CASE STUDY

Optimized Bearings and Dampers Provide Long-term Solution to Vibrations

PROJECT OVERVIEW

Over a 13-year span, a major South American oil company's maintenance department fought recurring high vibrations in three gas reinjection compressor trains. To reduce the likelihood of machine trips, technicians field balanced each compressor once or twice a year and replaced the worn tilt pad journal (TPJ) bearings and O-ring dampers yearly. The downtime from implementing these preventative measures and from trips in the compressor trains resulted in 1% capacity loss each year and additional flaring of the gas.

The company reached out to Bearings Plus®, the aftermarket arm of Waukesha Bearings®, to provide a long-term solution. A thorough analysis of the compressors and an inspection of damaged components pointed to a two-part solution: Flexure Pivot® tilt pad journal bearings and ISFD® technology, an integral squeeze film damper.

In 2013 the compressors were placed back in service with the optimized bearings and dampers (Figure 1). Since then the compressors have exhibited low vibration levels that do not grow over time. They have had no trips and have not required field balancing for continuous operation. Overall efficiency has increased by approximately 1% and site profits have improved.

Figure 1: Flexure Pivot tilt pad journal bearing with ISFD technology

AT A GLANCE

Industry: Oil & Gas production

Application: Gas reinjection compressor trains

- Discharge pressure: 33 MPa
- Rated speed: 11,456 rpm

Product Solutions:

- Flexure Pivot® tilt pad journal bearing
- ISFD® technology
- Rotordynamic analysis

Benefits:

- Elimination of pivot wear
- Consistent damper performance
- Low vibration levels that do not grow over time
- Reduced maintanence costs
- Continuous production through elimination of trips and maintenance downtime
- Increased efficiency

FINDING THE ROOT CAUSE

Put into operation in 2000, each compressor train has two casings: a low-pressure (LP) casing and a high-pressure (HP) casing. The vibration issues occurred in the first, LP casing only.

The OEM bearings were 5-pad load-on-pad point-contact-pivot TPJ bearings, with a bearing outer diameter smaller than the machine casing bore to provide a squeeze film damper function. O-rings at both ends of the bearings were installed to provide stiffness and control damper leakage.

After each direct OEM bearing replacement, rotor vibrations would be reduced for a time. As months wore on, however, vibrations would increase again – requiring repeat maintenance and another bearing replacement.

Inspection of the removed OEM bearings showed severe pivot wear on the tilt pads and bearing shell bore (Figure 2). This wear increased the bearing clearance by 63 microns or more in a five-month period, causing alarming vibrations. The inability of the O-rings to provide centering capability under static deflection, together with the increased vibrations, resulted in bearings bottoming out in the casing (Figure 3) and loss of squeeze film damper performance. These factors converged to increase vibrations over time in the LP casings of the compressors.

SOLVING THE CHALLENGE

With two root causes for the recurring vibrations – pivot wear and unreliable squeeze film damper performance – a combination of two solutions was implemented.

To address the pivot wear, Bearings Plus applied its proprietary Flexure Pivot TPJ bearing. The Flexure Pivot design has a pad and pivot that is integral to the bearing shell, eliminating metal-to-metal contact between the pad and shell when the pad tilts (Figure 4). The bearing manufacturing method, electrical discharge machining (EDM), provides tight control of the clearance and preload for bearing optimization. By eliminating pivot wear, the Flexure Pivot TPJ bearing permanently maintains the original bearing clearance and original preload, changes in which can contribute to vibrations.

Figure 2: Pivot wear on the point-contact-pivot tilt pad (top) and bearing shell bore (bottom)

Figure 3: Damage on the OEM bearing outer diameter from bottoming out

The second part of the solution was the use of patented ISFD technology in place of the O-ring squeeze film damper. Like the Flexure Pivot tilt pad, the ISFD design is manufactured by EDM as part of the bearing itself, not a separate piece. The design offers many benefits over an O-ring damper, including accurate stiffness control, optimized damping, and the ability to center the rotor under static load. Moreover, ISFD technology eliminates changes in stiffness and damping over time. The integral squeeze film damper will not experience degradation or cause the bearing to bottom out, as O-rings can.

