International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

Propulsion Through Plasma: The new age of Green Aviation

Jayendra Tamira[1], Honey Kumar[2], Kamil Ahmed[3], Abhishek Warke[4], Swapnil Shukla[5]

[1]Department of Mechanical Engineering, Kalinga University, Naya Raipur (C.G.)

[2]Department of Mechanical Engineering, Kalinga University, Naya Raipur (C.G.)

[3]Department of Mechanical Engineering, Kalinga University, Naya Raipur (C.G.)

[4]Department of Mechanical Engineering, Kalinga University, Naya Raipur (C.G.)

[5]Assistant Professor, Department of Mechanical Engineering, Kalinga University, Naya Raipur (C.G.)

Abstract - The primary objective of this research is to investigate the performance of the propulsion system and to optimize its design and operation for maximum efficiency and thrust. The research also aims to explore the potential applications of plasma-based propulsion systems in space exploration and other areas of aerospace engineering. The results of this research demonstrate the feasibility of plasma-based propulsion systems for space exploration and other applications. The optimized design and operation of the propulsion system are shown to produce basic levels of thrust. The research also highlights the potential advantages of plasma-based propulsion systems over traditional chemical propulsion systems in terms of fuel efficiency, scalability, and other characteristics. In conclusion, this paper presents a novel approach to propulsion system design and fabrication using plasma. The results of this research have significant implications for the future of aviation exploration and aerospace engineering, and pave the way for further advancements in plasma-based propulsion technology.

Keywords- Plasma, propulsion, ions, charges, aviation.

1. INTRODUCTION

The development of propulsion systems for space exploration and aerospace applications has been a critical area of research for decades. Traditional chemical propulsion systems have been the primary means of propelling spacecraft and satellites, but they have limitations in terms of fuel efficiency and overall performance. To overcome these limitations, alternative propulsion technologies have been explored, including plasma-based propulsion systems. Plasma-based propulsion systems operate by ionizing a gas and generating a plasma that is accelerated to produce thrust. Compared to traditional chemical propulsion systems, plasma-based systems offer several advantages, including higher fuel efficiency, scalability, and the potential for higher levels of thrust. The objective of this thesis is to investigate the development and fabrication of a plasma-based propulsion system and to evaluate its performance for space exploration and other aerospace applications. The plasma-based propulsion system consists of a plasma generator and a nozzle that accelerates the plasma to produce thrust. The primary focus of this research is to optimize the design and operation of the propulsion system for maximum

efficiency and thrust. This involves the investigation of the plasma generation and acceleration process, as well as the development of a suitable power supply for the system. The research also explores the potential applications of plasma-based propulsion systems for space exploration, including deep space missions and interplanetary travel. Overall, the development of plasma-based propulsion systems represents a significant step forward in the field of space exploration and aerospace engineering. The research presented in this thesis has the potential to pave the way for the development of more efficient and advanced propulsion systems that can meet the demands of future space missions.

2. LITERATURE REVIEW

Electric Propulsion of a Different Class: The Challenges of Testing for Megawatt Missions [1], Roland Florenz, Thomas M. Liu, A. Gallimore, H. Kamhawi, Daniel L. Brown, R. Hofer, J. Polk, The University of Michigan's Plasma dynamics and Electric Propulsion Laboratory (PEPL) developed a 100-kW-class Nested-channel Hall thruster (NHT) called the X3. • Several developmental and facility-related challenges were encountered and overcome during the X3's design, fabrication, and testing. • This paper presents these challenges and the lessons learned associated with the X3's development as a case study to inform other high-power EP development efforts.

Design, Set-Up, and First Ignition of the RF Helicon-based Plasma Thruster [2], F. Romano, Y. Chan, G. Herdrich, C. Traub, S. Fasoulas, P. Roberts, N. Crisp, B. Holmes, S. Edmondson, S. Haigh, S. Livadiotti, A. Macario-Rojes, V. Oiko, L. Sinpetru, K. Smith, J. Becedas, V. Sulliotti-Linner, M. Bisgaard, S. Christensen, V. Hanessian, T. K. Jensen, J. Nielsen, D. Garcia-Almiñana, M. Garcia-Berenguer, S. Rodriguez-Donaire, M. Sureda, D. Kataria, B. Belkouchi, A. Conte, S. Seminari, The RF Helicon-based Plasma Thruster is designed, built, and set-into operation with a low input power requirement of Pf ~ 60W, easy ignition, and minimized reflected power Pr. • The thruster is contactless and features a novel antenna called the birdcage antenna, derived from heritage of magnetic resonance imaging (MRI) machines. • A B-dot magnetic inductive probe is designed and integrated to verify the presence of helicon waves in the plasma plume.

