Predictive Maintenance
...for the masses

Ultrasound Detection Predictive Maintenance for the Masses

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The popularity of ultrasound inspection for maintenance and reliability managers is attributed to ease of use, versatility, and low implementation cost. Once considered a companion to core predictive technologies like vibration analysis and infrared imaging, the emergence of stand alone ultrasound inspection programs is more prevalent for reliability departments today. Ultrasound is now considered a front-line defence system in the everyday battle for manufacturing uptime. Airborne Ultrasound is Predictive Maintenance for the Masses.

Mass Appeal

The applications for which Ultrasonic technology can be used are nearly limitless which lends to its mass appeal. Compressed air leak detection, condition based monitoring of bearings, and acoustic lubrication of bearings, are popular apps. Some inspectors monitor thousands of steam traps and pinpoint in-leakage to boilers, condensers, and heat exchangers. Others marry ultrasonic inspection and infrared scanning together for added safety to MCC panel scans or surveys of high voltage substations and T&D lines.

Easy To Use

To borrow a well used cliché, ultrasound instruments have always been considered user-friendly. Being painted this way left consumers with the impression that user-friendliness equated to lacking sophistication. Nothing could be further from the truth for the new generation of instruments that hit the street in 2010. Take for example SDT's new SDT270. This powerful device retains the look and feel of its predecessor, the SDT170, but what is inside is a quantum leap forward for the global ultrasound technology family. SDT is a pioneer in the instrument design space and their innovative Building Blocks concept delivers a detector with more than 96 possible configurations. Inspectors can literally design their own instrument to suite their program's needs and goals, and flexibly change that instrument when as their program evolves.

Most detectors work on the basic principle of detecting high frequency ultrasound and converting it to corresponding audible sounds which can be listened to with headphones. Additional functions are dependent of the device but most provide a visual indicator on a bar graph display or a decibel measurement and some can even capture a time specified wave signal that can be analysed with software. Adding sophistication while maintaining simplicity is a challenge that some manufactures handled better than others; but the net effect is driving the popularity of this technology to mainstream PdM practitioners.

Ultrasonic analysis or Ultranalysis™ offers benefits for all areas of the manufacturing process. Most machine failures could be discovered early making them treatable issues instead of replaceable downtime issues. Excessive vibration and temperature increases are indicators of mechanical failure on the horizon but we also learned that microscopic changes in friction forces, detectable early with ultrasound provides a bigger window of opportunity for scheduled maintenance. When we hear problems this soon we are empowered with the ability to limit downtime and overall maintenance cost. Take a look at some of the most common maintenance applications for airborne ultrasound that could be applied at your plant today.

Compressed Air Leak Management

Compressed air is a top three most expensive utilities used in manufacturing. Leaks are expensive, and often ignored. While they can be heard with the naked ear they are difficult to pinpoint because of background noise. An ultrasonic detector hears leak turbulence through the ambient noise of the factory floor, no matter what. The high frequency component of a leak is directional making it fast and easy to locate its source. A compressed air survey with an ultrasonic detector once per quarter will reveal savings potential in the millions and benefit facilities managers looking to improve efficiency and reduce costs.

Condition Monitoring

One application that has really evolved alongside the new generation detectors is CBM (condition based monitoring) of rotating and non-rotating equipment. In both instances production machines produce frictional forces with high frequency ultrasonic signatures. These forces are often masked by ambient plant noise and low frequency vibrations. Changes in these signatures serve as early indicators of failure and provide comparative information for vibration data. We want to believe that the majority of our machines are not in an advanced failure condition. Would you rather

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spend days analysing gigabytes of data from machines that are not failing or use ultrasound technology to sort the many good from the few bad so your vibration analysts are focused only on trouble areas? The answer is obvious and reasonable. An ultrasonic instrument equipped with digital decibel metering measures and logs the intensity of high frequency frictional forces. Enhanced detectors like the SDT270DU also capture time signals alongside the decibel measurement. Time signals are useful for slow speed bearing condition assessment, one area where vibration analysis struggles.

