Flywheel Energy Storage Technology Being Developed

A flywheel energy storage system was spun to 60,000 rpm while levitated on magnetic bearings. This system is being developed as an energy-efficient replacement for chemical battery systems. Used in groups, the flywheels can have two functions providing attitude control for a spacecraft in orbit as well as providing energy storage. The first application for which the NASA Glenn Research Center is developing the flywheel is the International Space Station, where a two-flywheel system will replace one of the nickel-hydrogen battery strings in the space station's power system. The 60,000-rpm development rotor is about one-eighth the size that will be needed for the space station (0.395 versus 3.07 kW-hr).

The flywheel system is composed of a composite outer rim around an aluminum hub. This hub/rim assembly is connected to a shaft that uses a motor/generator to put energy into or take energy out of the flywheel. The shaft also has laminations to conduct the flux generated by the magnetic bearing actuators. This spinning portion of the system is contained in a housing that holds the motor stator, the magnetic bearing actuator circuits, and the backup mechanical bearings. The motor stator generates the magnetic fields to spin the motor rotor and the flywheel shaft; the magnetic bearing actuators generate and direct the flux to apply forces to the flywheel to keep it levitated. The back-up mechanical bearings capture the flywheel if the magnetic bearing fails. The housing provides structural support for all the systems and serves as a vacuum chamber to eliminate aerodynamic heating of the spinning flywheel.

One of the primary technical challenges to achieving the 60,000-rpm milestone was to develop the control algorithm for the magnetic bearings. Glenn worked with Texas A & M University to develop a multi-input, multi-output algorithm that controls the rotor modes (forward whirl, backward whirl, forward conical, and backward conical) of the flywheel using minimum control input. This is critical to demonstrating the efficiency and long life of the flywheel storage system.

Another primary technical challenge was to design and build the hub/rim system with sufficient stress margins to meet the safety standards of the space community. Glenn used a combination of analysis from finite element analysis programs and spin testing of assembled rotors to 110 percent to ensure the integrity of the flywheel design. In addition, a nondestructive evaluation test program is being developed by Glenn to analyze subsequent rotors for flight flywheel systems.

Development unit flywheel module that achieved 60,000 rpm.

Glenn contact: James F. Soeder, 216-433-5328, James.F.Soeder@grc.nasa.gov
Author: Frederick J. Wolff
Headquarters program office: OSF
Programs/Projects: ISS