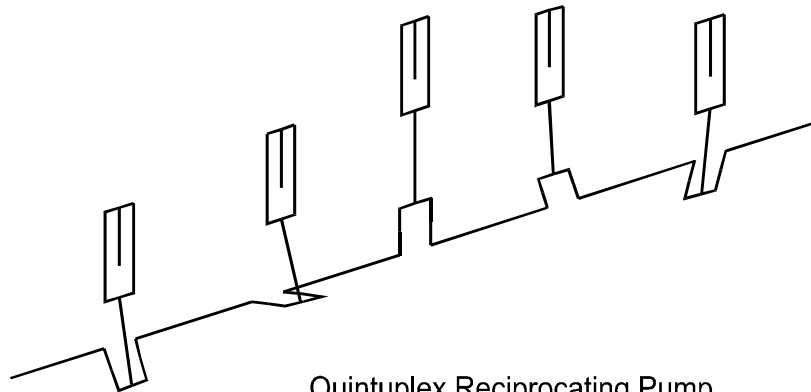


Case History: Reciprocating Pump Analyses

Reciprocating Pump Torsional Analysis #1

Mechanical Solutions, Inc. was contracted by a major domestic pump manufacturer to determine the torsional natural frequencies of a machinery train consisting of a five plunger reciprocating pump, a gear set including an intermediate shaft, and a VFD/motor driver. The natural frequencies were calculated and compared to likely excitation frequencies. A complete forced response analysis was performed, with modal damping and excitation force strengths based upon theoretically maximum loads and worst case torque spectra from shop and field testing of similar machines. To accomplish this analysis, a full 3D finite element model was constructed which explicitly modeled both the reciprocating and rotating parts, including all connecting rods, crossheads, and plungers.

The torsional critical speed analysis showed that some intersection of excitation frequencies and natural frequencies caused several resonances to occur in the operating range. However, the worst-case forced response analysis proved that the maximum amount of stress which would occur at these resonances was acceptable relative to shaft fatigue criteria. Using the information from these analyses, the manufacturer was able to proceed confidently with parts ordering and fabrication of the pump/gear/motor assembly, with the design unmodified.



Quintuplex Reciprocating Pump

Reciprocating Pump Torsional Analysis #2

MSI performed torsional analysis of a reciprocating pump/ gear/ motor system being designed for a large overseas petroleum drilling venture. Analysis of the initially designed system indicated that there was a possibility of resonant torsional vibration, driven by 50 Hz line frequency. The customer requested that additional analysis be performed to investigate how coupling options could be modified to provide improved factor of safety relative to the occurrence of torsional resonance. It was discovered that, by switching the pump coupling to a double engagement gear coupling from a flexible spring element coupling, the original problem was fixed, but a new resonance problem was created at twice line frequency. By lengthening the coupling hubs on each side to the maximum standard length, a factor of safety of over 15 percent was obtained relative to the closest torsional resonance, consistent with good engineering practice. The manufacturer of the system included the recommended design change, and the pump was placed in service, functioning with no vibration or reliability problems.

Reciprocating Pump Valve Failure Analysis

An offshore rig septuplex pump was experiencing chronic suction and discharge valve failures. A more robust valve design implemented by the manufacturer did not solve the problem. MSI performed test stand and on-rig pulsation and vibration testing. Structural and acoustic natural frequencies were determined by test, as well as the harmonic content of the pressure waves in the cylinders and manifolds. Tribological and metallurgical tests were also performed on the valves, guides, and seats. It was determined that a firm deposit film which was forming on the valve guides was hanging-up the valves, causing them to close late by slamming shut. Finite element analysis proved that the impact stress waves were strong enough to lead to fatigue of the valve plates. The valve guide clearances and seat angle were changed slightly to discourage hang-up and high closure rate, solving the problem.

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