Detect Early Roller Element Bearing Wear with Proximity Probes

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Yes, you can detect early roller element bearings with proximity probes!

Rolling element bearings are one of the most often analyzed elements of any machine train. As such there are many tried and true methods for measuring the degradation of these bearings. But what of actual bearing wear? With typical applications, the internal tolerances of the machinery allow for the normal wear that predates the actual degradation. However with the more modern, higher tolerance precision machinery, minute amounts of bearing wear can cause significant internal damage if not detected early enough. This fact is especially apparent in rotary screw compressors. For example a .007” shift in clearance can translate into a $100,000 repair.

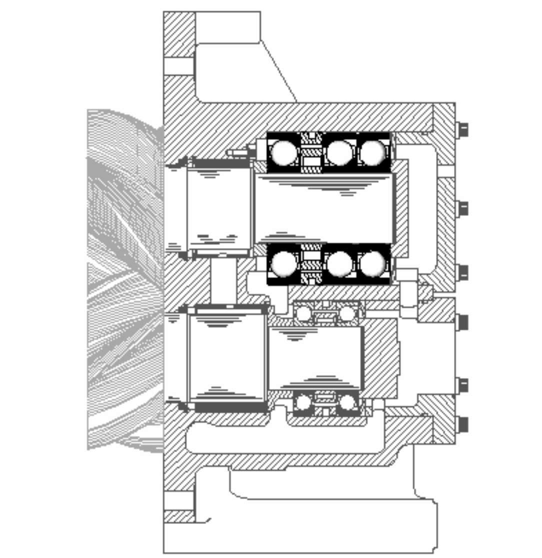

Figure 1 - Air compressor cutaway, courtesy of Ariel Corporation.

As mentioned there are many analytical methods for detecting rolling element bearings wear. The standard scheme is to employ vibration analysis techniques, and look for subtle changes in the FFT and time waveform. There are simpler and more robust methods available.

To better understand the dynamics of what is involved, let’s look at the standard wear progression of a rolling element bearing. There are four generally accepted phases of bearing degradation. First the bearing clearances start to loosen, yet all other indications are normal. There may be a measurable increase in ultrasonic energy, but the overall vibration will be low, and the amplitude of any bearing frequency information is negligible. Next there is a slight increase in emitted energy, in the form of noise and vibration. This is due to the flaking and spalling that are starting in the loaded zones of the bearing. As failure progression continues, the energy levels increase. At this stage in the bearing life there is perceptible damage within the bearing, with visible degradation and an increase in the amount of metal particles in the oil system. Late in its life the bearing exhibits a classic failure profile, with marked changes in the vibration and ultrasonic energy levels. Finally the bearing experiences complete failure.

To prevent these occurrences a typical industrial plant will have a crew obtain complete machine health information. Vibration analysis and oil sampling programs, handled by trained technicians, are useful in determining early stages of bearing wear.

Theories are great but what about real life?

Bearing wear is a major concern to the operators of modern rotary screw compressors. Principally if the bearing clearances open to a point where there is metal to metal contact within the unit, it can be a galling experience. Many of these compressors live out their life in a simple shed isolated from human contact. As such there becomes a defined need for an economical and simple solution to monitor these bearings and report the results remotely.

The Solution

Ideally if one could accurately measure the positional displacement of the rotating elements in relation to the static outer race the wear of the bearing could be measured. Although this seems to be a simple process, standard proximity systems don't have the accuracy or resolution to portray this shift in a 4-20mA loop. The standard API probe and cable assembly calls for an operating tolerance of 10%. With an 80 mil (.080) range, over 16 mA that tolerance can become a ± .38 mil/mA error. Additionally the system is allowed a ± 3 mil slope deviation. This system "looseness" will not allow the precision needed to accurately measure bearing wear displacement.

