MiTi Developments

Mohawk Innovative Technology, Inc.

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High Speed Auxiliary Bearing Demonstrated

The major stumbling block to successful commercial application of active magnetic bearings (AMB) is the lack of a reliable back-up bearing technology. Current back-up bearings do not adequately address the reliability and life concerns of the end-user. Until these concerns are addressed, the unique, high performance design possibilities afforded by active magnetic bearings will remain closed to new industrial designs.

As part of a program to advance the state-of-the art in turbomachinery design by developing new high performance rotor support systems, MiTi is addressing the auxiliary bearing needs of the AMB through the development of the Zero Clearance Auxiliary Bearing (ZCAB). This patented bearing concept is a significant departure from conventional wide clearance rolling element or solid bushing bearings. Recent testing, described below, demonstrates the soundness of the ZCAB concept.

ZCAB Concept

In essence, the ZCAB consists of a radial array of rollers positioned around the shaft as shown in Fig. 1. Under normal operation, there is a clearance space between the rollers and shaft as with a conventional rolling element back-up bearing. However, in the case of a magnetic bearing failure, the shaft drops onto several rollers which then move inward to eliminate the clearance space until all of the rollers contact the shaft. The ZCAB closure also serves to re-center the shaft for continued operation or magnetic bearing re-engagement. Following a re-engagement of the magnetic bearing, the ZCAB can then be re-opened to a non-contact configuration. During ZCAB operation, damping and compliance are provided through the ZCAB mount.

The elimination of the clearance space, lower component inertias, as well as the discrete roller contact will tend to eliminate the instabilities associated with a conventional clearance type rolling element back-up bearing. The design of this bearing also addresses many of the other concerns, such as ball skidding, cage instability, high rotation speed, etc. associated with a conventional rolling element back-up bearing. In the case of momentary magnetic bearing overload, the ZCAB can provide load sharing in either the open position, or a short term closure. ZCAB closure rate can be varied to suit the operational requirements, with a practical lower bound on the order of tens of milliseconds. Variations of the ZCAB which provide thrust load capability have also been developed.

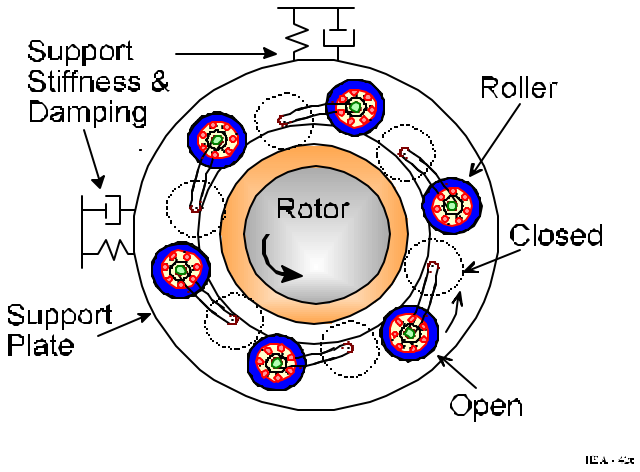

Figure 1 - ZCAB Concept

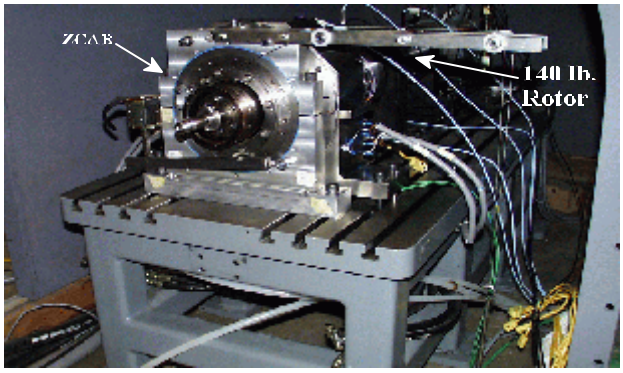

Figure 2 - Protype ZCAB Mounted on Full Scale Test Stand

4 Inch Diameter ZCAB Tests

The prototype ZCAB, described in a previous edition of *MiTi Developments*, is an eight roller ZCAB, designed for use with a 4 inch diameter shaft. This prototype ZCAB was designed to support 34 pounds at up to 10,000 RPM. More recently, this bearing was retrofitted to increase its load capacity, and installed in a larger, higher speed test rig. In this application, the ZCAB supports a 140 pound shaft in a rig capable of operation at speeds in excess of 30,000 RPM. The shaft in this rig is similar in size and weight to a typical helicopter class gas turbine. Figures 2 and 3 show the ZCAB in this test rig.

