TROUBLESHOOTING, VIRTUALLY

AUDIO-VISUAL COMMUNICATION OVER THE INTERNET FACILITATES PROBLEM SOLVING OVER LONG DISTANCES

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In the second half of 2005, an Asian power plant was experiencing high vibration and cracking in the exhaust hood of one of its steam turbines (Figure 2). The typical troubleshooting approach in such situations is to travel to the site of the machinery, collect the data, analyze it at the home office, and provide a specific solution.

However, the plant was under a tight schedule constraint, and the traditional approach would not have worked to the advantage of the operator. Further, the power plant is located in an area threatened by insurgents and the bird flu epidemic, making it hazardous for third-party consultants in the U.S. to travel to the site.

Instead, the required testing and analysis equipment was shipped to the plant. Along with the equipment, video cameras were also shipped. Under live supervision over the internet (Figure 1) operators performed the testing and collected the data. Analysts, sitting in the U.S., suggested a solution that was then executed by the operators. The entire troubleshooting was performed remotely, using the internet.

Equipment shipment took a month. The monitoring by plant personnel took about a week, similar to the typical time frame, with some additional time due to the lack of experience on the operators' part and occasional communication lapses.

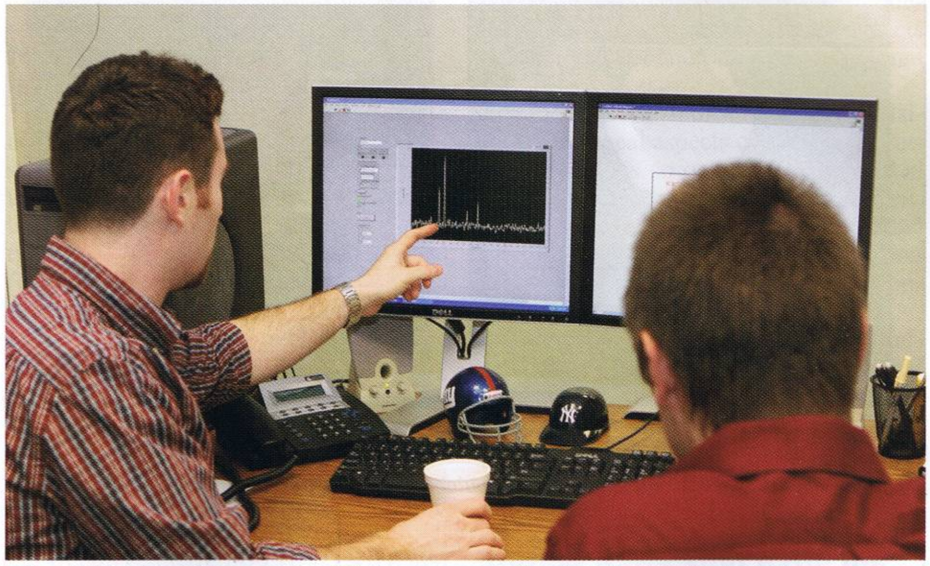

Figure 1: The internet can serve not just remote operation, but also troubleshooting

