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Valve Monitoring Maximizes Efficiency

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KNOXVILLE, TN.–Driven by operational, economic and regulatory factors, more emphasis is being placed on the reliability and health of the intake and exhaust valves on natural gas compressors.

When a valve begins to exhibit signs of leakage, compressor efficiency can be lost. Reciprocating compressors are designed to last a long time on the job site, but the health of individual valves needs to be assessed and addressed continually in order to maintain maximum compressor efficiency, optimize the overall performance of gas-producing assets, and prevent lost production.

Valve failures can occur as a result of numerous problems. Proppant flowback and fracturing fluid flowback are particularly hard on the valves in reciprocating compressors. However, even in clean gas, valve degradation will occur over time as a result of normal wear and tear. With any amount of valve wear comes a significant decrease in sealing capacity. Whether valve damage occurs as a result of liquid intrusion, or is simply caused by normal wear, it is essential that operators maintain an awareness of valve functionality.

Unfortunately, in many companies, valve maintenance comes well after efficiency and production quality losses have already begun to occur. By the time pressure and volume curves and temperature readings have signaled a problem in a valve, valuable product delivery has been delayed because of produced gas recirculation.

Continuous monitoring is the key to managing valve health in reciprocating compressors. By continuously monitoring the vibration and temperatures on a valve, a rate of degradation can be established, allowing the operator to predict the ideal time to schedule a valve replacement. This can be beneficial whether the organization is monitoring groups of valves regionally, or more ideally, continuously monitoring individual valves at each compressor location.

Monitoring Approaches

One common setup involves groups of valves monitored continuously through cumulative data collection on the compressor head. In this regional monitoring setup, the primary value comes from the improved efficiency associated with predictive maintenance. Instead of relying solely on lagging indicators from pressure/volume calculations and temperature variations, monitoring valves using vibration data will alert maintenance to issues well before they would have been detected in volumetric calculations. This means less time where horsepower is being wasted recirculating gas because of a leak in a valve.

In addition, by switching from periodic monitoring to continuous monitoring, maintenance teams no longer have to worry that an issue will arise shortly after a periodic maintenance check, leaving machines running at low efficiency for an extended time. This prevents situations where a problem begins the day after a check, and continues to impact production for an entire week or month until the next pressure, volume or temperature check.

In addition to increasing efficiency, switching to continuous monitoring of valves in reciprocating compressors means decreasing costly downtime. Letting a valve run to failure means adding the cost of lost production to the already undesirable cost of repairs. In pad developments where a single compressor is serving multiple wells, the lost production costs are compounded significantly.

Continuous monitoring enables equipment failures to be predicted. The value of this predictive data is in the ability to schedule and shorten the duration of maintenance on essential equipment. This avoids not only the cost of lost production during emergency repairs, but also the risk of added rework cost from having to make do with hasty repairs.

Monitoring individual valves brings the same benefits as regional monitoring, but with the added benefit of greatly decreasing repair times. When fully implemented, continuous monitoring of individual valves allows maintenance teams to pinpoint the particular valve in a compressor that is failing. This allows the maintenance team to schedule a replacement for only one valve, which could easily save six to seven hours over replacing all the valves in the compressor, as well as avoiding the rebuild cost for multiple valves in a system.

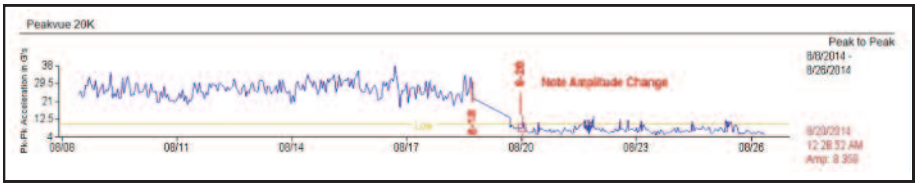
In addition, monitoring individual valves shortens unavoidable downtimes. It is far easier to schedule a two-hour repair than one that will take eight hours. Should downtime related to valve repair or replacement be necessary, being able to accurately diagnose the problem valve can save thousands of dollars in maintenance costs and lost production.

Case Study Application

Needing a solution for high valve failure rates on reciprocating compressors that were handling wet gas, an oil and gas company operating in the Midwest decided to take advantage of the predictive maintenance benefits of continuous monitoring. Monitoring specialists helped implement technology that would cut through the complexity of machinery analysis to

FIGURE 1

Changing Amplitude Trend Values As Compressor Shows Indications of Leakage



provide a simple, reliable indication of equipment health through a single trend by filtering out traditional vibration signals to focus exclusively on "impacting."

