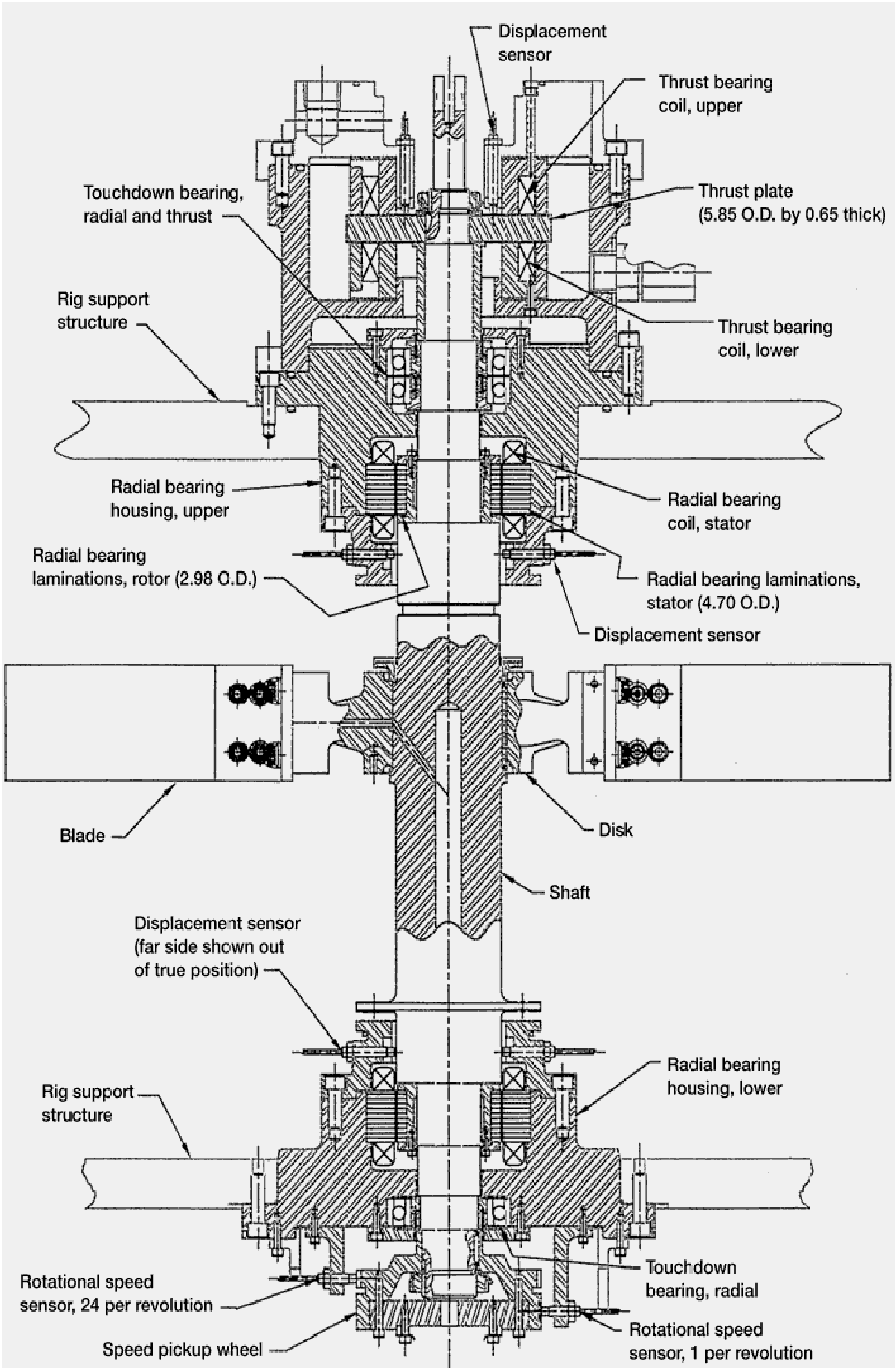
Dynamic Spin Rig Upgraded With a Five-Axis-Controlled Three-Magnetic-Bearing Support System With Forward Excitation

The NASA Glenn Research Center Dynamic Spin Rig is used for experimental evaluation of vibration analysis methods and dynamic characteristics for rotating systems (ref. 1). Measurements are made while rotors are spun and vibrated in a vacuum chamber. The rig has been upgraded with a new active magnetic bearing rotor support and excitation system. This design is expected to provide operational improvements over the existing rig. The rig will be able to be operated in either the old or new configuration.

