VARION: The Self-Refueling Ion thruster- by Kushal Polamarasetty

As humanity aims for deeper space exploration, sustained interplanetary missions and potential terraforming, traditional finite onboard propellant is not enough-as the fuel determines: how far, how fast, and how long missions can travel. Electric plasma propulsion, such as ion thrusters, provide a far more efficient alternative, achieving exhaust velocities 10 times greater (50 m/s compared to 5km/s) but are still limited by propellant. Inspired by the need for deep space exploration, I innovated the VARION (Versatile annular ion thruster) system, which aims to overcome these limitations by letting a spacecraft "Self-refuel". VARION is a multi-propellant gridded electrostatic thruster that works in both space and in atmospheres. In planetary orbit, VARION collects atmospheric gases such as CO2 on Mars and uses it as propellant for sustaining orbit. The new annular geometry increases lifespan, power handling, thrust density and scalability.

I created a Zero-Dimensional analytical model implementing plasma physics, rocket science, NRLMSIS 2.0 atmospheric data, and Mars exponential atmosphere model. This model calculates performance parameters/ plasma properties including beam current density, ion exhaust velocity, thrust force and various efficiency metrics by taking a set of inputs- thruster geometry, acceleration voltage, propellant data, etc. I validated my model against the NASA NEXT ion thruster data, achieving ~95% accuracy in performance calculations which confirms the model's reliability. I designed & built a functional 3D-printed prototype using CAD software that demonstrates electron emission and ion acceleration principles using ring-cusp magnetic field and copper grid electrodes in ambient atmosphere.

In space, VARION performs like a modern ion thruster, confirming the model realistically. In Mars, VARION produces 10x more thrust than required for orbiting at low power and 100x more at higher power. However, it produces significantly less thrust on Earth which informed me that the atmospheric composition is crucial for its viability. VARION performs optimally in thin atmospheres like Mars, comprising gases with large molecular cross section and low ionization energy such as CO2 and heavy

My innovation, the VARION thruster, is a first-of-its-kind that uses atmospheric gases to enable self-sustaining travel. This makes it the best choice for long duration missions such as mars missions, asteroid mining and station keeping. I hope that one day, this will enable us to travel faster than ever, further than ever and quicker than ever.

How I plan to expand it: Use a more advanced non-linear system model which I am working on currently and build real scale thruster and perform vacuum testing with different planetary gases.

By Kushal Polamarasetty

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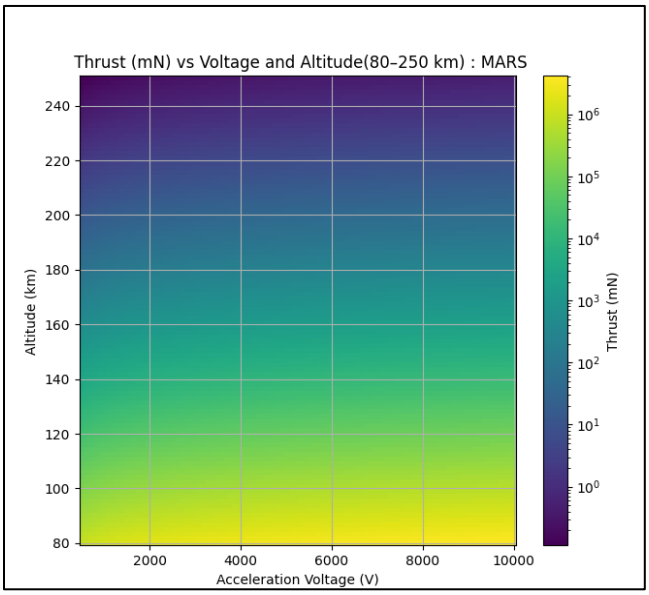

