No crystal ball

A wide range of tools and techniques is now available to ease the task of predicting when and what maintenance is required on machines and plant units. Steed Webzell reports

Get maintenance right and there are big rewards on offer – not just cost savings, in terms of plant and machinery spared, but also improved plant efficiency and uptime, as well as production quality and ultimately also profit. Hence the growing uptake of predictive maintenance technologies, which, although still surprisingly slow, is starting to enable a new era of informed plant intervention.

Far from gazing into crystal balls, interpreting tarot cards or trying to read tea leaves, today's predictive maintenance technologies are science-based. They are also increasingly easy to use, with modern equipment requiring less in the way of specialist user training, while some developers also offer interpretation services. Either way, users readily testify to the equipment's ability to reveal emerging problems in both rotating plant and static structures long before anything even slightly wrong is apparent to human eye or ear.

Let's go through some of the basics. Vibration analysis is probably the most common predictive maintenance technique and is highly productive for relatively expensive, high-speed rotating plant. Newcomers to the technology need to know that today's vibration analysers are capable of displaying the full vibration spectrum across multiple axes simultaneously – providing a detailed snapshot of what is going on – and that assistance is available to ease interpretation.

Acoustic emissions

Next, acoustic emissions analysis can be performed at a sonic or ultrasonic level, with the newer sensing techniques making it possible to 'hear' excess stress, particularly in slowly rotating machinery. As you might expect, ultrasonic technology is sensitive to high frequency sounds, inaudible to the human ear, making it adept at distinguishing latent mechanical problems from lower frequency mechanical sounds.

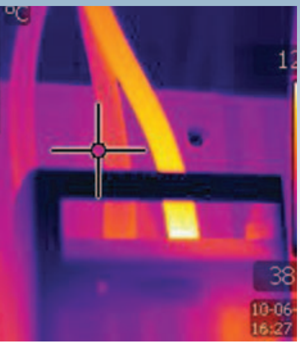
Then there is infrared (thermal) analysis, increasingly accepted as having the widest range of application – providing early warning of mechanical maintenance requirements in everything from high- to low-speed rotating plant, as well as electrical issues on all kinds of plant and equipment, including motors, but also wiring looms, connectors and busbars.

As is often the case, the sheer spread of options in these technology areas alone gives – in football parlance – a real selection headache. Yet, whatever your choice, no predictive maintenance technology is a substitute for professional plant installation, commissioning and basic maintenance procedures. As Phil Burge, communication manager at bearings expert SKF, puts it: "In many instances, plant failure is due not to normal wear, but incorrect installation and maintenance of equipment and components."

He's right: it is common for shafts to be misaligned, for rotating parts to be incorrectly balanced, but also for lubrication equipment and systems to be under-specified for a task. "It is estimated that 16% of all bearing failures, for example, are due to incorrect installation," he warns.

Burge is not alone in advocating the use of appropriate equipment, such as alignment tools, for commissioning and maintenance, but also automatic lubricators, to improve operational performance and equipment life in many plant situations. Taking the example of shaft alignment, for example, he argues that getting it right helps to extend bearing and shaft service life in plant involving coupled pumps, motors, mixers,

SKF's TKSA 20 laser shaft alignment tool: massively simplified and real-time proving



Above: the now classic thermal image revealing electrical cable problems
Right: SKF's Machine Condition Advisor, which measures vibration and temperature to indicate machine health and bearing damage

gearboxes, compressors etc, in both horizontal and vertical configurations.

He also reminds plant managers that the latest laser-based devices allow technicians to align shafts using real-time information, permitting the results of corrections to be 'seen' as they are being performed. Benefits, he insists, then include reduced energy consumption, vibration, noise, and stress on couplings and seals – as well as downtime and maintenance.

Returning to predictive maintenance, though, Ernesto Wiedenbrug, project manager at Baker Instrument (part of SKF specialising in electrical motor test equipment, represented in the UK by Whitelegg Machines), suggests that even workhorse vibration monitoring is not used to anything like its full capability – a situation that he blames on so many motors and/or driven loads being inaccessible. For him, that's why advances in electrical online motor monitoring are so important – opening up alternative opportunities for predictive maintenance.

Such systems look at several electric motor parameters, specifically now including instantaneous torque signatures, which Wiedenbrug argues are very good for highlighting mechanical problems well before failure. "The main benefit lies in the ease of assessment for both trained and untrained technicians," he insists. "Frequently, maintenance professionals ask 'Why go to the trouble of torque calculation?' Well, online monitoring of a pump motor [for example], using torque signatures, in comparison with current signals, provides a clear indication of why," he continues.

"Using current, it is often impossible to differentiate between signatures for good and poor operation. However, torque signatures show tremendous differences. Basic understanding of pump operation, for instance, tells us that in steady state they show very little torque ripple. Torque signatures offer a simple, intuitive and conclusive assessment of problems, such as pump cavitation, mechanical imbalance and bearing problems, where current versus time measurements cannot."

Pump trouble

Indeed, the methodology has been put to good use recently by a power generation plant in North Carolina, which harnessed a Baker Explorer to evaluate its 1,100kW, 4,160V submerged pumps online. The Explorer detected a problem with a slow turning pump (272rpm, 2.1m diameter), which exhibited an operating torque level 27% below the other two twin systems, with a significantly higher level of torque ripple.

