

High-Temperature Switched-Reluctance Electric Motor

Motors like this one would be incorporated into gas turbines as starter/generators.



The **High-Temperature Switched-Reluctance Electric Motor**, capable of operating at a speed of 8,000 rpm at a temperature of 1,000 °F (≈ 540 °C), is a modified version of a magnetic bearing capable of operating at 15,000 rpm at 1,000 °F (≈ 540 °C).

An eight-pole radial magnetic bearing has been modified into a switched-reluctance electric motor capable of operating at a speed as high as 8,000 rpm at a temperature as high as 1,000 °F (≈ 540 °C). The motor (see figure) is an experimental prototype of starter-motor/generator units that have been proposed to be incorporated into advanced gas turbine engines and that could operate without need for lubrication or active cooling.

The unique features of this motor are its electromagnet coils and, to some extent, its control software. Heretofore, there has been no commercial-off-the-shelf wire capable of satisfying all of the requirements

for fabrication of electromagnet coils capable of operation at temperatures up to 1,000 °F (≈ 540 °C). The issues addressed in the development of these electromagnet coils included thermal expansion, oxidation, pliability to small bend radii, micro-fretting, dielectric breakdown, tensile strength, potting compound, thermal conduction, and packing factor.

For a test, the motor was supported, along with a rotor of 18 lb (≈ 8 -kg) mass, 3-in. (≈ 7.6 -cm) diameter, 21-in. (≈ 53 -cm) length, on bearings packed with high-temperature grease. The motor was located at the mid span of the rotor and wrapped with heaters. The motor stator was instru-

*John H. Glenn Research Center,
Cleveland, Ohio*

mented with thermocouples. At the time of reporting the information for this article, the motor had undergone 14 thermal cycles between room temperature and 1,000 °F (≈ 540 °C) and had accumulated operating time >27.5 hours at 1,000 °F (≈ 540 °C).

The motor-controller hardware includes a personal computer equipped with analog-to-digital input and digital-to-analog output cards. The controller software is a C-language code that implements a switched-reluctance motor-control principle: that is, it causes the coils to be energized in a sequence timed to generate a rotating magnetic flux that creates a torque on a scalloped rotor. The controller can operate in an open- or closed-loop mode. In addition, the software has been modified to enable the simultaneous operation of the prototype motor or another, similar apparatus as both a motor and a magnetic bearing. Combined bearing/motor operation has been demonstrated at room temperature but had not yet been demonstrated at high temperature at the time of reporting the information for this article.

This work was done by Gerald Montague, Gerald Brown, Carlos Morrison, Andy Provenza, and Albert Kascaak of Glenn Research Center and Alan Palazzolo of Texas A&M University. 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-17287.

System for Centering a Turbofan in a Nacelle During Tests

The system helps to maintain safety and accuracy.

A feedback position-control system has been developed for maintaining the concentricity of a turbofan with respect to a nacelle during acoustic and flow tests in a wind tunnel. The system is needed for the following reasons:

- Thermal and thrust loads can displace the fan relative to the nacelle;
- In the particular test apparatus (see Figure 1), denoted as a rotor-only nacelle

(RAN), the struts, vanes, and other stator components of a turbofan engine that ordinarily maintain the required concentricity in the face of thermal and thrust loads are not present; and

- The struts and stator components are not present because it is necessary to provide a flow path that is acoustically "clean" in the sense that the measured noise can be attributed to the fan alone.

*John H. Glenn Research Center,
Cleveland, Ohio*

The system is depicted schematically in Figure 2. The nacelle is supported by two struts attached to a two-axis traverse table located outside the wind-tunnel wall. Two servomotors acting through 100:1 gearboxes drive the table along the Y and Z axes, which are perpendicular to the axis of rotation. The Y and Z components of the deviation from concentricity are measured by four laser displacement sensors mount-