# Seeing is believing

**Predictive maintenance is still often seen as a luxury. But Brian Tinham finds that falling cost of both tools and management systems is making it much more accessible**

Plant maintenance has always been seen as a necessary evil. So the idea of investing cash in technologies to predict when and what might be necessary doesn't cut much ice with many managers. They understand the basics of break/fix, where the regime is to wait until something goes wrong before intervening, versus preventive maintenance, where work is performed at fixed intervals whether it's needed or not. But predictive maintenance still raises eyebrows.

Those in the know understand that both reactive break/fix and time-based preventive maintenance aren't cheap, not just in terms of parts and labour, but inevitable planned and unplanned plant downtime. Some is due to premature failures, some down to unnecessary intervention and some is even caused inadvertently by the maintenance itself.

They might also know that predictive, condition-based maintenance, using fixed and mobile sensors and tools to diagnose emerging problems, cuts out such shortcomings. Hence its claim to savings: it lets plant engineers know what they need to do and when – and what they don't need to do. Which, in turn, means that only necessary downtime is incurred, mitigated by proper planning, with risk-based analysis and, for example, machinery cut back to slower running until intervention is feasible.

### Huge improvements

Reliable figures are hard to come by, but those available are hard to argue with: optimistic estimates show predictive maintenance costing one tenth that of an average breakdown and one-fifth the price of preventive maintenance. Even the most pessimistic suggest users can expect to take 30% out of their costs, and get better performance and reliability.

As wireless data firm T-mac Technologies' business development director Lisa Wilkinson says: "Predictive maintenance ... boosts profitability. One piece of research found that one in eight businesses put their annual loss of production due to downtime at over £250,000. No one can afford that."

Yet the vast majority of organisations don't even perform condition monitoring, never mind predictive maintenance. Why? Because there remain hurdles.

One is the macho culture still alive among some engineers, technicians and organisations that take a perverse pride in 'knowing' their plant and enjoying the fire-fighting. As Noel Grinstead, director of asset management firm MCP, points out: "The problem is that, especially in large manufacturing operations, we con ourselves into believing we know when to maintain equipment. But if you have five similar pumps side by side, they will wear out at different times because of the random nature of failures."

Secondly, although the principles may be simple,

setting up for predictive maintenance hasn't been trivial. At the top level, you need first to establish a structured regime for maintenance based on root cause analysis, plant lifecycle costing and risk analysis, as well as MTBF (mean time between failures), MTTF (mean time to failure) and MTTR (mean time to repair) measures.

That determines which technologies to use, what sensors and where to place them etc. Then it's a matter of installation, cabling and so on, followed by operational systems – providing work and route lists, and managing spares, permits, clothing and equipment (although much of that should already be in place). And you also need operator training and KPIs (key performance indicators) geared to plant efficiency factors such as OEE (overall equipment effectiveness), capacity utilisation and reliability.

Thirdly, at the sharp end, the range of technologies for predictive maintenance, although not huge, has required additional skills for selection, installation, commissioning and operation – not to

## Bottom lines

### Top tips

- The smart money is now on a piecemeal approach to setting up predictive maintenance, using selected fixed and portable tools to bring the benefits of low cost condition monitoring to improve preventive maintenance regimes
- If carried out properly, maintenance can support operations better than in organisations where there's a lot of shouting and finger pointing – and time, money and product wasted in the form of scrap and rework
- One of the keys is a decent CMMS, like MRO Software's Maximo, MVI Technologies' Mainsaver (now owned by CDC) and IMS Evolve
- Another positive move is installing a solution such as MVI's EventsEngine plant data capture and analysis system, which provides a bridge between operations and maintenance
- Such systems bring people and departments together, build new understanding and thus rapid, prioritised change for the better

mention interpreting the results. We're talking about vibration sensors for rotating machinery, acoustic emissions monitors for slower speed or variable load applications (Plant Engineer, January 2007, page 16), temperature sensors and infrared for viewing hotspots, and oil condition monitors. And there are electrical sensors for motors, non-destructive testing devices, embedded diagnostic systems for process transmitters and automatic valves in the process sector... The list goes on.

