Predictive maintenance

**Predictive maintenance (PdM)** techniques are designed to help determine the condition of in-service equipment in order to predict when maintenance should be performed. This approach promises cost savings over routine or time-based preventive maintenance, because tasks are performed only when warranted.

The main promise of Predictive Maintenance is to allow convenient scheduling of corrective maintenance, and to prevent unexpected equipment failures. The key is “the right information in the right time”. By knowing which equipment needs maintenance, maintenance work can be better planned (spare parts, people, etc.) and what would have been “unplanned stops” are transformed to shorter and fewer “planned stops”, thus increasing plant availability. Other potential advantages include increased equipment lifetime, increased plant safety, fewer accidents with negative impact on environment, and optimized spare parts handling.

1 Overview

PdM to evaluate the condition of equipment by performing periodic or continuous (online) equipment condition monitoring. The ultimate goal of PdM is to perform maintenance at a scheduled point in time when the maintenance activity is most cost-effective and before the equipment loses performance within a threshold. This is in contrast to time- and/or operation count-based maintenance, where a piece of equipment gets maintained whether it needs it or not. Time-based maintenance is labor-intensive, ineffective in identifying problems that develop between scheduled inspections, and is not cost-effective.

The “predictive” component of predictive maintenance stems from the goal of predicting the future trend of the equipment’s condition. This approach uses principles of statistical process control to determine at what point in the future maintenance activities will be appropriate.

Most PdM inspections are performed while equipment is in service, thereby minimizing disruption of normal system operations. Adoption of PdM can result in substantial cost savings and higher system reliability.

Reliability-centered maintenance, or RCM, emphasizes the use of predictive maintenance (PdM) techniques in addition to traditional preventive measures. When properly implemented, RCM provides companies with a tool for achieving lowest asset Net Present Costs (NPC) for a given level of performance and risk.[1]

One area that many times is overlooked is how to, in an efficient way, transfer the PdM data to a computerized maintenance management system (CMMS) system so that the equipment condition data is sent to the right equipment object in the CMMS system in order to trigger maintenance planning, execution and reporting. Unless this is achieved, the PdM solution is of limited value, at least if the PdM solution is implemented on a medium to large size plant with tens of thousands pieces of equipment. In 2010, the mining company Boliden, as a first, implemented a combined Distributed Control System (DCS) and PdM solution integrated with the plant CMMS system on an object to object level, transferring equipment data using protocols like Highway Addressable Remote Transducer Protocol (HART), IEC61850 and OLE for process control (OPC).

2 Technologies

To evaluate equipment condition, predictive maintenance utilizes nondestructive testing technologies such as infrared, acoustic (partial discharge and airborne ultrasonic), corona detection, vibration analysis, sound level measurements, oil analysis, and other specific online tests. A new approach in this area is to utilize measurements on the actual equipment in combination with measurement of process performance, measured by other devices, to trigger equipment maintenance. This is primarily available in Collaborative Process Automation Systems (CPAS). Site measurements are often supported by wireless sensor networks to reduce the wiring cost.

Vibration analysis is most productive on high-speed rotating equipment and can be the most expensive component of a PdM program to get up and running. Vibration analysis, when properly done, allows the user to evaluate the condition of equipment and avoid failures. The latest generation of vibration analyzers comprises more capabilities and automated functions than its predecessors. Many units display the full vibration spectrum of three axes simultaneously, providing a snapshot of what is going on with a particular machine. But despite such capabilities, not even the most sophisticated equipment successfully predicts developing problems unless the operator understands and applies the basics of vibration analysis.[2]

Acoustical analysis can be done on a sonic or ultrasonic level. New ultrasonic techniques for condition monitor-
ing make it possible to “hear” friction and stress in rotating machinery, which can predict deterioration earlier than conventional techniques.\[3\] Ultrasonic technology is sensitive to high-frequency sounds that are inaudible to the human ear and distinguishes them from lower-frequency sounds and mechanical vibration. Machine friction and stress waves produce distinctive sounds in the upper ultrasonic range. Changes in these friction and stress waves can suggest deteriorating conditions much earlier than technologies such as vibration or oil analysis. With proper ultrasonic measurement and analysis, it’s possible to differentiate normal wear from abnormal wear, physical damage, imbalance conditions, and lubrication problems based on a direct relationship between asset and operating conditions.

Sonic monitoring equipment is less expensive, but it also has fewer uses than ultrasonic technologies. Sonic technology is useful only on mechanical equipment, while ultrasonic equipment can detect electrical problems and is more flexible and reliable in detecting mechanical problems.

Infrared monitoring and analysis has the widest range of application (from high- to low-speed equipment), and it can be effective for spotting both mechanical and electrical failures; some consider it to currently be the most cost-effective technology. Oil analysis is a long-term program that, where relevant, can eventually be more predictive than any of the other technologies. It can take years for a plant’s oil program to reach this level of sophistication and effectiveness. Analytical techniques performed on oil samples can be classified in two categories: used oil analysis and wear particle analysis. Used oil analysis determines the condition of the lubricant itself, determines the quality of the lubricant, and checks its suitability for continued use. Wear particle analysis determines the mechanical condition of machine components that are lubricated. Through wear particle analysis, you can identify the composition of the solid material present and evaluate particle type, size, concentration, distribution, and morphology.\[4\]

The use of Model Based Condition Monitoring for predictive maintenance programs is becoming increasingly popular over time. This method involves spectral analysis on the motor’s current and voltage signals and then compares the measured parameters to a known and learned model of the motor to diagnose various electrical and mechanical anomalies. This process of “model based” condition monitoring was originally designed and used on NASA’s space shuttle to monitor and detect developing faults in the space shuttle’s main engine.\[5\] It allows for the automation of data collection and analysis tasks, providing round the clock condition monitoring and warnings about faults as they develop. This method has been uniquely adapted into a tool called “Artesis MCM” for industrial motors, generators and driven equipment by the Turkish company Artesis. In an agreement with General Electric the product was re-branded “AnomAlert”.\[6\] Artesis has received the “Editor’s Choice Award” for the 40 best products of 2000 by control Engineering USA and the “Technology Innovation Award 2007” for simplifying predictive maintenance by the Institution of Engineering in the UK for their work on the AnomAlert Motor Anomaly Detector.\[7\]

### 3 See also

- RCASE
- Root cause analysis

### 4 References

   This article looks at the value of RCM and introduces the Value Quadrant.


   Learn about condition monitoring beyond oil analysis, temperature and vibration in Sheila Kennedy’s monthly Technology Toolbox column.


7. Innovation Award for “Simplifying Predictive Maintenance”, The Institute of Engineering and Technology, United Kingdom, Dec 2007
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