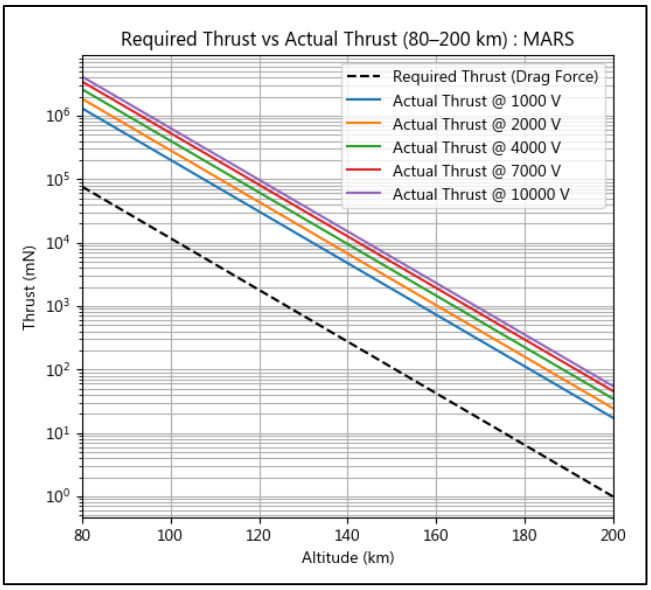

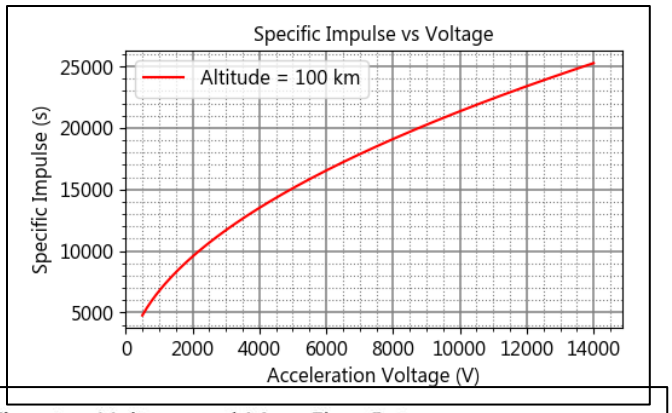

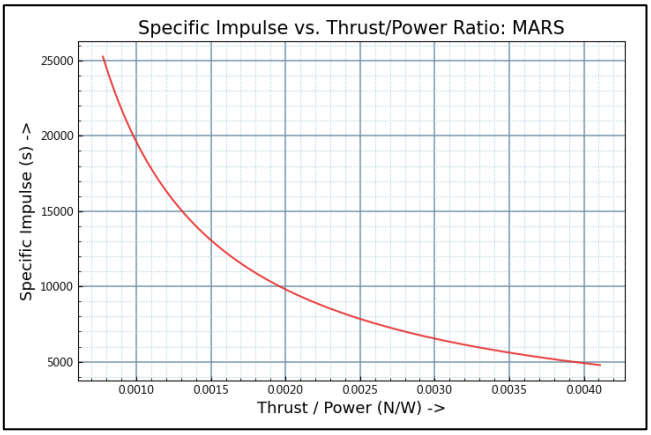

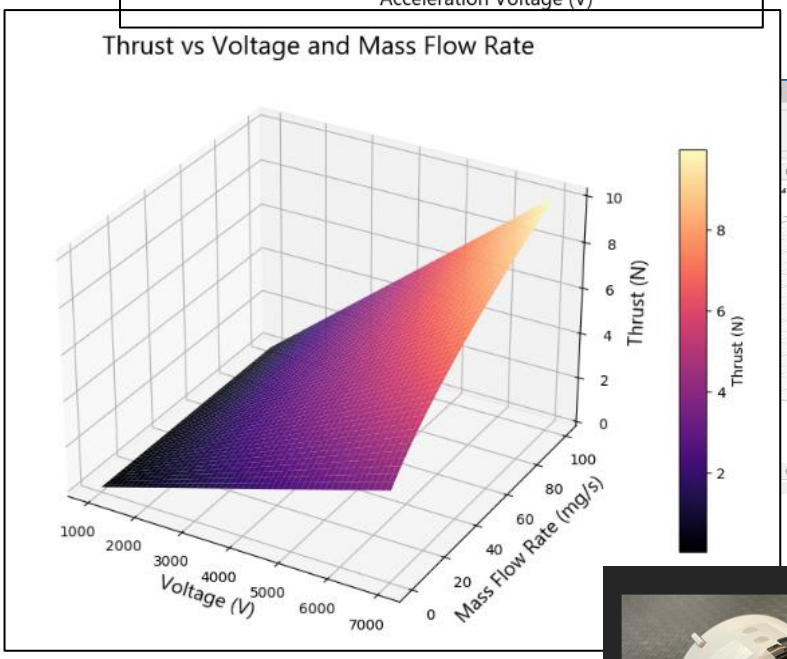

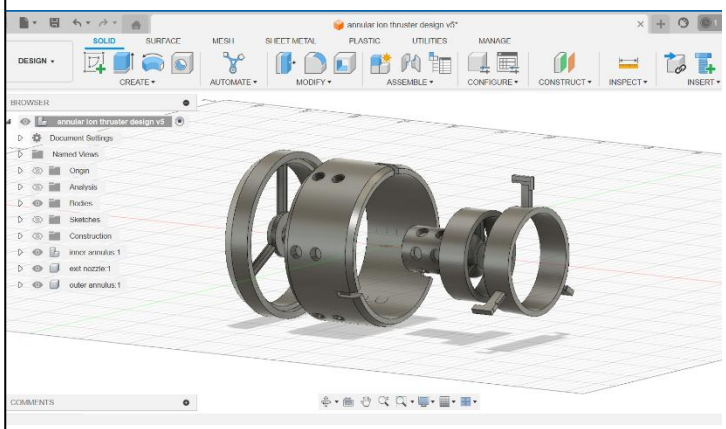

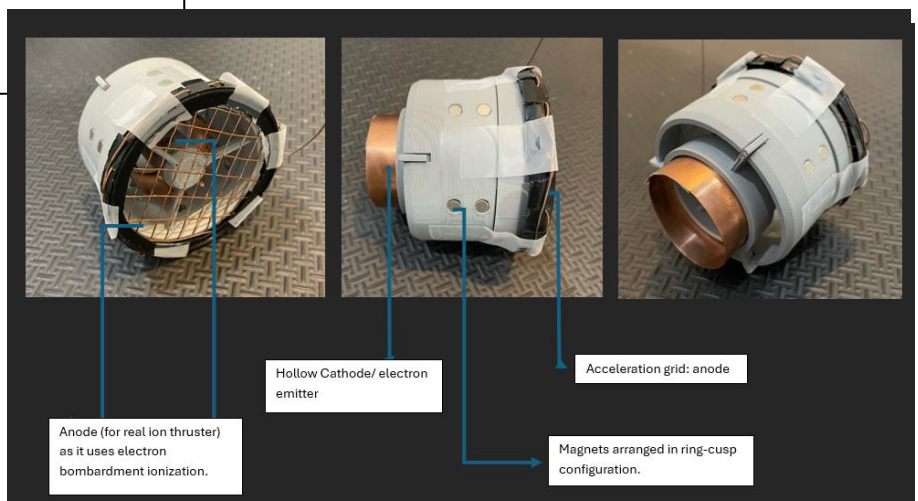

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