

MiTi Developments

Mohawk Innovative
Technology, Inc.



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942 Pounds on a Film of Air!

A Mohawk Innovative Technology, Inc. developed 4 inch diameter by 3 inch long, self-acting, compliant foil bearing has successfully supported a steady load of 942 pounds with a superimposed dynamic load of 200 pounds for a shaft spinning at 22,000 rpm. This load is more than 5 ½ times larger than previously demonstrated maximum load levels for foil bearings. With this successful test, it is clear that the hydrodynamic, compliant foil bearing is poised to revolutionize the design of high speed rotating machinery, and fulfill the prediction that foil bearings will be part of the next generation of aircraft gas turbine engines.

This breakthrough development was accomplished as part of a US Army sponsored Phase II Small Business Innovation Research program. Under this program, the operation of a unique MiTi hybrid bearing which combines the foil bearing with a magnetic bearing to provide a single integrated active and passive shaft suspension system was demonstrated for the first time ever. The test rig developed for this program is shown in Fig. 1. This test rig was designed to simulate typical speeds and loads for a helicopter class gas turbine engine, such as being developed under the DoD's Joint Turbine Advanced Gas Generator (JTAGG) program. The tested hybrid bearing is shown in Fig. 2. This bearing was sized to meet a wide range of potential applications and demonstrate scalability to larger systems.

Foil bearings are especially attractive for systems

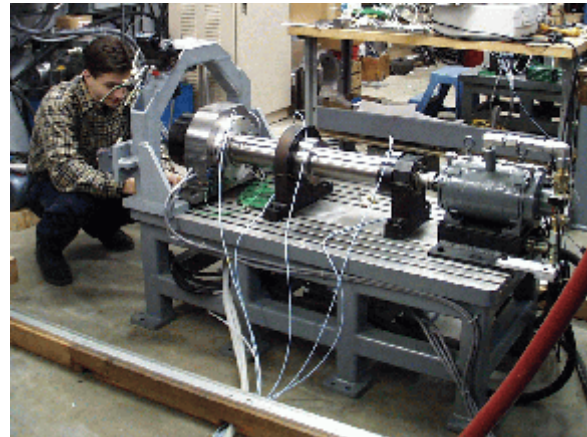


Figure 1 - High Speed Test Rig (JTAGG Simulator)

where conventional bearings are unsuitable due to temperature, speed, working fluid or any combinations thereof. Since foil bearings are oil free, and can operate with ambient air, they are also an environmentally friendly solution for systems where lubricant contamination would be problematic. Potential applications now possible for foil and hybrid foil/magnetic bearings include aircraft gas turbine engines, helicopter engines, auxiliary power units, microturbines, compressors and pumps.

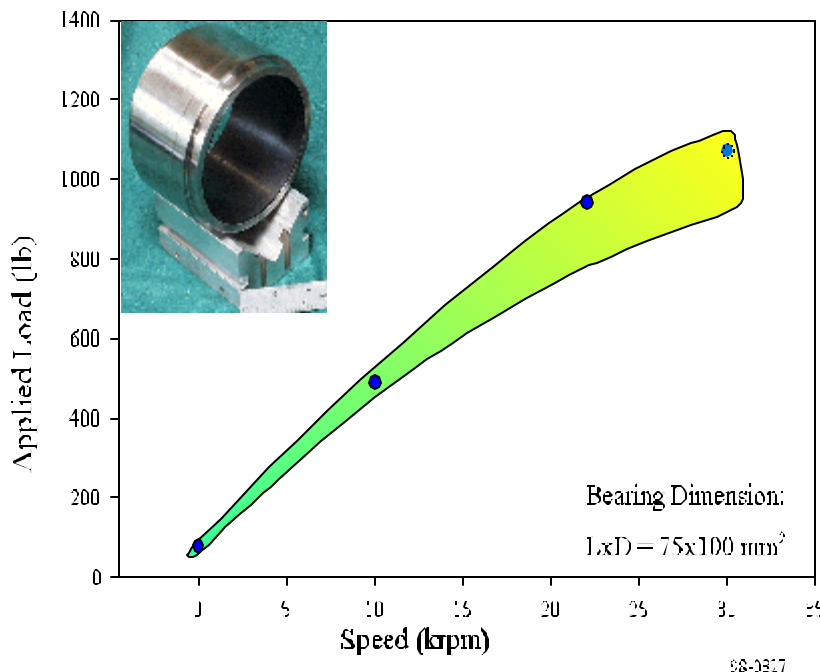


Figure 2 - Measured Foil Bearing Performance

The Foil Bearing

The essence of the compliant surface, hydrodynamic "foil bearing", is the combination of a gas lubricated hydrodynamic film with a flexibly supported bearing surface. This two level construction gives the Compliant Foil Bearing (CFB) the ability to provide a well damped, low friction, oil-free shaft support capable of adjusting to significant misalignment as well as thermal/mechanical shaft and housing deformations. The design permits the bearing to be tailored to each application for optimal performance through changes in geometry, construction, materials and special coatings.

