

# MiT*i* Developments

Mohawk Innovative  
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## Zero-Clearance Auxiliary Bearing Developed

As part of MiTi's continuing program to develop reliable, low maintenance back-up bearings for magnetic bearing supported turbomachinery, a novel back-up bearing has been developed and patented. This bearing, the Zero Clearance Auxiliary Bearing (ZCAB), solves most of the problems associated with conventional wide clearance and solid bushing back-up bearings. A prototype ZCAB is shown in Fig. 1.

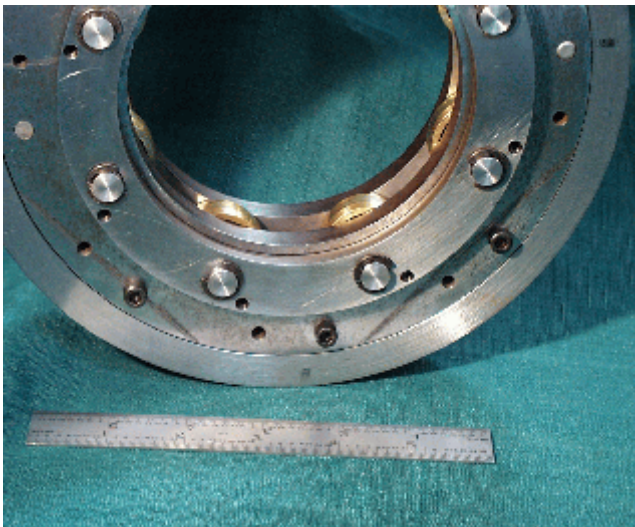


Figure 1 - 100mm Prototype ZCAB

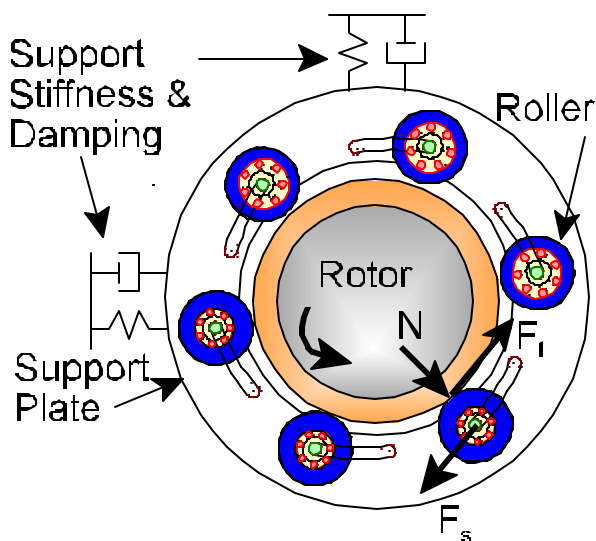


Figure 2 - ZCAB Concept

### DESCRIPTION OF ZCAB

In essence, the ZCAB concept consists of a radial array of rollers positioned around the shaft as shown in Fig. 2. 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. 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. Variations of the ZCAB which provide thrust load capability have also been developed.

### ZCAB TESTING

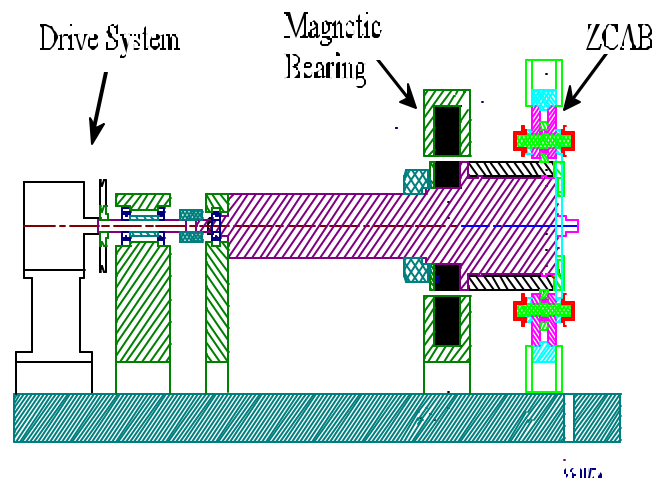


Figure 3 - ZCAB Test Rig

As a proof of the ZCAB concept, the prototype ZCAB shown in Fig. 1 was installed as a back-up bearing for a test rotor which is supported with a magnetic bearing at one end, as shown in Fig. 3.

With this test rig, the rotor can be operated at up to 11,000 RPM with the magnetic bearing supporting the rotor, and clearance between the shaft and ZCAB rollers. The magnetic bearing can then be deactivated, thus dropping the rotor onto the ZCAB. The subsequent rotor motion can then be recorded for analysis.

