Ultrasonic Testing Improves Power Plant Efficiency

At the Hawaiian Electric Company, experience has shown that ultrasonic examination can help to warn the maintenance staff of machinery problems, including those in bearings and valves.

An HECO technician demonstrates ultrasonic inspection using the UE Systems Ultraprobe 9000™

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"Power that elsewhere might cost $30-$50 a megawatt costs $300-$600 in California." -*The New York Times,* January 28, 2001

At the Hawaiian Electric Company (HECO), we have found that a well tuned predictive maintenance (PdM) program using time-tested technologies such as ultrasound, vibration analysis, tribology and infrared thermography greatly improves our efficiency. Energy losses and unscheduled downtime have been minimized. Production costs are down and productivity is up.

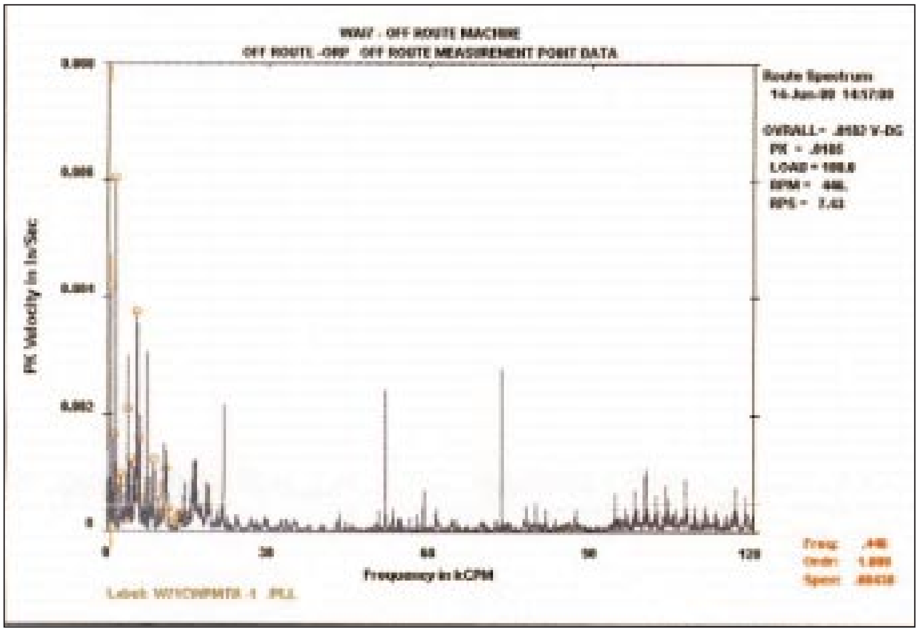
A public utility, HECO produces electricity for residential and business customers on the island of Oahu, Hawaii, U.S.A. The utility is comprised of three independent generating stations located in Honolulu, Waiau and Kahe with a total generating capacity of approximately 1,250 megawatts. HECO owns and operates several base loaded steam reheat units, cycling non-reheat steam units and gas turbine peaking units.

As a Predictive Maintenance Specialist, one of my responsibilities is overseeing HECO's acoustic maintenance program. This includes, but is not limited to, program development, setting up schedules, providing checklists of equipment to be inspected, and the acquisition and maintenance of test equipment. Operators then do the actual monitoring of the machinery. Bearings, valves and circuit breakers, for example, can be reliably inspected within hours. Lately, we have been conducting more frequent PdM inspections between each three-year overhaul.

Ultrasonic Inspection Confirms Bearing Faults

Just one faulty rolling element bearing can cause a generator to be derated or even shut down. This is why we routinely inspect them using vibration analysis. However, these standard tests for ball pass and other bearing fault frequencies do not always accurately portray what is happening within the bearing. This is because balls do not always roll—sometimes they slip—and fault frequencies are not always what they are supposed to be. To date, the only technology we have found to easily confirm rolling element bearing faults is ultrasonic inspection.

