Babies and bathwater

Plant, equipment, instrumentation and the regulatory frameworks have all been evolving to meet the challenges of pollution and climate change. Brian Tinham examines the issues

New legislation, changes to the discharge consents regime (see panel), relentless energy efficiency concerns and tightening reduction targets for climate-changing emissions... Those are among key issues in the water, wastewater and effluent treatment sectors that, together, are driving plant engineers and engineering managers to review not only their equipment choices, but also some of their fundamental process and plant technologies. What's more, they are finding some useful new solutions. Which makes them interesting for most of us – particularly given the obvious crossover between municipal wastewater treatment plants and those handling industrial effluents.

Veolia Water Sensors & Technologies, for example (which designs and builds water treatment plants and equipment for municipal and industrial sites), has been gearing much of its R&D towards energy saving. Why? Kieran Healey, integration manager, reckons that the water industry in the UK currently consumes 2–3% of grid electricity, which makes it responsible for around 5 million tonnes of CO_2 equivalent every year, 60% of which is down to aeration processes alone on the wastewater side.

Star performer

"Our STAR [superior tuning and reporting] online control system is one very quick way to significantly reduce that figure," he claims. "The system optimises biological processes by taking data from existing plant sensors and interrogating it online to improve decisions around sludge recycling flows, aeration plant power etc. Treatment plants in Aalborg, Denmark, which helped with the development, doubled their water throughput and increased nutrient removal, without increasing energy, using STAR."

Healey describes it as "like having an automated process consultant on site 24/7". Inline probe data is used to predict optimal plant operational requirements, taking the entire process into account – as opposed to conventional feedback control systems that mostly regulate process units. "So, if it's a BNR [biological nutrient removal] plant, STAR calculates the best operating conditions for the whole consortium of bacteria. That works for any size and complexity of plant – including organics, nitrogen and phosphorous removal, and phosphate removal – taking into account all plant hydraulics," he explains.

"If you have a plant operating on dissolved oxygen control, installations on sites in France,

Measure of success

In wastewater applications, it's very easy to underestimate measurement errors, particularly with inlet wastewater levels, open channel flows and sludge blanket thicknesses.

As Peter Ward, Emerson's level products manager and a qualified MCERTS (the Environment Agency's monitoring certification scheme) inspector, says: "With open channel flows, for example, people tend to think they can get accurate results from their level instruments. But even where you're using advanced, non-contact probes that need virtually no maintenance, it's the primary structures that let you down, because of fouling.

"MCERTS defines uncertainty that all operators must achieve as ±8% of daily flow. It sounds wide open, but you can easily eat into that budget. Our instruments measure to ±0.5%, but that translates to an uncertainty of ±5% of flow because of all the other uncertainties – such as tolerances on the structure and the discharge coefficients, which are based on empirical data. You have to build in all of those and then remember that no process is constant. I've failed sites because there was no evidence of quality processes on measurement maintenance. But also, if they're measuring trade effluent into a sewer or a water course, they are being overcharged, because most poorly maintained systems over-read."

That said, level measurement technologies have improved hugely. Good ultrasonic and radar devices can now learn to ignore false echoes from pipework, ladders, handrails etc, and routinely cope with poor water surface conditions caused, for example, by build-up of scum and fats.

It's a similar story with sludge blanket measurement, used to control pumping cycles in secondary clarifiers. Best practice has moved beyond delicate optical instruments to robust ultrasonic sensors. Equally, on activated sludge plants, today's dissolved oxygen and suspended solids instruments are providing for reliable RAS (return activated sludge) pump control – not least because sensors are now available flush with pipework to cope with the harsh conditions.

And there's more. Ward sees the next development as wireless, using spread-spectrum 2.4GHz self-generating and healing mesh networks, which, he says, will enable far more plants to take advantage of modern instrumentation. "With wireless, instrumenting these plants is far cheaper, simply because it cuts out so much of the civil engineering and wiring work."

Technology on your radar?

Earlier this year, Environment Agency hydrologists trialled a radar water level sensor at a site by Molesey Lock on the River Thames, near Hampton Court Palace. The sensor was installed during October 2008 and, so far, results indicate that significant time and cost savings are possible with the new technology.

Water level data is now sent electronically to the Environment Agency's offices, using the phone network. Prior to the installation, level information was provided by a shaft encoder located in a stilling well 300m upstream on the other side of the river to the telemetry outstation. This meant that the data transfer cable had to pass under the river, and Agency staff had to walk back and forth between the sensor and the outstation to set the head level.

Rikk Smith, for the Environment Agency, explains that not only is the new system more accurate, but that radar meant no requirement for civil engineering works. The radar sensor scans every 30 seconds, providing values for on-site screen display, and logs a reading every 15 minutes for transmission via the telemetry outstation.

