Seeing is preventing

An ability to anticipate mechanical breakdowns before they impact plant performance can be invaluable in minimising unplanned downtime. Dr Tom Shelley reports

Pointers

- The range of available plant condition monitoring techniques is growing
- Digital camera techniques can now detect microscopic structural changes
- Thermal camera equipment is now a de facto 'standard'
- Vision systems can see moving plant problems
- Vibration monitoring is getting lower cost
- Electric motor monitoring is extremely powerful
- Schaeffler has published a white paper: 'The role of Vibration Monitoring in Predictive Maintenance'

Nowadays, there is no need to wait for breakdowns and even less requirement to replace parts 'just in case'. Technology has reached the point where problems in either rotating machinery or static structures can readily be pinpointed long before anything even slightly wrong is apparent to eye or ear. The only issue is choosing the most useful and cost-effective approach.

So what's out there? Most plant engineers will be familiar with portable and fixed vibration, and probably also acoustic emission sensing, infrared thermography and, more recently, motor current monitoring. However, how many are aware of systems based on digital cameras, aimed at assessing structural integrity? Turns out, these can now discern infinitesimally small changes.

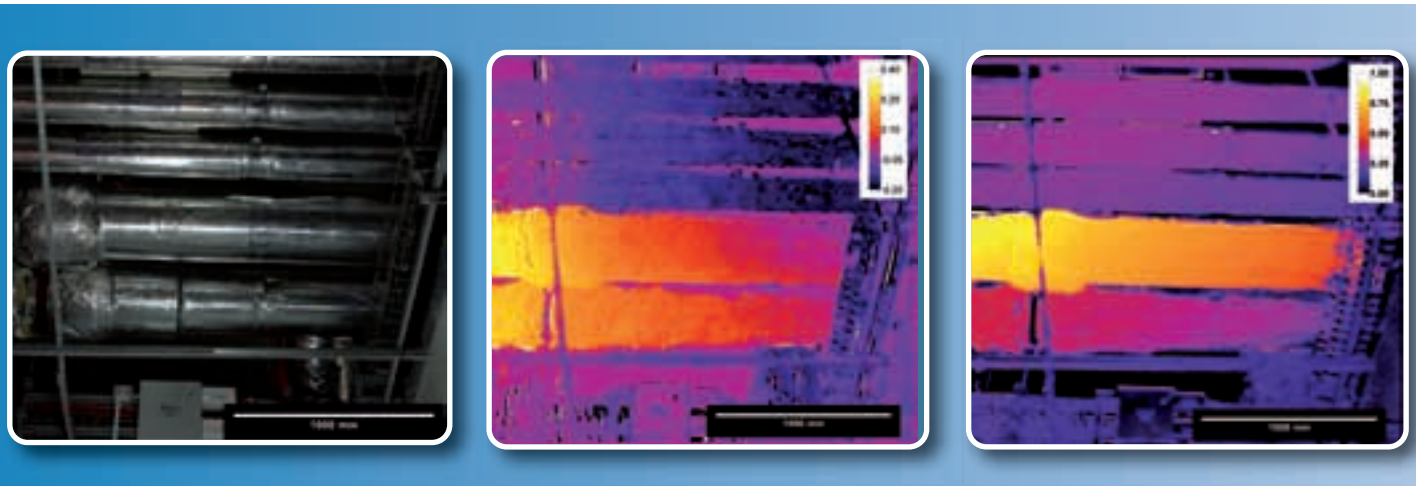
Digital cameras coupled to lasers are widely used to monitor structures, particularly in aerospace maintenance. Dantec Dynamics, for example, is keen to demonstrate how four laser diodes can produce a speckle pattern on an item that enables a video camera to detect nanometre changes. The technique is called laser shearography and rival British firm Laser Optical Engineering shows similar technology. Areas under test can be from square millimetres up to square metres, and one of the largest users is the Royal Air Force, which employs the tool to inspect radomes under vacuum hoods. Inspection times are typically 20–40sec.

Meanwhile, in the dynamic sphere, Nigel Peart, sales manager for Polytec, claims that his company's technology "can measure the 3D displacement across a component down to several picometres", using laser Doppler vibrometry. Peart says his company recently sold a system to look at aerospace turbine blades, replacing strain gauges.

