'Look for signs of failure to protect critical assets'

Complete online monitoring of the plant's most critical assets includes shutdown protection, predictive, and performance monitoring – all integrated with the process automation system, says *Deane Horn*.

Rotating equipment seldom fails without providing hints well in advance. Machinery health warning signs come in the form of vibration changes, process parameter changes, and performance changes to name a few. So imagine a form of machinery protection that allows you to anticipate and recognize these warning signs. A complete protection strategy can then be formulated based on the use of early information gathered from a combination of vibration, performance, and process data. Shutdown protection would be relegated to the last line of defense, and costly outages could be eliminated.

Advanced technologies, including online and wireless vibration monitoring and ASME calculations based equipment performance, can all be integrated with the process control system to nurture the health of machinery that is essential to maintaining uninterrupted production.

More than ever, it is important to utilize reliable information about the operating condition of critically important process equipment, not just a "trip" signal that comes only after significant internal damage has already occurred. It is no longer prudent to rely heavily on a vibration protection system for the most critical machines in your plant.

Machinery shutdown protection is only part of a complete online monitoring strategy to guard against events that can happen suddenly with little or no apparent warning. It is very important to have the right monitoring equipment, trained personnel, and a good analytical software package to pick up and identify those signs of failure long before a key compressor, turbine, gearbox, coupling, or even instrumentation fails unexpectedly. Timely maintenance is preferred over catastrophic failure and the costly repairs that will follow.

Mission: machine health

Studies indicate that more than 50 percent of industry maintenance man-hours is spent fixing equipment after a failure has occurred, whereas less than 18 percent of the time is spent determining when equipment might fail and acting accordingly. The numbers will improve only when maintenance departments establish the monitoring of machine health as a key mission, and go beyond shutdown protection that meets minimal requirements.

With warning signs coming in the form of vibration, process parameter and performance changes, rotating equipment seldom fails without providing hints well in advance.

The four components of a complete online monitoring solution for a plant's top five percent most critical assets are:

- Shutdown protection monitoring
- Prediction monitoring
- Performance monitoring
- Integration of all the above with the process automation system

Shutdown protection monitoring

These systems typically function to prevent severe machine damage or even injury in the event of a totally unpredictable event, such as a turbine blade suddenly breaking away due a metallurgical imperfection.

In this case, the "trip" signal must be instantaneous, like the inflation of an automobile air bag, to minimize damage. Protection systems are still necessary for safety because unpredictable events can and do happen. However, implementing prediction monitoring with protection monitoring can allow "black box" analysis after an unplanned emergency trip.

The machinery health monitor captures information at all bearings simultaneously across an entire machine train so that a user can replay the event as it unfolds and determine the cause of the event. In this way, similar shutdowns can be prevented in the future.

Prediction monitoring

Newer technologies are enabling users to predict what was once thought unpredictable. In reality, most events actually can be predicted. As long as personnel have access to detailed diagnostic information, they can identify potential faults and gauge their severity months in advance. This allows maintenance planners to determine the optimum time to make repairs.

Prediction monitoring of rotating assets is intended to provide the information needed for accurate planning. Information is frequently obtained by acquiring machinery vibration data and analyzing signatures and levels, either periodically or continuously. Analysis of the results generally leads to a decision as to how long that piece of equipment can continue to operate productively before maintenance will be necessary.

While periodic monitoring of production equipment using a hand-held data collector has been a staple of maintenance departments for decades, the data produced by this method are valuable in helping analysts determine what was happening at the time readings were taken, but equipment that is critical to keeping a production process in operation should be monitored continuously. Indeed, some critical situations can be averted only if real-time data on equipment condition is available.

Online monitoring using the CSI 6500 Machinery Health Monitor, for example, provides a continuous flow of data, so a changing condition can be immediately recognized. When

properly interpreted, these signals pinpoint the location, nature, and even the severity of developing problems. Personnel can use such data to predict with greater accuracy when a machine will need maintenance to prevent damage and avoid lost production

Predictive maintenance of rotating assets also uses information gathered through oil analysis, infrared imaging, and ultrasonic detection. If the data indicates trouble ahead, a judgment can be made as to when a failure might be expected. With critical equipment, immediate repairs may be necessary. That's when a reliable early warning system will pay for itself. On the other hand, it may be possible to delay repairs until a scheduled unit turnaround.

Health information can be obtained by acquiring machinery vibration data and analyzing signatures and levels, either periodically or continuously.

Ultimately, technology helps plant/unit maintenance managers make business decisions about what to do, when, and how to do it. Gathering and analyzing of machinery information is far less expensive than reacting after something breaks.

Performance monitoring

With as much as 50 percent of machinery malfunctions caused by the process around the machine, real-time vibration information integrated with the process automation system can give operators key information to understand how their actions can have an impact on machinery health.

Performance monitoring is based on comparing the actual real-time performance of a major piece of equipment, such as a boiler or large compressor, with design specifications. As equipment performance deteriorates, energy usage increases and throughput decreases. Plant personnel may not even be aware that the performance of a piece of equipment is below normal or that it is consuming excessive energy.

Actual efficiency loss versus design for the given operating conditions can be determined by comparing a machine's actual performance with a thermodynamic model. Specialists are thus able to identify laggards and formulate actionable recommendations. For example, blade fouling on a compressor can degrade performance and simultaneously increase vibration. Online water washes can improve performance and minimize downtime needed for an offline wash, but most turbo compressors are being pushed to their design limits and sending a bunch of water into the compressor can be quite stressful. An online water wash can be observed from a performance perspective to ensure it is helping to increase efficiency – and from a vibration perspective to ensure the compressor is not damaged. If efficiency in downstream stages does not improve, an offline water wash may be necessary.

Without real-time performance feedback, degrading performance may go unrecognized by production personnel for a long time, but the rigorous mathematical routines embedded in this technology will highlight operating degradation very quickly and help identify root causes.

Ideally, vibration monitoring becomes an extension of the central control system such that operators can see for the first time what is happening deep inside critical machinery.

Complete solution

To obtain a continuous flow of vibration measurements, a large turbo generator might have more than 10 bearings with two sensors at each bearing plus other unique instrumentation – like speed sensors, thrust sensors, and eccentricity measurements. As many as nine different types of measurements might be needed at various locations down a machine train depending on the size of the machine.

The cables leading from these sensors are connected to online monitoring hardware that is the foundation for the complete online solution. By measuring for detailed vibration in addition to peak vibration, the complete turbomachinery protection system, which is intended as a retrofit on shutdown systems, has the ability to recognize developing conditions as well as a severe condition requiring total shutdown to protect the machine.

Ideally, data from continuous monitors are integrated with the plant's control system, so vibration monitoring becomes an extension of the central control system. When the position and the motion of the shaft inside the bearings are integrated with the control system, operators can see for the first time what is happening deep inside critical machinery – information of much greater value than just a trip signal once vibration has exceeded a limit.

When operators have real-time vibration information at their disposal, they can observe the impact of process adjustments on a machine's health and learn what steps actually improve performance.

New meaning to protection

Traditionally machinery protection systems monitor for high vibration and close a relay when a setpoint is exceeded to initiate shutdown of a machine. Looking for signs of failure rather than a setpoint excursion to protect critical assets gives new meaning to protection and even adds a new layer of protection, decreasing the need to actually call upon that relay to fire.

Complete online monitoring of the plant's most critical assets includes shutdown protection, predictive, and performance monitoring – all integrated with the process automation system. Technology is providing new opportunities to improve overall machinery health, increase efficiency, and optimize the process. **CEA**

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