And Simon Wills, managing director at OTT Hydrometry, which supplied the sensor, adds: "This technology offers a number of attractive features. For example, it has a wide measurement range up to 35 metres, with ±1cm accuracy, and offers a number of communication options." Importantly, it also employs pulse radar, rather than a frequency modulated wave, which means high accuracy, but low power, so the sensor can operate from a solar- or wind-powered battery."

Belgium, Poland, Germany and Korea prove that you save 20% of the aeration costs, which corresponds to 10% of the overall plant energy and a corresponding reduction in greenhouse gas emissions," he adds.

Sounds impressive? It is, and the beauty of this kind of approach is that it does not require sites to throw the baby out with the bathwater by changing their plant infrastructure. It's about sweating the existing assets through better 'big picture' control. Additionally, those same overarching controls can be harnessed to optimise effluent quality – both to minimise discharge consent costs and to guard against compliance breaches.

But there are other ways. Bluewater Bio, which set up in the UK three years ago, says it has adapted advanced water treatment technology from South Korea. Spanish water company Aqualia Gestion Integral del Agua is the brave guinea pig. Its engineering subsidiary, Aqualia Infraestructuras, is currently commissioning a pilot plant in Ávila, near Madrid, using Bluewater's HYBACS (hybrid bacillus activated sludge) technology to remove nitrogen, phosphorus and organic matter, producing what it describes as "a high-quality, odourless water resource that can be reused".

Bluewater technical director Garry Hoyland explains the advantages. "Compared with competing processes, such as conventional nutrient removal activated sludge, HYBACS consumes up to 50% less energy, while offering capex reductions of 30%, opex reductions of 45% and a footprint that is up to 40% smaller. It also produces treated effluents

Left: Mono NOV mutrator installation at Port Issac sewage treatment works

with average BOD values typically less than 10mg/l from domestic sewage, and removes at least 98% of the BOD from concentrated industrial wastewaters." And he adds that the technology is well suited to upgrading existing plants, typically retaining "more than 80%" of an activated sludge plant's infrastructure.

Hoyland depicts HYBACS as a two-stage process, the first involving a fixed biomass, the second a suspended biomass. "The first treatment stage operates like a traditional RBC [rotating biological contactor], but with our SMART [shaft mounted advanced reactor technology] units – using a plastic biomass mesh 50mm thick, rather than the usual solid plate lamellae. That enables much higher levels of reactivity: we've proven about 10 times more biological removal capacity."

It's a similar story with the second stage, which mimics an activated sludge aeration plant, but with different dissolved oxygen profiles along the aeration lane. "We need that to select for the bacillus, but we can upgrade existing aeration tanks," explains Hoyland. "The hydrodynamics change and we typically need four tanks in series, but we can install partition walls, for example. Then each zone is provided with its own fine-bubble diffused aeration system from a common manifold, feeding back on DO_2 for control. It's also worth noting that our bacillus is not dosed: it's grown in situ. That saves money and provides a much greater concentration than most operators could otherwise afford."

All convincing stuff and Hoyland goes on to claim that the technology can be configured for plants handling everything from concentrated effluents to municipal wastewaters. "We have around 40 plants operational, removing nitrogen

Legal watershed

Changes to the old plant discharge consents regime are now imminent, as the UK moves to extend the environmental permitting (EP) programme, administered by Defra (the Department for Environment, Food and Rural Affairs).

The goal is apparently to improve and simplify the regulatory regime, extending the framework launched in April 2008 – initially only to cover industrial pollutants under PPC (Pollution Prevention and Control) and waste management – now to include all discharges into waterways, whether from municipal wastewater or industrial effluent treatment units.

From April 2010, all water discharge consents will become part of the EP regime, and plant engineers and managers will need to select from standard environmental permits (for relatively low risk pollutants), appropriate to their plant type and industry, or go the bespoke EP route, depending on the nature of their business and composition of discharges.

Lucy Fletcher, an associate with solicitors Norton Rose LLP, explains that installations hitherto requiring several permits and consents will be able to get inclusive permits. "From this point of view, the new regime will be more flexible and easier to manage. Plants will be able, for example, to transfer, surrender, revoke or add aspects to their environmental permits, without the overhead of separate administration and documentation," she says.

Plants can carry on working with the existing discharge consents for now, advises Fletcher, "but they need to be aware of the changes taking place, and review their requirements and what a bespoke or standard permit might allow".

Sounds simple? Sadly, no. There may be as many 'standard' permits as there are industry sectors and plant types. Fletcher makes the point that the set of conditions for a scrap yard may well differ significantly from those for an effluent treatment plant on a refinery site. "That is one of the drawbacks, and it does mean there are bound to be delays in getting the standard conditions sorted out and ensuring they are applicable to similar plants," she advises.

"Going forward, the water discharge consent you have may be considered adequate [and will automatically be considered as an EP], unless something needs to be varied. However, plant managers should be thinking about steps they might want to take to improve their plants, considering both the new EP regime and future legislation."

