Flywheels Upgraded for Systems Research

With the advent of high-strength composite materials and microelectronics, flywheels are becoming attractive as a means of storing electrical energy. In addition to the high energy density that flywheels provide, other advantages over conventional electrochemical batteries include long life, high reliability, high efficiency, greater operational flexibility, and higher depths of discharge. High pulse energy is another capability that flywheels can provide. These attributes are favorable for satellites as well as terrestrial energy storage applications. In addition to energy storage for satellites, the several flywheels operating concurrently can provide attitude control, thus combine two functions into one system. This translates into significant weight savings.

The NASA Glenn Research Center is involved in the development of this technology for space and terrestrial applications. Glenn is well suited for this research because of its world-class expertise in power electronics design, rotor dynamics, composite material research, magnetic bearings, and motor design and control. Several Glenn organizations are working together on this program. The Structural Mechanics and Dynamics Branch is providing magnetic bearing, controls, and mechanical engineering skills. It is working with the Electrical Systems Development Branch, which has expertise in motors and generators, controls, and avionics systems. Facility support is being provided by the Space Electronic Test Engineering Branch, and the program is being managed by the Space Flight Project Branch.

NASA is funding an Aerospace Flywheel Technology Development Program to design, fabricate, and test the Attitude Control/Energy Storage Experiment (ACESE). Two flywheels will be integrated onto a single power bus and run simultaneously to demonstrate a combined energy storage and 1-degree-of-freedom momentum control system. An algorithm that independently regulates direct-current bus voltage and net torque output will be experimentally demonstrated.

The major tasks completed this year were upgrades of the two flywheel modules to be used for the ACESE demonstration and assembly of the High Energy Flywheel Facility where the testing will be conducted. Both flywheel modules received upgraded avionics, position sensors, and control systems. One module was redesigned to incorporate a higher energy, longer life rotor. These upgrades will enable the system-level test program. The two technology demonstrator flywheel modules will be integrated at Glenn’s High Energy Flywheel Facility. This facility consists of an airtable where the modules are mounted and surrounded by a water-containment safety system. This photograph of the setup shows thermal, vacuum, and instrumentation support hardware on the upper platform.

Two-flywheel system on airtable.

The current experiment will be a hardware demonstration of a flywheel system that provides both power bus regulation and single-axis torque and attitude control. The long-term objective is to extend this work to a bus regulation and 3-degree-of-freedom attitude control system representative of a satellite platform.

References

1. Jansen, Ralph H., et al.: Redesign of Glenn Research Center D1 Flywheel Module. NASA/TM--2002-211788, 2002.

2. Kascak, Peter E., et al.: Single Axis Attitude Control and DC Bus Regulation With Two Flywheels. NASA/TM--2002-211812, 2002.

3. Dever, Timothy P.; Brown, Gerald V.; and Jansen, Ralph H.: Estimator Based Controller for High Speed Flywheel Magnetic Bearing System. NASA/TM--2002-211795, 2002.

4. Trase, Larry M.: The Evaluation and Implementation of a Water Containment System to Support Aerospace Flywheel Testing. NASA/TM--2002-211722, 2002.

5. Kenny, Barbara H.; and Kascak, Peter E.: Sensorless Control of Permanent Magnet Machine for NASA Flywheel Technology Development. NASA/TM--

2002-211726, 2002.

6. Dever, Timothy P., et al.: Evaluation and Improvement of Eddy Current Position Sensors in Magnetically Suspended Flywheel Systems. NASA/CR--2001-211137, 2001.

7. Kenny, Barbara H., et al.: Advanced Motor Control Test Facility for NASA GRC Flywheel Energy Storage System Technology Development Unit. NASA/TM--2001-210986, 2001.

8. Kascak, Peter E., et al.: International Space Station Bus Regulation With NASA Glenn Research Center Flywheel Energy Storage System Development Unit. NASA/TM--2001-211138, 2001.

9. McLallin, Kerry L., et al.: Aerospace Flywheel Technology Development for IPACS Applications. NASA/TM--2001-211093, 2001.

University of Toledo contact: Ralph Jansen, 216-433-6038, Ralph.H.Jansen@grc.nasa.gov

Glenn contact: Ray Beach, 216-433-5320, Raymond.F.Beach@nasa.gov
Authors: Ralph H. Jansen
Headquarters program office: OAT
Programs/Projects: Energetics, ACESE