In short, with a few exceptions, the tools themselves have been anything but cheap or easy to manage or to use. Until quite recently, that is – and it's not just infrared cameras that have crashed in price and complexity to the point where they're now almost standard kit for an engineer's toolbox. The fact is, maintenance equipment developers keen to grow beyond specialist users have been investing big time in embedding automatic

diagnostic software on low-cost hardware. And the result is much more usable predictive maintenance tools for the mass market.

Look at electric motors: fixed and mobile predictive maintenance kit, based on sensing changes in electrical characteristics, is now much cheaper and easier to use, with names like Artesis and Baker Equipment, the latter from Whitelegg Machines in the UK, among the leaders.

Andy Bates, sales director at Artesis, makes the point that, in the past, users wanting condition-based maintenance on electric motors had to worry about frequency bands, alarms, channels, displays – as well as how to recognise changing machinery loads. "We wanted a tool that could provide most of the benefits without the downsides, so that, instead of the minority benefiting, the majority could."

Hence Artesis MCM (motor condition monitor), which focuses on three-phase motors and their driven systems – pumps, fans, compressors, transmission systems etc. Users simply install what look like panel meters in their MCCs (motor control centres) and plug in current transformers and voltage taps. There's an RS485 connection for a computer, if required, but that's the installation done. Pressing a button on the front then puts the device in self-learning mode, where it monitors the motor and its driven system under varying load conditions to build a model of normal operations. That's it.

The device compares current and voltage against its model every 90 seconds and provides a green light for OK, but gives warnings for everything from harmonics and lost phase to a capacitor breaking down – as well as mechanical problems, such as developing imbalances, misalignment and bearing failures, including their severity.

### As good as it gets

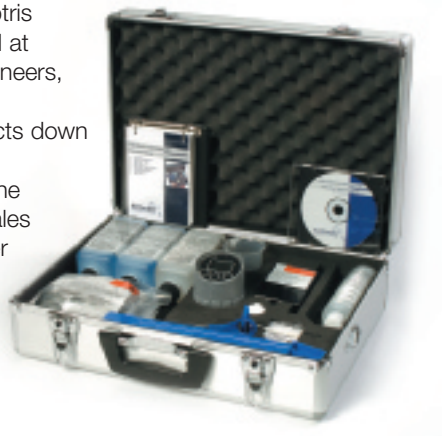
As Bates explains: "If there's a bearing problem in the motor or the driven system, vibrations will start to appear at the micron level, making the shaft wobble. That moves along the shaft through the couplings and appears at the air gap between the rotor and stator, which is where we're monitoring. We can give up to four months' warning of bearing defects, which is as good as it gets." And the price: £1,100 per motor and its driven equipment. "We've turned software model-based fault detection into a practical tool for SMEs," says Bates.

Moving on to non-contact thermography, companies such as Flir Systems, Fluke, InfraTec, Irisys, Micro-Epsilon and Thermoteknix have all been slashing prices, while also making hand-held infrared cameras and simpler pyrometer devices easier for engineers and technicians to use.

For example, InfraCAM SD, Flir's latest 'find-it, fix-it' thermal imaging camera, costs just under £4,000, yet it's rated at 0.12ºK NETD, displays a clearer image than its predecessor and comes with a removable SD card that stores up to 1,000 jpegs – meaning more time between downloads and the ability to leave copies of surveys with users. As for functions, it includes: max/min, enabling operators to find hottest and coldest temperature on small targets; a laser pointer; an IP54 housing; and ThermaCAM QuickReport software.

Then again, Micro-Epsilon's latest pocket-sized infrared pyrometer, Optris MiniSight, costs only £69. It's aimed at maintenance technicians, plant engineers, test engineers and service and field engineers wanting to measure objects down to 13mm, from –32°C to 530°C.

It's all a far cry from devices on the market just five years ago. As Flir sales and marketing manager Paul Sacker says: "In 2000, there were only two portable camera types and they cost £25,000—35,000. Now we start at £4,000 and the thermal



**Portable, on-site oil condition monitors can give results in two minutes**

sensitivity is at least equivalent to the earlier very specialised cooled cameras." He expects facilities managers and technicians, looking after HVAC, energy efficiency, electrical inspection, conveyors and motors etc, increasingly to use what are now standard tools – particularly where their non-contact nature makes regular inspection more feasible.