There is another aspect to this: the Environmental Liability Directive, implemented through the Environmental Damage (Prevention and Remediation) Regulations 2009, which became law on 1 March this year. Says Fletcher: "In the past, there has been a general reluctance to set large fines for environmental offences. But now, the new legislation imposes a fundamental requirement to remediate damage to the environment. Financially, that could have a huge impact on a company – and there's the additional prospect of future legislation encouraging the Environment Agency to name and shame."

Best advice is to redouble efforts not only to prevent discharges, but to reduce your plant's overall environmental impact – both to ensure that you do not find yourself in non-compliance and also to cut your discharge costs.

One final point: discharging contaminated water into the environment can also have direct consequences for directors and managers, if they are found to have been instrumental in a release incident through their consent, connivance or neglect. It's time to take a long, hard look at your plant equipment and maintenance on the installation that might lead to a breach. "If all your maintenance records are up to date, and you can prove that you have been operating within engineering guidelines and practice, that may afford a good defence," agrees Fletcher.

Pumped-up macerator

As part of an ongoing initiative to improve efficiency and reduce maintenance costs, Severn Trent Water has installed two mutrators (progressing cavity pump, with a tri-hammer macerator fitted in the suction line) from Mono NOV at its Burnhill Green sewage treatment works in Staffordshire.

Neil Horton, project engineer for Adroit Construction Services, the framework contractor, explains that the new units were specified to replace existing CMD40 mutrators, which had performed successfully for nearly 30 years, transfering raw sewage at a capacity of 13m^3/h to a high-level RBC (rotating biological contactor).

"The new mutrators are not only saving us energy, but also reducing our maintenance costs," says Horton. And he adds that, because the mutrators lift raw sewage from the collection sump into the cutting chamber when pumping cycles end, unmacerated solids fall back into the sump, clearing the suction pipe and preventing blockages.

Far left: Tony Hoyle, ABB flow products manager
Left: STAR performing water treatment plant at Aalborg, Denmark

and phosphorous, as well as carbonaceous matter," he declares.

All of which comes just as the provisions of the Water Framework Directive (which was put into UK law in 2003, but with a timetable of implementation running out to 2015) start biting, in terms of river basin and coastal water nutrient levels. Upgrading treatment plants in this way appears to offer substantial capital savings.

And also energy and emissions savings. Hoyland explains that, whereas conventional RBCs operate at about 2kg of oxygen per kWh, HYBACS units run at nearer 7kg per kWh, typically removing 50% of the pollution load very efficiently.

"Secondly," he says, "we use comparatively low DO_2 concentrations in the aeration tanks, again yielding higher energy efficiency. Thirdly, our reactors are much smaller than in a typical activated sludge plant for the same performance and we don't need anaerobic plants, with mixers, to keep the biomass in suspension. Fourthly, the recycling we need to keep the process working is smaller than in conventional activated sludge plants, so our pumping costs are reduced."

Severn Trent is currently running a pilot HYBACS plant in a vehicle container at its largest works in Coleshill, Birmingham. The unit treats 20 cubic litres per day, but is equipped to mimic full-scale operation, and performance is currently running at 98% ammonia removal and 90% total nitrogen. With figures like that, it can't be long before the organisation starts upgrading. PE

Energy efficiency opportunities

Aside from water treatment process changes, there are relatively simple changes to existing wastewater and effluent treatment plants that can significantly reduce energy expenditure. Tony Hoyle, flow products manager with ABB, makes the point that pumping air into aeration tanks can account for more than 70% of energy usage on a typical sewage treatment plant.

"Regulated dissolved oxygen levels optimise the rate of tank aeration and reduce pumping requirements. They also provide a stable environment for the micro-organisms that process the wastewater, which, in turn, reduces sludge production and chemical usage," he advises.

It's all about maintaining dissolved oxygen just above the critical 2mgl-1 to keep microorganisms working at their peak – and no more. Installing variable speed drives (VSDs) to minimise running of mechanical agitators or air diffuser pumps and compressed air plant (using dissolved oxygen concentration as the control parameter) can make very significant inroads into energy and emissions cutting.

Incidentally, although the argument for using VSDs is clear (typically, reducing the speed of a pump from 100% to 80% cuts energy by 50% – and reduces operational cost, maintenance and environmental impact), there is another factor. Hoyle makes the point that many were installed 10–15 years ago and modern units result in substantially lower motor energy losses.

Severn Trent proved that some years ago, when the organisation replaced three 37kW ac drives on water process pumps at its works in Wanlip with new technology alternatives – and achieved a further 65% energy saving and a payback of only seven months.

Pointers

- Changes to the discharge consents regime mean engineers need to review plant and instrumentation
- The Environmental Liability Directive, Water Framework Directive and associated UK legislation will up the ante on plant compliance
- The Environment Agency's MCERTS scheme is key and plant engineers need to understand the requirements
- Veolia's STAR system is one way of getting much more out of existing plants
- Bluewater Bio's HYBACS is an attractive proposition, in terms of plant performance and cost-cutting
- Modern sensors and instrumentation are radically improving process operations
- Variable speed drives take automation to a new level