Fuel for fire

Achieving new plant efficiencies is, in part, about selecting best measurement and automation equipment. Hemant Narayan looks at lessons from bio-ethanol production

Converting corn into fuel ethanol is a fast-growing business, responsible for one of the fastest plant-building programmes in the world. But it's not been without its challenges, particularly in terms of process optimisation. So it's well worth looking at plant engineers' choices of instrumentation technologies.

Their first lesson has been that understanding practical process requirements is key. Second is that selecting instruments for accuracy and repeatability is only part of the story: installation is also critical. Third is that it now makes sense to insist on self-diagnostics, at least on critical loops, so that problems are revealed by the device itself.

Fourth is that, while you pay more for high performance, or multi-parameter instruments, that may mean reduced lifetime costs, factoring in installation work and downtime for recalibration and repair. And fifth is that it's worth considering manufacturers who offer interchangeable components, such as universal signal converters, compatible with a variety of meters and sensor technologies: it simplifies engineering, procurement and parts inventories.

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Online improvements

That said, let's walk through the main bioethanol processes, looking at key devices used – starting with fermentation, where per cent solids control is important. Here, plant engineers have traditionally used sampling systems and laboratory analysers, and accepted the time lags, periodicity and resulting process operating limits. Recently, however, they've been opting for real-time, online measurement, particularly for the mixing tanks, because they help operators to maintain processes within, say, 0.5% tolerance – delivering tighter slurry mix consistency and enabling higher solids percentages, which, in turn, reduce enzyme usage.

Beyond that, by continually measuring per cent solids, good batch records are being established, thus improving alcohol yield predictions and assisting with process optimisation. Newer Coriolis flowmeters have proved invaluable here, delivering density measurements as the basis for solids. Users have found that problems of fouling and blockages experienced on old designs – due to bends and flow splitters – have been eliminated by straight tube types, such as Krohne's Optimass 7000.

Moving on to ethanol rectification and dehydration – common to all fuel ethanol processes – the goal is to achieve maximum purification, using rectification (to 190 proof), followed by the push to 200 proof, using molecular sieves that take moisture content from 5% to 0%. The problem is that, if the process fluid moves too quickly through the sieves and some moisture remains, then the entire batch must be reflowed, wasting energy and causing bottlenecks.

Density measurement helps by detecting exactly when the ethanol reaches its anhydrous threshold, so that the process meets its target without overshooting. Again, single, straight tube Coriolis meters have proved accurate and reliable, effectively covering proof, density, temperature and flow – and obviating the need for additional instruments. And it's a similar story on the evaporator syrup draw. Installation of online Coriolis meters, at the intermediate and final stages of the evaporator, improves control of syrup per cent and flow, resulting in significant energy savings.

But there's also a place for volumetric flowmetering in bioethanol production, for example upstream of fermentation. Dry-milling plants make extensive use of electromagnetic flowmeters for flows containing high solids, such as backset, corn slurry and mash, as well as on whole, thick and thin stillage. Most use pulsed dc technology, which has replaced older ac equipment that had problems with drift and zero stability. However, they do have performance limitations, especially with noisy, high-solids applications, such as slurry, and plant engineers are turning to signal converters with digital noise filtering and low-noise electrodes.

They're also using self-diagnostics to detect sensor coating degradation and predict electrode or liner failure. And they're harnessing some of these units' concurrent conductivity measurement – for example, during CIP (cleaning in place) – enabling automatic control, improved efficiency and reduced waste, without buying, installing and maintaining extra instruments.

And yet magnetic flowmeters can't handle everything, and downstream of rectification, where conductivities are very low, vortex shedding and ultrasonic flowmeters are being installed instead – in favour of older devices with moving parts, such as turbines and paddle wheels, which are prone to coating and mechanical failure.

But it's not quite the same with steam services, used extensively for cooking, dehydration and evaporation. Here, although the required measurement is mass flow, Coriolis and thermal mass meters can't be used, because the high moisture content in saturated steam causes failures.

In the past, that has led most plant engineers to choose orifice plates or vortex meters – accepting the limitation that density corrections for mass flow (usually fixed around the operating pressure) can mean inaccuracies up to 25%, if the pressure changes by 10%, even though volumetric accuracy remains better than 1%. Modern thinking it again to use multi-variable steam meters, such as Krohne's Optiswirl 4070, measuring flow, pressure and temperature with integrated sensors to provide accurate density compensation.

Finally, for inventory management, level meters play an important part – for example, in tracking the use of enzymes in the slurry tanks during mash preparation, or of chemical consumption in CIP routines. Level measurement in fermentation tanks also enables regulation of foam, and it's critical in operating reboilers and distillation tanks, as well as from final storage tanks.

Conventionally, equipment based on hydrostatic pressure is used to measure from the bottom of the tank – an indirect indicator that assumes constant density to determine surface level. However, temperature changes affect density and a better approach is non-contact radar level devices that detect level from the top of the tank. PE