

MiT Development

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100mm Diameter Self-Contained Solid/Powder Lubricated Auxiliary Bearing operated at 30,000rpm

A major breakthrough development of a self-contained solid/powder lubricated auxiliary bearing (PLAB) has recently been successfully operated at speeds to 30,000rpm and loads to 445N (100lb) for record breaking operations equivalent to 3 million DN (DN = shaft diameter in mm x speed in rpm).

This highly advanced bearing technology is an excellent candidate for high temperature and vacuum environments, where liquid lubricants are known to have limitations. Potential applications include systems requiring auxiliary backup bearings for magnetic bearings, such as, ground and space based Flywheel Energy Storage Systems, Gas Turbine Engines and Advanced Auxiliary and Integrated Power Unit Systems. This bearing design approach eliminates the problems associated with conventional backup bearings, which are prone to backward whirl induced instability and extremely short life. Backward whirl instability is eliminated through reduced stiffness and friction coefficient at the contact as well as through inherent bearing damping. The short life associated with conventional rolling element backup bearings (REBBs) is overcome since no moving parts are involved. In conventional REBBs the elements must be accelerated from rest to full speed in extremely short times causing skidding and large forces on the separators, which leads to early failure.

The two major technology components for this system are the powder pelletized lubricant delivery system and the compliantly mounted slider type journal bearing. Figure 1 shows the conceptual layout of the pads and the pellets.

PLAB Concept

The uniqueness of the PLAB bearing lies in its application of dry triboparticulate powders to provide a long life, low power loss backup bearing. The introduction of powders between the bearing pad and rotating shaft generates a Quasi-Hydrodynamic film that separates the shaft and bearing, eliminating wear and transferring a significant portion of the heat out of the contact zone.

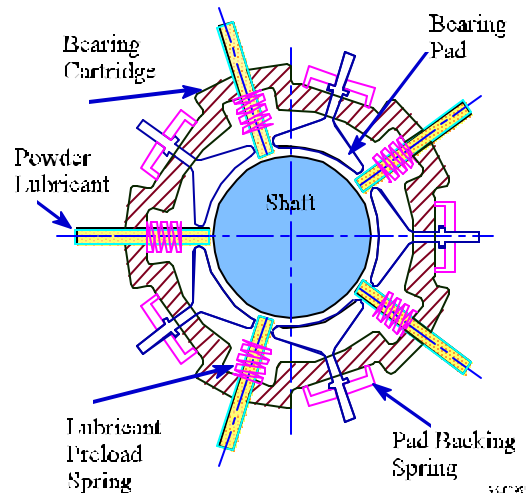


Figure 1 Conceptual Layout of Pellets and Pad

PLAB Test Data

The prototype bearing as shown in Figure 2, for the first of a kind feasibility demonstration testing. For these feasibility tests, a journal bearing with 5 flexibly mounted titanium carbide pads with intervening pellets was assembled.

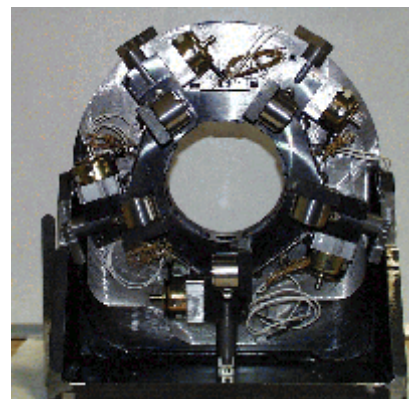


Figure 2 100mm PLAB Assembly

The lubricant pellets, made from Molybdenum Disulfide powder with a proprietary MiTi binder, were placed in a cylindrical sleeve with a constant force spring which was controlled by an electromechanical system employing solenoids, in order to control the pellet engagements to the shaft only when required.

The final prototype test assembly, shown in Figure 3, incorporated an electric drive motor, shaft, magnetic bearing and the powder lubricated bearing.