In the old configuration, two ball bearings support the vertical shaft of the rig, with the test article located between the bearings. Because the bearings operate in a vacuum, lubrication is limited to grease. This limits bearing life and speed. In addition, the old configuration employs two voice-coil electromagnetic shakers to apply oscillatory axial forces or transverse moments to the rotor shaft through a thrust bearing. The excitation amplitudes that can be imparted to the test article with this system are not adequate for components that are highly damped. It is expected that the new design will overcome these limitations.



Displacement sensor
Thrust bearing coil, upper
Touchdown bearing, radial and thrust
Thrust plate (5.85 O.D. by 0.65 thick)
Rig support structure
Thrust bearing coil, lower
Radial bearing housing, upper
Radial bearing coil, stator
Radial bearing laminations, rotor (2.98 O.D.)
Radial bearing laminations, stator (4.70 O.D.)
Displacement sensor
Blade
Disk
Shaft
Displacement sensor (far side shown out of true position)
Radial bearing housing, lower
Rig support structure
Touchdown bearing, radial
Rotational speed sensor, 24 per revolution
Speed pickup wheel
Rotational speed sensor, 1 per revolution

Glenn's upgraded Five-Axis Three Magnetic Bearing Dynamic Spin Rig. All dimensions given in inches. O.D., outer diameter.

Long description of figure Illustration-- of rig showing (top to bottom) displacement sensor, upper thrust bearing coil, thrust plate (5.85 O.D. by 0.65 thick), lower thrust bearing coil, radial and thrust touchdown bearing, rig support structure, stator radial bearing coil, upper radial bearing housing, rotor radial bearing laminations (2.98 O.D.), stator radial bearing laminations (4.70 O.D.), displacement sensor, blade, disk, shaft, displacment sensor (far side shown out of true position), lower radial bearing housing, rig support structure, radial touchdown bearing, rotational speed sensor (24 per revolution), rotational speed sensor (1 per revolution), and speed pickup wheel.

.

A preliminary upgrade of the Dynamic Spin Rig (ref. 2) incorporated a single heteropolar radial active magnetic bearing, which allows for both magnetic excitation and suspension of the rotor. The magnetic bearing replaced the lower mechanical ball bearing and gave improved operations. Results from that upgrade have been used in building a total magnetically suspended rotor (see the engineering drawing of the rig). The new design, called the Five-Axis Three Magnetic Bearing Dynamic Spin Rig, has five independent axes of controlled motion. There is an *x*-axis and a *y*-axis translation at each upper and lower magnetic radial bearing, as well as a *z*-axis translation at the magnetic thrust bearing. Both radial bearings are heteropolar. Simultaneously energizing the bearings (refs. 3 and 4) fully levitates the rotor. This rig design allows for higher excitation amplitudes (by virtue of full rotor suspension, which permits larger rotor translation and tilt displacements) than are achievable with the older rig configuration. At the time of this writing, the rig was operated up to 10 000 rpm with an unbladed rotor. For a detailed description of the rig, see reference 5.

References

1. Brown, G.V., et al.: Lewis Research Center Spin Rig and Its Use in Vibration Analysis of Rotating Systems. NASA TP-2304, 1984.

2. Johnson, Dexter; Brown, Gerald V.; and Mehmed, Oral: A Magnetic Suspension and Excitation System for Spin Vibration Testing of Turbomachinery Blades. NASA/TM--1998-206976, 1998.

3. Morrison, Carlos R.: A Comprehensive C++ Controller for a Magnetically Supported Vertical Rotor, 1.0. NASA/TM--2001-210701, 2001.

4. Choi, Benjamin, et al.: A Comparison Study of Magnetic Bearing Controllers for a Fully Suspended Dynamic Spin Rig. ISMB-8-Paper 0160, Proceedings of the 8th International Symposium on Magnetic Bearings, Mito, Japan, 2002, pp. 387-392.

5. Morrison, Carlos R., et al: A Fully Suspended Five-Axis Three-Magnetic-Bearing Dynamic Spin Rig.To be published as a NASA TP, 2003.

Glenn contacts: Carlos R. Morrison, 216-433-8447, Carlos.R.Morrison@nasa.gov; Dr. Dexter Johnson, 216-433-6046, Dexter.Johnson-1@nasa.gov; Andrew Provenza, 216-433-6025, Andrew.J.Provenza@nasa.gov; and Dr. Benjamin Choi, 216-433-6040, Benjamin.B.Choi@nasa.gov **QSS contact:** Timothy Czaruk, 216-433-3296, Timothy.M.Czaruk@nasa.gov
University of Toledo contact: Ralph Jansen, 216-433-2191, Ralph.H.Jansen@grc.nasa.gov
U.S. Army, Vehicle Technology Directorate at Glenn contact: Gerald Montague, 216-433-6252, Gerald.T.Montague@grc.nasa.gov
Authors: Carlos R. Morrison and Oral Mehmed
Headquarters program office: OAT
Programs/Projects: SEC