Hall Effect Thruster Technologies

New breakthroughs in durability and efficiency

Innovators at NASA’s Glenn Research Center have developed new technologies that increase the operational lifetime of a Hall effect thruster (HET), which is used primarily on Earth-orbiting satellites and can also be used for deep-space robotic vehicles. The operational lifetime of HETs is determined by the amount of time the thruster can operate before the plasma within the channel damages the magnetic system. Prior to this innovation, the plasma would erode the ceramic chamber of the HET in just over a year of operation. Glenn’s breakthrough technology prolongs this operational lifetime through two related innovations. The first is an innovative magnetic field configuration that provides magnetic shielding to eliminate interactions between the high energy xenon plasma produced by the HET and the ceramic chamber that contains it. The second is a means of replacing eroded discharge channel material via a channel wall replacement mechanism. By increasing the lifetime and efficiency of HETs, Glenn’s technology will enable a new era of space propulsion.

BENEFITS
- Improved efficiency: Unique designs minimize energy loss to the discharge chamber, which improves discharge efficiency
- Increased lifetime: HET lifetime is extended five times, from approximately 10,000 hours to more than 50,000 hours
- Improved performance: Glenn’s innovations result in a greater fraction of the electrical energy from the solar array being used to produce thrust, and a decrease in electrical energy being lost as waste heat radiated to space
THE TECHNOLOGY

Used for propelling Earth-orbiting satellites and deep-space robotic vehicles, the HET gets its name because it traps electrons with an intense radial magnetic field in an azimuthal Hall current moving around the circumference of an annular ceramic channel. The electrons in the circulating Hall current ionize the onboard propellant - the inert gas xenon - and create an ionized plasma. The xenon plasma is then accelerated axially, via an applied electric field along the coaxial channel, to an exit velocity of up to 65,000 miles per hour to produce thrust. The interaction of the accelerated plasma and the downstream edge of the channel, where the plasma is the most energetic, results in erosion of the surrounding magnetic system used to generate the plasma. One of NASA Glenn’s novel designs relies on an azimuthally symmetric configuration that minimizes radial magnetic fields at the discharge chamber walls. This configuration completely shields the walls of the discharge chamber from the high-energy plasma ions. With regard to the discharge-channel-wall replacement innovation, an actuator can be configured to extend the discharge chamber along the centerline axis. The actuator can be either mechanical or programmable. In either case, the sleeve can be extended while an upstream portion of the discharge chamber remains stationary, thereby preventing plasma exposure. These novel designs increase the efficiency and extend the lifetime of the HET to five times that of unshielded thrusters, enabling a new era of space missions.

APPLICATIONS

The technology has several potential applications:
- Satellite propulsion
- Material processing (e.g., ion implantation, ion etching)
- High-energy physics
- Deep space probes

PUBLICATIONS

Patent No: 10,273,944
Patent Pending
See also U.S. Patent 7500350