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Solving piping vibration problems due to pressure pulsations

One day you walk out in your plant or manufacturing facility and a pipe is vibrating. It is a relatively high-frequency vibration. What is your response? Maybe it is to put in new supports or just to leave it alone. However, you know from previous experience if the supports are not put in the correct locations and are stiff enough, they may make the problem worse. You also know any failure resulting from that effort has no basis involving proper engineering. Perhaps you might look at the problem in some detail from an engineering point of view.

Piping vibrations due to pressure pulsation can come from many sources. One source is acoustical-driven pulsations due to reciprocating or centrifugal equipment in process systems. Other sources can originate from process dynamics. In order for the pipe to vibrate, several conditions must be satisfied. First of all, we know if a pipe is vibrating in a harmonic manner, there must be a corresponding driving force to cause the vibration.

For pressure pulsations to vibrate a pipe, the pressure pulsations must match the natural frequency of the piping system. You might be asking yourself how or why the fluid is pulsating in the first place. That's the part of this ball game that is often difficult to determine. Piping systems have acoustic natural frequencies. When pressure and flow fluctuations match the acoustic natural frequencies of the pipe, the fluid can resonate at different acoustic modes. It is usually but not always at higher modes. There you have it; the fluid fluctuations match the acoustic natural frequency, the fluid resonates, the resonating fluid matches the natural frequency of the pipe and vibration occurs. They want the right flow conditions to occur to make noise, which hopefully is pleasant, unless you have an 8-year-old practicing music.

So how do you fix the problem? You must first determine if you have a problem. This can be accomplished by calculating the dynamic stresses in the piping system. If the dynamic stresses are too high, you need to do something.

Some but not all options might be as follows:

1. A metallurgical review should be conducted to characterize any fractures if the physical evidence is available.

2. Conduct a field study to determine what the forcing functions are in the systems. Such a study would include but is not limited to dynamic pressure readings and vibration, along with the process conditions. It may also be that the study should include monitoring over several shifts to capture any transients.

3. Eliminate the source of the pulsations. Sometimes process changes can be made to eliminate the problem. Perhaps a variable speed drive could be installed and the equipment could run at a different rpm (revolutions per minute). Process changes are not always easy or practical.

4. Add hardware to the piping system to eliminate the pulsations. The existing system must be analyzed to determine the acoustic natural frequencies and hardware added to the process, such as pulsation bottles. These can be suction stabilizers, discharge dampeners or Helmholtz resonators. These should be acoustically tuned to the entire system. Remember, minor modifications to the piping in the future could void this effort. Also, all details of the piping systems are important, such as drain valve stub-in.

5. Add supports. Adding support can sometimes solve the problem. It changes the mechanical natural frequency of the system. In other words, the supports might detune the system. However, adding supports can sometimes make the problem worse if it causes the system to respond at a harmful mode of vibration.

6. A combination of all of the above.

7. The next part of the problem is validating the fix, which is important for high-frequency problems. Pulsation frequency could be so high that cracking occurs in components like the pulsation equipment. Field data acquisition should be conducted to capture vibration and dynamic pressure to ensure the design is working.

Solving a piping vibration problem due to pressure pulsations is not always a quick fix. These problems should be analyzed and reviewed by a professional engineer competent and experienced in these types of problems.

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