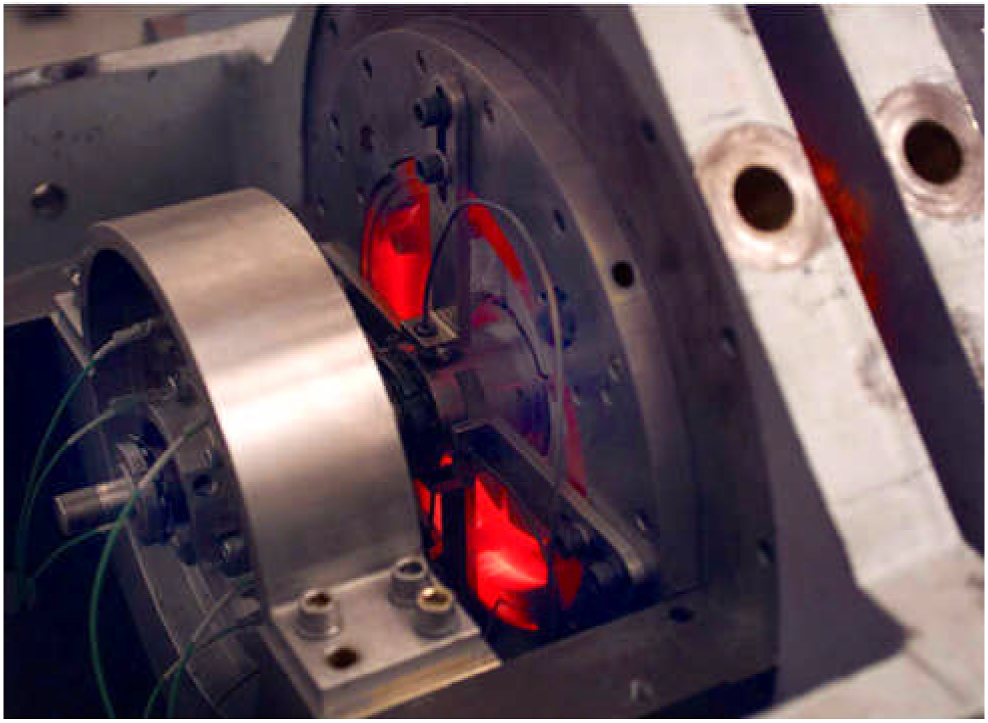
Magnetic Suspension Being Developed for Future Lube-Free Turbomachinery Application



Glenn's third-generation radial magnetic bearing at 1000°F.

The NASA Glenn Research Center, the U.S. Army, Texas A&M University, and other industrial partners are continuing to work together to develop magnetic suspension technology to withstand the harsh environmental conditions inside current and future turbomachinery. In fiscal year 2002, our third-generation radial magnetic bearing successfully controlled rotor motion while at 1000 °F (540 °C) and 20 000 rpm. The ability to command the rotor's position while spinning at this speed was also demonstrated. Future work is planned to include radial bearing tests to 1100 °F (593 °C) and 30 000 rpm. In fiscal year 2003, we plan to test a high-temperature thrust bearing.

This third-generation radial magnetic bearing was designed specifically to operate at 1000 °F with high force production. The stator design includes six individual C-cores that slide into a common back-iron. The modular nature of the stator allows for improved winding of the poles with specially insulated silver wire.

High-temperature eddy-current probes are used to measure rotor position. Centrifugal and thermal growth are compensated for by summing probes on opposite sides of the rotor on each axis. Currently, only two independent axes are used in the control; however, this bearing can be controlled along three axes to provide redundancy. A proportional-integralderivative (PID) controller, rolled off at 400 Hz, was used to provide levitation and control. This controller was written in Simulink and compiled to run on a power-PC-based digital-signal-processing system. The control loop time was 25 μs. Tri-state pulse width modulators were used to provide alternating-current power to the stator coils.

Open-loop experimental force and power measurements were also recorded at temperatures up to 1000 °F and rotor speeds up to 15 000 rpm. The experimentally measured force produced by a single C-core using 22 A was 600 lb (2.67 kN) at room temperature and 380 lb (1.69 kN) at 1000 °F. Results of testing under rotating conditions showed that rotor speed has a negligible effect on the bearing's load capacity. A single C-core required approximately 340 W of power to generate 190 lb (8.45 kN) of magnetic force at 1000 °F. However, lower force and higher power at elevated temperatures were due primarily to a larger air gap caused by different component heating rates-they were not due to magnetic material property degradation. Analytical thermal calculations showed that the air gap could have been at least 28-percent larger at 1000 °F.

References

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