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More is better with predictive maintenance

By *Andy Page, Allied Reliability and Shon Isenhour, Life Cycle Engineering -- Plant Engineering, 9/15/2008*

When it comes to the application of predictive technologies, more can definitely be better. The use of a complement of predictive tools can more effectively identify various failure modes much earlier than traditional preventive maintenance programs or one-tool predictive programs. The powers of the tools are multiplied when they are used together.

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The need for an integrated approach stems from three known facts about the nature of machinery failures and the ability of predictive technologies to detect the onset of these failures:

- Machinery failures can present themselves in a host of different failure modes
- No single technology can effectively detect all possible failure modes
- Even among technologies that can detect multiple failures modes, some are detected early on the P-F curve and some late to very late on the P-F curve.

The PF & IPF curves

Two different curves represent the nature of component failure. First is the P-F curve, the philosophical progression of any given defect. Point P on the curve represents the point in time when the defect enters the system. For example, point P could represent the exact moment in time where a particle of dirt comes between a rolling element and its raceway, producing a gouge in both components. No longer defect free, the bearing's condition worsens as the defect matures, accelerating towards point F, the point of functional failure. Different points along the curve indicate changes in the nature of the defect, which correlate to different inspection methods that can be used to identify the current status of the defect.

Second is the IPF curve, which is the standard P-F curve with the I-P portion added and where point I is defined as the point of component installation. The I-P portion of the curve is the failure-free period.

Figure 3 shows what the IPF curve for two identical machines might look like when one machine is installed using precision measuring devices and well-trained crafts personnel, operating with a properly designed procedure. The other machine is installed by inadequately trained personnel who were not using precision instruments or techniques and had no procedure to follow.

Maintenance per the curves

An excellent way to determine the maturity of the maintenance effort is not by looking at the age of the maintenance program, but by where its focus is on the IPF curve. An organization that is constantly focused on point F and on staying clear of it will undoubtedly be a reactive culture. As the organization matures, the focus shifts from point F to point P. The organization then focuses its efforts on understanding how things fail and their ability to detect these failures early. Then another transition is made from the focus on point P to a focus on point I. These organizations use root-cause analysis methods to eliminate or postpone point P and have applied best practices early on with fits, tolerances, alignment standards, contamination control and documented procedures. It is these groups who will see the step-change in performance.

Organizations that operate in a reactive mode typically spend all of their time reacting to failures. This behavior finds them with all of their focus around point F on the curve. For that organization to make a step-change in performance, they will need to shift their focus to point P. As the organization shifts its focus to detecting defects early, they buy themselves the single most valuable commodity a maintenance organization can have: time. Time provides the ability to plan and schedule work at a substantially lower cost of execution. Detecting defects the moment they occur provides the maximum amount of time for the defect to be eliminated.

While detecting defects the moment they begin isn't exactly possible, understanding the nature of the defects and how they are initiated and propagate is. A comprehensive inspection strategy, performed at the correct intervals, will increase the conditional probability that the defects will be found very near their origination. In addition, detecting defects early allows for a proper RCA to be performed, because many of the conditions that led to the defect are likely still in effect and can be analyzed. If we can analyze the failure using RCA tools, then we can, in many cases, eliminate the recurrence of the failure mode. Letting the defect progress down the curve or degrade changes the nature of the defect, making analysis more and more challenging. Perhaps just as importantly, it makes the failure that much more expensive to correct.

Predictive technologies and their capabilities

Vibration analysis is far and away the cornerstone of any condition monitoring program – especially one where a large percentage of the asset base is rotating equipment. Vibration analysis uses different types of sensors to record the vibration signature from a machine. The vibration signature is then analyzed by a technician to determine if there is a presence of a defect in the rotating drive train.

Unlike vibration analysis of old (pre-1984), spectral analysis facilitates the identification of the defect and provides a very accurate assessment of defect severity. Old analysis only had a single number with which to work, making data like machinery baselines very important. With spectral analysis, baselines aren't all that important as very accurate assessments of asset health can be made with astonishing results.

The data in Figure 4 comes from two different vertical turbine pumps sitting on the same floating platform. The spectral data (upper plot) on the left shows a rolling element bearing fault perfectly, indicating that the defect is on the pure thrust bearing located in the top of the motor, and it is specifically on the stationary (bottom) raceway. The same exact data on the other motor, taken within just a few minutes, shows no defect present. The time waveform (lower plot) shows that the left motor bearing has an advanced fault and that failure is imminent.

Infrared thermography traditionally has been reserved for electrical faults. But when it comes to mechanical faults, such as the example in Figure 4, it can be a powerful analysis tool. We already know from vibration analysis about the significant bearing fault on the left motor. The infrared thermography data shows a problem as well. The difference in temperature between the left motor and the right motor shows the fault on the left motor to be severe. Consider if the only data available was the infrared thermography data: What would the conclusion be? Is this thermal anomaly a bearing defect or a case of inadequate or contaminated lubricant? That assessment would be all but impossible to detect with infrared thermography alone. Using the two technologies together gives a much clearer picture of both the nature and severity of the defect.

Another technology that can be used is ultrasonic emissions testing. Ultrasonic emissions are suitable for numerous applications, ranging from leak detection in pressure or vacuum systems to electrical inspections for arcing, tracking and corona. Ultrasonic devices also identify the presence of a fault in a bearing very close to point P from the P-F curve, and they are quick tools for use in covering many bearings in a short period of time. When combined with the use of vibration analysis on known defects, users can begin to glean more specific data about the origin of the ultrasonic emission, even identifying what specific part within the bearing is failing. These two technologies allow users to identify early and verify in detail.

It's clear that a comprehensive condition monitoring inspection program has to include a sufficient number of technologies to cover all of the dominant failure modes of the equipment base. The implementation of these technologies should compensate for the fact that different technologies identify the same failure mode at different points along the P-F curve. More is indeed better when it comes to identifying failures early and accurately and can accelerate a facility along its journey to reliability excellence.

Author Information

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