Predict problems

Using condition monitoring technologies to anticipate a requirement for critical plant maintenance isn't new, but novel systems are improving their potential, reports Dr Tom Shelley

Plant engineers are living in interesting times, as technologies for assessing the condition of equipment, and even its instrumentation, improve in sophistication and ease of use. And as prices slowly fall, the message is becoming clear: providing early diagnosis of problems need no longer be the preserve of critical plant – other equipment could be eligible, too.

One of the big areas of progress concerns the software behind the scenes that not only diagnoses problems and anticipates when they might need to be fixed, but also tailors its predictions to individual equipment. That is extremely significant, given the fact that, despite modern manufacturing methods, no two pieces of machinery run exactly the same.

For instance, what may be a normal running temperature for one plant item, where tolerances are on the tight side, might well indicate trouble developing in another, where tolerances are not so tight. In this example, the desired indication, is not the absolute temperature, but whether it has suddenly started to rise when it shouldn't.

Plant fingerprints

The base technology is Predictive Analytics and, while its use depends on the piece of equipment to be monitored, it is a general technique based on statistics, data mining and even game theory. Currently, it is used to provide health checks in financial services more than it is in plant condition monitoring, to which it is a relative newcomer.

According to Steve Tonissen, vice president of developer SmartSignal, his system develops a set of 'fingerprints' for each piece of equipment across all known loads and operating contexts. "It calculates the normal relationships among all relevant parameters, such as loads, temperatures, pressures, vibration and ambient conditions," he explains.

"It then takes real time sensor readings and, based on their difference from normal, predictive analytics detects and isolates abnormal behaviour. It then posts these incidents and provides notification of developing problems to users," he says, adding that such a system is currently in use in about half the US power generating fleet, as well as on major oil and gas companies' plants.

The same company also offers so-called Predictive Diagnostics. Whereas Predictive Analytics forecasts that something is going to fail, Predictive Diagnostics reveals the likely cause of failure, its severity and the priority that should be applied to fixing it. Tonissen explains that it is based on analysis of data from hundreds of millions of machine hours and thousands of incidents over the last decade. Hence its unerring ability to identify fault patterns from operating behaviour.

A very similar approach lies behind systems offered by British company Artesis, with its Motor Condition Monitor, (MCM) and Plant Condition Monitor (PCM). MCM uses its knowledge to diagnose electrical motors and their driven loads, while PCM handles generators. They, too, establish a norm for each item of equipment, so as to detect changing conditions that might indicate developing problems. They also provide a diagnosis of mechanical and electrical problems, and indicate the severity of faults.

MCMs have recently been trialled with good effect in William Grant & Sons' Girvan distillery on the Ayrshire coast. Units were installed to monitor an agitator on a batch cooking vessel, a drive motor for hammer milling malted barley and a motor for wheat milling. As well as detecting faults early enough to make a difference, the monitoring system on the batch cooking vessel agitator has allowed the company to reduce the running cycle of its motor by 20%, so reducing energy consumption. Meanwhile, for malt milling, the MCM has additionally allowed William Grant to be more accurate in determining stop times and the point at which

Pointers

- Developments in software are behind recent advances in machine diagnostics
- Predictive Analytics and Predictive Diagnostics learn normal plant behaviour before detecting problems and revealing causes
- Similar technology is behind motor and generator condition monitoring – sensing electrical nuances
- For slow moving plant, acoustic emission sensing is becoming widely available
- Vibration-based condition monitoring is now very mature and sophisticated
- Thermal imaging is fast becoming one of the first lines of plant defence

Thermal imaging broadens its plant monitoring appeal

screens need to be changed, by basing decisions on electrical signal analysis, rather than engineers' judgement alone.

"We will now be installing the MCM units on two troublesome grain elevators, both of which are outside and rise to around 30m in the air," comments process team leader Andrew Napier. "They are known to fail two or three times a year and without warning, so this will give us a real insight and enable preventive action before failure – saving us downtime, expense and loss of production," he adds.

