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Magnetoplasmadynamic Electric Propulsion Thruster: Design, Fabrication and Application – ISRO Sponsored Project

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Abstract:

As conventional chemical rockets reach the outer limits of their abilities, significant research is going into alternative thruster technologies, some of which decouple the maximum thrust and efficiency from the propellant's internal chemical energy by supplying energy to the propellant as needed. Of particular interest and potential is the electrically powered thruster, which promises very high specific thrust using relatively inexpensive and stable propellant gasses. Some such thrusters, specifically ion thrusters, have achieved significant popularity for various applications. However, there exist other classes of electrical thrusters which promise even higher levels of efficiency and performance.

This paper will focus on one such thruster type – the Magnetoplasmadynamic thruster – which uses an ionized propellant flow and large currents to accelerate the propellant gas by electrical and magnetic force interactions. The necessary background will be presented in order to understand and characterize the operation of such devices, and a theoretical model will be developed in order to estimate the levels of performance which can be expected. Simulations will be performed and analysed in order to better understand the principles on which these devices are designed.

Finally, with our GRANTS received from ISRO, My team has started the design & fabrication of the thruster in order to determine the performance of the device and accuracy of the model. This will include a high-current power supply, ignition circuit, gas delivery system, and nozzle. Finally, the measured performance of this thruster package will be measured and compared to the theoretical predictions in order to validate the models constructed for this type of thruster. A theoretical model, based on normal MPD thrust behaviour, will be used to estimate fall voltages and pumping coefficients. An empirical model for thruster voltage is created to estimate the behaviour of voltage as a function of the similarity parameter. The experimental and theoretical models will be then put together to find the self-consistency. Total temperatures, specific impulses, and efficiencies for assumed isentropic nozzle expansion will be then calculated.

The following paper will also present the study on the prospect of sending humans and autonomous humanoid robots to Jupiter's moons, Callisto and Europa, using an all Nuclear Electric Propulsion (NEP) space transportation system architecture with Magnetoplasmadynamic arc (MPD) thrusters. The mission reactor system utilizes high temperature uranium dioxide (UO2) in tungsten (W) metal matrix/cermet" fuel and electricity is generated using advanced dynamic Brayton power conversion technology. The mission timeframe assumes on-going human Moon and Mars missions and existing space infrastructure to support launch of cargo and crewed spacecraft to Jupiter in 2041 and 2045, respectively.

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