Keep the Boss Happy: Look Inside a Turbine During Startup

Deane Horn

An automated monitor provides a live, continuous picture of exactly what is happening inside a turbine for protection, prediction, performance monitoring, and integration of the data with process control.

Process control brings a turbine, used to drive a boiler feed pump, online after a hot outage. As load is steadily applied, technicians maintain a close watch on process parameters, vibration alarms and vibration plots when, all of a sudden, the overall vibration begins climbing abnormally.

The lube oil supply temperature is running cool, so the techs bring up an orbit plot for deeper investigation. The orbit plot is a little erratic, and phase is moving around (not normal). Next, they pull up a live spectral plot for quick confirmation of what they suspect is happening inside that turbine. They're not surprised to see a vibration peak at 0.48 times the turbine speed (see Figure 1).

Their monitoring equipment is unique because it allows them to view different plots of transient data from the turbine as it is being brought up to operating speed. The live data presentations yield real-time information that leads to instant recognition of a developing problem before a "trip" occurs. That knowledge might just prevent a catastrophic failure.

Continuous online monitoring of essential turbomachinery represents technology well beyond vibration monitoring systems that provide only periodic snapshots of the operation of a piece of equipment. The advanced architecture allows users to continuously view live, as well as record, over 60 hours of data simultaneously from up to 32 sensors for later retrieval and analysis.

This information can be critical for protecting the turbine, predicting its future operation for maintenance or repair planning, improving performance, and taking immediate action when necessary. This is a level of sophistication never previously available from a single vibration monitoring system.

Field-based intelligence processes the vibration waveforms into useful frequency and amplitude content (FFT spectral data). Preconfigured spectral parameter calculations take only seconds to collect, sample, and average in order to depict specific frequencies that identify defects such as misalignment, imbalance, looseness, rubbing, oil whirl, etc. Field-device based analysis leads a specialist to a specific defect, enabling faster decision-making.

In the turbine startup scenario described previously, the phone rings and an operator wants to know "what's going on?" He is advised to get out of the high vibration zone immediately by backing off the load or decreasing speed and then slightly increasing bearing #2 lube oil pressure. Another suggestion is increasing the lube oil temperature.

First, the operators reduce the steam load and then go to work on the lube flow and temperature. They are unable to pinpoint an oil flow issue, so they increase the oil temperature a few degrees in order to change the viscosity of the oil around the bearings. When the operators try once more to start the turbine, it comes up to operating speed without a hitch. What *was* going on in there?

There certainly was a malfunction, which the maintenance technicians quickly and confidently diagnosed as *oil whirl* at bearing #2. This abnormal condition of bearing lube oil instability can lead to bearing damage, seal damage, or even loss of performance. The cyclic vibration caused by this phenomenon can actually bend the rotor, resulting in a fatigue failure. At best, without an integrated online monitoring technology, the safety shutdown system will save the machine but provide no answers for the boss when he starts with the questions.

So, how is it that the maintenance staff seemed to have all the answers, while everyone else was wondering and asking, "What is oil whirl? Why does it happen? And how did maintenance know how to fix it?"

Here's their secret. They recognized the presence of "oil whirl," the name maintenance workers give the first stage of fluid instability around the shaft or rotor of a machine. This type of fluid instability might be between the shaft and a bearing pad, or it might occur between the rotor and a seal. Oil whirl, although bad, is actually a stable form of fluid instability. When oil whirl becomes more severe and unstable, it transitions into "oil whip," causing violent full contact between shaft and bearing.

There are many reasons oil whirl occurs. Some are process related and others are machinery health related. For the most accurate diagnosis, it is best to correlate information from both process control and vibration monitoring.

Process parameters such as oil flow, oil temperature, and oil pressure can affect lube oil stability of a multi-ton machine that is spinning 60 times per second, essentially hydroplaning on a thin film of lube oil with clearances as small as a human hair.

By monitoring these parameters of the turbine in combination with online vibration monitoring, technicians have access to the essential information needed to let operating personnel know what's going on as they try to start precision, high-cost machinery. Abnormal conditions will show up during the transition period long before they become serious enough to trip the unit or cause a catastrophic event.

The condition of the machinery can also help initiate the oil whirl condition. For example, if the rotor is slightly misaligned, the shaft may be nearly suspended, and not properly supported by the middle bearing. Since forces acting on the rotor have now changed, the performance of the lube oil at this bearing location may also be negatively impacted.

When advanced data plots from online vibration monitoring are combined with process control information, the evidence is available to capture the criminal before the crime occurs. Technology exists today to actually replay a turbine startup, just as video surveillance and instant replay aid in solving crimes.

As the event is reenacted, certain changes can be applied electronically, such as filtering of the orbit plot or adjusting the resolution of the data or time span. Plots can also be rotated on a 3D axis to provide a different perspective, and the replay speed can be increased or decreased for closer examination.

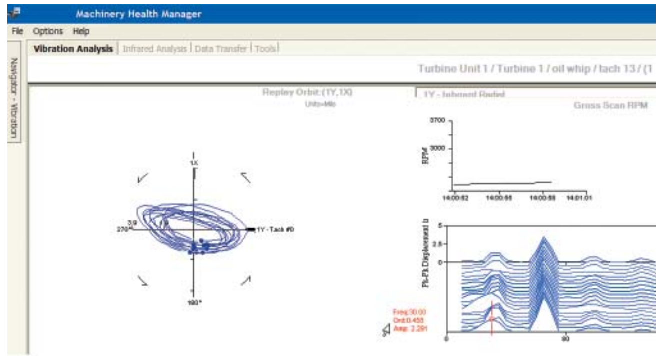

Figure 1

This mode of analysis is like looking at instant replay from multiple camera angles, allowing the analyst to zoom in on a specific area of interest. Most machine malfunctions provide many clues prior to the "big event." The key is to be able to recognize these clues as they occur.

A complete online monitoring solution can provide big returns, resulting in safe and optimized operations for this class of high-cost, high-speed machinery. Such a solution includes machinery protection monitoring, real-time predictive monitoring, and performance monitoring, all integrated with process control.

P&S

Deane Horn is the marketing product manager for online systems at Emerson Process Management, 835 Innovation Drive, Knoxville, TN 37932, 865-675-2400, Fax: 865-218-1785, deane.horn@emersonprocess.com, www.emersonprocess.com.