KNIGHTHAWK TECH NOTES

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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 yourself 'what is this all about?' Acoustical pulsation occurs in a contained volume when there is a forcing function that exists, which is capable of exciting the acoustical natural frequency of that volume. The pulsation in itself is not necessarily detrimental unless it causes problems with equipment, or unacceptable vibration. These problems can be caused by liquids, gases, or even three phase flow fields.

You might wonder how acoustical pulsations can cause problems in equipment. For an example, let us consider reciprocation 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, typically suction stabilizers or discharge dampeners are installed. It is important that the "pulsation bottles" be acoustically tuned to the compressor and piping system. I would not advise you to let anyone sell you a system that is not tuned in such a manner, because the physics at the root of the issue is 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 called "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 external or internal 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 but not limited to, 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 become part of the ball game. 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 piping system itself in order to not act as a player in the system. In the industry, typically a structural dynamics model and digital pulsation model are simultaneously conducted to analyze the system. Boundary conditions and exact piping details are important to obtain a reliable solution. Problems are typically solved by detuning the system from the forcing function or "snuffing out" the forcing function.

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

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

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

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

Cliff's Notes: KnightHawk is your one stop shop when it comes to fixing acoustical problems in industry. KnightHawk has performed many field studies in complex systems over the last 20 years with our Field Service group. Our Specialty Engineering group has digital pulsation software and finite element software to get the job done. Finally, KnightHawk has a metallurgical laboratory to diagnose and characterize any fracture surfaces that may have resulted from failures.

On a personal note I would like to wish everyone a wonderful summer. Houston is really a "hot" place to spend time in the summer.

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KnightHawk Project Update

- Bearing Fluid Flow Analysis – Subsea
- Gas Pipeline Coupling Failure – Oil & Gas
- Water Pump Failure Analysis – Nuclear
- Motor Thermal Analysis – Subsea
- Pump Vibration Analysis – Petrochemical
- Centrifugal Compressor Failure Analysis – Petrochemical
- Gas Plant Explosion – Oil & Gas
- Deaerator Efficiency – Petrochemical
- Vessel Destructive Testing – Oil & Gas
- Critical Pipe Stress – Petrochemical
- Corrosion Analysis – Gas Pipeline
- Elevator Torque Measurements– Petrochemical
- Reactor Failure Analysis – Petrochemical
- Critical Pipe Stress – Refining
- Balanced Torque Measurements – Power
- Creep Tensile Testing – Communications
- Gasifier Equipment Design – Power
- High Temperature Molten Salt Tank Design – Green Energy
- TLE Inlet Cone Design – Petrochemical
- Bearing Design – Heavy Manufacturing
- Vaporizer Design – Petrochemical
- Transient Fluid Dynamics – Petrochemical
- Waste Heat Boiler – Petrochemical