Bearings Plus determined the optimum stiffness and damping of the ISFD technology for the gas reinjection compressors through a full lateral rotordynamic analysis of the compressor. Due to the low-profile nature of the Flexure Pivot and ISFD designs, the new bearings were installed as drop-in replacements for the OEM bearings.

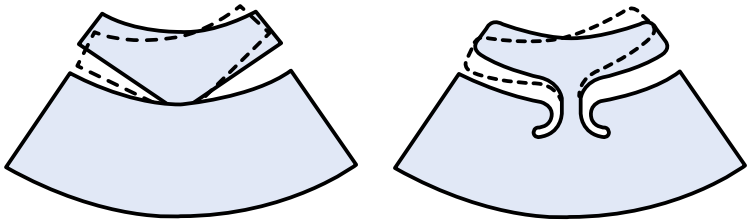

Figure 4: Conventional contact point tilt pad (left) and Flexure Pivot tilt pad (right)

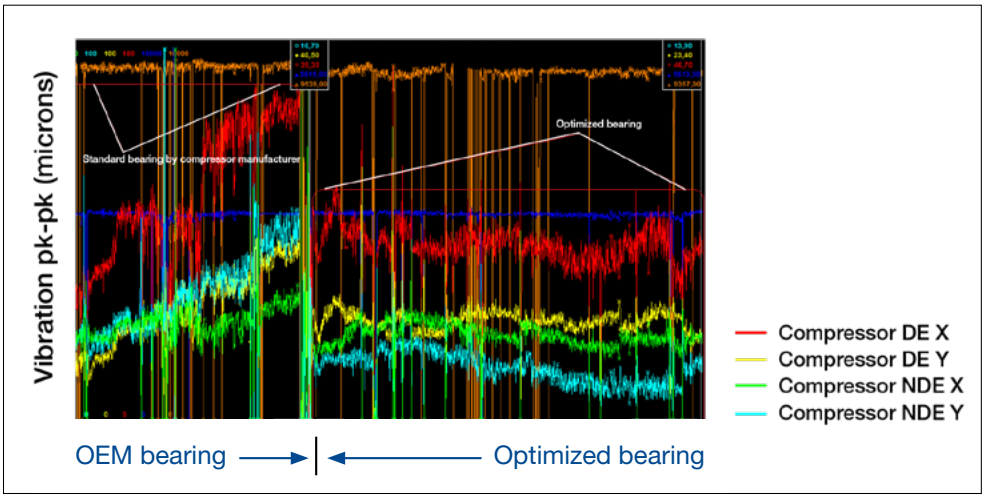

Figure 5: Compressor vibration trend with an OEM bearing over a six-month span followed by the upgraded bearing over a 10-month span.

PROVEN RESULTS

The three upgraded compressors all showed significant improvement with the optimized bearings and dampers. Compressor A vibrations dropped by more than half, Compressor B vibrations dropped from 90 µm to less than 50 µm (Figure 5), and Compressor C vibrations dropped to less than 30 µm with the upgrade. The compressors have maintained the low vibration level over time (Figure 6). In addition, the optimized Flexure Pivot TPJ bearings with ISFD technology have eliminated the small subsynchronous vibrations experienced with the O-ring damper.

Two and a half years after the bearing upgrade, the compressors have required no field balancing, experienced no trips, and had no bearing replacements. The compressors' first set of optimized bearings and dampers from Bearings Plus continue to perform as new. Not only have the vibration problems been fixed but overall efficiency of the compressors has increased by 1%, bringing improvement in site profits.

A LONG-TERM SOLUTION

While replacing worn bearings with another set of bearings of the same design can provide a stopgap, it ultimately incurs additional costs for maintenance, replacements and lost production. A rotordynamic analysis followed by implementation of optimized bearings can reduce or eliminate vibration problems in rotating equipment and provide long-term return on investment. Addressing the root cause of vibrations is the most efficient and cost-effective solution.

This case study was originally presented at the First Asia Turbomachinery & Pump Symposium (ATPS), February 22-25, 2016, Singapore, by Jong Kim, PhD, Senior Consulting Engineer for Bearings Plus and Senior Principal Engineer at Waukesha Bearings. The presentation was co-authored by Marcio Felipe dos Santos, Senior Maintenance Engineer at a major South American oil company, and Barry J. Blair, Chief Engineer at Waukesha Bearings. Adapted with permission of the authors and the Turbomachinery Laboratory, Texas A&M University, College Station, Texas.