### ZCAB IN ACTION

Using this test rig, a number of rotor drops onto the ZCAB were performed. Figure 4 shows the typical rotor

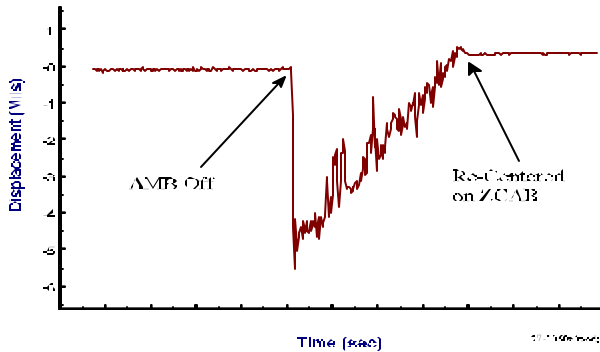


Figure 4 - Typical Rotor Vertical Motion with ZCAB

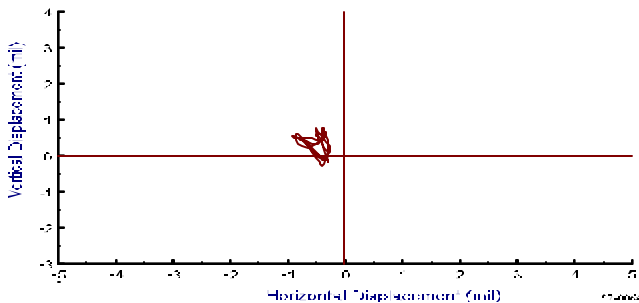


Figure 5 - Typical Rotor Orbit with ZCAB

vertical motion as a function of time during a magnetic bearing shut-down and ZCAB recovery. Note that the ZCAB effectively contains and re-centers the rotor. Figure 5 shows a typical rotor orbit once the ZCAB has closed.

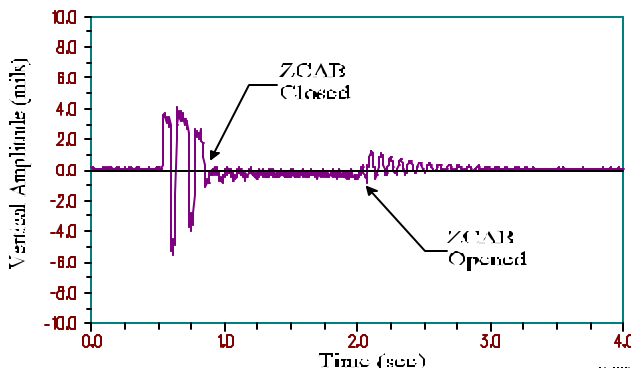


Figure 6 - ZCAB/Magnetic Bearing Response to Shock

The ZCAB can also function in a load sharing mode during a transient overload due to maneuvers or shocks. Figure 6 shows the shaft vertical motion during a 14-G shock which overloads the magnetic bearing support.

The very well controlled ZCAB orbits can be contrasted with the violent backwards whirl shown in Fig. 7,

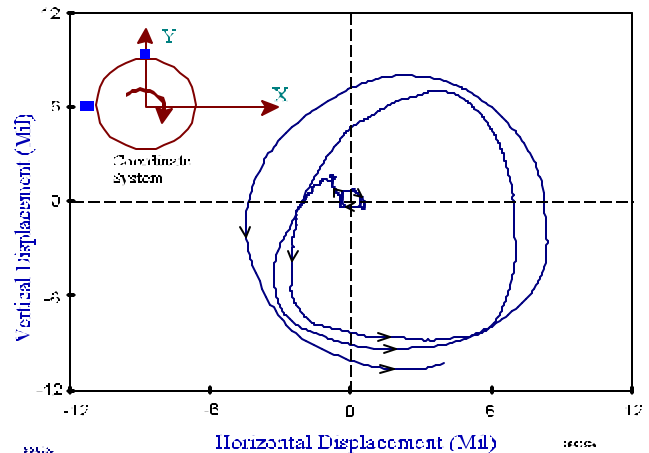


Figure 7 - Backwards Whirl in Conventional Bearing

which was obtained with the same test rotor and a conventional, loose clearance back-up bearing. This motion was so severe, that the magnetic bearing was unable to recover control when it was re-energized.

### ZCAB DEVELOPMENT

The next step for the ZCAB is further testing of this prototype in a larger test rig. This test rig is capable of much higher speeds and loads and has a shaft comparable in size to a helicopter class gas turbine.

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 existing 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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