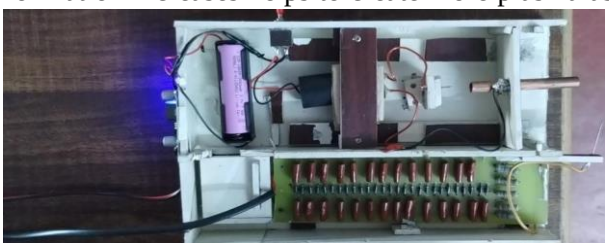
Plasmas for space propulsion [3], E. Ahedo, Plasma thrusters are challenging the monopoly of chemical thrusters in space propulsion due to their higher specific energy. • Plasma processes and conditions differ widely from one thruster to another, with the pre-eminence of magnetized, weakly collisional plasmas. • Plasma–wall interaction affects energy deposition and erosion of thruster elements, and thus is central for thruster efficiency and lifetime.

Perspectives, frontiers, and new horizons for plasma-based space electric propulsion [4], I. Levchenko, S. Xu, S. Mazouffre, D. Lev, D. Pedrini, D. Goebel, L. Garrigues, F. Taccogna, K. Bazaka, • Electric and plasma thrusters have a theoretical capacity to deliver virtually any impulse, the latter being ultimately limited by the speed of light. • Rapid progress in the field driven by consolidated efforts from industry and academia has brought all-electric space systems closer to reality. • There are still obstacles that need addressing before we can take full advantage of this promising family of propulsion technologies.

Application of plasma technology in aerospace vehicles: A review [5], A. A., • Plasma technology can be used to create a radiation shield, propulsion system, and coatings for space-crafts. • A strong magnet and power supply are needed to generate a magnetic field for electron cloud. • Practical experiments and financial assessments are needed to assess the effectiveness of plasma technology for space missions.

3. EXPERIMENTAL PROCESS

If a force is applied on an object, a force of intensity which is equal but in the direction opposite to the one exerted on the object that produced it. This is newton's Third law or principle of action reaction. We reduce the amount of the propellant, but ejecting the objects at the speed of even 100km/sec. It's simple terms we had built, it uses the electric field to accelerate the atoms and eject them at high velocity. An atom is composed of three subatomic particles the Neutrons- High Mass and no electric charge, Protons- High Mass positive charge, Electrons- Low mass, negative charge. We understand that when less protons(+ve charge) than electrons(-ve charge) the atom has negative(-ve) charge, when less electrons than protons the atom has positive(+ve) charge and when the protons and electrons are in equal the positive and negative charges cancel out leaving the atom with neutral charge. In this paper we have made the experiments and tested the release of accelerated air coming out of the nozzle in the fabricated model which has been specially made to obtain results with a simple flame blowing test and a wind meter to measure the speed of the air. A positive propellant is used, if only a positive propellant is used the atoms will go off from one end and they never return (high atomic mass). Now an electron will be added, electrode will be attached, the principle is the resistance over it will be heated this will cause the electrons to emit or thermionic emission happens. Now the positive propellant the ion generator attached causes the positive ions to get released and added to in small amount to the electrodes. Now with the input source the 4V supply is given with the ion generator, small volume with high temperature with electrons being emitted creates a plasma arch, and the collision happens with the positive charge causing them to lose electrons. The arch which is created will be composed mostly with electrons the electrons and neutral charges collided and the electron is supplied and convert into negative ions generating plasma, the ionization increases helps to create more plasma as the



pressure is high the nozzle made of copper can be adjusted at different distances to control the velocity of air which comes out.

Fig-1: Experimental setup for the flame blow test

Fig-2: Arch being crated and flame test for accelerated

4. RESULTS AND OBSERVATION

Now when the experiment is being conducted, first the high velocity air when the supply is given in the model creating the plasma the accelerated ions come out from the nozzle and the air with certain velocity blows off the flame of a candle when kept near it proving that the air is being accelerated meaning this force which is created pushes the object forward by producing certain amount of thrust. The velocity of air with varying input have been note down in the table below. And figure of the graph obtained with the results have been presented for best observation.