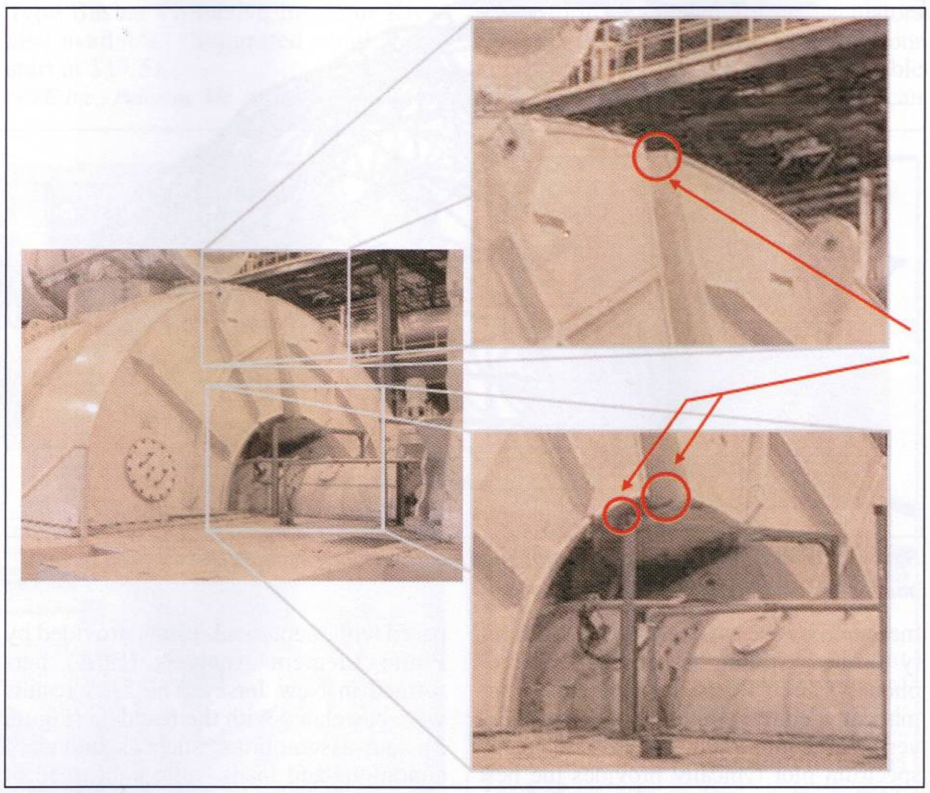

Figure 2: Exhaust hood cracking created reliability and safety concerns

Distance does not matter

The cracks in the exhaust hood of the steam turbine led to a drop in efficiency, lowering plant output from 660 MW to approximately 500MW. There were safety concerns over possible vacuum leaks. The cracks could have propagated, leading to a potential safety hazard.

Test instrumentation including signal analyzers, data acquisition computers, accelerometers, pressure transducers, strain gages, an impact hammer, and shaft-rider sticks were packaged and shipped to the job site. An Internet Protocol (IP) telephone and camera were also shipped to allow inexpensive visual, as well as continuous verbal communication with the site in real time. The test hardware was installed by the plant's local personnel, under careful oversight from 12,000 miles away by Mechanical Solutions, Inc. (MSI) in Whippany, New Jersey.

The troubleshooting process was implemented by plant personnel, guided step-by-step by specific instructions provided in real time. Visual and voice communication was accomplished without interruption, by using the camera and IP phone. Staff from MSI remotely controlled the Fast Fourier Transform (FFT) 40-Ch analyzer — a key instrument in vibration data collection and analysis.

Vibration signals (velocity, acceleration, and displacement) versus time were

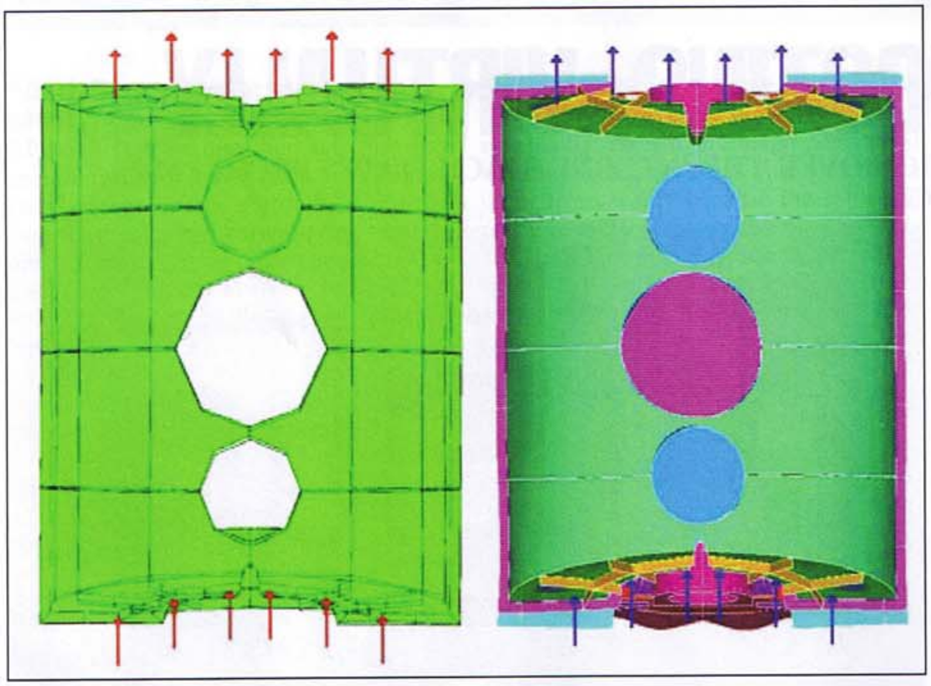

Figure 3: Remote test data applied to the computer generated model (left) vs. Finite Element Analysis results (right).

