

High-Temperature, High-Load-Capacity Radial Magnetic Bearing

Speed and temperature limits of rolling-element bearings can be exceeded.

John H. Glenn Research Center, Cleveland, Ohio

A radial heteropolar magnetic bearing capable of operating at a temperature as high as 1,000 °F (≈ 540 °C) has been developed. This is a prototype of bearings for use in gas turbine engines operating at temperatures and speeds much higher than can be withstood by lubricated rolling-element bearings.

It is possible to increase the maximum allowable operating temperatures and speeds of rolling-element bearings by use of cooling-air systems, sophisticated lubrication systems, and rotor-vibration-damping systems that are subsystems of the lubrication systems, but such systems and subsystems are troublesome. In contrast, a properly designed radial magnetic bearing can suspend a rotor without contact, and, hence, without need for lubrication or for cooling. Moreover, a magnetic bearing eliminates the need for a separate damping system, inasmuch as a damping function is typically an integral part of the design of the control system of a magnetic bearing.

The present high-temperature radial heteropolar magnetic bearing has a unique combination of four features

that contribute to its suitability for the intended application:

1. The wires in its electromagnet coils are covered with an insulating material that does not undergo dielectric breakdown at high temperature and is pliable enough to enable the winding of the wires to small radii.
2. The processes used in winding and potting of the coils yields a packing factor close to 0.7 — a relatively high value that helps in maximizing the magnetic fields generated by the coils for a given supplied current. These processes also make the coils structurally robust.
3. The electromagnets are of a modular C-core design that enables replacement of components and semiautomated winding of coils.
4. The stator is mounted in such a manner as to provide stable support under radial and axial thermal expansion and under a load as large as 1,000 lb (≈ 4.4 kN).

In a test, the bearing was shown to suspend a rotor stably at a speed of 25,000 rpm at a temperature of 1,000 °F (≈ 540 °C). The static load capacity

and power demand were measured as functions of supplied current, air gap, rotor speed, and temperature. Fault tolerance was demonstrated at 15,000 rpm and 1,000 °F (≈ 540 °C) by intentionally disabling power and maintaining a stably levitated rotor. At the time of reporting the information for this article, the bearing had withstood more than 30 hours of operation that included 18 thermal cycles up to 1,000 °F (≈ 540 °C). The bearing had also been operated for hundreds of hours at lower temperatures.

This work was done by Andrew Provenza of Glenn Research Center, Gerald Montague and Albert Kascak of the U.S. Army Research Laboratory; Alan Palazzolo of Texas A&M University; and Ralph Jansen, Mark Jansen, and Ben Ebihara of the University of Toledo. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17545-1.