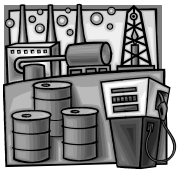
KNIGHTHAWK TECH NOTES

PHONE: (281) 282-9200 • FAX: (281) 282-9333
WEBSITE: www.knighthawk.com

February, 2006 *Issue 06.01*

"Acoustics – What is it about? "

It's your time again; the boss has landed another weird problem on your desk and he expects an update at the next staff meeting. It's a vibration problem in the plant and as usual, no one exactly understands the ball game. All you know is that you have to fix it. The failure is causing shutdowns and there are safety concerns as it is a high pressure hydrogen system. The system is essentially a control station with a compressor.



First, you pay a visit to operators to get the scoop as to what is going on. Once again, you hear that it has never happened before. This system has been in operation for 25 years with no problems. The operators claim they have fixed the pipe twice before, but have never seen any vibration. The metallurgist suggests that the failure is due to fatigue. Next, it is time to pay a visit to the plant and observe the control station. As you might guess, it's as smooth as glass. How could something running so smooth, yet fatigue and fail? It just doesn't make sense.

Back at the office you start making some inquiries and investigate any changes. The system has been essentially the same for many years with the exception that a variable speed driver was put on the compressor to control product mix and eliminate so much recycle. You discover there were no failures prior to the variable driver being put in. Now you have something to go on to determine the root cause. The compressor is 50 feet from the failed areas with many supports and it does not make sense that the vibration is coming directly from the compressor. It is a reciprocating compressor so you know there could be some potential acoustical issues, but the compressor has discharge dampeners and suction stabilizers so it still doesn't make sense. Then you think about acoustics, the variable driver and what effect it might have. You realize that when the variable driver changes speed, it tuned into detrimental acoustical frequencies.

What is acoustics? In a process system every contained volume has a set of acoustical natural frequencies. When a driver (forcing function) is coincident with the acoustical natural frequencies the fluid will resonate and the pulsations in the process will be amplified. If these pulsations are coincident with any mechanical natural frequencies, then things can be interesting. What a unique scenario with this system. The root cause analysis of this problem identified acoustics from the variable speed driver that were not damped by the existing dampers and/or suction stabilizers. So how do you solve a problem like this? While each problem is unique into itself one approach is as follows:

1. Field study – Perform a field study with a high speed data acquisition system that can measure pulsation and vibration together. In a system such as above, it would be desirable to tie in with the PLC to capture both compressor and process conditions.
2. Evaluate alternatives for control – In this system the short term solution was to capture the problem areas and program the compressor so it would not run in these areas.
3. Long term – Look at an acoustic filter to "snuff" out the bad drivers.
4. Mechanical – Look at additional supports to detune the system as an added factor of safety, but beware the supports must be approximately 10 times stiffer than the piping or they may become part of the problem.
5. Develop acoustical and mechanical models to prove the designs.
6. Review with plant personnel.
7. Measure the results.

Acoustical waves can cause practically any mechanical system to fail such as piping, exchangers, vessels, furnaces, and structures. Acoustically generated noise is also a big issue now days. For instance, compressor stations might be next to residential areas. Acoustical liners and other hardware can be installed to quiet things down. In all cases, have a professional engineer competent in acoustical design and analysis to review the overall work product.

Cliff's Notes:

KnightHawk has been working in the acoustical area for many years. We have solved problems ranging from complex compressor volutes to furnace vibration caused by acoustics. KnightHawk can solve your acoustical issues and in many cases, provide the hardware to do it as a complete turnkey package. In short, we can do the modeling, field data acquisition, supply the hardware, and if need be, the installation.

KnightHawk welcomes Lee Hill, Ph.D as a Mechanical Group Leader for KnightHawk Engineering. He has over 22 years experience in design, troubleshooting and failure analysis of static and rotating equipment. Prior to working for KnightHawk, Lee worked for MechAssociates in Victoria, Texas where he specialized in failure analysis, design audits and design modifications using numerical methods. Prior to MechAssociates, he worked for Dresser-Rand Corporation in Olean, New York, Emerson Ventilation Products in Lenexa, Kansas, the Mechanical Engineering Department of Texas A&M University, Pratt & Whitney Aircraft in West Palm Beach, Florida and Hercules Aerospace, Inc. Some of Lee's accomplishments include development of transient CFD technology for turbomachinery problems and noise reduction technology for centrifugal compressors, troubleshooting multi-phase flow problems, acoustic problems, turbine aerodynamic issues, particle erosion and deposition issues with hot gas expanders, combustion chamber issues, structural dynamic issues and thermal stress analysis issues. Lee is widely published on topics such as finite element analysis, bearing design, computational fluid dynamics, component interaction in rotating equipment, noise reduction, and machinery performance improvement. Lee holds 7 patents related to rotating equipment. Lee earned a B.S., M.S. and Ph.D. in Mechanical Engineering from the University of Texas A&M.

Cliff Knight
cknight@knighthawk.com

KnightHawk Project Update

- Waste Heat Boiler Failure Analysis – Petrochemical
- Rotordynamics - Petrochemical
- Furnace Acoustics – Power
- Critical Pipe Stress – Crack Gas – Petrochemical
- Structural Dynamics – Acoustic – Nuclear
- Level 3 Reactor Fit For Service – Petrochemical
- Level 3 Waste Heat Boiler Fit For Service – Petrochemical
- Rotordynamics – Motor Compressor Train – Refinery
- Turbine Generator Wreck – Power
- Polymer Gear Pump Failure Analysis – Petrochemical
- Polymer Heat Exchanger – Petrochemical
- Structural Dynamics – Off Shore
- Residual Weld Stress – Non-linear Plastic Analysis - Petrochemical
- Waste Heat Boiler Failure Analysis and Redesign - Petrochemical
- Valve Design Troubleshooting – Off Shore
- Level Control Problems – Nuclear
- Gas Turbine Ducting and Damper Exhaust Failure Analysis – Off Shore
- Process Transients Field Data Acquisition – Petrochemical
- Reactor Design Optimization – FEA - Petrochemical
- Steam line fluid dynamics – CFD – Nuclear
- Special Process Reactor Design – FEA, CFD - Defense
- High Pressure Flange Design Riser – FEA – Off Shore
- 10,000 psi Oxygen Valve CFD – NASA
- Structural Vibration – Petrochemical
- Process flow problems – CFD - Petrochemical
- Nonlinear Membrane Bladder – Nonlinear FEA – Equipment Mfg
- Compressor Vibration Study - Petrochemical
- Gasifier Reactor Redesign – Petrochemicals
- Steam Turbine Failure - Power
- Non Linear FEA - Petrochemical
- Inlet Cone Design for TLE's – Petrochemical
- Aerodynamic Study of Inlet of TLE – Petrochemical
- Structural Dynamics – Rotating Equipment – Petrochemical