Compressor Testing

using the ZonicBook

Sometimes a product test that invalidates a suspected cause of failure can be just as valuable as a test that confirms a failure mode. Such was the case for a hydrogen reciprocating compressor test intended to discover a failure called "wiped" wrist-pin bearings, a condition where the bearing surface shows excessive, premature wear from the wiping action of the journal. The new compressor appeared to behave normally during short, startup test runs and gave no obvious outward sign that the bearings were in the process of being damaged. The maintenance personnel found the wiped wrist-pin condition when the machine was disassembled after the test runs. If the condition was not discovered at that time, the machine could have suffered more severe damage such as a broken connecting rod.

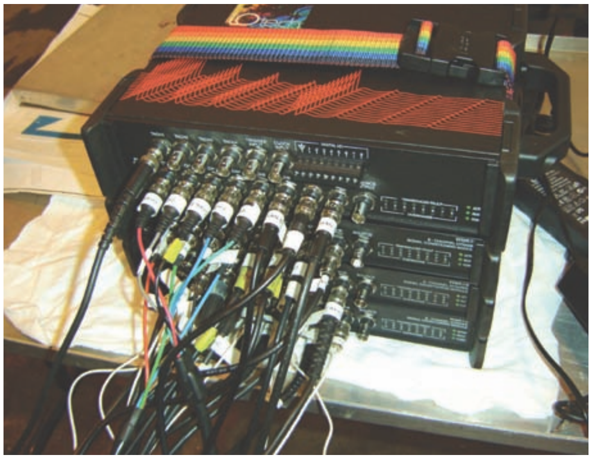
Watching a Prime Suspect

Engineers decided to instrument the compressor to collect data that would help them identify the root cause of the wrist-pin bearing failures. They used strain gages and pressure sensors. The compressor manufacturer was looking for crankcase twisting or other possible deflection problems. Concurrently, Ken Singleton, manager of KCS Consulting, Bristol, Va., was hired to measure compressor vibration and analyze operating deflection. He connected an IOtech ZonicBook/618E and three expansion modules with 32 channels to measure data from accelerometers located around the compressor and a once-per-revolution phase reference signal from the crankshaft.

The number of data channels eventually totaled about 100, which included the OEM's and plant site analyst's sensors. Singleton used IOtech's eZ-Analyst for data acquisition and ME'scopeVES software to calculate the operating deflection shapes (ODS). The software includes a drawing module that lets him develop 3D models in which the data, either modal or ODS, can be mapped and animated. First, data were collected during no-load and then full-load conditions. After the compressor was thermally stable, data were measured to develop the ODS model. This procedure let Singleton inspect the vibration modes of the crankcase and cylinders at different frequencies between 0.50 Hz and 1000 Hz with about 0.25 Hz resolution. Other forms of data were also calculated which included coherence and phase.

