Complementary Condition Monitoring Boosts Reliability

Combining ultrasound and vibration sensing adds precision to recip valve analyses

A technician uses an ultrasound needle sensor to test for problems.

Vibration sensors with wireless transmitters are attached to the suction and discharge valve caps.

BY KARL HOFFOWER

Over the past decade, ultrasonic condition monitoring of reciprocal compressor valves has become more widely known. However, it does not seem to be widely used.

Ultrasonic testing measures high-frequency sound waves, well above the range of human hearing. These ultrasound devices record the high-frequency signals for analysis later. Trending valve cap temperatures is the most common condition monitoring technique for monitoring compressor valve health.

Ultrasonic testing of compressor valves and vibration monitoring of rotating components are an informative, preventative-maintenance practice. Compressor valve deficiencies with opening, closing or leaking may be diagnosed using the ultrasound recording functions.

Steven Schultheis, a Shell Oil Co. engineer, addressed the issue in a paper presented at the 36th Turbomachinery Symposium in Houston in 2007.

"Trending valve temperatures have proven to be valuable in identifying individual valve problems, but are most effective if the measurement is made in a thermowell in the valve cover." Schultheis wrote. "Ultrasound has proven to be the preferred approach to analysis of valve condition."

Failure Prevention Associates completed an experiment with a major midstream gas transmission company to see if this type of condition monitoring tool can effectively find fault conditions well before other technology used.

Ultrasound meters (such as the SDT270 from STD Ultrasound Solutions) have digital readouts that indicate the level of ultrasound detected. These devices have been used for decades to "hear" air, gas and vacuum leaks. The intensity or amplitude of the signal is expressed in decibels — microvolts. (dB[A] µV). The dB(A) is a common intensity unit for sound intensity; µV designates the engineering reference unit being used with a piezoelectric sensor.

Converting an airborne ultrasound detector with a contact sensor allows a technician to monitor what is happening inside a machine, whether it is a bearing, steam trap, or valve.

Ultrasound detectors are designed operate in a specific and narrow frequency band. Then through "heterodyning"

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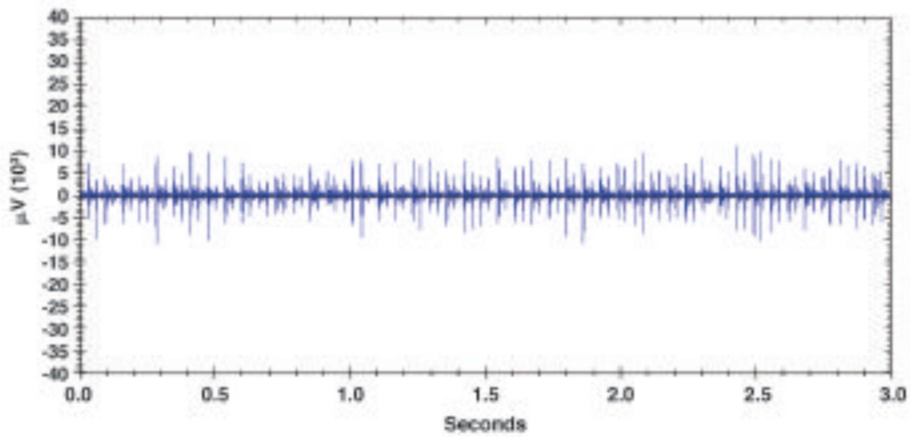

Figure 1. Ultrasound reading of a valve in good condition.

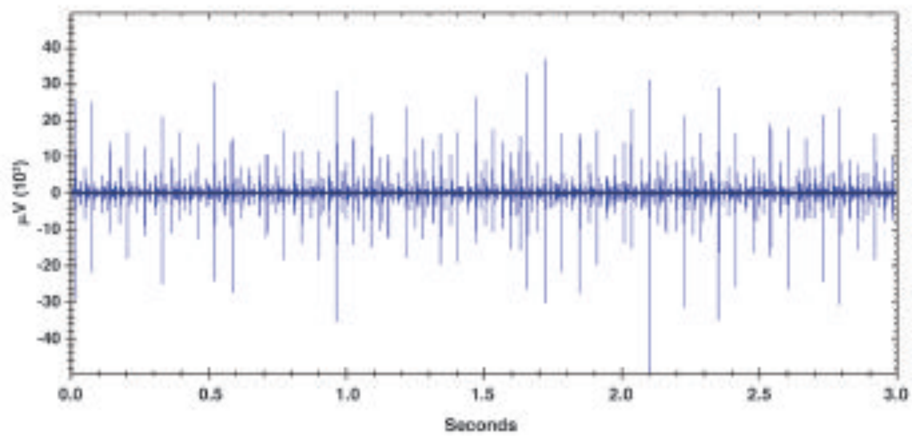

Figure 2. Ultrasound of a valve showing signs of valve failure.