Table-1: Values recorded at time of experiment

Input(Volts)	Output(cm/sec)
0.5	0
1	8
1.5	19
2	37
2.5	44
3	58
3.5	69
4	72

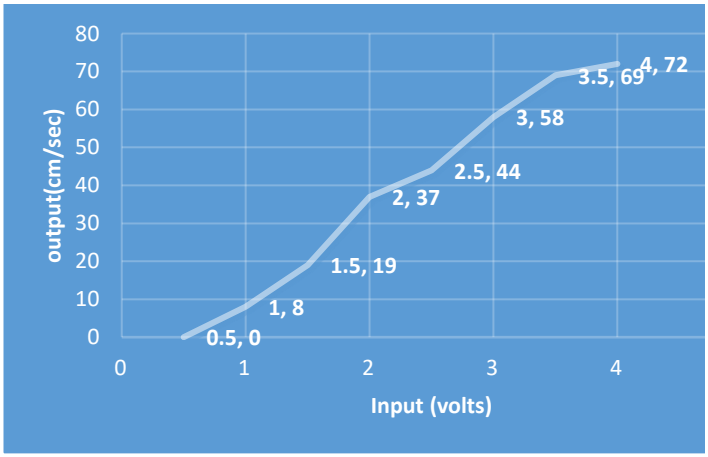


Fig-3: The scatter plot of the obtained values

5. CONCLUSION

Propulsion through plasma includes a wide range of technological products and apparatuses that span a wide range of dimensions, powers, thrusts, particular impulses, and efficiency. While some thrusters are now prototypes being developed and tested in labs, others have a lengthy history of flying and are commercially accessible. There are advantages and disadvantages for the electric propulsion to get implemented in aviation completely, but in starting stages they could be used as mounting agents for traditional jet engines which can result in saving the fuel, The main point is that if plasma generates high temperature then there will be no need to use combustion chambers, if we completely replace it with the gas turbine the power can be harnessed from the sun, in case of bad cloudy weathers, the electricity could be provided by different sources,. Plasma propulsion can be the new dawn in the field of aviation more methodologies being developed and implemented.

ACKNOWLEDGEMENT

I express my sincere gratitude to many people who have helped me and supported me during project work. Without them, I could not have completed the project on time. I am thankful to my guide, **Mr. Swapnil Shukla** for his valuable guidance, encouragement, and patience. I would like to thank **Dr V. C. Jha** (Head of Department) who contributed directly or indirectly in shaping and achieving the desired outcome. I thank all my colleagues and friends for their cooperation while completing this project work. I want to thank my family members; without whose emotional and moral support nothing was possible.

References

1. Florenz, R., Liu, T., Gallimore, A., Kamhawi, H., Brown, D., Hofer, R., & Polk, J. (2012). Electric propulsion of a different class: The challenges of testing for megawatt missions. In 48th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit (p. 3942).

2. Romano, F., Chan, Y. A., Herdrich, G., Traub, C., Fasoulas, S., Roberts, P., & Seminari, S. (2020). Design, set-up, and first ignition of the RF helicon-based plasma thruster. In Space Propulsion Conference (Vol. 1, p. 2021).

3. Ahedo, E. (2011). Plasmas for space propulsion. Plasma Physics and Controlled Fusion, 53(12), 124037.

4. Levchenko, I., Xu, S., Mazouffre, S., Lev, D., Pedrini, D., Goebel, D., & Bazaka, K. (2020). Perspectives, frontiers, and new horizons for plasma-based space electric propulsion. Physics of Plasmas, 27(2), 020601.

5. Anvari, A. (2019). Application of plasma technology in aerospace vehicles: A review.

6. Fabris, A. L. (2014). Experimental Characterization of Plasma Sources for Space Propulsion (Doctoral dissertation, PhD thesis, Universita degli studi di Padova).

7. Levchenko, I., Xu, S., Cherkun, O., Baranov, O., & Bazaka, K. (2021). Plasma meets metamaterials: Three ways to advance space micro propulsion systems. Advances in Physics: X, 6(1), 1834452.

8. Herdrich, G., Bauder, U., Boxberger, A., Gabrielli, R. A., Lau, M., Petkow, D., ... & Fasoulas, S. (2013). Advanced plasma (propulsion) concepts at IRS. Vacuum, 88, 36-41.