Solution Brief

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

Cavitation Assessment on Large Double-Suction Pumps

Challenge: Apply a new non-intrusive test method for quantifying the amount of damage caused by cavitation.

Results: Impeller modification and impeller/wear ring material change.

Impact: Increased impeller operating life from less than two years to 15 years for four duplicate pumps saving $840K in repair costs.

Mechanical Solutions, Inc. (MSI) has developed a high frequency accelerometer technique for quantifying the amount of damage occurring in a cavitating pump. This new method can quickly diagnose cavitation in pumps, valves, and other fluid system components. Additionally, MSI can estimate the severity of the cavitation damage; determine if component modifications are essential (for meeting reliability), and determine if the cavitation noise is simply a nuisance.

Both an OEM and an End User recently installed large double-suction pumps and determined that the pumps were a suspected noise source. The pump station owner needed to prove that the noise was a result of cavitation and to assess the potential for cavitation to significantly reduce pump life. Of particular concern was a periodic chugging sound which was present when the largest pumps were operating within a flow range of approximately 100% to 130% of BEP.

MSI has found the most valuable indicator of potential cavitation damage is measuring the instantaneous casing acceleration while the pump is operating in suspected cavitation conditions. This technique measures the high frequency (short time period) spikes in the vibration time signal which result from cavitation bubbles collapsing on the internal surfaces of the pump. Since the vibration spikes are considerably higher in amplitude when the bubbles collapse on a surface as opposed to collapsing in the free stream, a quantitative assessment of the potential for cavitation damage to the pump can be made. By measuring the instantaneous acceleration spikes, MSI can directly measure the pump's local structural response to the cavitation events. Whereas measuring the sound spectrum provides less direct measurements since the effects must be transmitted from the pump casing to the air before being measured. Even difficult-to-perform dynamic pressure or hydrophone measurements are less direct because of the distance between the sensor location and cavitation bubble burst.

MSI performed tests which consisted of measuring the pressure pulsations in the suction pipe, sound pressure near the impeller inlet, instantaneous casing acceleration at many surface locations, and sound pressure in the air surrounding the pumps. Past experience shows us that peak instantaneous acceleration levels in excess of 100 g's are indicative of damaging cavitation, while levels below 15 g's indicate no damaging cavitation. In this case, peak acceleration levels on the pumps were measured as high as 400 g's which is indicative of enough cavitation to erode the impeller and/or casing. Further post-test inspection of the internal pump revealed cavitation erosion damage to the impeller vane, shroud surfaces, and the nearby casing surface. In a similar pump investigation using

MSI's technique, we determined that after 1000 operating hours at 300 g's the vanes of a 316L impeller had lost half their thickness.

Comparing the various measurement methods shows good correlation between suction pressure measurements, suction sound pressure measurements (hydrophone), and instantaneous acceleration (Figure 1). The measurement which provided the most ambiguous data was the more typically performed airborne sound pressure measurement. Discussions with the pump OEM revealed the pump suction had been 'oversized' to meet the stringent NPSH requirements at the minimum suction head condition. The result was a pump which experienced suction recirculation at flow rates well above BEP flow rate (in other cases, damage occurs below BEP). The problem was compounded as the recirculation set up an unsteady flow pattern in the pump suction resulting in cavitation surge; not only damaging the impeller, but also shaking the entire pump system. In order to minimize this cavitation surge or "chugging" effect, the impeller design was modified and materials changed.

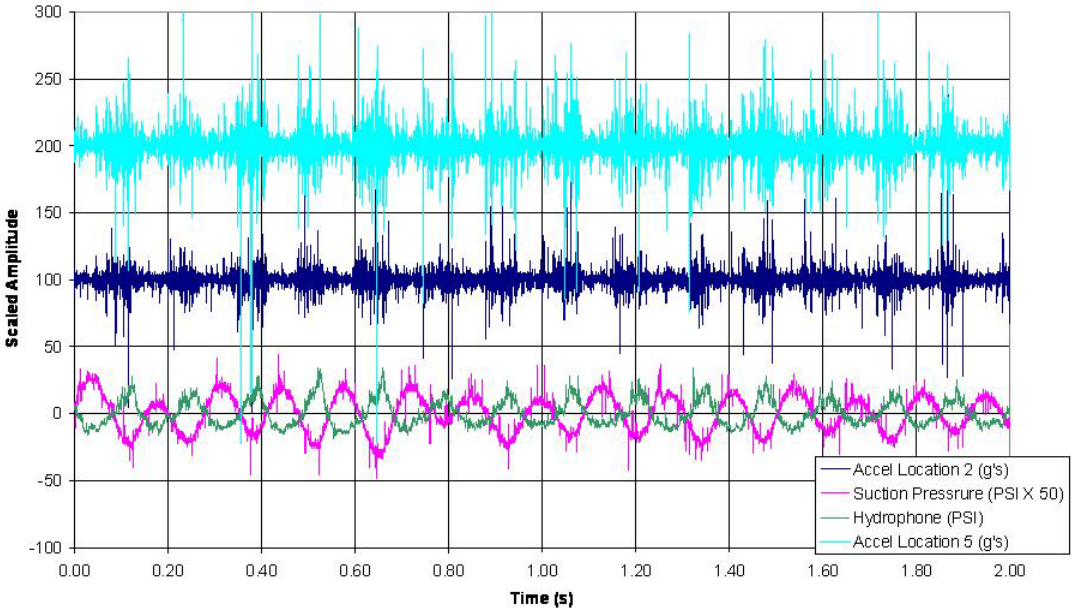

Figure 1: Plot showing the periodic acceleration, suction sound pressure, and suction pressure measured while the pump was operating in a condition of cavitation surge.