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Acoustics — 'It can rattle your cage'

One complex area of physics that frequently causes problems in production and pipeline facilities is acoustics. At first thought you might ask, "What is this all about?" Acoustical pulsation occurs in a contained volume when there is a forcing function that exists capable of exciting the acoustical natural frequency of that volume. The pulsation is not necessarily detrimental unless it causes problems with equipment or unacceptable vibration. These problems can occur in liquids, gases or even three-phase flow fields.

You might wonder how acoustical pulsations can cause problems in equipment. For example, consider reciprocating compressors or piston/plunger pumps. If the frequencies — or multiples of the frequencies — match the acoustical natural frequencies in the piping system (i.e., the contained volume), then the fluid will resonate. The flow field becomes a transient pressure momentum field. In reciprocating equipment, the valves will be pounded as a result and the life of the equipment can be reduced. In compressors or pumps with vanes, the blades can fail. It is like waves pounding against the shore during a storm.

To mitigate the problem in pumps and compressors that are reciprocating types, suction stabilizers or discharge dampeners are typically installed. It is important the pulsation bottles be acoustically tuned to the compressor and piping system. I would not advise you to let anyone sell you a system not tuned in such a manner because the physics at the root of the issue are not being properly addressed.

Screw compressors can also excite the acoustical natural frequencies of a system. In these systems, silencers are put in to knock out the detrimental frequencies. The silencers should be mounted as close to the screw compressor as possible, otherwise you may be introducing an unwanted "horn" in the system that can cause all sorts of problems.

One interesting area in rotating equipment is cavity acoustics. There are many cases where noise is generated from the rotating equipment where the contained volume inside the equipment (cavity) resonates and emits detrimental energy that can cause damage, either externally or internally, to the machine.

Acoustics is also a problem in piping systems or pressure vessels. Generally, the problem is caused by any number of things including control valve action or interconnected rotating equipment. Acoustic problems in piping systems can be challenging at times to resolve, particularly at higher frequencies where the supports are involved. To properly address these problems, it is necessary to include the supports as part of a structural dynamics problem. Generally, supports have to be 10 times stiffer than the piping system to not act as a player in the system. A structural dynamics model and digital pulsation model are usually simultaneously conducted to analyze the system. Boundary conditions and exact piping details are important to obtain a reliable solution. Problems are solved by detuning the system from the forcing function.

The other major area to consider in regard to acoustics is field studies. For existing systems, the measurement of dynamic pressure pulsations, acoustical noise and vibration are important to determine an accurate response to the system and a good fix.

Some simple points that are not all inclusive regarding this complex subject are:

1. There are no quick fixes to acoustically generated problems. I have seen several occasions where a quick fix was tried, and major failures and plant shutdowns occurred as a result. If there is vibration, randomly putting in supports can make the situation worse.

2. In gases, a change in molecular weight can lead to multiple solutions to the problem.

3. A contained volume needs to be analyzed as a system.

4. For existing systems, a field study will provide useful information to diagnose and fix the problem. It is also useful for correlation to numerical models.

5. Validate changes on start-up.

These problems are often complex and should be reviewed and approved by a professional engineer with experience in these types of problems.

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