Rotordynamic Performance of a Turboexpander Supported on Gas-Lubricated Bearings

NEW PROPOSAL

Dr. Adolfo Delgado, Associate Professor

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Introduction

One of the fundamental limitations preventing the use of gas-lubricated bearings in a broader range of turbomachinery applications is related to their dynamic performance (i.e. lack of damping) [1]. Compliantly damped hybrid gas bearings (HGB), shown in Fig. 1, represent an alternative design to gas foil bearings (GFB) with improved dynamic performance [2]. The HGB combines key enabling functions from both fixed geometry externally pressurized gas bearings and compliant foil bearings in efforts to improve load capacity and damping while maintaining tolerance to misalignment [3]. This design addresses fundamental GFB limitations while retaining key characteristics required for implementation into large size turbomachinery (MW output range), such as tolerance to misalignment, room for rotor centrifugal growth and thermal growth. Ertas [2] demonstrated superior load capacity and damping performance of HGBs compared to GFBs for small size diameters (70 mm). In 2015, Delgado [3] demonstrated scalability of the bearing performance for a bearing 110 mm in diameter with component level tests yielding the largest amount of damping ever measured for a gas-lubricated bearing. HGB static and dynamic performance from these tests demonstrated feasibility of implementing this concept in high power density turbomachinery in the MW power output range.

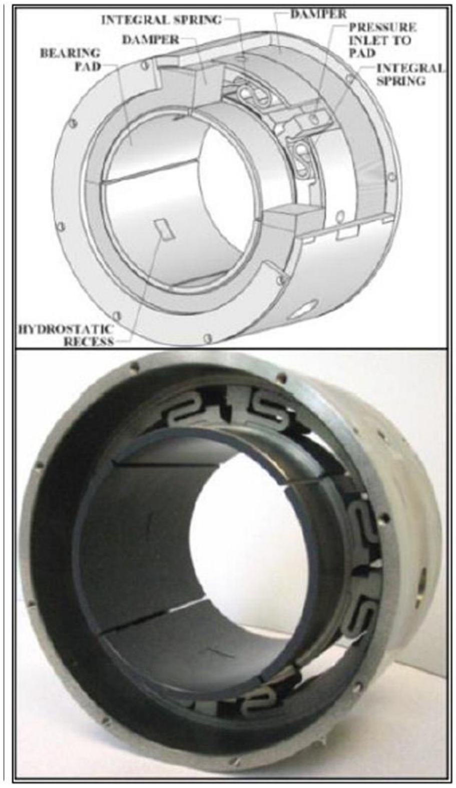

Figure 1. Compliantly damped hybrid gas bearing [2].

The HGB concept had been further developed to increase damping performance and reliability [4,5]. However, the technology development has been limited to component-level testing of single bearings in controlled motion test rigs. The next step in the bearing development is to evaluate its performance at a system level.

Proposed work 2019-2021

The first year of the project will focus on completing the design and manufacturing of the system-level test rig and test bearings. The test rig will feature a 36,000/40 HP spindle motor and it will be capable of housing rotors with up to 1m (3.2 ft) bearing span. The second year will concentrate on testing a dummy rotor up to 30,000 RPM. The rotor, donated to the Turbomachinery laboratory, is part of a turboexpander system used in pressure letdown stations for natural gas distribution applications. The actual machine features magnetic bearings to simplify sealing and overall architecture. This application, not suitable for GFBs, provides a good platform for evaluating the capabilities of HGB at a system level. There is currently no machine in this size-class supported on process gas-lubricated bearings.

The deliverables after the first year will be an operational test rig. The final deliveries after the second year will include experimental and numerical unbalance response detailing damping factors (through shaker tests) and peak vibration amplitudes.

Budget

Graduate Student Payroll, 12 months @ $2200/month	$ 26,400
Fringe Benefits	$ 5,755
Tuition and fees	$ 13,275
Test rig hardware	$ 4,570
Total	$ 50,000

References

[1] DellaCorte, C., and Bruckner, R., 2010, "Remaining Technical Challenges and Future Plans for Oil-Free Turbomachinery," ASME J. Eng. Gas Turbines Power, **133**(4), p. 042502.

[2] Bugra E. H., 2008, "Compliant Hybrid Journal Bearings Using Integral Wire Mesh Dampers," J. Eng. Gas Turbines Power, **131**(2), p. 022503.

[3] Delgado, A., 2015, "Experimental Identification of Dynamic Force Coefficients for a 110 MM Compliantly Damped Hybrid Gas Bearing," J. Eng. Gas Turbines Power, **137**(7), p.072502.

[4] Delgado, A., Ertas, B., Hallman, D., Smith, W., "Hermetically Sealed Damper Assembly and Methods of Assembling Same," U.S. Patent 9,121,448 B2, filed Sep. 2013 and issued Sep. 2015.

[5] Ertas, B., Delgado, A., Hallman, D., Smith, W., "Journal Bearing Assemblies and Methods of Assembling Same," U.S. Patent 9,429,191, filed Sep. 2013 and issued Aug. 2016.