His only warnings: "Infrared cameras give great images, but engineers need to remember the effects of materials emissivities. If they use a camera to look at stainless steel, for example, it needs to be calibrated for that – and they might need to take into account other surfaces and reflections."

The story of improvment is similar in oil condition monitoring which, although well known as a powerful tool for combating premature failure in engines, gearboxes and hydraulic systems on industrial and marine plant, has mostly required offline work by chemists in oil test laboratories. On-site, portable test cell systems, such as those from Kittiwake Developments, are now getting better and cheaper – enabling engineers to assess oil condition, diagnose machine changes, and make adjustments on the fly to maintain optimum performance and avoid downtime.

Clearly, getting a result in two minutes instead of two weeks makes a huge difference, especially when the results are quantitative and trended. Kittiwake also says its latest Digi test cell range offers an extended base number range, stronger construction, reduced weight and improved ease of use and transducer technology.

Software built into the cell takes the user through a step-by-step process to analyse samples, and the display provides previous and current results, with readouts in ppm, % water or total base number (TBN). You can get the device with just the TBN or water program, but most engineers will want the combined cell. Beyond that, there's a TAN (0-6) drop test kit with all necessary reagents and equipment for on-site TAN testing, and Kittiwake also has online sensors and oil test suites for wear debris, viscosity, density, insolubles etc.

Manx Electricity Authority, which runs two power stations on the Isle of Man – one all diesel and the other CHP (combined heat and power), with five diesel engines and a dual gas turbine and steam turbine combination for heat recovery – provides an excellent example of good practice.

"We run preventive and predictive maintenance using a range of tools: a portable ultrasonic flowmeter for listening for valves passing fluid; a mobile vibration analyser for plant bearings; and an infrared camera to look for hot spots on everything from boiler equipment to bearings on motors," says Bill Castelow, EC&I maintenance engineer.

### Manx Electricity Authority choices

He is responsible for mechanical, electrical and instrumentation requirements on plant, and says: "Condition monitoring is very important to us – mostly looking at heat and vibration to detect mechanical wear. We purchased an infrared camera because although vibration analysis gives you some lead, infrared makes the case. On a feed pump, for example, it gives you the information you need to justify a strip-down."

All work is driven by the CMMS (computerised maintenance management system), which provides maintenance lists, also downloading details (such as where to place the sensors) on to the Vibscanner. "At first, we just used that," says Castelow, "but then we needed to diagnose problems like valves passing, so we started using our commissioning flowmeter. Then we decided to try an infrared camera. The flowmeter is most useful: we also use it alongside the instrumentation to check it's reading correctly. But the other big one is the infrared camera: it's never really in the office…

"Predictive maintenance does save us downtime – which at £10,000 per day for a gas turbine offline is very important. It's also helped us to improve reliability and to adjust our preventive maintenance programme: we can see if we're inspecting plant too much or too little, and then make changes. It's all part of risk management." PE

**Infrared cameras can make a huge difference to predictive maintenance programmes**

## PAS55 risk-based maintenance

A proposed standard aimed at asset management is already being adopted in the utilities. PAS55 is currently at the 'publicly available specification' stage. Formal review is continuing this year, preparatory to the specification becoming a BSI standard and then moving up to an ISO standard.

PAS55 recommends a rounded approach, favouring predictive maintenance based on condition monitoring. It brings together best practice in management and operations. Like ISO 9000 and 14000, it aims to embed structures into organisations, so users get maximum efficiency and safety benefits.

As Noel Grinstead, director of asset management consultancy MCP, says: "PAS55 connects well with predictive maintenance. Ofgem [the UK regulator] has already announced that it requires the electricity supply industry to come up with responses for compliance by the end of this year."

National Grid Transco is PAS55 certified and EDF has been through the process; now interest is growing in transport. Manufacturing, the process industries, rail and construction will be next.

Says Grinstead: "It depends on how much an organisation relies on its plant assets: how much productivity, for example, would be impacted by maintenance problems." Engineers can buy the spec for £80 from the Institute of Asset Management at www.iam-uk.org/default.asp?section=sales.