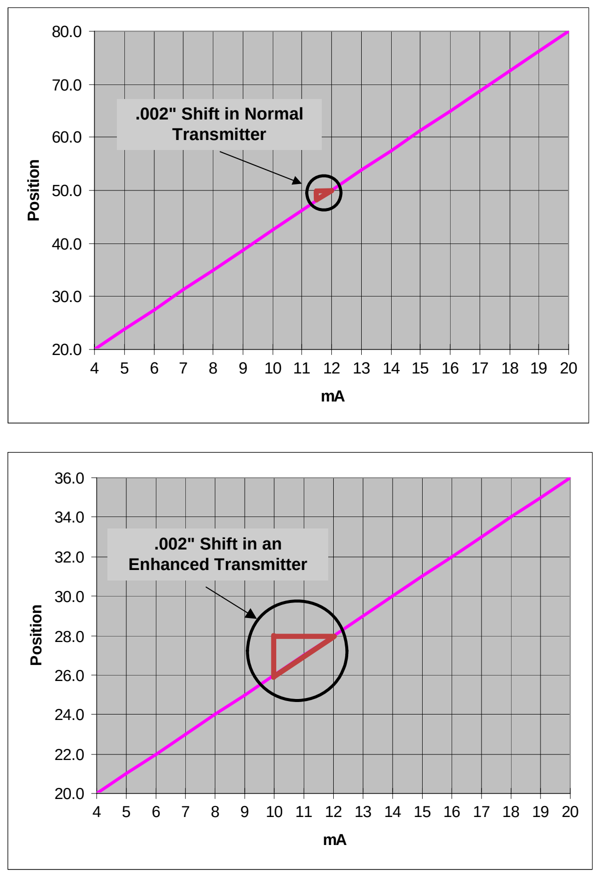

Figure 2 – Sensitivity differences.

A joint project between Ariel Corporation and Metrix set out to analyze this problem and to evaluate possible solutions. Enter the Metrix TXA transmitter. This device differs from a traditional probe driver / transmitter in that it is fully factory programmable. Therefore, the overall range of the system can be lowered to allow for substantially higher resolution. In addition, the electronics are calibrated with the actual probe and cable being used.

When the probe, cable and transmitter are calibrated as an assembly, the tolerance induced error drops to less than 1%, and the slope is within .00003". To further increase accuracy the system is calibrated using a target manufactured from the rotor end plate.

The engineers at Ariel had the foresight to install a ½” NPT opening in the rear cover plate on their screw compressors. This provided an excellent mounting location for a probe and holder. A system was installed on a compressor at the Ariel facility in Mount Vernon Ohio. Due to the design of the holder the initial set up was accomplished in less than 30 minutes. The rotor was cycled one revolution to insure the clearances were not violated in any way. It was noted the system accuracy was such that engineers could measure the end plate run-out at .0015”! As the run-out is a sinusoidal function, the effects will be averaged out at machine speed.

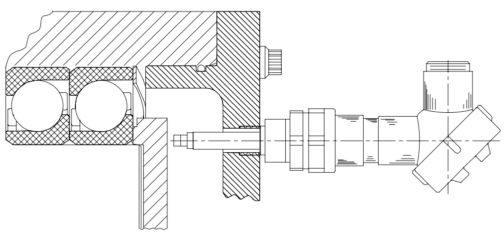

Figure 3 - Proximity probe installed on compressor.

To prove the systems effectiveness engineers placed a series of .003” shims around the periphery of the end plate containing the probe holder then tightened the bolts to the proper torque. This allowed engineers to simulate the small movements that would be seen by the probe. These movements were witnessed on the 4-20 display. The shims were then removed, and the change in dimensional distance compared to the PLC readout.

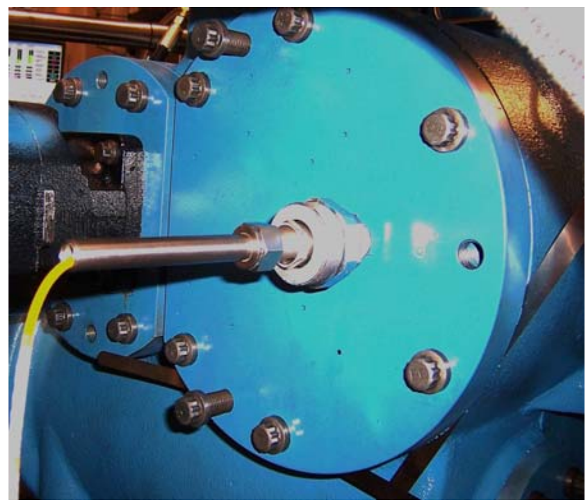

Figure 4 - Test setup

Bench testing comprised of installing the probe into a micrometer assembly or commonly called a static calibrator. The resolution was checked and proven quite accurate and repeatable.

Figure 5 - Micrometer assembly or “static calibrator”

For field trials several units were installed in compressors residing in the rugged area of Western Canada. Although early in the testing stage, initial results are very promising. Additional tests are being conducted in the labs at Mount Vernon.

Conclusion

With the sensitivity enhancement and the components being calibrated as a system, this robust measurement system will allow users to see the minute changes forecasting bearing wear. This measurement method will provide an economical and viable means of machine protection.

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