Paper ID: 4754
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SPACE PROPULSION SYMPOSIUM (C4)
Electric Propulsion (4)

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QUASI-STEADY MPD PERFORMANCE ANALYSIS

Abstract

Magneto-Plasma-Dynamic thruster operation has been investigated through Thrust Stand technique, both in the self-induced and applied magnetic field cases. Parameters such as thruster energy and applied field have been varied over a certain range in order to analyze performance dependencies, with focus on total impulse bit and electric parameters like total power and discharge efficiency. Thruster energy has been set to four values between 2000 and 3000 J, while magnetic field values are below 0.3 T.
Thrust measurement has been performed using a classical displacement method: the thruster is positioned over an oscillating parallelogram linkage whose motion is tracked by an optical sensor. Known that for an ideal harmonic system the impulse can be obtained as $I = mA\omega$, where m is the oscillating mass, A the amplitude and ω the angular frequency, there's the need to deal with natural damping of the real system. At least two methods have been used to calculate the initial maximum displacement (the one of an equivalent undamped oscillator) to be inserted in the impulse formula: the first is an exponential regression to be performed on the displacement curve; after the analysis of such data a simpler maximum peak estimate proved to be feasible. Both methods lead to an underestimate, mainly because of the system non-ideality: the exponential method appears extremely precise only after high frequency filtering. Some of the energy related to this frequencies, though, could contribute to thrust. The maximum peak estimate overrides this problem leading anyway to an underestimate, as the measured amplitude is a quarter period late.
As reported by other researchers, when operating with applied magnetic field an undesired coupling between the electromagnet coil and the vacuum chamber is experienced. Such phenomenon must be taken into account when measuring the impulse. The displacement due to magnetic coupling alone has been measured for different values of the applied field and compared to the impulse increment observed when firing the MPD with corresponding applied field. Thruster operation in these conditions has also been analyzed through electric parameters comparison: discharge stabilization, i.e. duration enhancement and noise reduction, has been observed for convenient applied field values which vary with thruster energy. Current measurements allow use of the Maecker formula as a reference for comparison between theoretical and empirical results as well as between self and applied field operation.