

Nuclear Pump Bearing Testing

using the ZonicBook

Application Summary

Nuclear power plants depend on electric motor-driven pumps to circulate coolant through a closed system of pipes to help dissipate excess heat. These machines, called reactor coolant pumps, RCPs, must be monitored continuously to ensure dependable operation. RTDs located on the pump's bearings measure temperature and send the signal to an automatic alarm and control system that quickly alerts operators of any change in status. RCP bearings are likely suspects for failures, which could delay power production and cause the plant to lose significant revenues. One failure mode is a bearing seal that leaks lubricant and can become a fire hazard. Because of their importance, RCP bearings are a high priority component to watch, and usually, multiple sensors serve each bearing to provide a certain amount of redundancy.

Because issues with bearing seals have been a reoccurring problem in numerous nuclear power plants, the Nuclear Regulatory Commission (NRC) has issued a multilevel procedure for powering down the facility when it crops up. One company has gone even further by initiating a special program to research the cause of seal failures and develop a method for testing thrust-bearing seal leaks outside of the machine. It is a simulator composed of a test stand that accommodates a large motor and bearing assembly, hydraulic actuators that place an external, vertical and horizontal stress on the bearing shaft, and a data acquisition system for monitoring temperatures, forces, pressures, oil flows, and vibration in the motor and bearing.

Potential Solution

Stress analysis engineers at a Pittsburgh, PA based consulting firm, were assigned the project to design and develop the test stand and appropriate instrumentation. The consultants had several dual-channel data acquisition systems from which to choose, but the design eventually called for more than 50 channels of simultaneous data collection. Clearly, they had to find a compact data acquisition system capable of handling that many channels and flexible enough to accommodate a wide variety of sensor types.

IOtech's Solution

After investigating several possible systems, the consulting team selected the IOtech ZonicBook for the application. Although it was the first IOtech system they had experience with, their Mechanical Engineer learned how to use it in less than a day. The data acquisition system let him connect 56 channels with a mix of sensors that included RTDs, flow sensors, pressure sensors, tachometers, and proximity probes.

The Mechanical Engineer worked with a thrust bearing assembly that weighs about 12,500 lb, and measures three feet high by five feet in diameter. The test stand also contains a 500-hp motor coupled to a 600-hp electronic drive and a thrust bearing assembly. The system contains hydraulic cylinders that apply vertical and horizontal thrust to the bearings to simulate loads. The vertical thrust loads are 100,000 to 177,000 lb, and the side loads range from zero to about 700 lbf. The thrust load is controlled over a range of 170,000



Stress analysis engineers at a Pittsburgh, PA based consulting firm built a test stand to analyze nuclear reactor pump bearings. The stand supports a 500-hp motor, a 600-hp electrical drive, and a bearing assembly. Means are provided for applying both horizontal and vertical loads to the bearing assembly to simulate extreme stresses, temperatures, and loads that could be expected when the bearing seal leaks lubricant, or when the bearing simulator fails for other reasons. The ZonicBook records these variables, and with the help of eZ-TOMAS software, analyzes the data that can predict a possible failure.

to 102,000 lbf as the shaft runs up to operating speed. The shaft ramps up from zero to 1190 rpm in 16 seconds and down in five minutes to simulate actual field-spin times. The bearing reservoir contains view ports in the top cover and sidewalls and features that accommodate thermocouples, pressure and flow sensors, three borescopes, and five cameras.

“The original design called for about 20 sensor channels,” says the Mechanical Engineer, “but it expanded to 56 channels as the project developed.” Six WBK18, 8-channel dynamic signal conditioning modules were added to the ZonicBook to expand the channel count, as well as two DBK84 thermocouple modules to handle multiple temperature channels. “The ZonicBook and

ZonicBook/618E

Vibration analysis and monitoring has never been easier than with the ZonicBook/618E and eZ-Series analysis and monitoring software. The ZonicBook leverages 30+ years of experience providing vibration measurement solutions. The ZonicBook hardware is the signal conditioning and acquisition engine, while the eZ-Series software in the PC defines the specific analysis and monitoring features of the system. The ZonicBook's

architecture makes expansion beyond the eight built-in channels less expensive than other suppliers. You can expand the ZonicBook in 8-channel increments up to 56 channels, and each additional 8 channels are approximately one third the cost of the first 8 channels. All channels in a ZonicBook system are measured synchronously, providing 1 degree phase matching between channels.

