

“ The P - Myth ”

It is the morning meeting with the C-ZR Compressor Team that has been recently assigned to determine what caused the compressor wreck. This is the second wreck in the past six months and management is “hot” and everyone is under pressure to figure out what happened. After a short speech by the plant manager, the team starts its meeting. It feels like the movie “Groundhog Day” where you are repeating the same meeting. It appears that the wreck is the same as before with broken blades. As maintenance goes through the presentation showing broken part after broken part, you have a lump in your throat as you remember the conclusions from the last wreck which was as follows:

- No process upsets.
- No mechanical defects
- No controls issues
- No metallurgical materials issues

Although the team has a conclusion that is heavily worded with thousand dollar words; in your mind, nothing was really found. All the experts wooed everyone with their long winded theories containing certain phenomena. The word “slug” comes to mind in some of the explanations. Your process people said no liquids could form, but the experts explained how this phenomenon could occur and it sounded really convincing to the team. In response, your team increased the heating on the intercooler to avoid this possible slug.



Now the situation has arisen again with apparently the same broken blades. However, you are now the team leader! So while all the data is being gathered, you start looking at previous work. You expected the metallurgical to show fatigue and you view the recent failure as the same. You also

noticed that all the interferences between the natural frequencies and running speeds were all discounted. There is a mystery here and you must figure it out. As it turns out, you see that the compressor wrecked at the same rpm, a “safe” rpm, as you understand. The experts involved used a diagram to prove that everything was o.k.....

Unfortunately, this story and similar ones occur over and over again and again. The word “phenomenon” shows up and hence, we have the P-Myth. The P – Myth is when the problem is at a level outside the experience domain of the group and phenomenon theory is applied. A phenomenon refers to an event that appears real to the sense but cannot be proven or understood.

In the story as described above, the root cause of the problem was acoustic pulsation that occurs within the cavity of the compressor. There are diagrams in industry that use a “shortcut” scheme to match the forcing function to the mode shape in vibration. While these diagrams are good within their domain of applicability, they cannot be used “cart- blanc” in compressor failure analysis. These diagrams typically rely on the calculation of a nodal diameter, natural frequencies and so forth. What they don’t consider is cavity acoustics or secondary wake disturbance in the flow field. The phenomena associated with the compressor wreck described above is a myth. The experts just missed incorporating all the physics into the problem. While a rotating equipment example is given here, the P-Myth applies everywhere and don’t let it bite you.

In general, for turbomachinery equipment the following should be considered but not limited to failure analysis and/or design. All these conditions should be evaluated on a transient and steady state basis.

1. Process
2. Controls
3. Materials / Metallurgical
4. Mechanical
5. Field services if possible



The acoustics as described above can be determined through field studies with high speed data acquisition equipment.

Finally, to address the P-Myth. Go back to the fundamental physics that govern your situation. Be careful when employing conference, symposium short cuts, or “new” methods, as they have limitations. As always, these situations should be reviewed by a professional engineer competent in the field.

Knighthawk Project Update

- 15 MW Compressor Wreck - Mining / Metal processing
- Material Handling Audit - Offshore
- Compressor Vibration - Petrochemical
- Vessel Fluid Dynamics - Petrochemical
- Gasifier Failure Analysis - Petrochemical
- Rot Mill Failure Analysis - Fossil Power
- Reactor Failure - Petrochemical
- Steam Turbine Failure - Power
- Gear Box Failure - Paper
- Polymer Gear Pump Analysis - Petrochemical
- Structural Dynamics - Power
- CFD of Exchanger - Petrochemical
- CFD of Pumps - Petrochemical
- Non Linear FEA - Fossil Power
- CFD of Ethylene Furnace Burner – Petrochemical
- Flange Leak Finite Element – Petrochemical
- Reactor Acoustic Vibration - Petrochemical
- Pump Skid Design – Off Shore
- Rotordynamics – Off Shore
- Waste Heat Boiler Failure Analysis and Redesign - Petrochemical
- Level 3 Reactor Fit For Service - Petrochemical
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- Turbine Generator Wreck - Power
- Reactor Design Optimization (FEA) - Petrochemical
- Structural Vibration – Petrochemical
- Inlet Cone Design for TLE’s – Petrochemical
- Integral Gear Compressor Failure Analysis - Petrochemical
- Rotordynamics - Petrochemical

Cliff's Notes:

Knighthawk has circled the wagons around phenomena involved with many problems throughout the last fifteen years of its existence. KHE has worked several remarkable compressor wrecks involving secondary wake disturbance and/or acoustical cavity vibration. We have also looked at complex flow and process dynamics in furnaces and boilers. Knighthawk is a one stop shop for metallurgical, mechanical, process/controls, and process evaluations of turbomachinery / static equipment including field services.

We also have a staff that consists of individuals that come from OEM’s, production, and academia. For complex industrial problems where we have the opportunity to provide full turnkey service I believe we are one of the strongest players in the world.

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