KNIGHTHAWK TECH NOTES

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"Reciprocating Compressors Running Together – Is it a problem?"

You have just started your new job as a maintenance engineer in a petrochemical facility. Like many facilities you are responsible for large critical rotating equipment. Contained within your facility are vent gas compressors that in general run good but on occasion fail. The system consists of three compressors in parallel and the piping unfortunately looks like an afterthought on both the suction and discharge. The compressors have had a remarkable number of valve failures and on occasion some instrumentation connections have broken off. You have questioned the staff about the operation and as it turns out many studies have been performed. The design contains pulsation bottles on the suction and discharge to "snuff" out any acoustical driven vibration problems.

In this problem the typical pulsation studies have been conducted to meet API 618. On the surface, everything looks like it has been done correctly but the fact is the compressors are still failing. The suspected culprit was acoustical driven vibration issues. Let's review what this is all about. In a nut shell, every contained volume has a set of acoustical natural frequencies. When a forcing function is coincident with one of the acoustic natural frequencies the fluid contained within the volume will experience pulsations that can be remarkable at that frequency. When these frequencies are coincident with the structural natural frequency, then the piping can vibrate. Also the pulsation can cause damage in the compressor in a multitude of ways. In this particular problem there were two areas where the actual field conditions conflicted with the study. Frist each compressor was analyzed on a unit basis and not as a combined parallel system. The second problem was that the molecular weight varied in the system and therefore the acoustic natural frequency will change throughout the operating range. The final challenge to the system with the drivers was variable speed. To solve a problem of this nature one has to consider the following approach.

1. Historical Review – It is important to look at the original design basis. "Garbage in, Garbage out" applies here. As with the given problem above, the way the machine was running did not match the way the analysis was performed. Acoustic analysis is different from many forms of engineering analysis in that the actual response has to be evaluated based on the actual operating conditions. Sometimes, there is a misconception with this work that there is a factor of safety for the acoustical analysis. That is not the case. Also, it is important the final piping configuration be evaluated based on the "as built" from the field. The suction and discharge pulsation bottles must be acoustically tuned to the actual piping system for the best results.
2. Field Study – A field study should be conducted on a multichannel system that measures both vibration and dynamic pressure. Typically, a protocol is developed for the test in advance. It is important to place the pressure transducers in a location where it can pick up any pressure pulsation that may be present. If the location is at a "node" point in the domain then one may falsely conclude that there is no pulsation present. Also another problem with this measurement is that the location of the dynamic pressure transducer may be too far away from the flow field. This may be the case for example, if the pressure transducer is contained within a double block and bleed. The other issue is to make sure the process conditions are recorded at the time of the test. If valves are failing as described in the problem above it is desirable to have dynamic pressure readings in the head. The bottom line is, that good planning which involves good placement of transducers, can achieve good results in the field study.
3. Structural Dynamics/Digital Pulsation Study This involves the development of a numerical model that duplicates the response in the field study. The idea is to match up to the field and then see what it takes to fix the problem. There is essentially two numerical models. One predicts the acoustical response and the other predicts the mechanical structural response. Once the model is reconciled or validated to match the field data, then the "what if" question can be asked. In other words the "fix" can be determined on a numerical basis with the confidence of a valid numerical model. Remember every process scenario should be evaluated including the variable speed range as in this problem. One thing to remember is supports. Unless the supports are approximately 10 times stiffer than the piping, it generally should be considered part of the domain of the structural model. Also for the acoustic model the side branches for instrumentation are important, as these could act as side branch resonators. For variable systems sometimes it is desirable to design the pulsation bottles to "snuff" out everything from the compressor, especially to avoid interaction problems.
4. Design Review – Once the proposed design is determined, it should be reviewed with plant team consisting of operations, process engineering, mechanical, and controls. The design basis should be discussed and approved by the team. It is important that the team be given an overview of how important the design detail is.
5. Installation – Once the modification is installed in the field, measurements should be taken to validate the response.

The problems are not that remarkable with the right approach addressing the details. Unfortunately too many times the quick and easy study is invalid because of those important details. The resulting analysis should be reviewed and approved by a Professional Engineer.

Cliff's Notes: KnightHawk has evaluated and performed many field studies on reciprocating compressors. What we bring to the table is the capability as a one stop shop with full field study capability, process, controls, mechanical, and metallurgical and materials analysis. In short, we are a one stop shop. No need for you to find contractors for other aspects as we have full capability in all areas.

Well I am finally back to work full time after my unique Mongolia experience. Thanks for everyone's prayers and thoughts for the miracle of healing that occurred in my life from our Lord.

Take care and God Bless,

Cliff Knight

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KnightHawk Project Update

- FFS High Pressure Flange – Oil & Gas
- Combustion CFD Analysis – Power
- Liquid Ring Compressor Failure – Petrochemical
- CFD of Separator – Petrochemical
- Hydrogen Gas Reformer Design – Oil & Gas
- Air Compressor Failure – Petrochemical
- Compressor Motor Turbine Train Analysis – Petrochemical
- Critical Pipe Stress – Petrochemical
- Vertical Cast Transporter Failure – Nuclear Power
- Flue Gas Cooler – Petrochemical
- Compressor Cross Head Failure – Oil & Gas
- Transient Fluid Dynamics – Petrochemical
- API Tanks FFS – Petrochemical
- Gear Pump Failure Analysis – Petrochemical
- Transfer Line Exchanger – Petrochemical
- Flare Efficiency Analysis – Petrochemical
- Fit for Service Analysis – Petrochemical
- Tensile Testing – Manufacturing
- CFD of PSV Systems – Petrochemical
- Pump Vibration Analysis – Petrochemical
- Motor Shaft Failure – Petrochemical
- Gas Pipeline Coupling Failure – Oil & Gas
- Ultra High Pressure Vessel FFS – Petrochemical
- Reciprocating Compressor Failure – Petrochemical
- Pump Vibration Analysis – Petrochemical
- Corrosion Analysis – Gas Pipeline
- Gasifier Equipment Design – Power
- Gas Plant Fire & Explosion – Oil & Gas