

Case History: Pump system structural analysis

Mechanical Solutions, Inc. (MSI) was contracted by a manufacturer to perform a seismic structural analysis on three identical large pump systems in a low-activity and high-activity nuclear waste treatment process. The scope of the analysis included the pressure containment casing, nozzle attachments, support system and driver. The pump systems were required to meet the specifications of Seismic Category 1 (SC-1).

Finite element analysis (FEA) techniques were employed to perform an equivalent static analysis to evaluate stress levels as a result of the seismic input in combination with nozzle loading, impeller thrust and torque. The effects of the motor, motor attachment means and rotating components were incorporated into the model. A conservative seismic approach was taken due to the uncertainty in the design of the attached piping and pipe support configuration. Natural frequencies and mode shapes were also investigated and compared to running speed and other excitation sources.

The final analysis indicated that the seismic stresses in the pump components as well as all bolting were found to be within acceptable levels. Peak stress levels were below the yield strength of the materials used. The major structural natural frequencies were identified and determined to be at a safe margin excitation sources, and therefore resulted in minimal increase in the quasi-statically calculated seismic stresses. The normal operating peak stresses due to internal pressure, nozzle load, and upthrust are well below the threshold of expected load cycling, so fatigue failure was not expected. In the final analysis, MSI concluded that the pumps would meet their seismic and fatigue analysis criteria.

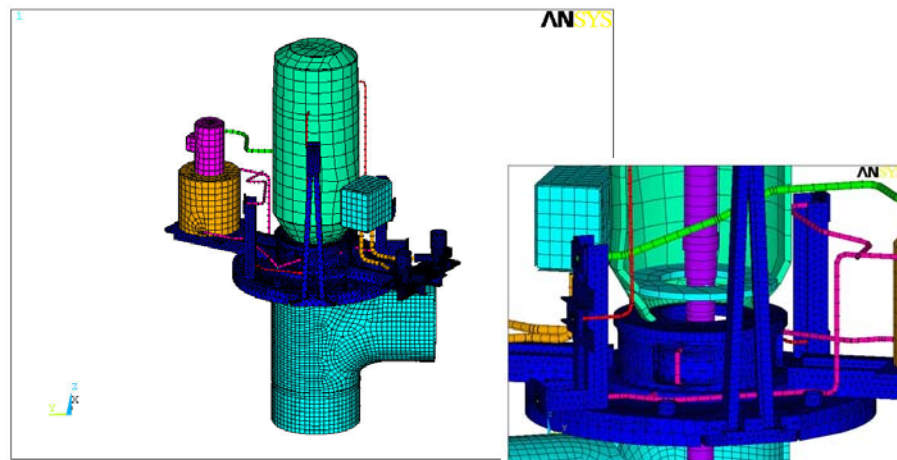


Figure 1. Left - Finite Element Model including pressure containment casing, nozzle attachments, support system, and driver. Lower right –close up view.

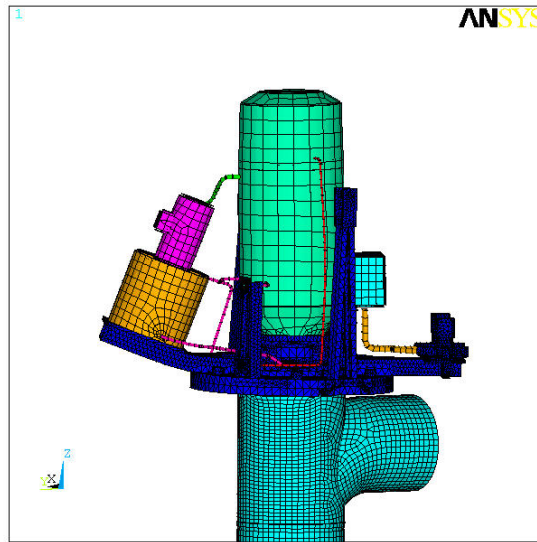


Figure 2. A heat exchanger was one key component in the model and resultant analysis (1st Vertical Natural Frequency of heat exchanger shown)

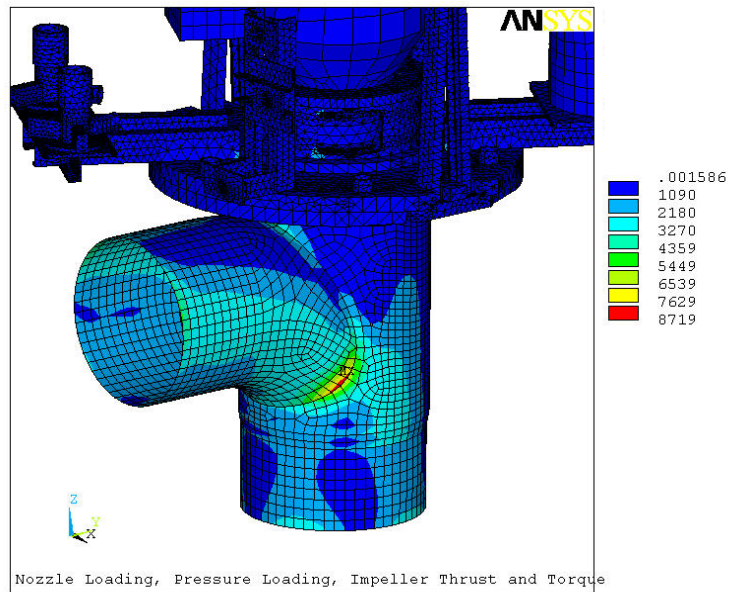


Figure 3. Nozzle load stress distribution - von Mises Stress (psi)

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