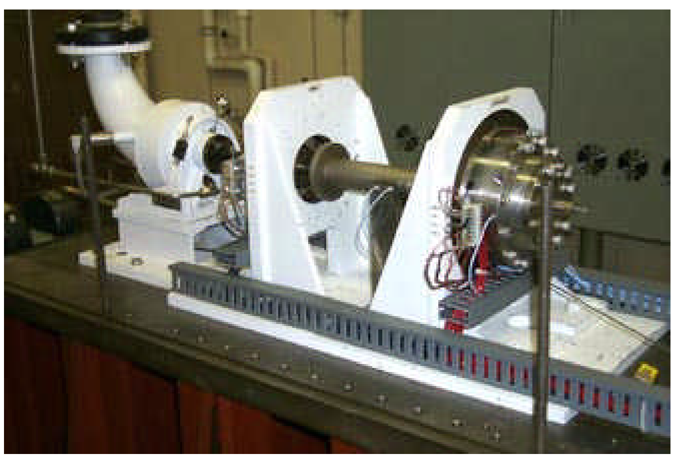
Failure Accommodation Tested in Magnetic Suspension Systems for Rotating Machinery

The NASA Glenn Research Center at Lewis Field and Texas A&M University are developing techniques for accommodating certain types of failures in magnetic suspension systems used in rotating machinery. In recent years, magnetic bearings have become a viable alternative to rolling element bearings for many applications. For example, industrial machinery such as machine tool spindles and turbomolecular pumps can today be bought off the shelf with magnetically supported rotating components. Nova Gas Transmission Ltd. has large gas compressors in Canada that have been running flawlessly for years on magnetic bearings.

To help mature this technology and quiet concerns over the reliability of magnetic bearings, NASA researchers have been investigating ways of making the bearing system tolerant to faults. Since the potential benefits from an oil-free, actively controlled bearing system are so attractive, research that is focused on assuring system reliability and safety is justifiable. With support from the Fast Quiet Engine program, Glenn’s Structural Mechanics and Dynamics Branch is working to demonstrate fault-tolerant magnetic suspension systems targeted for aerospace engine applications. The Flywheel Energy Storage Program is also helping to fund this research.



Fault-tolerant magnetic bearing rig.

The fault-tolerant magnetic suspension facility in Glenn’s Engine Research Building, test cell SW18, was completed in fiscal year 1999. The test rig has two eight-pole heteropolar magnetic bearings that suspend the rotor radially. Each pole is individually controlled with its own pulse-width-modulated amplifier. Opening the circuit between the pulse-width-modulated amplifier and the coil simulates coil failures. Turning off the amplifier supply power simulates amplifier failures. All possible combinations of failures can be realized by flipping switches on the facility control panel.

In fiscal year 1999, Glenn researchers tested unique solutions to 22 different combinations of single and multiple coil failures on a single bearing at zero speed. In all cases, levitation of the rotor was achievable. In addition, levitation with only three of the eight coils operational was demonstrated. A test case where every other coil in the outboard bearing was unpowered behaved satisfactorily to 3000 rpm. In fiscal year 2000, we plan to develop a controller that can detect any combination of failures and accommodate it without loss of levitation.

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