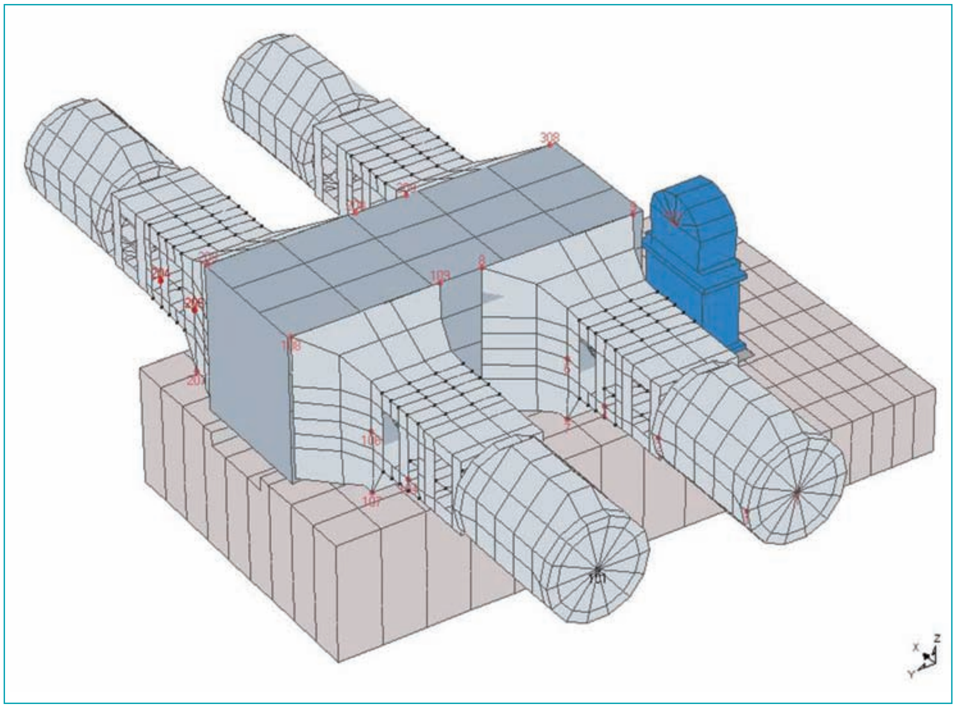
Reducing the Data

After the data are imported to ME'scopeVES, they must be "curve-fit." Several methods are used to fit the curve, including "peak fitting." This approach uses two cursors to enclose a narrow band of data in the frequency domain. The peak fit finds the highest amplitude frequency and its associated phase. These data are then used to animate the 3D model.



The ZonicBook/618E with expansion modules and a laptop computer collect vibration data during start up and full load to develop a 3D operating deflection model or ODS

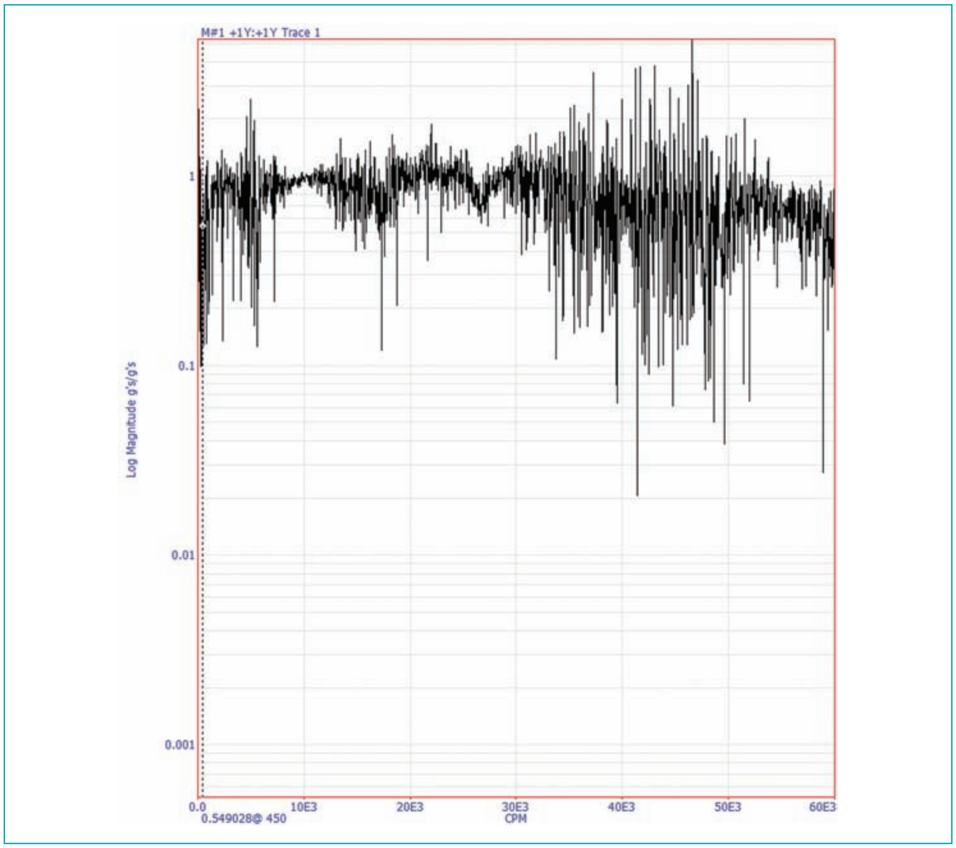
Transmissibility data for developing the operating deflection model or ODS comes from cross-channel, accelerometer measurements with units of g/g. The data represent the relative amplitude and phase between an accelerometer that remains fixed throughout the test, and one or more roving sensors that are moved to different locations on the structure under test. The fixed sensor establishes a reference point, and all other vibration frequencies are measured with respect to this reference. The roving sensors measure vibration at other various points on the machine. These points are called degrees of freedom or DOF. The DOF are laid out in a mesh pattern on the machine or structure and match the 3D model. The cross-channel data are measured at each DOF, imported to the ME'scopeVES software, and then curve-fit. The curve-fit data are used to animate the 3D model. The motion of the 3D model can then be analyzed to understand how the machine or structure is moving or vibrating at a specific frequency. Also, the structure can be animated in the time domain to view the complex motion.



