Investigating the Effects of Propellant Mass Flow Rate and a Swirl Ring on the Efficiency of a Magnetoplasmadynamic Thruster

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The magnetoplasmadynamic thruster (MPDT) is one of the most powerful and efficient forms of electrical spacecraft propulsion. Designed for deep space travel, it promises extensive application in the up-and-coming space race. We created a low-cost version of a MPDT and modified it to include a swirl ring, a part used to increase plasma cutting accuracy. We tested this idea in an MPDT using the following procedure. We placed a sacrificial wire between the electrodes for discharge initiation (it vaporizes and allows propellant ionization). A low-friction cart with a vertical plate faced the nozzle for thrust measurement. After setting the argon propellant flow rate entering the nozzle, we pulled a switch, releasing a powerful capacitor's stored energy through the completed circuit and pulsing the rocket. For three tests, cart mass, initial capacitor voltage, and flow rate were constant. We compared the cart's movement to whether the swirl ring was used and found the swirl ring increased the thrust significantly, as predicted. We recorded the change in capacitor voltage, and the lowest final voltage was 45 volts, far from zero. This means argon could not maintain the arc between the electrodes, i.e., ionized particles were ejected faster than new ones formed. This evidence supports the hypothesis that as flow rate increases, efficiency increases. Going forward, we want a better gas delivery system to match the flow rate to the current. A hall-effect sensor could also be used to measure current and compare thrust to the predicted value from the Maecker formula.