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Root cause analysis and reduction of high frequency vibrations in three propane pumps

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Summary

Triggered by the high noise levels produced by high-speed propane pumps at an energy conversion plant (ISAB, Siracuse, Italy) detailed vibration measurements have been carried out to assess the danger of failure and determine the root cause. In addition at some points, pressure pulsations could be measured. From the measurements it appeared that at certain process conditions the vibrations were too high and it was recommended to avoid these process conditions until countermeasures had been taken. The pulsation measurements showed that pressure pulsations occurred at twice the vane passing frequency that were much higher than expected. Therefore it was suspected that a resonance condition occurred in the pump or in the discharge pipe system.

In order to determine the nature of the resonance a model of the pump and discharge pipe system was built. Also the vibration amplitudes have been calculated by means of a Finite Element Model (FEM), which showed an acceptable agreement between the measured and calculated vibration levels.

Further analysis with the pulsation model showed that in the pump a standing wave resonance could occur at certain process conditions, which was excited by pulsations resulting from interaction between the impeller vanes and both volute tongues of the pump. Once the cause of the resonance was known, a modification of the volute geometry was designed that could be installed in addition to the existing volute. Also the gap between impeller and volute tongues was increased to reduce the pulsation source strength. The modifications resulted in a considerable reduction of the noise and the vibrations.

In this paper the pulsation and vibration measurements are discussed. Also the pulsation and mechanical response models of the pump and piping are presented, showing the way in which the internal resonance could occur. Finally the modifications of the pump design are shown and the effect on the pulsations and vibrations.

The paper concludes with a discussion of the lessons learnt from this case.