EXPERIMENTAL INVESTIGATION OF MAGNETIC EFFECTS AND FLOW GENERATION IN 15cm ION THRUSTER

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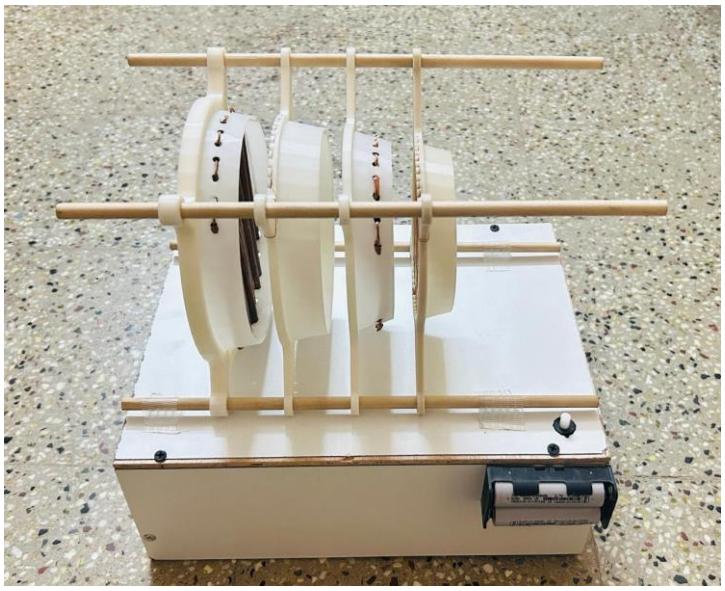
Introduction:

Ion thrusters are a form of advanced electric propulsion that generate thrust by accelerating charged particles using electric and magnetic fields, offering significantly higher efficiency than conventional chemical rockets. Unlike traditional propulsion systems that rely on high fuel consumption, ion thrusters use minimal propellant—commonly noble gases like xenon or krypton—and achieve extremely high exhaust velocities, making them ideal for long-duration space missions such as deep-space exploration, satellite station-keeping, and orbit raising. The working principle involves ionizing a neutral gas to form plasma and then accelerating the ions through electrostatic fields to produce thrust, while magnetic fields can be used to enhance confinement and efficiency. Despite producing very low thrust, their ability to operate continuously for thousands of hours allows spacecraft to achieve large velocity changes over time. This project focuses on the design and experimental investigation of a 15 cm ion thruster, particularly analysing the effects of magnetic fields and flow generation to improve performance, efficiency, and applicability in modern aerospace missions.



Objectives:

1. To design a 15 cm diameter ion thruster model with suitable geometry and components.
2. To study the effect of different magnetic field configurations (permanent and electromagnetic) on thruster performance.
3. To analyse ion flow generation and thrust characteristics under varying operating conditions.
4. To experimentally validate the performance of the developed ion thruster and compare with theoretical predictions.

Methodology:

The methodology of this project follows a systematic and iterative approach to design, develop, and evaluate a 15 cm ion thruster. It begins with an extensive literature review to understand existing technologies and identify research gaps, followed by defining clear objectives for the thruster design and performance analysis. A conceptual design is then developed, including electrode geometry, spacing, and material selection, which is further optimized through computational modelling and simulation of electric fields, ion flow, and thrust characteristics. Based on simulation results, a prototype is fabricated with proper alignment and high-voltage integration. Experimental testing is conducted to measure parameters such as thrust, ion flow, and power efficiency, while observing system stability and performance issues. Finally, the results are analysed and compared with theoretical predictions to draw conclusions and suggest improvements for future development.

Result and Conclusion:

The developed 15 cm ion thruster successfully generated stable plasma and measurable ion flow, confirming the feasibility of the design and power system. Magnetic field integration improved ion confinement and beam collimation, resulting in enhanced thrust efficiency and reduced losses.

References:

1. Christina Bramanti and Roger Walker (2006) – *The Innovative Dual-Stage 4-Grid Ion Thruster Concept – Theory and Experimental Results.*
2. Dan R. Lev and Gal Alon (2018) – *Operation of a Hollow Cathode Neutralizer for Sub 100-W Hall and Ion Thrusters.*

Future Scope:

The future scope of this project includes:

1. Optimization of electrode geometry and magnetic field configuration to further improve ion acceleration efficiency and thrust output.
2. Testing under controlled vacuum conditions to better simulate space environments and obtain more accurate performance data.
3. Scaling and miniaturization of the thruster design for application in CubeSats and small satellite propulsion systems.