White Paper
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Turbo-Expander Case History: Knowledge of Turbomachinery Health Helps Make Process Decisions

The following presentation includes graphics and charts to describe a problem that occurred in a turbo-expander in a gas processing facility and how process information and vibration information helped to explain the anomaly.

EMERSON. Process Management

Introduction

Every chemical plant has critical rotating machines that can halt production if they go down.

In May of 2008, a gas processing facility in Southern Canada commissioned a new 8100 RPM, 1500 HP turbo-expander. This plant has one spare. During the initial commissioning of the machine, the vibration protection monitor tripped the machine offline. With no machinery health monitoring in place, the decision to restart was made, essentially blind.

In September 2009, machinery health information was collected on this critical machine and it was discovered that the machine posed a serious risk to production – even though overall vibration levels were only reading 1.4 milPP.

In this paper, you will see what anomaly was occurring, and how the vibration information coupled with process information helped tell the rest of the story. You will see live displays that represent the motion of the shaft inside this machine. You will learn how the right tools integrated together can provide immediate feedback to operators for action, or maintenance for planning and analysis. Learn how the vibration protection system protects assets and machinery health integrated to process automation protects the bottom line.

Turbomachinery and Prediction Monitoring

Process upsets may cause damage to rotating machinery that does not appear to immediately impact the operation of the machine. A machinery vibration protection monitor may protect the machine from excessive vibration; however, no detailed machinery health information is available from this type of monitor. Without detailed machinery health diagnostic data, the decision to restart or continue operation is difficult to make.

Integration of machinery health information with process control data is also very important. Process data may help provide insight into the overall health of a particular machine. Other non-process machinery data sources may also provide such insight. In this specific case, one seemingly irrelevant measurement parameter was overlooked, yet it could have caused catastrophic damage to the machine that would have resulted in a significant unplanned plant-wide outage.

A 1500 HP, 8100 RPM, turbo-expander (see Figure 1) was installed and commissioned in a gas plant in Southern Canada in May 2008. The machine rotor is supported by tilting pad journal bearings. During commissioning, high vibration of unknown origin occurred, causing the machinery protection monitor to trip the machine offline. All pre-trip archived process and vibration data was reviewed. No visible damage to the machine was apparent, so the decision was made to restart without performing any internal inspection. Elevated overall vibration levels (~1.4 milPP) at the outboard bearing location were noted after restart. The vibration levels were cause for concern, but no apparent process impact was observed, so the decision was made to place the machine in service.

In February 2009, a machinery prediction monitor was installed in an effort to determine the source of the persistent elevated vibration. The prediction monitor was installed utilizing the buffered outputs from the machinery protection monitor, so there was no need to remove the machine from service.

Vibration data collected from the machine revealed significant sub-synchronous vibration at the outboard bearing location (see Figure 2 & 3). Although the synchronous data appeared stable, the sub-synchronous component was very unstable and caused the vibration levels to oscillate significantly. This vibration oscillation was not indicated by the protection monitor.

Process data was then examined and compared with the vibration data in an effort to determine the source of the sub-synchronous component in the vibration signature. During this examination process, several process and non-process (machine specific) parameters were examined. It was determined that the seal purge gas pressure on the outboard honeycomb gas seal was ~1.5 PSI – well below the specified range of 4-6 PSI. This condition was verified by a visual inspection of a pressure gage mounted on the machine. Attempts to raise the seal purge gas pressure were unsuccessful.

After thorough review of all the available data, the source of the sub-synchronous vibration was determined to be a condition known as ‘gas whirl’. This is a condition similar to ‘oil whirl’ in a journal bearing. The machine was removed from service for an inspection. The diagnosis was confirmed during a subsequent disassembly inspection of the machine.

Plant personnel suspect that during the high vibration event, the outboard wheel contacted the seal surface and rubbed additional clearance in the seal fit, making it impossible to maintain proper seal purge gas pressure.

The machine was removed from service and is currently undergoing rebuild. A machinery protection/prediction monitor will be permanently installed and available for start up.

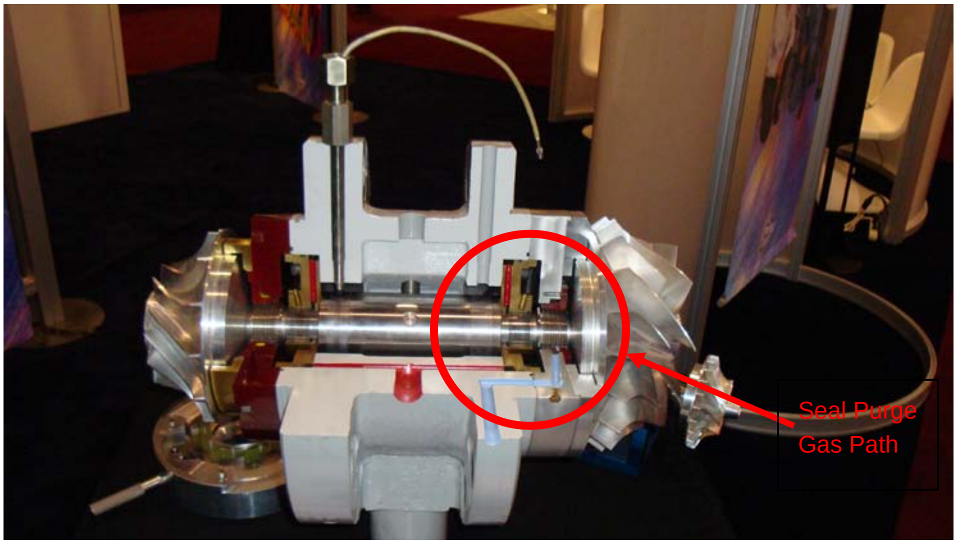

Figure 1 – Typical turbo-expander
(Note seal purge gas path)

