Mechanical Solutions, Inc.
Rotating Machinery Analysis, Test & Troubleshooting

Case History: 425 MW Steam Turbine Commissioning

MSI was called on behalf of an engineering construction firm building a new power plant in the Southern Hemisphere. The plant was only weeks away from the commissioning deadline, after which hundreds of thousands of US$ per day liquidated damages would be due. The plant consisted of two 425 MW steam turbine/ generator sets, the first of which had been commissioned without a hitch. The sister unit, however, which was nominally identical in all design details including the piping and foundation, tripped out at the first critical speed every time the OEM tried to bring it up to operating speed.

The vibration was almost entirely at 1x running speed and the OEM had assumed that the issue was simply one of appropriate balancing. However, the addition of balance weights, based on information at low speed and at a speed just below where the unit tripped on start-up, was not making any progress, even after 10 trials. The OEM concluded that the problem was not balancing after all, but rather some machining error or other internal anomaly which could only be determined by full disassembly of the unit in the field, with subsequent repair at the OEM shop. Unfortunately, this path would lead to many weeks, and perhaps months, of schedule slippage, at enormous contract cost.

MSI used its 14 channel B&K Pulse Spectrum Analyzer/ Digital Recorder to monitor proximity probe, bearing housing, and casing accelerometer signals simultaneously. It was determined that no internal rub was taking place, although a mild rub on the HP outboard bearing was indicated. In addition, the shaft orbits suggested that both of the HP bearings were misaligned, such that the shaft was constrained from developing a roughly circular orbit, but was forced instead into a highly elongated

orbit. Furthermore, an inconsistent and roughly 20% shift in the HP first critical speed was observed as the shaft approached the trip point, such that the phase angle of the vibration response (as related back to the keyphasor) would vary considerably at any given speed in the trip zone.

MSI concluded that the bearing misalignment situation was leading to significantly different bearing stiffness than the turbine was designed for. However, the transient thermal growth of the rotor and casing made the bearing "pinch", and therefore the critical speed shift, different from one run-up to the next. This meant that basing the balance correction weight angular positions on the phase information from one run, generally would not hold true for what was required for proper balance in a succeeding run. Therefore, although working with the OEM balance team MSI was able to get through the first critical speed in only two trials using an influence coefficient approach, MSI also advised that balancing efforts could not come close to spec until the bearing problem was fixed.

Based on these findings, MSI firmly recommended a week long shut-down for inspection and repair of the HP bearing installation. The OEM felt that this was a waste of effort. However, it was discovered that the HP outboard bearing had been installed horizontally cocked, forcing the shaft out of the intended operational position on the bearing fixed central pad, and into the center of the anti-whirl pocket, greatly shifting the bearing k. In addition, the HP inboard bearing pedestal was found to be cocking during the start-up thermal growth, because of accidental mis-placement of one of the thick shims between the casing and the bearing pedestal. Fixing of these bearing issues eliminated the critical speed shifting near the original problem speed, and allowed balancing to quickly progress. The disassembly of the turbine was avoided, and the rigidly-coupled machinery train was brought fully within the ISO-7919 vibration specification, one week prior to the initiation of contract liquidated damages.

Recent other steam turbine projects that MSI has performed include design audits of re-rates, blade and bladed disk natural frequency resonance identification and fix, an impulse stage shroud failure fix, field test identification of rotor critical speeds without unit shut-down.

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