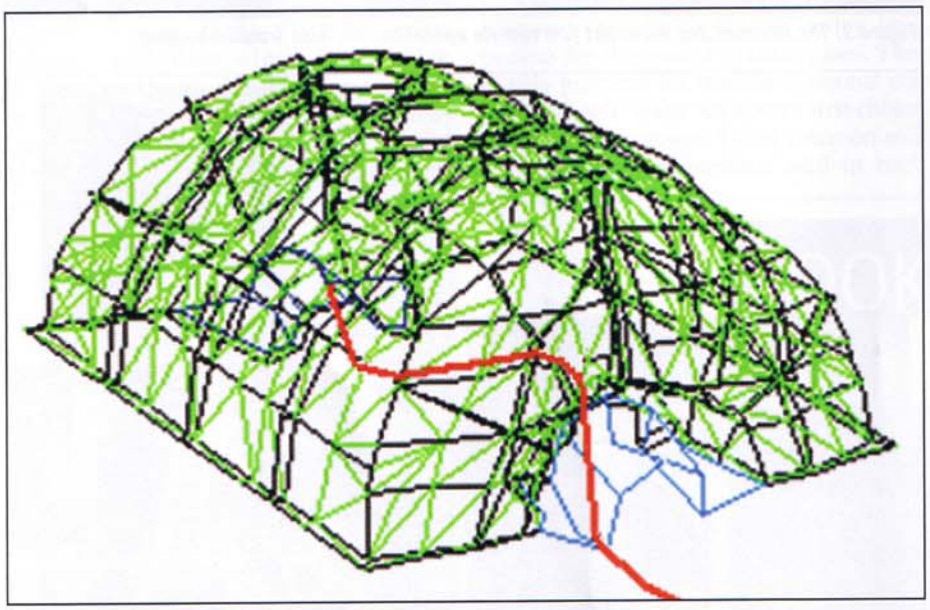

Figure 4: Operating Deflection Shape (ODS) and modal test data showing exhaust hood (green), bearing housing (blue), and shaft (red) motion

measured by the accelerometers, proximity probes, straing gauges and microphones. The FFT is an algorithm that automatically converts the signals measured versus time into a signal-versus-frequency spectrum plot typically provides the best indication of specific problems. While the signal-versus-time plot is still very useful, especially to vibration experts, the signal-versus-frequency plot is ubiquitous. This plot is made quickly and easily by analyzers that use the FFT algorithm. The FFT analyzer and data recorder was linked using broadband internet through a high-speed satellite connection.

Remotely collected data was compared with theoretical results provided by Finite Element Analysis (FEA) performed in New Jersey. The FEA results were correlated with the test data (Figure 3), and assumptions, such as boundary conditions and loads, were confirmed or adjusted until the theoretical predictions matched the actual behavior. The resulting "calibrated" analysis was able to be used to analyze potential fixes, such that solutions could be recommended and installed with confidence.

Remote test data from the exterior of the machine, and on the shaft within the bearing housings, were combined with a calibrated companion model. This helped vibration experts to "look inside," the machine since test probes in this area were too expensive or impractical. This approach helped to determine complete rotor behavior in concert with the structural motion.

Finding a solution

The combined test and analysis model indicated there was a serious running speed resonance of a natural frequency of the exhaust hood with synchronous motion at both ends close to 50 Hz. This was coupling with an unexpected S-shaped rotor natural frequency, also near 50 Hz (Figure 4).

Excessive misalignment was driving the rotor mode, which was driving the bearing housing. This in turn drove the exhaust hood casing motion, and the swaying structural motion inertially reinforced the rotor second bending (S-shaped) mode shape, completing the problem cycle.

The ends of the exhaust hood were stiffened by adding additional support ribs and bolting thick metal plating across the casing ends. The ribs were manufactured as per geometrical information supplied from the analysis.

The vibration was dramatically reduced, and the cracking stopped. Trial-and-error problem solving was avoided. The remote approach allowed a quick response, while minizing travel-related costs. TI

Author

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