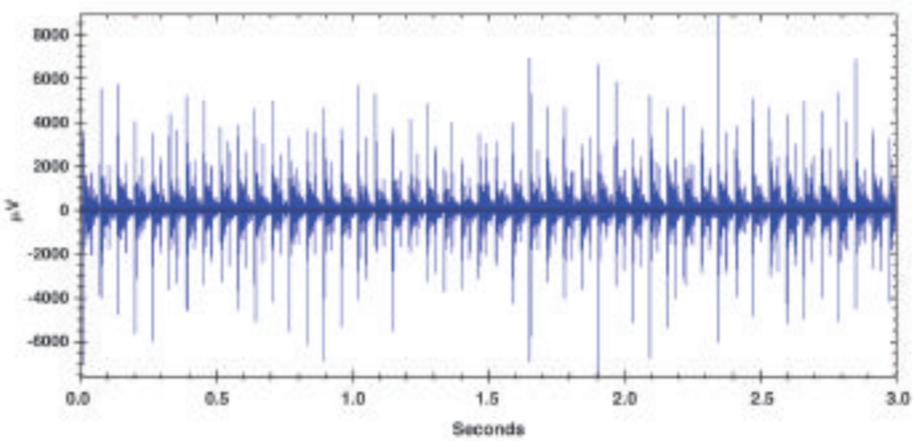

Figure 3. Ultrasound of a failed valve.

step high frequency sounds down into an audible format that the technician can hear though headphones. During the heterodyning process the quality and characteristic of the original ultrasound signal is preserved.

While a mechanic's stethoscope can be used to "hear" a cracked valve making noise, an ultrasonic detector can quantify the intensity of the valve opening and closing as well as record the sound waves generated by those actions.

The huge benefit of ultrasound recordings of reciprocating compressor valve heads is that the dynamic wave can be compared over time, generating data for evaluating when a valve is losing performance and needs to be replaced.

Using simple time waveform analysis software, it is easy to expand a tenth or a hundredth of a second of data to see a valve open, exhaust and close. The data can show if there is complete sealing of the valve seat and can even be used to assess the strength of the valve spring.

All of this data can be printed in a logical report, which managers can use to decide if further action is necessary. Because the document becomes a historical archive, the next decision will have a basis of comparison.

By quantifying the level of ultrasound that a valve makes, operators can determine which valves are doing badly and which are operating within acceptable levels.

Figure 1 is a closer look at a good valve. The amplitude in this graph is ± 10 dB(A) µV.

As the valve begins to enter a failure mode, there is a noticeable increase in the amplitude measured at the valve covers.

Figure 2 shows a valve problem developing. The bad valve is generating 5000 to 8000 microVolts as it fails to open and close properly.

Figure 3 shows a failed valve. The compressor station had observed that this valve needed repair. To test the validity of the ultrasound technology, a different inspector was sent to evaluate the four-throw compressor and all of its valves. Without disclosing which valve was known to be bad, the ultrasound survey inspector found the bad valve easily.

Having a contact probe engineered to perform under the conditions necessary and with appropriate engineering is crucial to acquiring good data.

The optimum length and diameter of the contact probe was researched to eliminate artificially induced resonance while transmitting the greatest amount of structure-borne ultrasound.

Having an ultrasound detector that is capable of recording valve noise is important. Training is important as well.

Wireless condition monitoring

Sometimes a compressor is in a remote location where daily valve temperature or ultrasound logging with a walk-around system is not practical.

Several improvements in wireless condition monitoring have been made within the past year. One such advance is the creation of intrinsically safe, long-lasting, battery-operated vibration and temperature sensors. Using microelectromechanical sensors (MEMS) technology accelerometers, the costs have been reduced significantly. When you tilt a smartphone, imbedded MEMS sensors automatically change the orientation on the screen.

With today's widespread cellular phone coverage, it is possible to connect a wireless sensor to a collection server that, when plugged into a cell modem, can send the data anywhere in the world.

KCF Technologies, a company established to utilize research conducted at Pennsylvania State University, has produced such a vibration sensor system.

The sensor is capable of measuring vibration in two axes 90° apart, as well as temperature. An integrated magnetic base makes for a low-profile, easily attached sensor.

Using 10 sensors placed on the piston houses, frames, and bearing housings, near-real-time vibration and temperature monitoring can be established and monitored from miles away.

In a case study, David Kraige of KCF Technologies detailed how the comparison of high and low levels of vibration from the wireless sensors indicated a valve entering a failure mode.

The case study said, "The right rear, right front, and left front valve sensors are registering peak accelerations around 7 Gs. The left rear valve sensor is registering peak accelerations around 20 Gs."

With remote condition monitoring, being able to review vibration and temperature data in near-real-time enables operations, maintenance and engineering personnel to review a large volume of data to improve efficiencies, direct maintenance and lower costs.

If certain flow rates are causing pulsation, the changes can be implemented and the results viewed by anyone given permission to log onto the cloud.

There has been much discussion about the Industrial Internet of Things (IIoT). The use of low-cost, wireless sensors shows that IIoT is finally here. **CT2**
