ULTRASONIC DETECTION

The Precision of Ultrasonics

APPLYING ACOUSTIC VIBRATION MONITORING TO PREDICTIVE MAINTENANCE

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A What is Ultrasound?

Sound vs. Ultrasound

All sounds are produced by vibrations in bodies. In musical instruments the sound is emitted by vibrating strings or a reed. Our voice is the result of vibrations of our vocal cords. The number of vibrations a body makes per second is called its frequency and is commonly referred to as hertz.

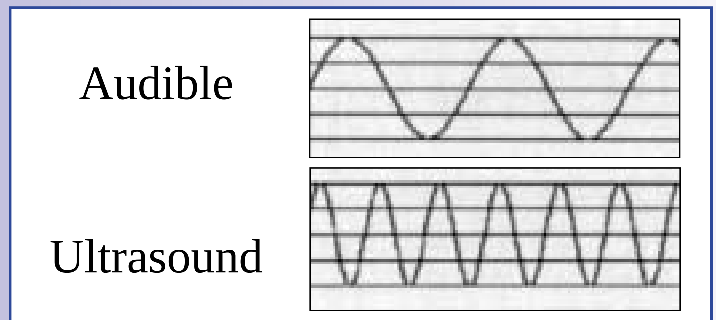
Ultrasound is defined as "…sound waves having a frequency above the limits of human hearing, or in excess of 20,000 cycles per second (hertz)." So by definition, ultrasound is totally undetectable by human ears unless aided by instruments capable of translating ultrasound to audible sound. In the marketplace, these instruments are commonly known as ultrasonic detectors and have been used for various maintenance related functions for over 25 years.

Sound Propagation Theory

Sound is propagated by longitudinal waves through virtually any medium (air, water, glass, metal, etc…). A wave is a moving disturbance that causes the particles of the medium through which it is passing to vibrate. In such waves, the particles over which the wave is passing are made to vibrate in a line parallel to the direction in which the wave is moving.

Properties of Ultrasound

The energy of a sound wave diminishes the further it travels from its source. Because sound waves spread out in widening spheres their energy is dispersed over a large area. This phenomenon is known as attenuation. Audible sound will propagate further and wider than ultrasound with the same energy, because an audible sound wavelength is much longer than an ultrasound wavelength. For this reason ultrasound is more directional to its source than lower frequency audible sounds. This directional characteristic makes it easy to pinpoint the exact source of the ultrasound even in very loud and noisy environments (like your plant floor).



B How Ultrasonic Detectors Work

If we want to listen to ultrasound, we need an instrument capable of translating high frequencies into a range we can hear (normally 200-5000 hertz is a comfortable listening range). That is the function of an ultrasound detector. If we want to listen ONLY to ultrasound we need a detector with certain filters to eliminate audible or "parasite" noises. If we want to measure the energy of the ultrasound then the detector should have digital measurement capabilities. This equipment can usually store the measurements to an onboard memory chip and transmit the data to PC software.

Types of Sensors

Ultrasonic detectors use sensors with piezo-electric quartz crystals which are excited by the energy of certain ultrasonic vibrations. These vibrations are sensed by the detector and translated from their high frequency state to a low frequency state. The sound quality is maintained during this translation so the ultrasound is clearly heard in a headphone. Sensors are designed to receive both airborne and structure-borne ultrasound.

Treatment and Measurement of Signal

Ultrasonic or acoustic vibration is energy created by the friction between moving components (bearings, couplings,

gear mesh, etc…). This energy is really an AC voltage or current that is at best, highly unstable and erratic. To provide useful data for acoustic vibration monitoring this energy must be made linear for repeatability purposes. A quality ultrasonic detector uses True RMS conversion techniques to accomplish this. RMS means "Root Mean Squared." It's a way of measuring an AC voltage by means of taking the root of mean squared samples. Basically, True RMS measurement is a technique that provides consistent theoretically valid measurements of electrical signals derived from mechanical phenomena such as strain, stress, vibration, shock, expansion, bearing noise, and acoustic vibration. The electrical signals produced by these mechanical actions are often noisy, non-periodic, non-sinusoidal, superimposed on DC levels, and require True RMS for, valid, accurate, and repeatable measurements.

C Acoustic Vibration Monitoring

What is Acoustic Vibration Monitoring?

Bearings, good or bad, new or old, produce ultrasonic friction as the internal rolling elements turn against the inner and outer raceway. A good bearing will produce less acoustic energy than a bearing with typical wear flaws such as pitting, spalling, flattening of the balls, and scarring of the raceway. Likewise, the friction absorbing properties of grease means a well-lubricated bearing produces less friction than a bearing that lacks lubrication. As the lubricant's viscosity deteriorates, and/or the bearing's material composition stresses and fatigues, the friction and the corresponding ultrasonic emissions increase. Monitoring and trending high frequency bearing energy allows us to determine proper lubrication intervals and predict when the bearing enters its FIRST stages of wear.

Acoustic Vibration Monitoring vs Vibration Analysis

Ultrasonic inspection must not be confused with low frequency vibration analysis. Low frequency vibration measurements (velocity or displacement) indicate a bearing in an advanced state of wear and provide information about root cause of premature failure (misalignment, imbalance, etc…). Normally there is a smaller window of opportunity to schedule downtime since the bearing is already advanced to a failure state. High frequency acoustic vibration monitoring controls the evolution of the bearing, indicates necessary lubrication intervals, and triggers alarms before the bearing enters failure state.