However, although monitoring the nuances of electric motor current is a good way of detecting faults in fast-moving machinery, it is better to turn to other techniques, such as acoustic emissions monitoring, if rotation speed is less than 80rpm.

Proof of the power of this technique comes from the pipe-laying vessel Seven Navica, owned by Subsea 7. In August 2008, following reports of an unusual noise when its pipe reel was turning, engineers from Schaeffler conducted an acoustic emission survey on the main reel bearings when the ship was in port at its base in Vigra, Norway. Four sensors were mounted on the drive end spherical roller bearings, each of which was made by FAG and weighed around 3 tonnes, with an outer diameter of 1.58m.

The sensors were connected to a Schaeffler AE-Pro semi portable acoustic emission monitoring system and indicated a static fault in the starboard drive end bearing, when rotated forwards and backwards. On closer examination, this turned out to be a small fracture in the bearing outer ring. The bearing was then replaced, prior to the vessel's departure for pipe-laying operations off Brazil, where a failure on the job would have been particularly expensive and time wasting.

At the other extreme, for faster running systems, such as gearboxes, Schaeffler has recently unveiled a combined oil and vibration monitoring system – the FAG Wear Debris Monitor. The oil monitor is normally installed directly before the oil filter or on a separate circuit. It uses an inductive particle counter. Meanwhile, the vibration sensors are mounted on the equipment to be monitored.

Arch rival SKF also offers vibration-based predictive maintenance and recently completed a pilot implementation at a joint Linde-Sinopec gas plant in Nanjing, China. Local Chinese suppliers were originally invited to do the work, but, after a year of trials, Linde chose SKF. Equipment being monitored includes high speed compressors and ancillary equipment, such as pumps and expansion machines.

For the compressors, SKF says readings are taken at positions capable of revealing the condition of each of the stages. Measurements are routinely collected using the company's Microlog CMVA60 or CMXA70 data collector, with data then compared with that collected by the plant's control system. To date, the system has been rolled out to nine plants in China.

Vibration expands

Incidentally, plant vibration monitoring systems are not just available from the bearing manufacturers. Process instrumentation and control systems giant Emerson recently released a compact version of its CSI 6500 Machinery Health Monitor – in this case, aimed at predictive diagnostics on rotating equipment in hitherto unviable remote or skid mounted applications.

This system uses state-based triggered acquisition, so monitoring can be tailored to process conditions or machine states, rather than simply collecting reams of generic vibration data. With Emerson's system, trends and machinery health information are then delivered to its AMS (asset management system) suite for analysis and documentation.

But vibration monitoring is not just about fixed installations: hand-held instruments have been available for years to monitor and record vibrations, diagnose faults and download data for trend analysis. C-Cubed was one of the pioneers, with its Pocket VibrA, but other firms have entered the field, including Fluke. The Fluke 810 uses an accelerometer with a magnetic mount, which is placed on the machine under test. The instrument then provides a plain text diagnosis of the machine, as well as recommended actions based on rules that the company says were developed over several years.

The other general technique currently becoming more commonplace is thermal imaging, which is particularly suited to monitoring medium and high voltage equipment, where it can reveal developing faults from a safe distance. It is, however, equally applicable to mechanical and process equipment, because the camera can quickly scan large areas. Anything running hot, especially if it is hotter than its immediate neighbours, can at once be homed in on and investigated. PE

Partial stroking for valves

Large process valves can present difficult problems, particularly in the petrochemical industries. The key universal requirement is that they work accurately on demand – and especially where the function involves safety critical processes.

Parameters to monitor may well include vibration, torque, position, lubricant state and electric power consumption or compressed air pressure. For safety-related valves that, by their very nature, are not often used, periodic partial stroke testing, or similar, is also likely to be required, both to ensure that they do not seize and to maintain the desired SIL (safety integrity level).

Commercially available products include Cameron's DynaTorque D-Stop, Rotork's Smart Valve Monitor and Emerson's AMS ValveLink system.