Condition monitoring with ultrasound provides overall data that is indicative of elevated friction levels from random impacting, rubbing, and spalling. These non-sinusoidal events are more interesting to analyse in the time domain making ultrasonic monitoring useful as a first line defence instrument. Collecting information is quick and inexpensive. Much more data can be taken extending condition monitoring to more machines which may have been overlooked by vibration due to time and costs. Ultrasonic monitoring will detect a change earlier in the fault cycle than other technologies. For this reason ultrasound is generally used to alert changes in condition and do a preliminary diagnosis.

Acoustic Condition Based Lubrication

Over time lubrication breaks down and the friction forces inherent in any bearing increase. Ultrasonic systems that measure dBµV levels monitor and predict the relevant need for re-greasing of the bearing. When a baseline ultrasonic alarm is compromised a lubricator is alerted to the problem and can correct it before the bearing is physically damaged. Condition-based lubrication monitoring advises lube techs when grease is needed, and warns them when too much grease is added. One problem with adding too much grease is compromised seals. For electric motor bearings this means grease pushed through the seal and into the windings. For one paper mill in the USA it was decided to STOP greasing motor bearings altogether as it was cheaper to replace just the bearing versus cleaning out piles of grease from the motor. This technique has become the norm for establishing lubrication requirements on most production machinery.

Electrical Applications

The versatility of ultrasonic inspections extends to the electrical maintenance department where routine scans of switchgear, substations, and high KV transmission and distribution lines are commonplace. There is mounting concern about safety and specifically the danger of arc flash. Prior to opening high and medium voltage electric panels inspectors use ultrasound detection to listen to the levels of ultrasound inside the cabinet. The importance of finding problems at an ultrasonic level can't be overemphasized.

Radio and TV interference are common complaints from local cable companies. Often the source can be traced to a faulty transformer or a failed lightning arrestor. Pinpointing the culprit is quick and simple with an ultrasonic scan. The directional nature of ultrasound focused on a parabola reveals problems from a safe distance.

Steam System Inspections

A steam trap is an automatic valve that opens for condensate and non-condensable gases and closes for steam. It is designed to trap and remove water, air, and CO2 which hinder the efficient transfer of steam, corrode system components, and cause damaging water hammer. Ultrasonic surveys of the entire steam system will reveal system leaks, blockages, stuck valves, and failed traps. Increasing steam efficiency translates to huge dollar savings and increased product quality. Certain types of traps can benefit from dynamic signal analysis, a new feature in the recently rolled out SDT270. When monitoring continuous traps it can be difficult to discern between live steam from a failed trap and flash steam which is produced when the reduced pressure of the condensate line causes condensate to regenerate back to steam. Viewing the time signal of suspect traps can help distinguish between flash and live steam.

Pump Cavitations

Cavitations are the result of a pump being asked to do something beyond its specification. Small cavities of air develop behind the vanes. These pockets have a destructive effect on the pump's internal components.

During normal data collection, inspectors use ultrasonic detectors to isolate random cavitations which can be masked by low frequency modulations. Using an ultrasonic detector

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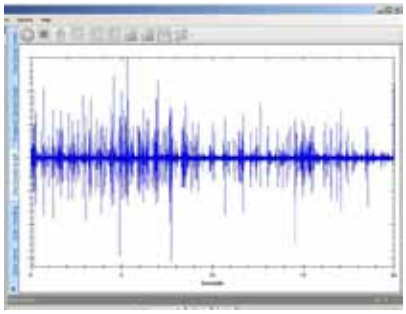
in contact mode, isolate the pump vanes and listen for small air pocket explosions. Place the contact probe on the housing of the pump vane and adjust amplification to filter down shaft noise. Comparing similar pumps will help the uninitiated, but with some experience an operator will quickly be able to identify when pump cavitations are present.