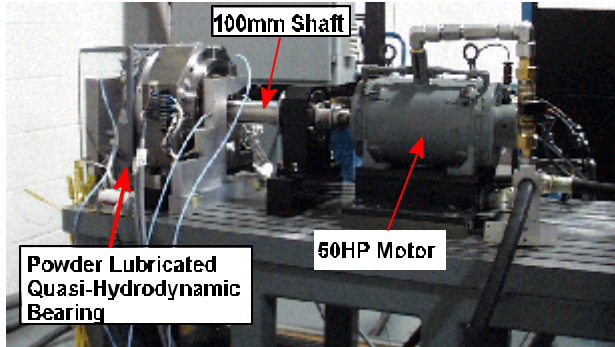


Figure 3 PLAB Prototype

The basic feasibility of developing powder-lubricated quasi-hydrodynamic bearings was successfully demonstrated under low speed tests from 2,000-5,000rpm, simulating magnetic bearing failure at 15,000rpm, high speed tests ranging from 20,000-30,000rpm and varying load tests from 35-100lbs.

The acquired test data spanned the range of the expected operating conditions, including lubricant feed rate, bearing temperatures and operational dynamic performance. This has clearly been demonstrated by the resistance to wear following 6 hours of accumulated testing. Thermal stability was achieved at all load and speed combinations. An intermediate layer of powder adhered to the shaft and pad surfaces, resulting in wear protection to the bearing mating surfaces. Torque measurements with Molybdenum disulfide pellet and slider pad arrangement from the initial tribomaterials tests confirmed the expected low power loss.

The temperature results for the high speed test at 30,000rpm are presented in Fig. 4 and these clearly show that the lubricant is operating within the temperature limitations of molybdenum disulfide, which has a maximum temperature capability up to about 850°F. Figure 5 shows a compilation of the instantaneous FFT's (Frequency Spectra) taken at discrete time intervals, showing an overall view of the test process. For this test the rotor was run up to 30,000rpm on the Magnetic Bearing. The Magnetic Bearing was then deactivated and the Powder Lubricated Auxiliary Bearing (PLAB) engaged. As seen, the shaft operated very smoothly on the PLAB, both at speed and during coastdown

The observed low frequency motion was due to the first rigid body mode. These results have clearly validated the overall design analysis of the bearing and the lubricant delivery system.

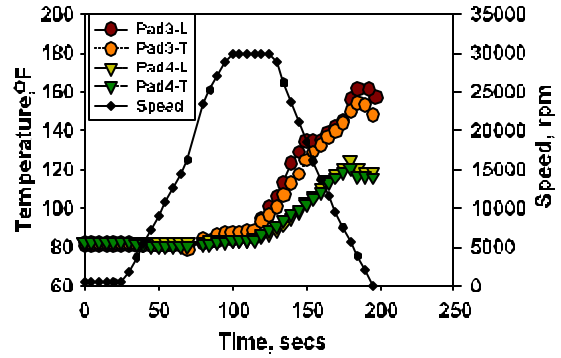


Figure 4 Temperature Change of Pads at High Speed Test of 30,000rpm

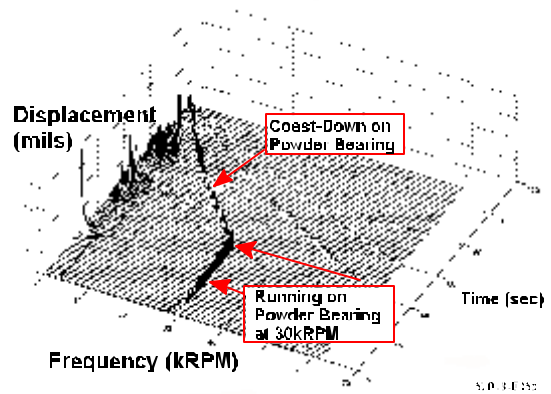


Figure 5 Front Horizontal Displacement

Demonstrated

The feasibility of using a Solid Lubricated Hydrodynamic Auxiliary Bearing for magnetically supported rotors has been successfully demonstrated. Combined with MiTi's other bearing technologies, the ZCAB and the Compliant Foil Bearings, a wide range of unique bearing solutions are being developed for advanced high speed machinery.

For Additional Information, contact:

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