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

Case History: Plant Expansion / Revamp Evaluations

South American New Refinery Process Compressor/ Gas Turbine Train

A major South American petrochemical company involved in building a new refinery purchased their required turbomachines (four complete trains of three compressors and a gas turbine each) and peripheral equipment (gear sets, valves, lubrication systems, anti-surge systems, compressor controls, etc.) from foremost manufacturers around the world. However, they decided that their several hundred million dollar investment might be jeopardized unless someone was assigned responsibility for analyzing how the entire system interacted, throughout all reasonably possible operating conditions. MSI was retained as a third party to perform this function, analyzing the linked compressors and turbine for torsional response, analyzing the steady and transient system coupled mechanical/ fluid dynamic/ control system response, and analyzing the lubrication system adequacy per API specifications and "good practice". Many hours of senior level engineers, as well as supporting staff, were going to be required by such an analysis, but the company felt that this was necessary as insurance against start-up problems in this expensive venture.

The machines and peripherals themselves were found to be without fault, and generally in full compliance with the purchase specifications. However, it was discovered that the anti-surge valve in one of the three compressors in the train had insufficient capacity in certain operating conditions, and likely would have plagued the train with surges and associated trips, and possible bearing and shaft damage from the first day of operation. This problem, however, was minor compared with the discovery that the post-trip oil feed reservoir was sized to provide oil for only seven minutes following a system trip. Analysis of the combined train rotary inertia, including the massive gear sets and couplings, versus the frictional losses during coast-down showed that coast-down from full speed would take at least ten minutes. Both of these problems were able to be avoided very inexpensively during the design stage, but could have involved enormous cost later. In the case of the inadequate lubrication supply, the source of the likely catastrophic failure would have been very hard to track down and prove. Along with the lost maintenance time and production profits, this might have spawned warranty collection problems with several of the manufacturers. Even worse, once the system was re-built, the root problem might never have been solved.

Centrifugal Pump/Steam Turbine/ VFD-Motor Torsional Analysis and Rotor Modification

A series of centrifugal pumps were to be purchased and installed in a petrochemical plant in Taiwan. Prior to purchase, the user contracted MSI to perform a complete mechanical design evaluation, including rotor dynamic, torsional critical speed, and rotor forced response analysis. In addition, the pressure-carrying capability of all casings at full and part load was to be assessed. Some of the pumps were driven by motors through variable frequency drives (which have unique and strong torsional excitation harmonics), and some of them were driven by steam turbines. Our analysis showed that all aspects of the design were acceptable with sufficient factor of safety, except for the second torsional natural frequency, which was excited by twice line frequency of the motor (this is usually the strongest torsional excitation frequency in electrical motors), and by the partial admission steam turbines' second harmonic of running speed, which could be easily excited by misalignment. A low-speed-shaft coupling modification was determined through "what-if" analysis that allowed the second torsional mode to be shifted up and out of the range of excitation by these harmonics, without creating any new problems. The pumps were installed, and have operated for several years without any mechanical difficulties.

Lube Oil System and Bearing Re-design

A major international oil company was experiencing chronic bearing failures of a system of four centrifugal pumps involved in very hot "bottoms" pumping service in the Pacific Rim. The failures generally occurred soon after re-starts that shortly followed system shutdowns. A bearing/ lube oil system design audit, including a rotor dynamics analysis, showed that the rotor system had a critical speed that would get excited under conditions of poor lubrication. During shutdowns, our staff discovered that the bearing housings were not sufficiently cooled to allow the reduced oil flow from the lube oil system to keep the bearing oil film area cool enough to prevent coking. A new lube oil system was designed MSI and installed to provide sufficient cooling capacity, and to provide more certain venting of vapor trapped in the oil supply lines. An alternate less expensive system was also proposed by our staff, involving continuous water cooling of the bearing housings, but the plant thought that the improved lube system design had enough peripheral benefits to justify the additional cost over a "band-aid" to the existing system. A bearing design change was also proposed by our staff which would be more tolerant of minor coking, and would possess greater damping in order to resist possible excitation of a critical speed. The new lube oil/bearing assembly was installed by the plant, and the failures were eliminated.

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