The pump was raised for visual examination, and diagnosis found that over time the bolts that attached the end-bell to the pump had rusted and broken. This had allowed the end-bell to fall 6m into the water pit – meaning no more laminar water flow. The knock-on result was some cavitation, even with decreased water flow. Both of these problems were diagnosed by maintenance professionals looking at the steady state torque and its signature. Without the Explorer, this problem would have remained undetected until further and more costly problems developed.

Of course, there are plenty of applications where relatively straightforward vibration monitoring remains ideal for plant predictive maintenance – but even these might benefit from recent improvements. Take wind turbines: Schaeffler recently released a combination online oil and vibration monitoring system, designed to detect the earliest signs of damage to heavy duty, oil-lubricated industrial gears.

On the oil analysis side, the FAG wear debris monitor uses an inductive particle counter that distinguishes between ferrous and non-ferrous particles in the lubricating oil. On a typical industrial gearbox application, the sensor is installed in the oil flow, directly before the oil filter, or as a separate

BP ship-shape with motor condition monitor

BP Shipping is reporting success, following trials of motor condition monitoring (MCM) technology from Artesis. Its MCM units were fitted to two seawater pumps aboard an LNG carrier, with the aim of validating this predictive maintenance approach, compared to traditional vibration monitoring and analysis.

"As with all new technologies, there is a degree of scepticism when embarking on an initial R&D and trial period," comments Mark Pellow, engineering superintendent at BP Shipping, which has more than 50 vessels in its fleet. "To prove this a useful and worthwhile tool, we needed to determine whether the MCM unit could accurately detect a fault prior to catastrophic failure and, ultimately, provide us with a non-intrusive monitoring process with cost saving benefits."

For BP Shipping, the validation trial ran up to the point where a failure was predicted and maintenance recommended, so that the MCM equipment's forecast could be compared with visual maintenance reports. Initial assessments indicated that both seawater pumps were being affected by rubs, misalignment and impeller-related issues, with the equipment using power factor and kW to predict that these would worsen as the pump eroded, leading to degraded performance.

Delivering a maintenance report at the end of the trial, Artesis stated that there was indeed impeller-related erosion, as well as signs of wear ring damage and a loss of performance consistent with a hole in the pump casing. Subsequent replacement of these components returned the efficiency of the pumps to normal, while fixing the hole in the casing where the retaining grub screw for the wear ring sits also saved the pump casing itself.

circuit. Meanwhile, the unit also monitors vibration of the machine and its components, covering rolling bearings and gear wheels. Schaeffler claims that, by installing vibration sensors on the machine and/or gearbox, the system can detect changes in operating behaviour – providing both belt and braces.

What about comparable developments with thermal imaging systems? Most observers of the thermal cameras market would say simply that would-be users are spoilt for choice and that a little homework is required before choosing a suitable model. Flir, for example, suggests that plant engineers should always make sure that an infrared camera meets the minimum industry standard sensitivity of ±2% or 2.2°C, whichever is greater. If the specification of the model being considered can't perform at this minimum level, look for an alternative camera.

Why is this important? Quite simply, accurate measurement equals efficient fault finding. And, on that note, it's also worth remembering that, just as with digital cameras, the quality of images from an infrared camera is determined by the number of pixels – the better the resolution, the sharper the infrared image. There is a caveat here, however: if an infrared camera boasts 640 x 480 pixels resolution, check that this refers to detector resolution and not just the resolution of the LCD display – which cannot make up for an inferior detector.

Above: Baker vibration systems watch Vancouver's Sky Train

Left: an Ashtead endoscope checks jet engines at Biggin Hill during the volcanic ash scare

Thermal imaging

One company benefiting from Flir thermal imaging technology as part of its predictive maintenance programme is Medite Europe, an MDF manufacturer based in Clonmel, Ireland. Medite's plant manager says that regular infrared maintenance surveys, conducted by thermographic consultant Bob Berry, have helped to ensure the factory's smooth running for more than 10 years.

Interestingly, despite such long experience, consistency of measurement here has recently been significantly boosted – in this case, by the introduction of a Flir Meterlink Bluetooth wireless connection between the infrared camera and electrical test and measurement instruments. Essentially, Meterlink allows measurement data from the electrical meters to be embedded in the infrared images. Consultant Bob Berry says the development brings greater intelligence to the infrared inspection.

A final thought, though: predictive maintenance is one thing, but sometimes an event happens that prompts plant engineers to consider 'precautionary' maintenance. Take the aerospace industry and last year's ash cloud debacle. Aircraft passing close to the cloud were subject to careful scrutiny on return, as the presence of ash in the engines could have catastrophic consequences.

Rather than simply strip engines down on the off-chance of discovering colonised ash, an innovative form of endoscope from Ashtead Technology was deployed by Avalon Aero, at Biggin Hill Airport. Avalon performed internal inspections of engines following flights in the 'red zone', an area in which ash might be encountered, but was deemed safe to fly by the Volcanic Ash Advisory Centre.

Says Martin Darling, Avalon Aero's technical director: "Ashtead's engineers recommended the IPLEX Videoscope and the device proved extremely useful, providing quick visual access to the internal components of aircraft engines. Our investigations did not find any ash within the engines and this evidence was extremely reassuring to our clients."

Predictive maintenance is far from guesswork. The combination of available technologies and astute plant engineering is proving a genuine foundation for reduced downtime, repairs and costs. But while the technology is the clever bit, plant engineers need to remember that ensuring the basics are correct is the first step to assuring long plant service life. PE