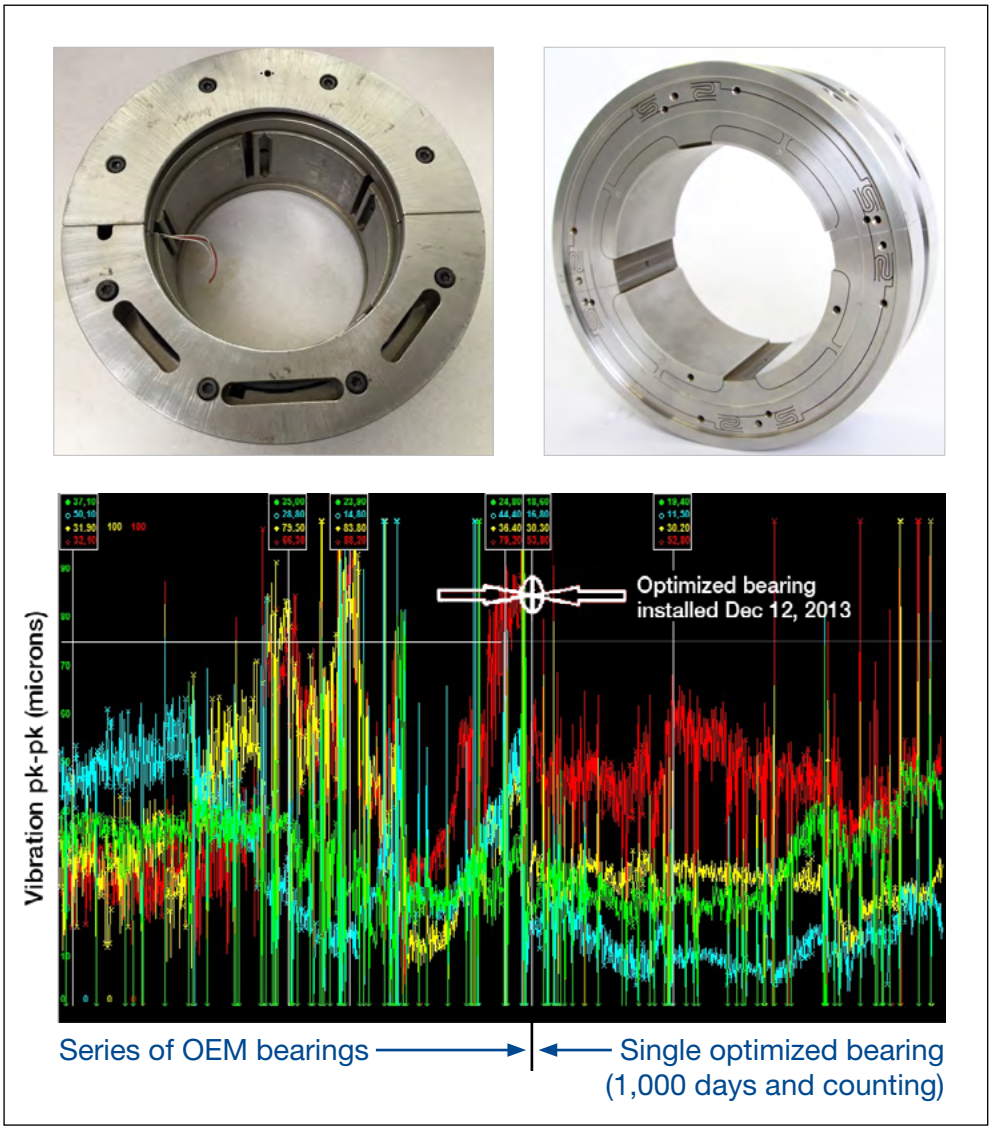

Figure 6: Compressor vibration trend with a series of OEM bearings (top left) over approximately 1,000 days followed by performance of an optimized bearing (top right) over a similar period. Vibration with the optimized bearing has remained steady with no problems and no bearing replacements.