for launch next year, as well as the vast majority of P&O cruise liners and the massive Princess fleet, Holland America lines, and a raft of gas and bulk carriers and tankers.

However, a few enlightened running land-based installations have gone for the on-demand system – and report valuable savings. Emptage speaks of a brewery site in Alton, GSK in Dartford, Authentic Food Company, Manchester, Intervet in Milton Keynes and power stations in Macau and Malaysia.

Time for a swift review? PE

Condensate recovery on steroids

The last 20 years have witnessed significant strides in the effectiveness of condensate recovery systems, mostly driven by improvements in mechanical and electrical pumping sets, pump traps etc. As a result, today it's a no brainer: plant engineers routinely specify the equipment on new plant and many have gone for retrofit installations on existing boilers.

The vast majority are configured to preheat boiler feed water, because typically a full 1% is cut from a boiler's energy bill for every 6°C increase in feed water temperature. However, in some operations, these systems are so effective that too much energy is recovered, and the excess has to be dumped. Why? Quite simply, because feed tanks are at atmospheric pressure, if the feed water exceeds 85–90°C, the boiler feed pump is likely to experience cavitation on the upstream side, causing premature pump failure.

That's why there was a flurry of interest when Spirax Sarco launched its FREME (flash recovery energy management equipment), which is designed to ensure that all the energy from both the liquid condensate and flash steam return phases can be used, regardless of temperature. It promised to further reduce steam-raising costs, increase boiler efficiency and, because it recycles all water through the system, it would also reduce water and chemical treatment costs.

How does it work? The system – which comes as a pre-engineered, skid-mounted package – passes condensate returning from the steam distribution system through a flash steam separation vessel. The flash and condensate streams each travel through dedicated plate heat exchangers, where they pre-heat feed water to well over 100°C on the downstream pressurised side of the feedwater pump. The two return streams are then recombined and sent back to the boiler feed tank. Since that combined stream is sub-cooled, it is warm enough to heat the feed water, but not so hot that it could cause an overheat.

Since its pre-launch in 2003, there have been around 20 installations, and Spirax marketing and development manager Marcus Bellot reckons they have together saved around 10,000 tonnes of carbon emissions. The largest installation, at the De Mulder rendering plant in Nuneaton, is on its own saving 1,179 tonnes of CO_2 annually – as well as shaving 20% off energy costs and cutting make-up water. As operations director Rob Ratcliffe explains: "The boilers work closer to their optimal firing capacity, saving an extra 10% on top of the 10% saved directly by waste heat recovery."

Similar savings are reported by Leighton Hospital in Crewe, which commissioned a retrofit FREME plant a couple of years ago. That site improved energy recovery and reduced carbon emissions by around 95 tonnes a year, simultaneously cutting fuel bills by more than £10,000 and helping the hospital meet its emissions trading targets.

In its case. the skid-mounted system was simply fitted on the condensate return from the laundry. Around 1,500kg/h of condensate returns, of which some 14% was previously vented as flash steam. The feed water used to pass directly from the feedtank to the boiler at around 80°C, but the flash steam now heats it under pressure to between 120 and 140°C.

Most recently, Synergy Health in Sheffield claims that it has reduced gas consumption on its laundry boiler by 11%, using a FREME system. "To validate the scheme, we installed gas, water and steam meters before the FREME system was put in place," comments Darren Haddock, operations manager at Synergy Health. "Since the installation, we have been able to see great savings in all of these areas and specifically our gas usage." He says he expects full payback in just two years.