Ultrasonic Condition Monitoring: An Application Overview

Ultrasound inspection offers a unique position for condition monitoring as both a “stand-alone” inspection technology, and as an effective screening tool that can speed up the inspection process and help inspectors determine effective follow-up actions for mechanical, electrical, and leak applications.

Whether you refer to proactive inspections as “predictive maintenance” or “condition monitoring,” the goal is the same: to note a deviation from a normal or baseline condition in order to determine whether to take corrective action in a planned orderly manner and to prevent an unplanned incident.

The ideal end result is to maintain asset availability, reduce maintenance overhead, and improve safety conditions. Not one technology can cover everything. The recommendation is to incorporate as many technologies as possible into inspection procedures to assure reliable results.

Ultrasound Technology

Airborne/structure borne ultrasound instruments receive high frequency emissions produced by operating equipment, electrical emissions, and by leaks. These frequencies typically range from 20 kHz to 100 kHz and are beyond the range of human hearing. The instruments electronically translate ultrasound frequencies through a process called heterodyning, down into the audible range where they are heard through headphones and observed as intensity and or dB levels on a display panel.

The newer digital instruments utilize data management software where information is data logged on the instrument and downloaded to a computer for analysis. Some instruments contain on-board sound recording to capture sound samples for spectral analysis.

Sounds are received two ways: through the air and through solid surfaces (structures). Airborne sounds such as leaks or electrical emissions are received through a “scanning” module. The structure borne ultrasounds, such as generated by bearing or leaks through valves, are sensed through a wave-guide or “contact” module.

What makes airborne ultrasound so effective? Operating mechanical equipment, electrical emissions (arcing, tracking, corona), and most leakage problems produce a broad range of sound. The high frequency ultrasonic components of these sounds are extremely short wave in nature. A short wave signal tends to be fairly directional and localized. It is therefore easy to separate these signals from

background noises and to detect their exact location. In addition, as subtle changes begin to occur in mechanical equipment, the directional nature of ultrasound allows these potential warning signals to be detected before actual failure.

When used as part of a condition monitoring program, ultrasound instruments help improve asset availability and save energy.

Once established, ultrasound can be used as the “first line of defense” to:

- Inspect equipment quickly
- Screen out anomalies
- Set up alarm groups for detailed analysis and further action
- Accurately detect energy waste, enabling timely reduction in carbon footprint, as well as plant-wide energy savings

Technological Advancements

As the industry has changed, so too has ultrasound instrumentation. The need for documentation, trending, reporting, and analysis of equipment condition has brought about changes that improve inspection capabilities and equipment availability. As these instruments are incorporated into reliability and energy conservation programs, the meantime between failure rates improve along with a reduction of energy loss.

The changes in instrumentation have been substantial. No longer analog based, most of the newer instruments are digital. This allows users to view intensity levels as decibels, which provides more reliability for analysis of test results. In addition, data is now logged on-board the instruments and downloaded into data management software. The software enables users to review test results, compare current data with baseline data and trend changes. It also produces reports which can be reviewed by all involved.

In addition to on-board data logging, some of the new digital instruments incorporate on-board sound recording so that users can capture sound samples of equipment for sound analysis. The recorded sound samples can be viewed in spectral analysis software. An important feature of the spectral analysis software, in addition to viewing sound samples in spectral, time and waterfall screens, is the ability of users to hear the sound sample as it is played.

Using both the visual and audible modalities in this manner adds a new dimension for enhanced diagnostics. Other key abilities include:

- A range of diagnostic and analytical software tools that will keep users informed of the savings generated through compressed gas surveys and steam surveys. In fact new developments in compressed gas software provides users the ability to manage leak programs while demonstrating savings in energy and carbon gases. Should a company become involved

with carbon trading, these reports can prove to be extremely useful.
- Specialized module development, created to meet specific needs. For example, a magnetically mounted transducer is used to test bearings to provide consistency in test approach and results.
- Parabolic modules, which can double the detection distance of standard scanning modules and can be used to safely identify electrical emissions in transmission lines or substations without inspectors getting too close.
- Remote sensors, which can be mounted on test points. Some of these sensors have cables that can run out to an accessible area where an inspector using a portable instrument can attach the cable end to a sensing module and log the data. Other types use 4-20 mA , 0-10V and heterodyned outputs to transmit data to a control panel, alarm, or recording device. While many of these remote sensors are used to monitor bearing wear, with the increased awareness of arc flash prevention, some of these sensors are placed in enclosed electric cabinets to alarm when arcing, tracking, or corona are present.

Applications

Leak Detection: Leaks can form practically anywhere in a plant. This includes pressurized systems and systems under a vacuum. Leaks can occur internally through valves and steam traps, in heat exchanger and condenser tubes or to atmosphere.

While it is important to locate potential safety hazards from leaks, loss of gases through leaks cost facilities lots of money. One area that can show fast returns is through establishing a compressed air leak survey program. In fact, the U.S. Department of Energy has started a compressed air challenge. The reason? They estimated that of all the compressed air used in the U.S. by industry, about 30 percent is lost to leaks. They estimate this to cost from 1 to 3.2 billion dollars annually.

Based on 100 psi, at a cost of $0.25/mcf for one year (8,760 hours), a leak as small as 1/16” (.16 cm) can cost $846.00 annually. By doubling this to 1/8” (.125 cm), the cost jumps to $3,389.00 annually. If your plant had 10 leaks or 50 leaks, imagine the savings! We’ve had reports of users who, after performing a leak survey and repairing the leaks, have eliminated the use of an extra compressor.

Electric Emissions: Ultrasound inspection works on all voltages— low, medium and high—to detect arcing, tracking, and corona in both enclosed and open access equipment. Arcing, tracking, and corona ionize the air molecules around them, which produces ultrasound.

With the advantage of digital sound recording and spectral analysis, inspectors can analyze sound samples to determine the type and severity of an electric emission.

Mechanical Inspection: As ultrasound technology has evolved into the digital age, it has created many opportunities for detecting, trending, analyzing and reporting changes in operating mechanical equipment to improve asset availability. Data can

be stored, uploaded, and downloaded into data management software. The software is used to produce trend charts, and generate reports with selected criteria. In addition, alarm levels can be set to create work orders for equipment in need of corrective action. When changes in mechanical equipment exceed an alarm value over baseline, spectral analysis can be used to analyze sound samples for accurate diagnosis. Fault frequencies can be determined for bearings or gears. It is recommended that baseline readings be taken both as stored decibel levels and with recorded sound samples. Baseline sounds will be very useful in determining whether or not changes have occurred in equipment and if corrective action should be taken.

Conclusion

Ultrasound technology has advanced from using simple analog “search and locate,” or “trouble shooting” instruments to a sophisticated technology that is digitally-based, offering systematic approaches to leak management, electrical monitoring, and mechanical inspection, including bearing condition analysis and trending. They provide savings in energy and improve meantime between failure rates, which will lead to improved productivity and cost reduction.