Electromagnetic Pumps for Conductive-Propellant Feed Systems

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There has been a recent, renewed interest in high-power electric thrusters for application in nuclear-electric propulsion systems. Two of the most promising thrusters utilize liquid metal propellants: the lithium-fed magnetoplasmadynamic thruster and the bismuth-fed Hall thruster. An important element of part of the maturation of these thrusters will be the development of compact, reliable conductive-propellant feed system components.

In the present paper we provide design considerations and experimental calibration data for electromagnetic (EM) pumps. The role of an electromagnetic pump in a liquid metal feed system is to establish a pressure gradient between the propellant reservoir and the thruster — to establish the requisite mass flow rate. While EM pumps have previously been used to a limited extent in nuclear reactor cooling loops, they have never been implemented in electric propulsion (EP) systems. The potential benefit of using EM pumps for EP are reliability (no moving parts) and the ability to precisely meter the propellant flow rate.

We have constructed and tested EM pumps that use gallium, lithium, and bismuth propellants. Design details, test results (pressure developed versus current), and material compatibility issues are reported. It is concluded that EM pumps are a viable technology for application in both laboratory and flight EP conductive-propellant feed systems.