International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-7, July 2014

A Review on Applications of Future Generation Ionic Engine

Umesh Kumar Sharma, G. Srivastava

***Abstract*— In propulsion technologies thrusters powered by ionic wind may be efficient alternative to conventional atmospheric propulsion technologies. And in this reference ionic engine means to speak about a new aircraft. This review paper presents the introduction and future possibility of actual ionic engines. Ionic engine (ion thruster, which accelerates the positive ions through a potential difference) is about 10 times more effective than classic system based on combustion. We can still improve the efficiency of 10-50 times if one uses pulses of positive ions accelerated in a cyclotron mounted on the ship; the efficiency can easily grow for 1000 times if the positive ions will be accelerated in a high energy synchrotron, synchrocyclotron or isochronous cyclotron (1-100 Ge.V).The force is an asymmetric electrostatic force. *In this, the big classic synchrotron is reduced to a ring surface (magnetic core).* Future Generation (ionic) engine will have mandatory a circular particle accelerator (high or very high energy). We can thus increase the speed and autonomy of the ship using a less quantity of fuel and power. One can use synchrotron radiation (synchrotron light, high intensity beams), like high intensity (X-ray or Gamma ray) radiation, as well. In this case will be a beam engine (not an ionic engine), it'll use only the power (energy, which can be solar energy, nuclear energy, or both) and so we will remove the fuel. *It proposes using a powerful LINAC at the exit of synchrotron (especially when one accelerates electrons) to not lose energy by photons premature emission.* With a new ionic engine one builds a new aircraft, which can travel through water and. This new aircraft will can accelerate directly, without an additional combustion engine and without gravity assists from other planets.**

***Index Terms*— High energy synchrotron, synchrocyclotron or isochronous cyclotron, Variants, Propellants, Ionic Thruster**

I. INTRODUCTION

We require the search for more non-polluting energy sources and it should be eco-friendly. Few times back no one could imagine of going to mars because such trips would be long and grueling. It would take six long months to go there but now with the new advancement in technology it would take only 39 days to do so. And the answer for such trips is "Ionic Engines". An ion thruster (or ion drive) is one of several types of space craft propulsion, specifically electric propulsion. It is uses beams of ions — electrically charged atoms or molecules — for propulsion. The precise method for accelerating the ions may vary, but all designs take advantage of the charge-to-mass ratio of ions to accelerate them to very high velocities using a high electric field. Ion thrusters are therefore able to achieve high specific impulse, reducing the amount of reaction mass required, but increasing the amount of power required compared to chemical rockets. Ion thrusters can deliver an order of magnitude greater propellant efficiency than traditional liquid fuel rocket engines, but are constrained to very low accelerations by the power/weight ratios of available power systems. The thrust created in ion thrusters is very small compared to conventional chemical rockets, but a very high specific impulse, or propellant efficiency, is obtained. This high propellant efficiency is achieved through the very frugal propellant consumption of the ion thruster propulsion system. They do, however, use a large amount of power. Given the practical weight of suitable power sources, the accelerations given by these types of thrusters is of the order of one thousandth of standard gravity.

The father of the concept of electric propulsion is "Konstantin Tsiolkovsky" as he is the first to publish mention of the idea in 1911. However, the first documented instance where the possibility of electric propulsion is considered is found in Robert H. Goddard's handwritten notebook in an entry dated 6 September 1906. The first experiments with ion thrusters were carried out by Goddard at Clark University from 1916–1917. The technique was recommended for near-vacuum conditions at high altitude, but thrust was demonstrated with ionized air streams at atmospheric pressure. However a working ion thruster was built by "Harold R Koufman" in 1959 at NASA It was similar to the general design of a gridded electrostatic ion thruster with mercury as its fuel. Suborbital tests of the engine followed during the 1960s and in 1964 the engine was sent into a suborbital flight aboard the Space Electric Rocket Test 1 (SERT 1). It successfully operated for the planned 31 minutes before falling back to Earth.

II. WORKING OF IONIC ENGINE

There are two basic styles of ion engines, electrostatic and electromagnetic. An electrostatic ion thruster is a design for ion thrusters (a highly-efficient low-thrust spacecraft propulsion running on electrical power). These designs use high voltage electrodes in order to accelerate ions with electrostatic forces.

An electrostatic ion engine works by ionizing a fuel i.e. it is the initial step in which fuel is ionized (often xenon or argon gas) by knocking off an electron to make a positive ion or already it can be made ionized as poured a lot of **argon gas** into a plastic bottle and it is easily ionized by Tesla coil's electromagnetic process. By testing of b-phase W nanorods as a gas ionizer for neutral argon atoms. These **W nanorods** having square-base pyramidal apexes were grown on oxidized Si (100) substrate using glancing angle sputter deposition technique with substrate rotation. Only a few volts of positive anode voltage (3–4 V) applied to the W nanorods generates a

Manuscript received July 19, 2014.

Umesh Kumar Sharma, Department of Physics, Eshan College of Engineering, Mathura, INDIA, Mobile No.09412882101.