The ODS is depicted by a mesh model labeled with the accelerometer and DOF sites. The cross-channel data are measured at each DOF, imported to the ME'scopeVES software, and then curve-fit. The curve-fit data then animate the 3D model.

The Illuminating Results

Singleton's test results showed that the compressor housing deflections were within specifications and not the most likely cause of the wrist-pin bearing failures. The ODS model in ME'scopeVES showed the expected vibration motion of the compressor cylinders and frame under no load. At full load, the ODS showed the approximate shapes of the natural frequencies of the compressor that were being excited. Engineers then investigated other possibilities, which included insufficient bearing lubrication and overloading. The engineers concluded that the root cause of the problem was insufficient oil film development in the bearings. They modified the machine to solve the problem, and subsequent operation and inspection showed that the bearings were no longer being damaged. Fortunately, costly downtime and maintenance charges were minimized by eliminating frame flexure and misalignment as possible causes for the failure early in the investigation and analysis process.



This is an example of transmissibility data from the reference DOF output. The signal is plotted on a log/linear scale, where the magnitude in g/g is shown on the vertical log scale and the frequency is on the horizontal scale.

Conclusion

A new, large hydrogen compressor was found to have wiped wrist-pin bearings, a premature failure mode, during startup testing. The compressor was instrumented with accelerometers to record suspected excessive vibrations that could be used with ME'scopeVES software to simulate and animate any housing deflections in 3D. The vibrations were found to be within tolerance, and subsequent investigations uncovered a lubrication problem that was solved and verified in succeeding test runs. Early elimination of suspected vibration problems substantially reduced the cost of an otherwise long-term investigation and analysis.

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

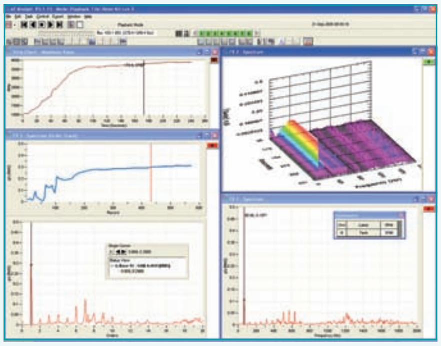
- 8 dynamic input channels, expandable up to 56 channels
- 4 tachometer channels for rotational measurements
- High-speed Ethernet connection to the PC for continuous recording
- Four eZ-Series software packages address a wide variety of vibration monitoring and analysis applications
- TEDS support for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

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

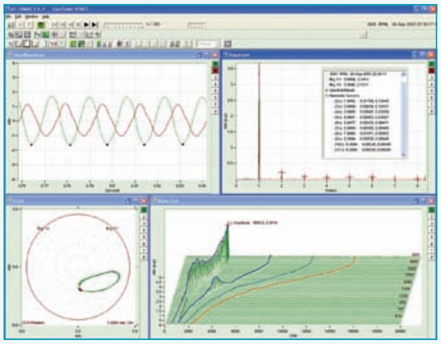
Software Overview

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** provides on-line vibration recordings, limit checking, storage, and analysis of rotating machinery. Order track, Waterfall, Orbit, Polar, Bode, Spectrum, and Trend displays show machine startup or shutdown events, as well as diagnose long-term changes in machine health.
- **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.



eZ-Analyst adds real-time continuous and transient data acquisition in the time, frequency, or order domain



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