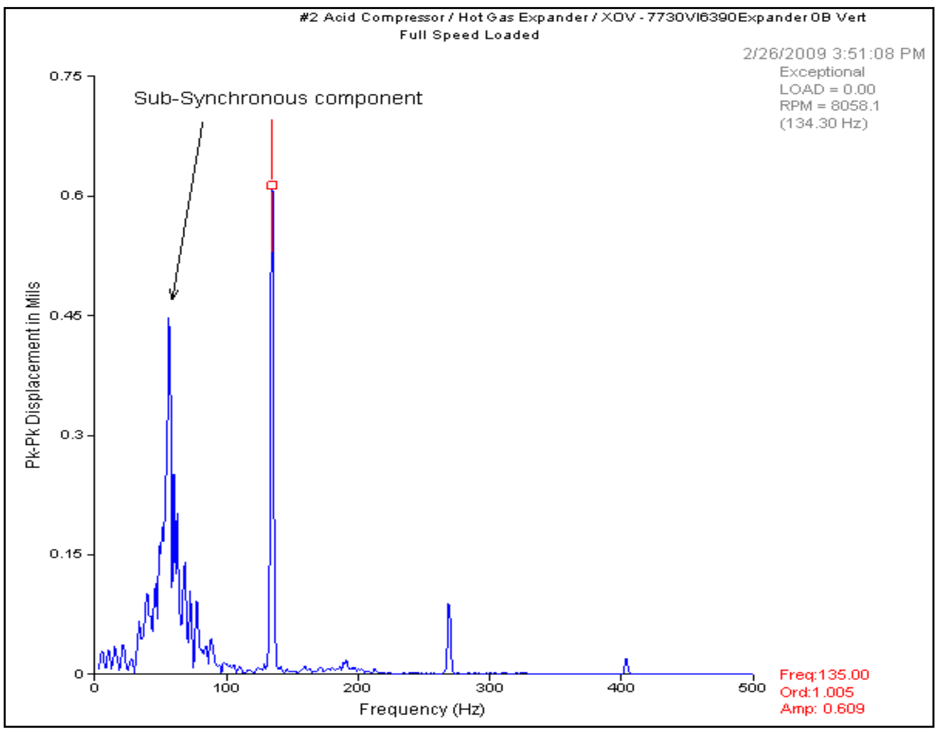

Figure 2 – Spectrum indicating sub-synchronous vibration component

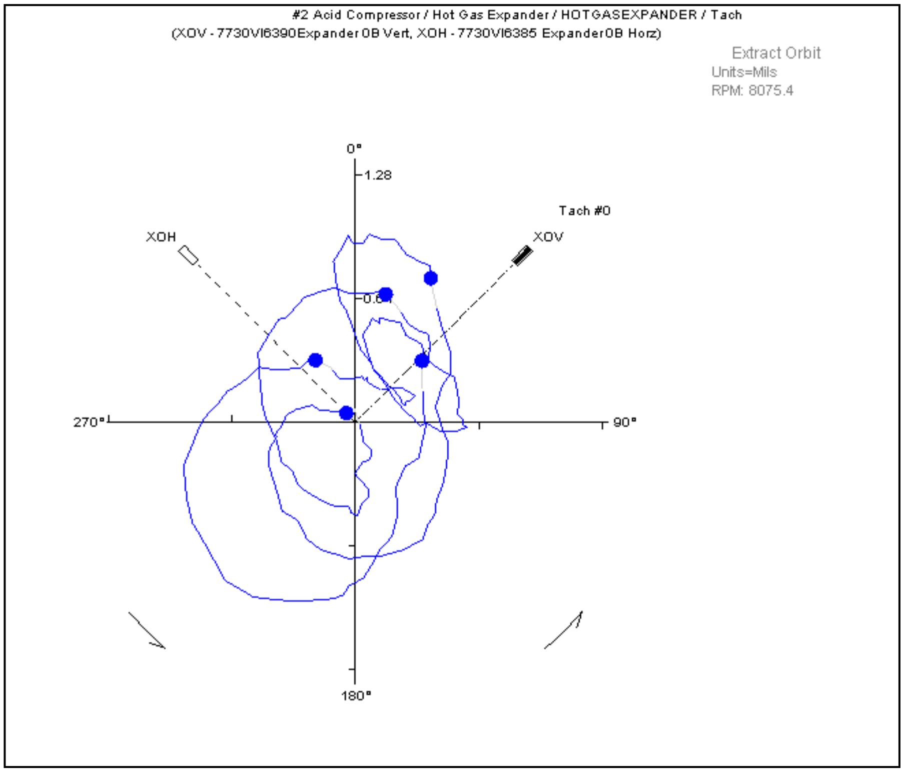

Figure 3 – Orbit data indicating sub-synchronous vibration component

Emerson Process Management
Asset Optimization Business
835 Innovation Drive
Knoxville, TN 37932