Our Ultraprobe 9000™ (manufactured by UE Systems, Inc., Elmsford, New York, U.S.A.) is a battery-powered, pistol-shaped device that weighs about two pounds. It contains circuitry that translates (hetrodynes) the high-frequency ultrasounds into sounds that are within the range of human hearing. The hetrodyned sounds are then fed through a pair of headphones to the inspector. A meter on the back of the detector displays the intensity of the sound waves in decibels and logs the information.



A graph of the sound spectrum produced by a bearing.

During a recent vibration survey of our rotating equipment, we suspected that we had a problem on a circulating water pump motor, but could not verify it. The circulating water pump moves seawater through a condenser, to provide the cooling medium to condense steam leaving the LP turbine. An inspector placed the ultrasonic instrument's contact probe on the bearing housing and heard a very distinct high-pitched squeal, a sure sign of a bearing fault. He submitted a work order and when the unit came down for an overhaul, the motor was pulled. We found railroad tracks (fluting) on the outer raceway, probably the result of a constant low current discharge through the bearing. Because of this, we inspected the shaft grounding brushes, which were found to be worn and making poor contact. The bearing and grounds were replaced during a scheduled outage, thus avoiding an unplanned derate, 100% risk condition and additional downtime.

Ultrasonic testing enables us to catch most potential failures before they happen. This cuts down on emergency call outs and having to pay overtime. Additionally, it helps us to avoid the inconvenience of taking a mechanic off another job and sending him out to repair the faulty bearing. It also helps us to gain control of our workload by giving us an early warning of impending failures, thereby allowing us to plan our shut downs, and get parts on order.

Indeed, ultrasonic inspection and monitoring of bearings is one of the most reliable methods for detecting incipient bearing failure. Experiments performed by NASA revealed that changes in frequency from 24khz through 50khz in a bearing gave warning long before other indicators such as heat and vibration.

The structural resonances of one faulty component, such as the repetitive impact of a ball passing over the pit of a fault in the race surface, produces ultrasounds. Faults are made evident by increases in amplitude in the monitored frequencies. Brinelling of bearing surfaces produces similar increases in amplitude as balls get out of round. The repetitive ringing of the flat spots are also detected as an increase in amplitude of the monitored frequencies.

As the ultrasonic detector reproduces the ultrasonic frequencies it detects as audible sounds, technicians must become familiar with the sounds of good bearings so that they can distinguish them from the sounds of bad bearings. Generally a good bearing makes a rushing or hissing sound. Loud, rushing sounds similar to those of a good bearing, only slightly rougher, indicate lack of lubrication. Crackling or rough sounds indicate a bearing is at its point of failure. In some cases, a damaged ball bearing makes a clicking sound which is detected by touching one of the ultrasonic instrument's probes to the bearing housing, and observing the changes in intensity displayed on the instrument's meter.

Bearing condition often can be plotted to failure by observing decibel increases over an established baseline. A more detailed analysis of bearing condition can be obtained by connecting the instrument to a vibration analyzer, or by using a special analysis software called SpectraPro, which may be downloaded from UE Systems' website.

Ultrasonics Pinpoints Leaking Valves: Listens in on High Voltage Circuit Breakers

On another routine inspection survey, our PdM team discovered a couple of boiler feed pump recirculation valves which were leaking. Ultrasound detected the problem, infrared confirmed it.

Inspection methods vary depending on the type of valve. Therefore, the primary rule is to be familiar with the details of your system, e.g. the way a specific valve works under specific conditions. To determine leakage or blockage, touch the ultrasonic instrument's probe upstream of the valve and reduce the sensitivity of the instrument until the meter reads about 50% of full scale deflection. If it is desirable to hear the specific sound quality of the fluid, tune the frequency until the sound you would expect to hear becomes clear. Next touch downstream of the valve and compare intensity levels. If the sound is louder downstream, fluid is passing through. If the sound level is low, the valve is holding.

Conclusion

The recent power crisis in California underscores the need to maximize plant efficiency and availability. Therefore, prudent power producers, with an eye toward lowering the cost of production, should not underestimate the financial and other rewards of an intelligent predictive maintenance program. With state-of-the-art technologies such as infrared and ultrasonics, monitoring the condition of equipment, scheduling repairs, and predicting equipment life need not be a daunting task. It is the responsible way to go. ■