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MAJOR BREAKTHROUGH IN LOAD CAPACITY, SPEED AND OPERATING TEMPERATURE OF FOIL THRUST BEARINGS

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ABSTRACT

This paper describes major breakthroughs in foil thrust bearings achieving a thrust load capacity in excess of 570 kPa (83 psi), supersonic tip speed of 625 m/s (2050 ft/s) and temperature capability of 815 °C (1500 °F). Compliant foil bearings surpass many of the inherently show-stopping and debilitating features of rolling element bearings. Foil Bearings not only provide an environmentally-friendly, oil-free system of support, but are also well suited for high speed and extreme temperature applications such as gas turbines, compressors, turbochargers, cryogenic-turbopumps, turboexpanders, high speed motors and others. Modern foil bearings have demonstrated stable operational capabilities at super-critical speeds due to their tribodamping intrinsicity and ability to operate with any process fluid (gas or liquid). Recent developments have allowed increased operating temperatures, soaring to 815 °C and above, thus, providing a broader operational temperature range from deep cryogenic to extreme high temperatures.

Foil journal bearings received more research and development attention in the past, achieving load capacity of 670 kPa (97 psi), reported by Heshmat in 1994. Foil thrust bearings' load capacity at that time was in the range of 150 kPa to 200 kPa (20 – 30 psi) and their temperature capability was ambient to 150 °C (300 °F). This paper discusses a recent major breakthrough in the improvement of the load capacity, high speed capability of compliant foil thrust bearings, as well as extending their operating temperature range to 815 °C. Applying the available analytical tools and newly developed coatings, new thrust bearings have been designed with improved bearing geometry and structural compliancy. The advancement in solid lubricant coatings provided excellent tolerance to intermittent high-speed rubs, thus, making the bearings more robust against shock and extreme loadings.

These advanced bearings, with outer diameters ranging from 90 mm to 230 mm, demonstrated a load capacity of 570 kPa (82.7 psi) at 200 m/s runner tip speed. This achievement constitutes two-fold improvement over any state-of-the-art hydrodynamic foil thrust bearings ever reported in the literatures and significantly expands the envelope of possible bearing applications. Improving the bearing load capacity at

speeds near Mach 1.6 and higher is also discussed, as well as hydrodynamic operation of a foil thrust pad at 815 °C.

Key words: foil bearings, compliant foil thrust bearings, oil free bearings, high-temperature coatings, gas bearings, fluid film bearings, hydrodynamic bearings.