Bearing design reduces performance variability

Tight-tolerance tilt pad journal bearings provide increased stability in high speed turbomachinery equipment. Dr. Kenneth R. Bischof reports.

As machinery builders strive for improved efficiency, higher pressure ratios or increased operational flexibility, static performance and rotordynamic challenges become even greater for rotor-bearing system engineers. Often these challenges are a direct result of a more flexible rotating system and increased rotor length, leading to increased bearing spans. To combat these challenges, fluid film bearing engineers have traditionally relied on a variety of features within a tilt pad journal bearing, such as assembled clearance, pad-angle, pre-load and pivot offset.

When traditional feature variations are not sufficient for more challenging systems, bearing structural stiffness and damping have also been improved through the use of higher performing ball-and-socket pivot designs as well as employing squeeze-film dampers, respectively.

System rotordynamic challenges have placed an increased emphasis on reliably maintaining tight tolerances within bearing manufacturing processes. Even the slightest tolerance variations can have dramatic impact on bearing stiffness and damping characteristics, ultimately leading to differences between predicted and actual performance of the machine.

Early in 2008 Waukesha Bearings completed development of a new bearing design aimed at solving many of the technical issues surrounding the dynamic performance of the rotor-bearing system. This new design utilises a patent-pending, single-piece frame construction with the tilt pads integral to the shell and without sacrificing pivot stiffness, creating a potential fatigue-failure point or restricting free-tilt of the journal pads. This is accomplished through the use of an EDM manufacturing process used in combination with a hardened steel pivot, offering a solution with reduced pad flutter, particularly in unloaded pads, and less vibration, fatigue and wear. The bearing is also designed with a secondary integral pad stop that prevents over-rotation as well as improved oil distribution across the pads.

One of the primary benefits of the single-piece construction used in combination with the hardened steel pivot design is the significant improvement in bearing and pad bore tolerance. The design eliminates the tolerance stack-up inherent to traditional tilt pad journal bearings and provides a platform where bearing bore machining is the final step in the manufacturing process. Bearing bore tolerances can be held to within 0.0003-in (8 microns), which decreases variability of dynamic performance prediction models, improves machine performance and ultimately reduces variation from machine-to-machine.

Fig. 1. Waukesha's tight-tolerance tilt pad journal bearing is designed to reduce bearing dynamic performance variability.

To date, applications realising the most benefit from this unique single-piece frame design have been turbomachinery that require tight tolerances relative to the overall bearing clearance in order to reduce machine variability and control rotordynamics. Specific applications include high speed compressors, gearboxes, turbochargers and turboexpanders.

Additional application-specific options available in this design are complex bore shapes for rotordynamic benefits and alternative materials such as bearing-grade bronze. For applications requiring combination thrust and journal bearings, this design can be paired with a variety of thrust bearing options.

In summary, Waukesha's tight-tolerance tilt pad journal bearing is designed to reduce bearing dynamic performance variability, providing increased machine stability. The design achieves high pivot stiffness without sacrificing the benefits associated with freely tilting journal pads. ❑

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