TROUBLESHOOTING THE FLUID DRIVE
OF A BOILER FEED PUMP

William Marscher and Eric Olson, Mechanical Solutions Inc

A boiler feed pump (BFP) driven off of the main steam turbine via a fluid drive was experiencing high vibration levels, leading to frequent replacement of the fluid drive bearings. The power generating plant depended on the single BFP for power production. Normal plant operation required the BFP and fluid drive output shaft to operate from 2,000 rpm to 3,500 rpm.

foto: Sulzer, boiler feed pump

Test results from Mechanical Solutions Inc. (MSI) allowed the end-user to modify the plant's operation slightly in order to more reliably continue power production until permanent fixes that were recommended, could be implemented during a future planned outage.

Test combination

MSI's field testing was a combination of impact modal testing as well as operating forced response testing. Data for each of these tests was acquired at approximately 125 locations on the fluid drive, pump, front standard and foundation. The impact modal testing was used to determine the natural frequencies and mode shapes of the vibration while the plant operated. The operating forced response test data was used to produce the operating deflection shape (ODS) of the pump and drive assembly (Figure 1). A detailed ODS of the type that MSI performs shows the relative motion (amplitude and phase) of each portion of a structure at a given frequency, and typically provides valuable insight into the problem sources and their relative importance. MSI also used shaft rider sticks to investigate for a possible torsional natural frequency in the machinery train.

Operational testing

The operational testing indicated that the high vibration levels occurred at 60 hertz (Hz), and were primarily on the input end of the fluid drive and the front standard, peaking at a fluid drive output shaft speed of 2,500 rpm (42 Hz). However, the vibration levels on the output shaft were much higher at 60 Hz than at 42 Hz. The conclusion was that the high vibration levels at 60 Hz were primarily due to a torsional critical speed of the rotor system, which was able to "tune in" to 60 Hz as a function of the amount of oil in the fluid drive. The torsional stiffness of the fluid drive controlled the output shaft speed, which is why the vibration level appeared to be related (but indirectly as it turned out) to the output shaft speed. In addition, a structural natural frequency of the fluid drive bearing pedestals at about 64 Hz was clearly identified via ODS and modal testing. The rotor/structural combined vibration led to severe deterioration of the foundation below the fluid drive, to the point where the ODS and modal analysis animation showed that the sole plates were no longer integrally connected to the foundation, further magnifying the system vibration as is evident in Figure 1. The bearing pedestal natural frequency and foundation separation amplified the overall system shaking at 60 Hz, but the torsional critical speed was the root cause of the problem.

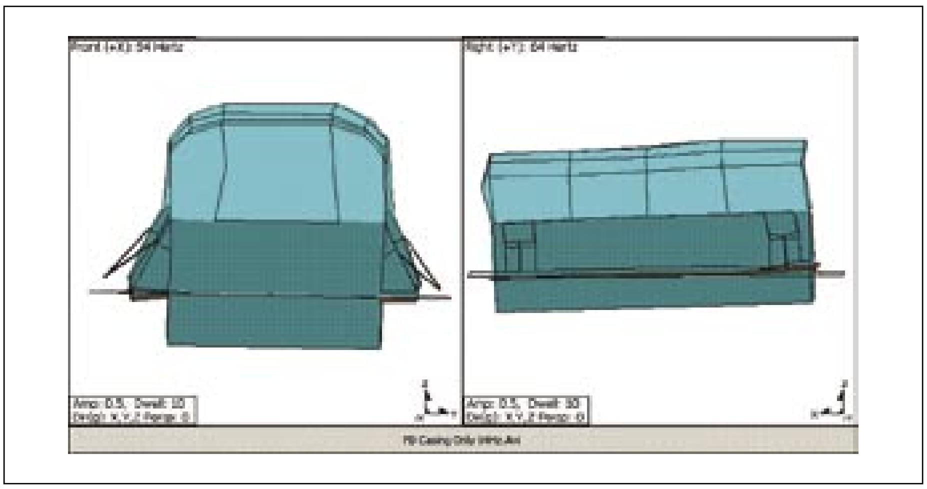

Figure 1: freeze-frame picture from an exaggerated-motion animation of the modal "bump" test performed while the pump train operated. Note the motion of the base of the fluid drive and sole plates relative to the concrete foundation.

New strategy

The plant had to remain operational; therefore, a long-term fix involving the foundation was not a near-term option. To maintain power production, the customer used MSI's results to establish a strategy of avoiding fluid drive operation at 2,500 rpm to limit rapid bearing wear/failure and front standard deterioration. Permanent fixes to the foundation, along with modifications to the coupling and other shaft components to shift the problem torsional frequency, were laid out and planned for a future outage. <<