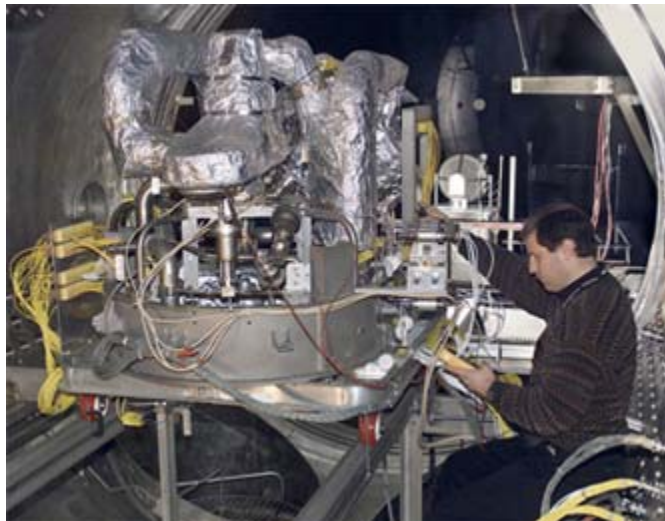


Brayton-Cycle Power-Conversion Unit Tested With Ion Thruster

Nuclear electric propulsion has been identified as an enabling technology for future NASA space science missions, such as the Jupiter Icy Moons Orbiter (JIMO) now under study. An important element of the nuclear electric propulsion spacecraft is the power-conversion system, which converts the reactor heat to electrical power for use by the ion propulsion system and other spacecraft loads. The electrical integration of the power converter and ion thruster represents a key technical challenge in making nuclear electric propulsion technology possible.

This technical hurdle was addressed extensively on December 1, 2003, when a closed-Brayton-cycle power-conversion unit was tested with a gridded ion thruster at the NASA Glenn Research Center. The test demonstrated end-to-end power throughput and marked the first-ever coupling of a Brayton turboalternator and a gridded ion thruster, both of which are candidates for use on JIMO-type missions. The testing was conducted at Glenn's Vacuum Facility 6, where the Brayton unit was installed in the 3-m-diameter vacuum test port and the ion thruster was installed in the 7.6-m-diameter main chamber.



Closed-Brayton-cycle and NSTAR thruster installed in Glenn's Vacuum Facility 6.

The Brayton test unit was a fully integrated power-conversion system including a turboalternator, recuperator, and gas cooler with helium-xenon working fluid designed for operation up to 2 kW. The heat source used in the test was a series of silicon-carbide electrical resistance heaters contained in a shell and tube heat exchanger that heated the helium-xenon gas to over 1000 K, simulating a fission reactor source. A commercial chiller with a pumped ethylene glycol cooling loop provided waste heat rejection, simulating a space radiator system.

The ion thruster used in the test was an engineering model of the NASA Solar Electric Propulsion Technology Application Readiness (NSTAR) gridded ion thruster used successfully as the main propulsion system on the NASA Deep Space 1 Mission in 1998. The NSTAR thruster is rated for operation up to 2.3 kW, providing 92-mN thrust and 3100-sec specific impulse using xenon propellant. The similar power rating of the Brayton-cycle power-conversion unit and the NSTAR made for a natural pairing.

The Brayton alternator power was routed through a fully representative power management and distribution (PMAD) system, designed and built in-house at Glenn. The PMAD converted the 55-V (root mean square, line-to-neutral), three-phase alternating-current (ac) alternator output to 1100 direct-current volts (Vdc) for use by the thruster beam supply. A transformer-rectifier-filter approach was used for the ac-to-dc conversion.

The PMAD system also provided Brayton speed and voltage control via a parasitic load radiator designed to maintain a constant load on the alternator regardless of thruster demand. High-speed load transfer between the parasitic load radiator and the thruster beam supply provided fault protection during thruster recycles. Recycles are intermittent and unpredictable electrical transients that occur with ion thrusters, resulting in a momentary short-circuit condition. If not properly managed, thruster recycles could harm the thruster grids, the PMAD, or the Brayton rotating equipment. The testing verified that a recycle could be detected, the power switched from the beam supply within several milliseconds, and the power switched back to the beam supply in less than a second, all while maintaining the thruster in operating mode.

Find out more about this research at <http://www.grc.nasa.gov/WWW/tmsb/>

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