In addition to needing to simplify the monitoring process, the organization wanted to expand its monitoring to encompass all of the crossheads and to take an axial reading on each throw, in order to more easily detect the looseness and/or impacting that occurs when some of the mechanical components begin to wear.

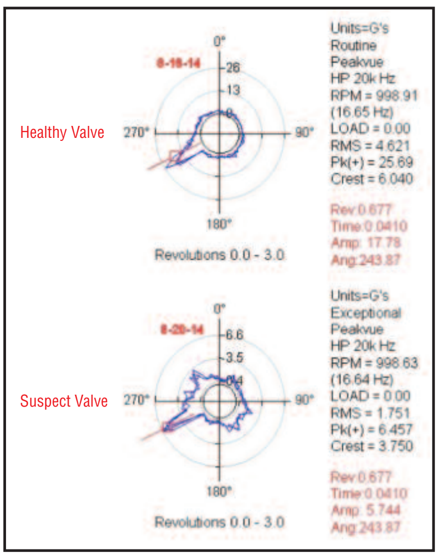
The compressors were outfitted with a high-frequency (10 millivolts/g) accelerometer mounted on one of the studs/bolts that held the valve cover in place. Standard accelerometers also were mounted vertically on the crosshead section, and axially on the head. Being able to determine the phase angle of the occurrence is essential so that other signatures present in a given valve reading can be related to other events happening on the compressor.

The user also had the option to utilize dual-purpose, high-frequency/temperature accelerometers on the valves, providing automatic data correlation between temperature and vibration, and giving additional predictive monitoring capabilities. As valves begin to leak gas, temperatures rise. By monitoring individual valve temperatures as well as individual valve vibration signatures, the problem valve is identified more easily.

The data collected provide a good indicator of high-frequency occurrences such as flow turbulence and friction, and show the flow turbulence that occurs as each valve opens and closes, relating it to a consistent time in each revolution in order to determine valve action. The transient capabilities also allow for the replaying of events in real time, permitting further diagnostic capabilities.

FIGURE 2

Circular Waveforms Associated With Healthy and Suspect Valves



Data Examples

Figure 1 shows the predictive benefits of continuous monitoring. In this example, the trend values, as well as the pattern present in the circular waveform, change as a valve shows indications of leakage. Dealing with a form of flow turbulence instead of impacting, it is clear that the amplitude actually decreases when a valve is not sealing properly. This is related to the fact that the delta pressure is reduced across an improperly functioning valve, instead of the usual "surge" of gas as the valve opens and closes.

Circular waveforms were used for pattern recognition in determining valve health. The circular waveform plots simply overlay one rotation on another, instead of plotting in strip format. This particular format enhances the repeating pattern seen in each revolution.

By utilizing data collection, temperatures, and viewing the circular waveform patterns, the user can determine the operational health of the individual intake and exhaust valves. This information, along with the associated trend values from the peak-to-peak waveform, helps to determine overall valve health as well as the rate of degradation of a given valve.

Adding the vibration data along with the individual valve temperatures helps to pinpoint issues and allows for proper scheduling of repairs to prevent catastrophic valve-related failures on reciprocating compressors.

This form of continuous monitoring of valves works well regardless of flow variance. Because the system monitors high-frequency flow turbulence, the heart of the data is in the consistency of the amplitudes and pattern of the turbulence data. If there is liquid mixed with the gas, the amplitudes will be higher, but the patterns will remain consistent. If, however, the valve is leaking, the pattern will change, while the amplitude remains consistent.

This pattern change can be seen in Figure 2. In the circular waveform graphs, there is a significant difference in the pattern. This shows that the valve is not seating properly because of the loss of the distinctive sharp crisp occurrence that is present in the top waveform.

Notice, in particular, the "crisp" event that is present on the upper plot. This can be related directly to the phase angle of the compressor crankshaft and the timing of the valve. On the lower plot, it also is evident that the event is less defined and shows a large amount of energy present during the entire revolution. Notice the energy present at approximately 225 degrees (revolutions). These waveforms also can be viewed in standard strip format, if preferred.

Continuous monitoring of valve health on reciprocating compressors provides significant short- and long-term benefits. Providing operators, maintenance and engineers with valuable, reliable, and easy to evaluate data on the health of compressor valves means giving them the tools they need to keep the organization running as efficiently and reliably as possible. With valuable analysis data at their fingertips, compression and operations staff can stay ahead of problems and remain focused on production. ❐

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