New software and diagnostic techniques are helping BP’s engineers to spot potential problems before they occur in the company’s giant acetyls chemicals complex in the UK. And being forewarned is forearmed, as Michelle Brown learns.

Foresight is a marvellous thing. On a busy chemicals complex, knowing what potential operating problems might be brewing can make the difference between taking timely action to keep things running smoothly, or facing an expensive, unplanned halt in production. At its UK petrochemicals site in Hull, BP’s acetyls business unit is using cutting edge techniques to monitor equipment and processes in ways that allow BP’s engineers to nip those potential problems in the bud.

‘Early detection of such problems will yield estimated savings approaching £2 million a year across the site,’ says process automation team leader Tim Law, ‘and it will help BP to extend the time between planned maintenance shutdowns from two to four years on our largest acetic acid plant.’

The new approach being applied in Hull is referred to as abnormal situation management (ASM), embracing a variety of ingenious diagnostic tools that engineers are using to spot seemingly insignificant early symptoms that could lead to trouble in a few hours or days. ‘A couple of hours’ warning can make all the difference,’ says Zaid Rawi, BP’s lead engineer on the ASM project and a member of the process automation team.

ASM is part of a wider initiative at Hull called PUMA – producing the ultimate manufacturing asset – a programme of improvements launched in 1999. PUMA is one of three pilot initiatives forming part of Manufacturing Vision, the focus within BP’s chemicals business for the BP-wide Operations Excellence efficiency drive, launched by group chief executive Lord Browne.

‘Before we began the pilots, we could not precisely predict the hard financial benefits of these technologies,’ says Steve Hetherington, project manager for PUMA. ‘Now BP can be much more confident of the financial justification for future projects because we’ve demonstrated that ASM technology does work and that it will reduce plant downtime.’

And reducing plant downtime at a complex as large as Hull has obvious economic benefits. The Hull chemicals complex, located at Saltend on the River Humber estuary, has a manufacturing capacity of over 1.5 million tonnes of chemicals a year, making it the largest producer of acetic acid and associated products in Europe and the second largest acetyls complex in the world. The plant boasts six production units making a variety of important feedstock chemicals: acetic acid, used in plastics, packaging, paints, food preservatives, pharmaceuticals and photography; acetic anhydride, for the manufacture of bleach, pharmaceuticals and herbicides; ethyl acetate, for pharmaceuticals, paints, printing inks and photography; vinyl acetate monomer, used in paints and adhesives; acetone, a key ingredient in coatings, polyvinylchloride (PVC), printing inks and pesticides; and mixed acids, for everything from biocides to perfume.

Chemical plants such as Hull went through a transition in the early 1990s with the advent of intelligent, distributed control systems, hailed to be ushering in a new age of what is happening on the plant, a proactive system rather than simply a reactive one.

Equipment health
The ASM strategy takes a two-pronged approach: equipment health management (EHM), which uses early symptoms to diagnose a physical fault – similar to knowing the ‘health’ of an equipment item – and overview plots, which help operators see the big operational picture of the plant at a glance.

For the work on equipment health management, BP teamed up with Honeywell as a main development partner, although several software companies became involved at subsequent stages. ‘This is cutting edge stuff,’ says Rawi. ‘It wasn’t just a question of buying in software. BP has had a lot of input, because we are really pushing the boundaries of the industry with what we’re doing at Hull.’

The prime candidates for EHM are the workhorses of any process plant, such as pumps, compressors and heat exchangers. The diagnostic system is programmed to recognise the symptoms that indicate an item of equipment is going to cause problems. For example, if a compressor’s bearings are about to fail the first sign may be contaminated lubricant. If the bearing
The compressor vibrates in ways that engineers can’t really define using equations. The equipment can be so complex that engineers calculate the pressure from hydrostatic head, using an upstream tank, calculating the pump inlet pressure measurement from an actual reading taken from the fluid level in an upstream tank, calculating the pump inlet pressure from hydrostatic head. Instead, the system is able to generate an automatic work order to prioritise maintenance work, and can generate work orders to accompany this.

A less obvious benefit of EHM is its ability to translate the trend data it collects from equipment into ‘operating envelopes’ to optimise processes in ways that would have been impossible before. 'Insidious problems such as accelerated corrosion or fouling previously had only limited early warning systems,’ explains BP’s James Chilton, group engineer at Hull. ‘In contrast, the new system at Hull can alert staff that corrosion or fouling is occurring due to movement of the plant to an undesirable operating regime within its normal boundaries. We’ve found we can operate the process in a ‘sweet spot’ that prevents these problems. It’s similar to driving your car gently to extend the time between maintenance services.’

Seeing the big picture

The second aspect of ASM is enabling operators to see the ‘big picture’, rather than overloading them with too much detailed information.

BP's chemicals complex at Hull is the largest producer of acetic acid and associated products in Europe
With modern digital displays the control room operator has lost the option of glancing across a panel of gauges to see the state of his plant by pattern recognition,' says Rawi. 'We have developed a way with ASM of taking advantage of the brain’s ability to rapidly recognise patterns and deviations from normal situations.’

The most powerful of the methods that underlie this is multivariate statistical analysis, which compresses many variables from the plant into fewer compound variables that can be plotted on a two- or three-dimensional chart.

Essentially, the technique results in a ‘bull’s-eye’ pattern, with the overall plant operating condition shown as a point that should fall close to the centre. If it doesn’t, the system can be interrogated to see which of the original variables is most responsible for knocking the process off-centre. The BP engineers worked closely with researchers at the University of Newcastle to develop the models.

The bull’s-eye technique has proved to work well once it is set up for a given operating regime at the plant, and work is in progress to make it effective when the plant is switched between alternative modes of operation. Meanwhile, other techniques for presenting the big picture have also been deployed.

‘Some of the other techniques we use may be less powerful than multivariate statistical analysis, but they are generally easier to deploy and visualise,’ says Rob Sutton, human-machine interface engineer.

Two such techniques are parallel co-ordinates and radar plots, each of which seeks to show multiple parameters in a graphical way to make any deviations easier to spot. The parallel co-ordinates approach takes a ‘snapshot’ of the different variables at a given moment and plots them on a row of vertical axes (see diagram above). The resulting curve is then reported at given time intervals. If the successive plots fall in the same place each time, the process is stable, but if parameters start to shift they can be detected well before they reach their alarm limits. Radar plots place individual readings around a central point to form a ‘blob’, rather than a curve.

Observing a problem in this way still requires someone to be watching the plots, which led Martin Brown, a BP control engineer at Hull, to devise a method of getting the control system itself to do the watching. ‘The system measures how much the current plot shape deviates from the learned norm and triggers an alert once the total deviation reaches a set limit,’ he explains. ‘The operator can then drill down for more information about what is causing this.’

The success at Hull is attracting widespread interest from other BP businesses that are keen to see what the new ASM techniques have to offer.

‘Now that we have the experience of developing the cutting edge, future implementations are likely to yield profitable results more quickly,’ Rawi points out. ‘The software market in this area is hotting up, and as the technology develops, more of the initial set-up work will be carried out automatically. At Hull, we are already seeing clear benefits from having the foresight we’ve always wanted.’

Inside the new control centre at Hull, where BP’s equipment health management system reports potential problems before they occur.
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