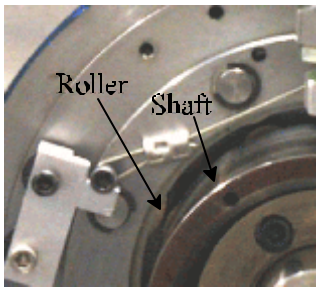

Figure 3 - Close-Up of ZCAB

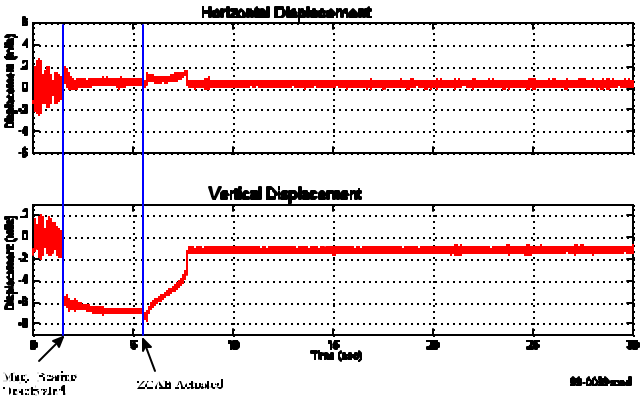

Figure 4 - 9000 RPM Drop and Recovery Transient

Figure 4 shows a typical rotor drop and recovery with the ZCAB on the larger test rig at 9000 RPM. As indicated in the figure, the sequence is as follows:

- AMB is deactivated
- Shaft drops onto the lower two rollers
- Shaft runs briefly on the rollers
- ZCAB closes
- Shaft is re-centered by ZCAB
- Shaft coasts to stop (approximately 10 kRPM/minute deceleration rate)

Figure 5 presents a series of ZCAB actuations for increasing shaft speed, from 9,000 RPM to 21,000 RPM. The initial drop transients are not shown in this figure in the interest of clarity. For the purposes of these tests, the length of run-time prior to ZCAB activation, and the ZCAB actuation rate were varied through-out the tests series. It should be noted that the 21,000 RPM test case is more than double the design speed of the ZCAB!

In all cases, the ZCAB provided a controlled, safe shaft support throughout the coast-down. No maintenance was performed on the ZCAB throughout the entire test sequence.

ZCAB DEVELOPMENT

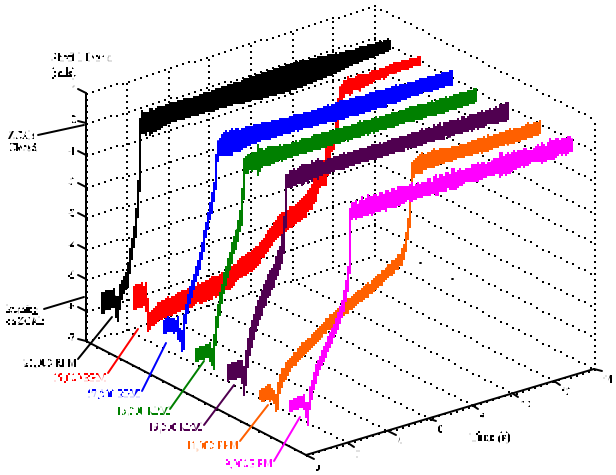

Figure 5 - ZCAB Actuations at Higher Speeds

With these very successful demonstrations of the ZCAB concept, along with MiTi's hybrid foil/magnetic bearing technology, and the extreme temperature possibilities of powder lubricated bearings, MiTi has given magnetic bearing designers more reliable, higher performance alternatives to loose clearance rolling element or solid bushing back-up bearing designs. These technologies remove one of the major obstacles to wider application of active magnetic bearings for rotating machinery. Be it high load, high speed or high temperature, MiTi leads the way in developing new back-up bearing system technology to give designers a variety of high performance bearing systems to meet today's and tomorrow's needs.

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