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Editorial

Editorial Note on Magneto-plasma Dynamic Thruster

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EDITORIAL

A Magneto-Plasma Dynamic (MPD) thruster (MPDT) is a type of electrically powered spacecraft propulsion that generates thrust by using the Lorentz force (the force exerted on a charged particle by an electromagnetic field). It is also known as the Lorentz Force Accelerator (LFA) or (mostly in Japan) the MPD arc jet. In general, a gaseous material is ionised and then fed into an acceleration chamber, where magnetic and electrical fields are generated with the help of a power source. The particles are then propelled out through the exhaust chamber by the Lorentz force created by the interaction between the current flowing through the plasma and the magnetic field (which is either externally applied or induced by the current). Unlike chemical propulsion, there is no fuel combustion. Specific impulse and thrust increase with power input, as with other electric propulsion variations, while thrust per watt decreases. MPD thrusters are classified into two types: applied-field and self-field. Magnetic rings surround the exhaust chamber to generate the magnetic field in applied-field thrusters, whereas a cathode extends through the middle of the chamber in self-field thrusters. The MPD thruster is composed of two metal electrodes: a central rod-shaped cathode and a cylindrical anode that surrounds the cathode. A high-current electric arc is struck between the anode and cathode, just like in an arc welder. As the cathode heats up, electrons are emitted, which collide with and ionize a propellant gas to form plasma. In theory, MPD thrusters could generate extremely high specific impulses (Isp) with an exhaust velocity of up to and beyond 110000 m/s, which is three times the value of current xenon-based ion thrusters and approximately 25 times better than liquid rockets. MPD technology has the potential for thrust levels of up to 200 newton (N) (45 lbF), which is far and away the highest for any form of electric propulsion and nearly as high as many interplanetary chemical rockets. This would allow electric propulsion to be used on missions that require quick delta-v manoeuvres (such as capturing into orbit around another planet), but with much greater fuel efficiency.

High-power MPD thrusters, which were first investigated in the 1960s and have been funded on a regular basis over the last few decades, have achieved slow but steady improvements in performance. A variety of thruster geometries have been investigated using various types of gas propellants, with lithium vapour propellant proving to be the most efficient to date. Lithium-fed MPD thrusters developed in Russia have reached 100 kilowatts of power, with efficiencies of up to 45 percent and plasma exhaust velocities approaching 50,000 metres per second (over 100,000 miles per hour (mph)).

Although MPD thruster technology has been studied academically, commercial interest has been limited due to a number of unresolved issues. One major issue is that optimum performance necessitates power requirements in the hundreds of kilowatt range. Current interplanetary spacecraft power systems (such as radioisotope thermoelectric generators and solar arrays) cannot produce that much power. NASA's Project Prometheus reactor, which was expected to generate hundreds of kilowatts of power, was cancelled in 2005. NASA is currently investigating both pulsed and continuous MPDs that use hydrogen or lithium as a propellant. While appealing in terms of efficiency, lithium is a condensable propellant that may coat spacecraft surfaces and power arrays. MPD thrusters powered by non-condensable hydrogen will eliminate these concerns while also providing higher exhaust velocities than lithium-fuelled thrusters. Glenn is currently working on high-specific-impulse, megawatt-class MPD thruster technology powered by hydrogen.

Exhaust velocities approaching 100,000 metres per second will be required for future high-powered robotic and piloted outer planet missions (over 200,000 mph). Higher velocities can be attained by using non condensable hydrogen plasmas, which are currently being studied at NASA Glenn. As research progresses, the MPD thruster's efficiency will improve, allowing for missions with lower propellant requirements or greater range. MPD thruster research has been conducted in the United States, the former Soviet Union, Japan, Germany, and Italy. Experimental prototypes were first flown on Soviet spacecraft and, most recently, on the Japanese Space Flyer Unit in 1996, demonstrating the successful operation of a quasi-steady pulsed MPD thruster in space. Moscow Aviation Institute, RKK Energiya, National Aerospace University, Kharkiv Aviation Institute, Institute of Space Systems of the University of Stuttgart, ISAS, Centrospazio, Alta S.p.A., Osaka University, University of Southern California, Princeton University's Electric Propulsion and Plasma Dynamics Lab (EPPDyL) (where MPD thruster research is ongoing).

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