Features

- Eight dynamic input channels, expandable up to 56 channels
- Four tachometer channels for rotational measurements
- High-speed Ethernet connection to the PC for continuous recording
- Four eZ-Series software packages address a wide variety of vibration monitoring and analysis applications
- TEDS support for accelerometers

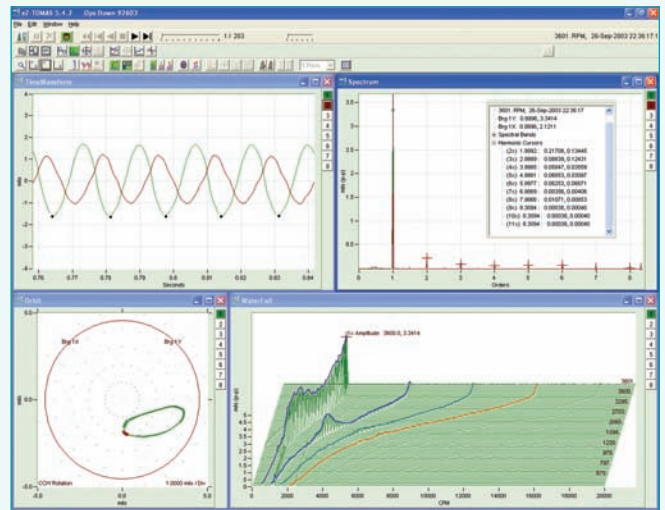
Software Overview

Four software packages are available for the ZonicBook, each tailored to a particular vibration measurement and analysis application. Choose the package that suits your application now, and upgrade to additional packages as your requirements evolve.

- **eZ-Analyst** provides real-time multi-channel vibration analysis, including overlay of previously acquired data while acquiring new data, strip charts of the throughput data files, cross channel analysis, and direct export to the most popular MODAL analysis packages, ME Scope and Star Modal.
- **eZ-TOMAS & eZ-TOMAS Remote** are highly sophisticated, yet easy-to-use tools for the monitoring and analysis of single or multiple machines, which allows the user to assess the reliability and operation of his process, and the critical machines pertaining to his process.
- **eZ-Balance** is used to balance rotating machinery with up to seven planes. A balance toolkit, including Split Weight calculations, supports the balance process. The balance vectors are displayed on a polar plot so the user has a visual indication of the improvement. Time and spectrum plots show detailed vibration measurement during the balance process.
- **eZ-NDT** package is exclusively used in production applications to determine the quality of composite-metal products at production rates of 1 part per second.



The ZonicBook/618E with eZ-Series software and your PC makes a real-time, portable vibration analysis monitoring system



View Time-Domain, Spectrum, Waterfall, and Trend simultaneously on one screen with eZ-TOMAS

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expansion modules worked out extremely well for us because they are flexible enough to handle the wide variety of variables in our customers specification," says the Mechanical Engineer. "We could monitor the data in real time and track changes as they appeared." The parameters measured included pressure from 0 to 60 psig, temperature from 80° to 350°F, and shaft speed from zero to 1190 rpm.

In addition to the original specification, proximity sensors were added to measure vibration and the axial position of the shaft and sensors to measure the oil level. Hydraulic cylinders were installed on mounting collars to apply side loads to the bearings and thrust runner reaction bearings to apply vertical loads. Load cells were installed on these actuators to measure the amount of force applied to the bearings.

"The simulator stand had to be compact," says the Mechanical Engineer. "We built a single control panel to contain the ZonicBook, signal conditioning modules, computer, TV monitor, and digital video recorder." The consulting firm also used the IOtech

DBK48 signal conditioning module containing NDT relay outputs to shut down the motor in the event of an over-temperature or over-speed condition, excessive vibration, low oil level, or excessive vertical or horizontal thrust.

"The eZ-TOMAS software supplied with the ZonicBook was easy to use and let me construct Bode plots of the vibration," says the Mechanical Engineer. "We were able to commission the system and turn it over to the customer within three months, and we taught its engineers how to use both the software and hardware in less than a week."

Conclusion

ZonicBooks are used to monitor the bearings in reactor coolant pump simulators. Thermocouples measure the bearing temperature, proximity sensors measure vibrations, and the software generates Bode plots, which give the vibration specialist a means to detect and analyze bearing failures easily and repair them quickly.