Reciprocating Compressors and Valves

Reciprocating valves give breath to compressors. Worn or dirty valves can't seat properly. Over time springs weaken limiting the force necessary to snap open and closed causing leakage. Valve condition is monitored with ultrasound inspection and spectral analysis software. The demodulated signal from the detector is fed directly to an analyzer or stored as a wave file. Spectra graphs visualize the compressor valve as it opens and closes, and intakes and exhausts.

Visualizing the recorded sound file of a compressor valve in the time domain tells us a lot about the condition of the valves and their components. Valves are opened and closed by a spring mechanism allowing reciprocating compressors to intake and exhaust. There are three distinct events (Open, Intake or Exhaust, and Closed) occurring all at split-second timing way to fast for our ears to process. By viewing the wave file in real time we can stretch it out to visualize each individual event. In Figure 12 the waveform shown is four cycles in less than 1/10th of a second. It clearly shows the valve closed (2 - flat line at zero), open and intake of air (3), then a small spike as the valve slams shut (1 & 4), and flat lined again to indicate a tightly sealed valve (2). There are a few things to look for in this picture. First, we can trend the small spike as the valve spring pulls closed (1 & 4). As the spring ages and wears this spike becomes smaller and smaller. As a result some noise may appear where the flat line (2) was as the valve is not held as tightly closed. Weak springs and poorly seated valves will also change the shape of (2&3). As the valves open and close there will be in-leakage or out-leakage lessening the abruptness of the spike. Time wave images are saved and compared over time to see the evolution of wear.



Heat Exchanger and Condenser Leaks

Tube condensers and heat exchangers cool steam, which condenses back to purified water and is returned to a boiler where it's superheated back to steam. Leaks in the tube allow contaminants in, opening the door for corrosion and reduced operating life. Keeping the water pure is the key to efficiency.

The general method of inspection involves scanning with the instrument a couple feet from the tube sheet. If a noisy area is found it is noted. Switch to an extended flexible sensor and scan tube to tube. If the sound signal on the digital dBµV meter or sound in the headset does not change from tube to tube, a leak is unlikely. This is particularly true of tubes located on the outer edges of the tube sheet as these tubes are more likely to have noisy steam flowing over their OD surfaces. If a significant signal change occurs then a leak is suspected. If the leak is within the tube the difference will be heard at the tube opening. If the noise level is heard on the tube sheet, block the area to eliminate reflected noise. Then place a rubber precision tip with an opening of one eighth inch on the flexible extended sensor and hold it almost on the tube sheet surface.

Valves and Hydraulic Leaks

Over time small leaks, blockages, and by-passing will manifest inside hydraulic systems. The sources of these faults are detectable with ultrasonic inspection. Hydraulic oil will form small bubbles which pop as they are forced across seals and wipers. With a magnetic or contact sensor placed against the housing set twhe sensitivity to maximum to reveal the tiny explosions. The signatures from a passing hydraulic valve can be a steady rushing sound or an intermittent gurgle. Comparing similar areas in the system to trace down blockages and passing will save hours of visual inspection and tear down time.

Where Do We Go From Here?

Ultrasonic inspection, detection, and data collection has been around for over 35 years. but only recently gained acceptance as a standard for predictive maintenance departments. Branded as "Ultrasonic Leak Detection", this technology has shed its type-cast role to become a versatile, important, dynamic member of the predictive family.

Beware the technology trap. Buying the latest and greatest gadgets, even the useful ones like ultrasound, will only take you so far as your planning, strategizing, and implementation. For a successful and long-lasting ultrasound inspection program be prepared to invest in a program implementation specialist to help you establish your goals, plan for the execution of those goals, and institute a means to measure the progress of your program as the benefits start rolling in.

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About the Author

Allan Rienstra is the President of SDT Ultrasound Solutions and co-author of Hear More; A Guide to Using Ultrasound for Leak Detection and Condition Monitoring. He has spent the past 19 years helping manufacturers around the globe establish world class ultrasound programs. His Solutions Oriented approach matches application to instrument and software selection, implementation training and continuous coaching. Predictive Maintenance for the Masses discusses the most popular applications for ultrasound inspection

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