Cooling Tower Application Study

By Peter Eitnier, Senior Application Engineer, Wilcoxon Sensing Technologies
with input from Ron Peterson, Reliability Specialist, Aux Sable

Wilcoxon SENSING TECHNOLOGIES

Part I – Motor Madness

Cooling towers are a critical component in many process facilities and contain several pieces of rotating machinery that contribute to their operation. Motors, gearboxes, fans and shafts require vibration monitoring to provide technicians with early warning signs of impending failures that could lead to catastrophic breakdowns. Such failures can result in lowered production, safety hazards and expensive repairs that can set a site back for months.

Aux Sable, a natural gas processing facility outside Chicago, Illinois, has experienced the benefits of vibration monitoring on their critical machinery for years. As far back as 2001, Aux Sable has monitored their cooling tower components with accelerometers from Wilcoxon Sensing Technologies.

The Wilcoxon Model 797, a standard 100 mV/g output accelerometer, was mounted on the drive-end (DE) of a motor directly coupled to an Aux Sable cooling tower fan. The motor operated at two different speeds, 1790 and 893 RPM. Over a three-year period from 2004 to 2006, the sensor tracked an overall vibration increase from 0.07 inches per second (ips) peak to 0.19 ips peak. While the vibration level did not trigger an alarm, which was set at 0.20 ips peak, the increase combined with an audible noise coming from the motor sparked Aux Sable's interest.

While investigating the issue on the motor DE, spectral analysis of the measured vibration signal showed a bearing defect that traced to the motor non-drive end (NDE) bearing, specifically relating to the ball pass frequency inner race (BPFI).

With this analysis, Aux Sable chose to pull the faulty motor in November of 2006 and replace it with a spare. The process was completed during a planned shutdown, and the motor was sent to a repair shop for inspection. As the vibration analysis indicated, inspection confirmed the motor NDE bearings defect and provided further root cause for the overall vibration increase.

The motor NDE bearing inner race defect damage can be seen in the top right photo. The outer race, seen in the bottom right photo, showed rust and corrosion caused by an improper bearing-to-housing fit.

The motor NDE bearing housing was also severely grooved at the bottom location due to the bearing outer race turning in the bearing housing. The rotor assembly showed signs of contact with the stator on the NDE as evidenced by visible wear marks. The rotor bars were visible through the rotor laminations due to contact on the NDE.

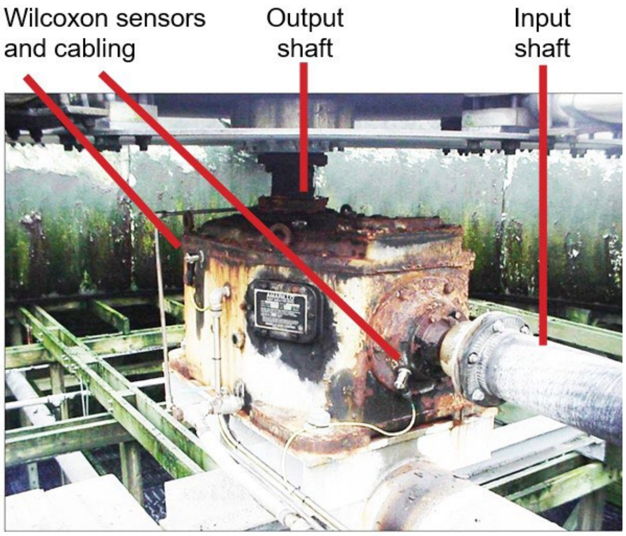
The machine shop was able to repair the motor in less than a month for under $5,000, a fraction of the $20,000 quotation for a replacement motor with a 10-week lead time. The technician who performed the repairs noted that the motor would not have lasted much longer before a catastrophic failure, which could have damaged the coupled fan and led to unplanned downtime or reduced production during peak demand.

By Peter Eitnier, Senior Application Engineer, Wilcoxon Sensing Technologies
With input from Ron Peterson, Reliability Specialist, Aux Sable

Part II – The Gearbox Grind

After dealing with the motor bearing issue in November of 2006, Aux Sable expanded their vibration monitoring program to include the cooling tower fan gearboxes. They mounted Wilcoxon accelerometers to each gearbox and ran cables from the sensors to a Wilcoxon enclosure mounted outside of the fan housing for convenient data collection.

Each gearbox was monitored on the input shaft, with speeds of 29.83 and 14.91 Hz, and the output shaft, which rotated at speeds of 2.13 and 1.06 Hz. Wilcoxon's 797L, with 500 mV/g sensitivity, was specifically designed for low frequencies and used to monitor the output shaft's low rotating speeds.



Vibration data was collected monthly from the enclosures and analyzed by the technicians. In October of 2008, the vibration trend showed a large increase and tripped a pre-programmed alert level. In addition to oil analysis from months earlier, which indicated abnormal wear on the gearbox bearings, the vibration analysis showed a bearing defect on the gearbox bottom output shaft bearing. The gearbox was replaced during a planned outage, and an inspection of the bearing confirmed what the sensors had been measuring. The image to the right shows extensive metal fatigue. Nearly 60% of the outer raceway had been eroded. All 21 of the tapered rollers on the bottom output shaft bearing and the output shaft inner race exhibited heavy corrosion damage.

