KNIGHTHAWK TECH NOTES

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"Feel the Pulse"

The morning meeting at the plant was long; especially for you, because operations had a lengthy discussion over vibrations in a pump and pipe system. This is the third verse of the same song and dance. You have worked at length to solve the problem. It does not make sense! You thought the problem was "nailed" and you were on to the next priority. The vibration is a major concern because of fatigue failures in the piping and because the instrumentation was shaking loose and shutting the plant down. The production supervisor met with you after the meeting and said "whatever it takes, get it done and fix it". With the reverberations of the production supervisor still sounding, you reflect on all the failed attempts. The process is a slightly subcooled (just below saturation conditions) fluid. You reflect on all the teams and their various attempts to fix the problem.

1. The first team that looked at the problem concluded that the piping was not supported properly and the process caused the vibration. The team decided to add more supports and improve the welding process. Metallurgical analysis indicated fatigue failures in the heat affected zone of the welds. After a major review it was decided to stress relieve the welds after repair. After this investigation everyone felt confident the problem was identified and a solution implemented. Unfortunately, after the startup another failure quickly occurred. Once again, the team with long faces met in the conference room and realized that there is more to this problem than they anticipated.
2. A vibration expert was called in and he suggested that the supports "tuned in" the system to a critical natural frequency and that is what caused the problem. The supports were reworked with the help of the piping vibration expert and the vibration did subside, but a failure still occurred.
3. A second team started thinking about a control valve upstream of the failure areas. It was noticed that the control valve oscillated greatly and it was concluded that that must be causing a pulse. After talking to what felt like a "zillion" vendors, a control valve was selected to provide better stability. The valve was installed and the plant noticed some improvement, but failures still occurred. This time the failures started on irregular cycles and were completely unpredictable. Although better - the job was not done.
4. The third team started looking at the pump upstream of the control valve. The inlet and outlet piping system was not in accordance with generally accepted standards. It was felt the configuration was leading to cavitations. The piping was revised with high optimism, but no remarkable improvement was achieved.

Obviously, our plant engineer is dealing with a complex problem. All the teams consisted of excellent staff with proven track records. The source of the problem was not indentified until a process evaluation of the system was included in the root cause analysis. Even though the process was a slightly subcooled state, the overall process based on steady state conditions suggested there should not be a problem. However, the system had several process streams coming together. When a control valve opened a pressure pulsation would send a pressure wave and the fluid would flash off. This led to further pulsations and then the system would go unstable. Hence, the root cause was a thermodynamic instability.

The problem was diagnosed and solved using the following procedure:

1. Metallurgical analysis to evaluate the failures to characterize the fracture surface.
2. Structural dynamics analysis to understand what "drives" vibration.
3. Acquire field data to determine the dynamic pressures and vibration during all operational modes.
4. Perform a process analysis to determine the thermodynamic limits of the system.

In this particular case, the problem is solved by determining how much subcooling is required to keep the system stable. The key to understanding the cause and effect, is understanding the process. Be careful when looking at the process conditions as there may be several species in the fluid that can flash out. I have worked on projects where there was less than one percent of the fluid component that was flashing out in the mixture. When looking at the basic chemistry, this flashing did not appear to be a problem. However, as with any problem, the details are what count.

Dynamic instability problems are often complex and involved. Spending ten dollars to save a nickel is not the answer or approach. An integrated systems approach as defined above is the best approach. Each problem is specific to itself and the governing conditions. Have a professional engineer, competent in this type of work, involved with the problem solving process.

Cliff's Notes:

KnightHawk has an integrated systems approach that has evolved over the past 18 years. We have been involved with countless problems involving two phase flow, cavitations, and transient flash off conditions in both static and rotating equipment.

On another note, I am pleased to announce that COSTAS C. CHRISTOFI, Ph.D. will be Lab Director of the KnightHawk Hobbs Road Lab. Costas's specialty is acoustics and vibration. While working for Trane he also served as Adjunct Assistant Professor at University of Texas, Tyler. He received is PhD from Penn State and has over 20 years experiences in complex systems in industry. Costas is also going to add more noise services to the lab and field. Costas will be responsible for the field services, metallurgical and materials, reverse engineering, and testing services.

I hope each and every one of you has had a blessed year, as we have here at KnightHawk. I am excited about the future and working with each of you to solve challenges and address new opportunities.

Cliff Knight

KnightHawk Project Update

- Mechanical equipment design – Off Shore
- Waste Heat Boiler Failure - Petrochemical
- Gear drive failure – Petrochemical.
- Valve Failure – Offshore
- Compressor wreck - Offshore
- Vessel Nozzle FFS - Power
- Crusher and conveyer – Mining - RAMS Analysis
- Fire Tube Boiler FFS – FFS -1/ API 579
- Titanium Tower FFS – 1 / API 579 Analysis – Petrochemical
- Flange Leak – Off Shore
- Structural Dynamics – Off Shore
- Fitness for Service Waste Heat Boiler – Petrochemical
- Thermosyphon Analysis - Petrochemical
- Pump Metallurgical Assessment – Off shore - Africa
- Waste Heat Boiler Audit – Petrochemical – Middle East
- 15 MW Compressor Audit – Petrochemical - Asia
- Compressor Vibration – Petrochemical
- Vessel Fluid Dynamics – Petrochemical
- Gasifier Failure Analysis – Petrochemical
- Pipe Clamp Analysis
- Pump Skid Design – Off Shore
- TLE Retrofit Design – Petrochemical
- Vessel Acoustics Data Acquisition – Petrochemical
- 60 Inch Seal Ring & Flange Reverse Engineering – Petrochemical
- Piping Vibration Analysis – Petrochemical