The earliest indication of change means corrective action can be taken quickly to increase the machine's longevity. If one goal of predictive maintenance is to extend the lifespan of production machines then monitoring acoustic vibrations must play an integral role.

Remember that ultrasonic inspection controls and trends the evolution of bearing wear. It should not be considered a replacement for vibration analysis, rather an enhancement to any good vibration based predictive maintenance program. Because of the relative low cost of ultrasonic detection equipment, this technology is also an excellent choice for small and medium sized companies with smaller budgets dedicated to capital equipment.

D Trending Bearing Wear with Ultrasonic Detection

Establish a Route-Based Method of Data Collection

Today's ultrasonic instruments allow greater flexibility than instruments from only a few years ago. Smaller, more powerful electronic components allow for complex data storage and two-way communications with PC's. Proper acoustic vibration monitoring means establishing a route-based method of data collection similar to that of your vibration routes. Establish routes or groups of machines in a logical sequence and identify asset names to each measurement point for storage, trending, and time-based graphical representation of bearing condition.

Measured Value (dBmV) and its Correlation to Condition

At the outset, the goal is to establish a baseline or normal operating range for each bearing to be checked. Throughout the life of a bearing its ultrasonic level should remain relatively constant (+/- 3 or 4 dBmV). As the condition of the bearing changes, increases in acoustic energy due to either lubrication breakdown or structural breakdown will be observed. Increases correspond with an elevated reading (dBmV) on the instrument. Trending acoustic energy with data logger software allows the user to accurately predict when lubrication should be applied to a bearing, and when the bearing itself is entering early failure stages. Remember, trending acoustic vibration warns us of the earliest signs of change in a bearing. Diligent use of the information gathered results in better lubrication practices and extended bearing life. The desired result is a much larger window through which to schedule repairs and change outs.

To optimise ultrasonic inspection techniques it is essential to listen to the bearings; not just read the values on the display. Listening to the ultrasound of a bearing provides significant qualitative information that correlates to the measured values. A low, muffled smooth noise associated to stable values indicates a normal functioning bearing. A strident high-pitched noise indicates a lack of lubrication, an overload or a rotation speed beyond spec of the bearing. A crackling noise associated to unstable or high dB values indicates faults, wear or loose metal particles in the lubricant. Ultrasonic detectors provide an excellent quantitative measurement via the digital display, but do not ignore the qualitative information provided by the headphone output.

E *Ultrasound Detection for Your Lubrication Program*

Lubricant absorbs energy created by friction between the rolling elements of a bearing. Acoustic vibration is low when the bearing is properly lubricated but as the lubrication film breaks down this energy logarithmically increases; even though the bearing may not have any significant wear. An increase of 8 to 10 dBμV over historical baseline indicates a need for lubrication. This is confirmed by listening to the bearing's acoustic qualities in the headphones, or by viewing the waveform on a spectrum analyzer. Bearings lacking lubrication will sound louder, with a rough growl, compared to the relatively smooth whirring noises of a well-greased bearing. The waveform on an oscilloscope will show inconsistent peaks if the bearing is lacking grease.

Ultrasonic Detectors Can Tell Us When to Stop Greasing

An ultrasonic detector tells us when its time to grease, and also when its time to stop greasing. Some ultrasonic detectors offer a lube adaptor that attaches an ultrasonic contact sensor to any standard grease gun to permit listening and lubricating simultaneously. While listening to the bearing's sound quality in the headphones, begin pumping the grease gun, giving only one half* pump at a time. The sound quality changes as the grease reaches its intended destination. Re-take the dBuV measurement and compare. You will notice a change in amplitude once the grease reaches the bearing. Stop greasing. Re-take the dBuV measurement and compare. In most cases the sound level or dBuV will be lower than the original baseline. Again re-take the reading and store the new baseline for future reference. If, after the initial half pump of grease you notice an increase in the sound level stop lubricating and wait 10-15 seconds for the sound ultrasound level to stabilize. If it does not stabilize or decrease, stop lubrication the bearing.

**A grease gun is capable of producing 150 to 200 pounds per square inch of pressure. For this reason, we caution against ever using a full pump of grease to avoid over lubrication and creating unnecessary damage to the bearing, seals, and motor.*

If too much grease is applied the overage may enter the motor and cause a short, leading to a motor failure. In our experience you will hear a slight increase while lubricating (it may be after one or two, half pumps of grease). Some time may have to pass for the increase to settle down or lower. If it does not settle down stop lubricating. The balls may be pushed up against the raceway due too much grease being applied. By using half pumps with the grease gun instead of full pumps, we are trying to avoid this pressure build up. In most cases, using the half pump method and listening with ultrasound will avoid over lubrication.

We suggest that this be done to all critical motors at least once, and all other critical bearings that are not read by vibration because of slow speed or accessibility.

F *Conclusions and Summary*

The goal of any predictive maintenance program should be to arm yourself with tools that give you the best information to make an informed decision on the condition of your plant's production machinery. Ultrasonic detection enables us to hear the earliest signs of machine failure and lubrication breakdown; normally with a large enough window to act within the confines of a planned shutdown. Ultrasonic inspection is an excellent stand-alone technology for all maintenance departments wanting to start or enhance a vibration monitoring program. Vibration analysts will also reap immediate benefits by implementing acoustic vibration monitoring techniques to enhance their existing vibration routes. The more "good" information we can give ourselves, the better able we are to make the right decision about the relative health of our production machines.

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For more information about AVM™ Technology please contact:

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