Because vibration monitoring triggered a warning before the gearbox reached catastrophic failure, only the bearings and seals had to be replaced. All other major gearbox components, including the gear sets, were in good condition. The repair costs totaled just under $2,700, while a rebuild would have cost over $13,000 more. Furthermore, if the gearbox had run to failure and had not been replaced during a planned outage, the fan's unplanned downtime and reduction of cooling water may have caused a loss of productivity during peak demand.

Cooling Tower Application Study

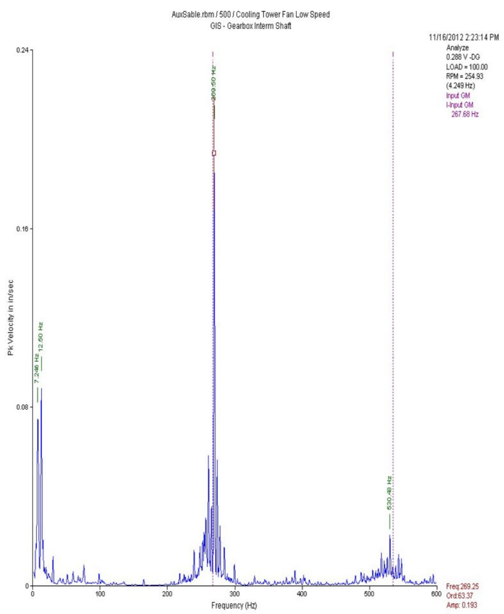
By Peter Eitnier, Senior Application Engineer, Wilcoxon Sensing Technologies
With input from Ron Peterson, Reliability Specialist, Aux Sable

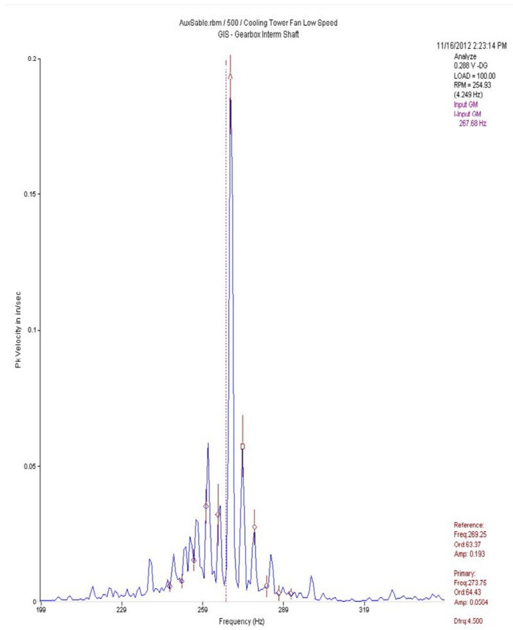
Wilcoxon
SENSING TECHNOLOGIES

Part III – New Gearbox, Continued Vibration Indicators

From January and November 2012, trending from a Wilcoxon sensor showed an overall vibration increase from 0.10 ips peak to 0.24 ips peak. Oil analysis showed that the oil level was normal and not related to the increase in vibration.

Vibration analysis indicated a spike in amplitude at the gear mesh frequency of 269 Hz. The graphs below represent the spectral data from the vibration sensors over the full frequency range (left) and the expanded troublesome spectrum (right). The expanded spectrum shows numerous sideband frequencies at intervals of 4.5 Hz, associated with the gearbox intermediate shaft speed. The amplitude was approximately 30% of the fundamental frequency, a moderate severity level.





A waterfall plot tracked over the year showed a continuous increase in the amplitudes of both the gear mesh frequency and sidebands. The gearbox was replaced with a spare at the first opportunity and repairs were made.

Wilcoxon Sensing Technologies
8435 Progress Drive
Frederick, MD 21701 USA

Tel: +1 301 330-8811
Tel: 1-800-WILCOXON
Fax: +1 301 330-8873

info@wilcoxon.com
www.wilcoxon.com
buy.wilcoxon.com

Cooling Tower Application Study

By Peter Eitnier, Senior Application Engineer, Wilcoxon Sensing Technologies
With input from Ron Peterson, Reliability Specialist, Aux Sable

Part IV – Monitoring Extreme Environments

After more than 10 years of operation in the cooling tower and being subjected to sulfuric acid, water spray, dirt and grime, the sensors were uninstalled and replaced. The image directly below shows the two sensors that came off the gearbox in 2012. The left sensor has been rubbed clean of most contaminants, while the sensor on the right appears as it did when it was removed from operation. Despite the harsh, wet and corrosive environment, both sensors still performed as they did at commissioning.

Paired with the R6Q(I) boot-style connector and Teflon-jacketed J9T2A cable, as seen in the image to the right, no contaminants penetrated the electrical wiring and the signal remained clear for the entirety of the sensor's lifetime.

With Wilcoxon's durable sensors, cables and enclosures, and Aux Sable's vibration analysis expertise, the company has avoided several catastrophic failures, coupled-equipment damage and unplanned downtime, to keep their cooling towers operational. Aux Sable continues to grow, extracting liquid fuel from natural gas across Canada and the Northern United States.