Early CFB's exhibited low load capacity and damping, thus limiting their applications. Current MiTi designs overcome these historical deficits. As can

be seen in Fig. 2, the current test bearing exhibits substantial load capacity. Previous editions of "MiTi Developments" and other publications from MiTi researchers have also highlighted the ability of MiTi's oil-free CFB's to handle shocks, operate over a temperature range from cryogenic to over 1200 degrees Fahrenheit, and operation of a foil bearing supported rotor at speeds above the first shaft bending mode.

Active Magnetic Bearing Load Capacity Tripled

Another exciting application of CFB's is in the hybrid foil/active magnetic bearing. This bearing combines the high speed load capacity and shock tolerance of the foil bearing with the zero speed load capacity and active control possibilities of an active magnetic bearing. As can be seen in Fig. 3, this combination effectively **triples** the load capacity of the magnetic bearing and eliminates concerns about foil bearing/shaft rubbing at low speeds. Since the hybrid bearing combines the foil bearing's specific load capacity of close to 9,000 pounds per pound of bearing weight with the magnetic bearing's specific load capacity of

about 40 pounds per pound of bearing weight, the weight penalty for tripling the magnetic bearing load capacity is negligible. Depending on the bearing design, the space penalty can also be very low.

Machine Ready!

With the successful completion of the recent Army sponsored SBIR Phase II Program, MiTi is now developing commercialization plans for these breakthrough foil and hybrid foil/active magnetic bearings. These bearings will allow the designers of the next generation of gas turbine engines, auxiliary power units, and other high speed rotating machinery to develop new and innovative machines which better meet the needs of the end user.

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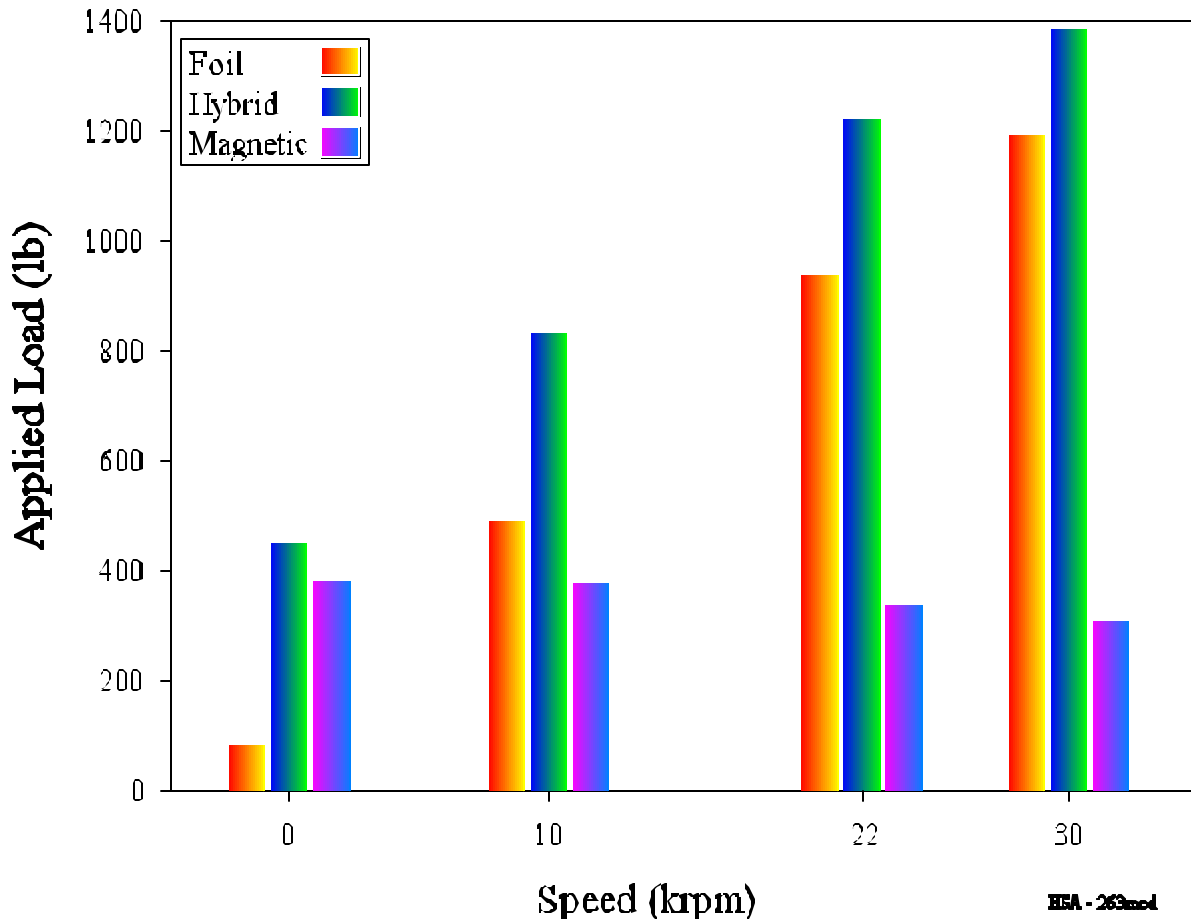


Figure 3 - Measured Hybrid Bearing Performance