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Foil Bearings Make Oil-Free Turbocharger Possible

Crystal A. Heshmat

Mohawk Innovative Technology, Inc. (MiTi[®])
1037 Watervliet-Shaker Road
Albany, New York 12205 USA

Mark J. Valco, Ph.D.

U.S. Army Research Laboratory
Vehicle Technology Directorate
NASA/Glenn Research Center
21000 Brookpark Road
Cleveland, OH 44135-3191

Christopher Della Corte, Ph.D.

NASA/Glenn Research Center
Materials Science Branch
MS23-2
21000 Brookpark Road
Cleveland, OH 44135-3191

Hooshang Heshmat, Ph.D.

Mohawk Innovative Technology, Inc.
1037 Watervliet-Shaker Road
Albany, New York 12205 USA

Kevin C. Radil

U.S. Army Research Laboratory
Vehicle Technology Directorate
NASA/Glenn Research Center
21000 Brookpark Road
Cleveland, OH 44135-3191

ABSTRACT

This paper describes an oil-free, 150 Hp turbocharger that was successfully operated with compliant foil bearings in a range of pitch and roll angles, including vertical operation, thereby demonstrating its viability for aircraft applications. On a gas test stand the turbocharger was operated to 120,000 rpm, under extreme conditions. In addition, the compliant foil bearing-supported turbocharger successfully tolerated shock and vibration of 40 g.

Advanced technologies have been applied to the second generation of this turbocharger, shown in Figure 1, including self acting, compliant foil hydrodynamic air bearings with advanced coatings capable of operation above 815 °C (1500°F). Journal foil bearings with maximum load capacity up to 670 kPa (97 psi) were used in conjunction with thrust foil bearings capable of maximum loads to 570 kPa (83 psi).

Bearing component development tests demonstrated 30,000 start stop cycles at 815 °C (1500°F) with a newly developed, solid lubricant coating, KOROLON[™]. KOROLON[™] exhibits a coefficient of friction of less than 0.1 at a wide range of temperatures. Current-designed foil bearings with KOROLON[™] have immensely decreased turbolag, allowing acceleration from rest to over 100,000 rpm in less than 2 seconds. Advanced bearing stiffness maintained rotor total axial end-to-end motion within 100 microns (0.004 inch).

Total radial static and dynamic motion was controlled within 25 microns (0.001 inch).

Development of this high speed turbomachine included bearing and solid lubricant component development tests, rotor-bearing dynamic simulator qualification and gas stand tests of the assembled turbocharger. Gas stand and simulator test results revealed stable bearing temperatures, low rotor vibrations, good shock tolerance and the ability of the rotor bearing system to sustain overspeed conditions beyond 120,000 rpm.

This combination of component and integrated rotor-bearing system technology addresses many of the issues associated with application of compliant foil bearings to industrial compressors, blowers, and gas turbine engines, overcoming many of the inherently show-stopping and debilitating features of rolling element bearings, i.e., speed and temperature limitations.

Key words: GAS TURBINE ENGINES, TURBOMACHINERY, TURBOCHARGERS, FOIL BEARINGS, COMPLIANT FOIL THRUST BEARINGS, OIL FREE BEARINGS, HIGH-TEMPERATURE COATINGS, GAS BEARINGS, FLUID FILM BEARINGS, HYDRODYNAMIC BEARINGS, HIGH TEMPERATURE BEARINGS, OIL RELIEF BEARINGS, ROLLING ELEMENT BEARINGS, OILFREE TURBOMACHINERY.