KNIGHTHAWK TECH NOTES

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"Molecular Weight Effects on Liquid Ring Compressors"

As a production engineer in the largest unit in the plant, you're constantly fighting battles every day to reach the production goals. Going through the equipment in the plant, you find that the real culprit in the unit is the liquid ring compressor. You look at the long history of running and it appears that there are major failures that require a rotor change out every year or so and sometimes several in one year.

The maintenance engineer in your unit has worked tirelessly to keep the equipment running. The OEM of the compressor has been in on multiple occasions and the answer is always the same; "We have these installed in this service in production facilities all over the world with no problems." Also, you have discussed it with your counterparts from other companies. In the failure reports, everything checks out ok, and there is no plausible root cause. Countless reports conclude rotating fatigue. The interesting thing is the vibration is never picked up on the vibration monitors. You have many metallurgical reports that show the fracture surface and the striations that indicate fatigue. You're not a metallurgist, but it all seems to make sense.

The machine has been in service for years and it was only recently, the last five years that the failures have become more frequent. Knowing that this machine has run fine in sister facilities and competitor's facilities, you wonder what are we missing. With the heat coming from the big dogs upstairs, you realize your common answer to them "We have maintenance engineering looking at it" is now falling on deaf ears. You have to resolve the issue, because your unit is not making the numbers it promised. To get this done you have come to the realization that you need a team to attack this problem. You need to get everyone in the room which includes but not limited to (1) Process/Controls engineering, (2) Plant engineering, (3), Maintenance engineering, (4) Lead Operator (5) Production, (6) Materials engineering, and (7) Team Leader, namely you.

You are all together and the discussions begin, while looking at failed parts all over the table. You come to understand more about fatigue than you ever wanted to know. The mechanical engineers tell you that a natural frequency is excited and the blade vibrates to failure. You ask all kinds of questions. You're told that the process creates what they call "a forcing function" that couples to the natural frequency of the rotor blades and it causes them to vibrate. Process says, it has been the same conditions forever and things seem to be going around in circles. Finally, the group realizes how the forcing function is developed and how it relates to the process. It all has to do with cavity acoustics which is a function of the speed of sound. The speed of sound is affected by molecular weight. The P&ID's are up on the conference room screen and you see a revision that occurred about 5 years back, just before all the failures really started. You ask what it is and you find out it is a low molecular weight gas that is used for purging and it is recycled back in. Someone had a great idea; "why flare it when it can be recycled back into the process?"

Well the cause of this problem was indeed the low molecular weight stream being put back in. To confirm the suspicions, the compressor was fitted with dynamic pressure transducers that pick up the dynamic pressure within the liquid ring. A production run cycle was recorded over a period of days, and indeed, it was the low molecular weight that was causing the problem. When the lower molecular weight gas was recycled, the dynamic pressure "went out of site". It was determined that the natural frequency of the cavity acoustics matched a critical blade natural frequency. Because of the coincident frequencies the blades would vibrate and fail.

Now you have an obvious question, "How to fix the problem?" Well, actually, it is quite simple. Change the control logic to prevent these conditions from happening to the compressor.

A good overall approach to liquid ring blade failure is as follows;

1. Metallurgical analysis of failed blades.
2. A field study to pick up the dynamic pressure during a process run cycle.
3. A finite element analysis of the rotor to identify its natural frequencies.
4. Determination of forcing functions.
5. Either change the process or the blade design to detune the blade from the destructive cavity acoustics.
6. Implement the solution.
7. Perform a field study and validate solution.

These problems can be challenging. A process change might solve the problem of today, but it might become a problem of tomorrow. The best solution might be to have a blade design that can handle all the process conditions expected. As always, have a professional engineer competent in the problems review the design and approve any changes.

Cliff's Notes:

KnightHawk has been one of the leaders in industry solving liquid ring compressor problems. We can review all of the machine dynamics and even evaluate the stability of the liquid ring. We have developed ground breaking fluid dynamics models of the liquid ring to shed light on many problems that can occur. Give us a call and we can show you how we can help solve your problem with this type of equipment.

Well I hope your team will win in March Madness. My team did not make it to the dance. The presidential election is in full swing and who knows how it will end up. Maybe your guy or lady is the one that will win. KnightHawk is well into 2016 after ending a record 2015 for us.

Take care and God Bless,

Cliff Knight

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KnightHawk Project Update

- Test rig design
- Motor Driven Structural Vibration
- Cryogenic Tank Design
- Pump Design Assessment
- Coke Drum Failure Assessment
- Storage Tank Fit For Service
- Gas Expander Design
- Process Valve Fit for Service
- Corrosion Failure Analysis
- Structural Vibration Caused by Acoustic Pulsation.
- Steam Let down Valve Vibration
- TLE Failure Analysis
- Compressor Vibration
- Time Lapse Corrosion Testing
- Pump Failure
- Piston Failure
- Pipe Stress
- Acoustical Vibration - Reciprocating Compressor
- Compressor Vibration Field Services
- TLE Design Audit
- Waste Heat Recovery Exchanger Vibration
- Low Temperature Brittle Fracture Analysis
- Nozzle Replacement Analysis