Low-cost imaging

So much for the relatively expensive approaches. Nick McCormick, of the National Physical Laboratory, recently revealed a technique that can work with an ordinary digital camera and no laser, at a much more modest price. Digital image correlation involves taking photographs of the same structural component at different times, and shows displacements and strains from pixel block movements down to 1/100th of a pixel. McCormick says the technique works just as well on bare surfaces as on painted structures, with ambient or flash lighting, provided they have texture.

NPL developed the technique for assessing the likelihood of failures on bridges, but McCormick now says the organisation is studying the feasibility of applying it to measuring pipe movements on, for



example, process plants. To date, NPL has been working with 6M and 39M pixel cameras, but McCormick says that one of the big issues is "how exactly to re-position the camera equipment". So far, NPL has been using surveying techniques.

Meanwhile, at a more conventional level, infrared cameras also now come with very usable resolutions and acceptable prices, and are increasingly in operation, locating incipient problems in everything from power cables and switchgear to the internals of ships. The latter is the speciality of Thermowind, a consultancy based in Bremerhaven, Germany, which uses Flir PM280 and ThermaCam E cameras, both to assess machinery on board large ships and the state of fibreglass yacht hulls. "A three to four hour trip at full speed ahead and loaded is ideal to get a clear picture of a ship's electrical and propulsion systems," explains Christian Ferber, the company's electro technical engineer.

However, if the item to be monitored is moving, not merely rotating, you're back to some kind of vision system. David Hannaby, product manager for Sick, says that one of his firm's Inspector I40 2D vision sensors has been used to inspect wheels on Parcel Force carriers as they are driven past, to look for damage. The sensor has VGA resolution, can capture images at up to 250Hz and download results via FTP, as well as buffer up to 30 pictures.

None of which is necessary, if the plant to be monitored is, for example, rolling elements on large plants. Then you're probably back to measuring and analysing vibrations. Installing a Fag Dtect X1 system on the exciter end bearing and the turbine end bearing of a steam turbine on Corus' Scunthorpe site, for example, recently detected a problem with one of the rotor blades. Chris Smith, Scunthorpe's PCM engineer, says: "By picking up the blade failure early on, we were able to prevent failure of the whole turbine. In lost generation alone, this machine is worth £35,000 per day. Minimal damage and a quick return to service is obviously the preferred option."

Alternatively, maintenance engineers can come at rotating machinery by looking at their motors' electrical characteristics. Motor condition monitoring (MCM) equipment manufacturer Artesis reports that Wessex Water has piloted one of its systems over 18 months on six pumps, including two borehole units near Yeovil. In July last year, Artesis' equipment warned of impeller-related problems on one pump. To test its diagnosis, Wessex left the pump – which duly failed within a couple of days of the predicted date. Says Dave Durkin, head of operational services at Wessex Water: "We are currently looking into investing in more MCM units for installation in our plants across the Wessex Water area." PE

Above: digital image correlation, using Dantec Dynamics' digital camera and laser systems
Far left: Thermal imaging, with Flir camera equipment hunting hot spots

Nuclear submarines ready for action

To maintain a credible naval defence strategy and nuclear deterrence, nuclear submarines must be ready for action outside planned maintenance shutdowns. Andrew Law, operational support specialist with the Astute class of submarines, says that is done primarily using planned and preventive maintenance schedules to keep plant components within their safety justifications.

"There are newer regimes on the latest plant that work on RCM [reliability centred maintenance], which is good, as it can reduce the overall maintenance burden on a plant," explains Law. "There is no point in taking things apart to see why they're still working. Checks and tests on systems and components are done at regular intervals – the periodicities being demanded by the safety justifications for the plant as well, so they are not necessarily maintenance-based," he adds.

Law concedes that there aren't many sensors that detect faults on these craft. "There are sensors on the plant at a variety of locations, looking at a number of parameters, but it's the combination of indications, alarms and human operator interpretation that detects whether a fault is developing – or has already developed," he says.

His view: "Defects form part of the maintenance burden, so, if something does go amiss, it needs a scheduled period to rectify the problem. That includes authorised procedures to carry out the work, if there are nuclear implications, followed by stringent tests on completion of the defect rectification.

"Plant monitoring could certainly be used to extend maintenance periods, but at the moment these technologies aren't deployed. Maintenance of the nuclear propulsion system is reasonably straightforward, to be honest. There are set routines to be carried out when the plant is shut down, and dedicated procedures, test rigs, tools and accessories for doing the work, so it's all accounted for."