G.Srivastava, Department of Mechanical Engineering, Eshan College of Engineering, Mathura, INDIA, Mobile No.09452907349.

high electric field, which ionizes gas-phase argon atoms and generates ion currents up to several tenths of microamperes. T The positive ions then diffuse into a region between two charged grids that contain an electrostatic field. This accelerates the positive ions out of the engine and away from the spacecraft, thereby generating thrust. Finally, an neutralizer sprays electrons into the exhaust plume at a rate that keeps the spacecraft electrically neutral.

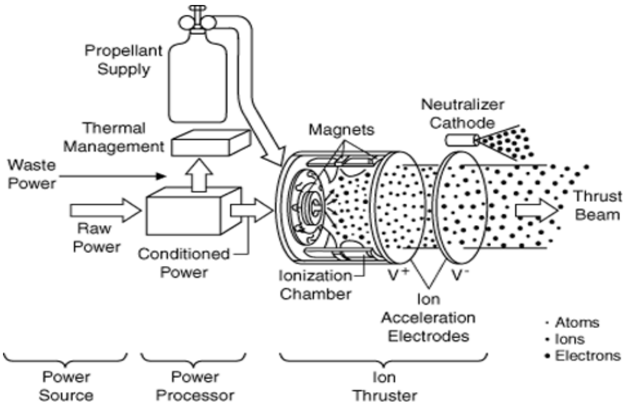

FIG 2.Working of Future Generation Ionic Engine

An electromagnetic ion engine also works by ionizing a fuel. In this case a plasma is created that carries current between the ionizing anode and a cathode. The current in turn generates a magnetic field at right angles to the electric field, and thereby accelerates the positive ions out of the engine via the Lorentz force – basically the same effect on which rail guns are based. Again a neutralizer keeps the spacecraft electrically neutral.

III. METHOD *OF OPERATION*

1. Propellant atoms are injected into the discharge chamber and are ionized by electron bombardment, forming plasma. There are several ways of producing the energetic electrons for the discharge: (1) The electrons are emitted from a hollow cathode and are accelerated on their way to the anode (Kaufman type ion thruster). (2) The electrons can be accelerated by the oscillating electric field induced by an alternating magnetic field of a coil, which results in a self-sustaining discharge and omits any cathode (radiofrequency ion thruster). (3) Microwave heating

2. The positively charged ions move towards the extraction system (2 or 3 multi-aperture grids) of the chamber due to diffusion. Once ions enter the plasma sheath at a grid hole they will be accelerated by the potential difference between the first (screen) and the second (accelerator) grid of the extraction system. The ions are ion-optically focused by the rather large electric field to pass through the extraction holes. The final ion energy is determined by the potential of the plasma (the plasma potential is a few volts larger than the screen grid voltage).

3. The negative voltage of the accelerator grid prevents electrons of the beam plasma outside the thruster from streaming back to the discharge plasma. Electron backstreaming occurs if the potential within the grid is not sufficiently negative, this can mark the end-of-life of the ion thruster. By increasing the negative voltage electron backstreaming can be avoided.

4. The expelled ions propel the spacecraft in the opposite direction according to ***Newton's 3rd law.***

5. Electrons are emitted from a separate cathode placed near the ion beam, called the neutralizer, towards the ion beam to ensure that equal amounts of positive and negative charge are ejected. Neutralizing is needed to prevent the spacecraft from gaining a net negative charge.

IV. VARIANTS*:*

When a current passes between two electrodes—one thinner than the other—it creates a wind in the air between. If enough voltage is applied, the resulting wind can produce a thrust without the help of motors or fuel. The largest difference in the many electrostatic ion thrusters is the method of ionizing the propellant atoms - electron bombardment (NSTAR, NEXT, T5, T6), radiofrequency (rf) excitation (RIT 10, RIT 22, µN-RIT), microwave excitation (µ10, µ20). Related to this is the need of a cathode and required effort for the power supplies. Kaufman type engines require at least supplies to the cathode, anode and chamber, whereas the rf and microwave types require an additional RF generator, but no anode and cathode supplies. In the extraction grid systems minor differences occur in the grid geometry and the materials used, which may have implications for the grid system lifetime.

V. NEW DIMENSIONS IN IONIC ENGINE

With the help of Eclectro-hydo-dynamics other technologies are flourishing in the field of alternative of conventional propulsion technology for the commercial purpose. Spaceship propulsion is key for a new approach in car, train or airplane transportation. New dimensions arises day to day advances like Ion thruster **(**Electrostatic ion thruster).Recently a young student from Egypt, Aisha Mustafa, has further developed the idea of ionic engines. This is a completely new form of energy harnessing based on a vacuum, a space free of any matter. Using the effects of attraction or repulsion of two surfaces in a vacuum might release an enormous quantity of energy.

VI. ADVANTAGES OF IONIC ENGINES

Ionic engine (ion thruster) has two major advantages and two disadvantages compared with chemical propulsion; the impulse and energy per unit of fuel used are much higher; 1-the increased impulse generates a higher speed (velocity; so we can walk longer distances in a short time), 2-the high energy decreases fuel consumption and increase the autonomy of the ship; generate force and acceleration are very small; we can't defeat any forces of resistance to lodging by atmosphere and we have no chance to exceed gravitational forces - ship will not leave a planet (or fall on it) using the ion thruster (It required an additional motor). Vacuum ship acceleration is possible but only with very small acceleration.

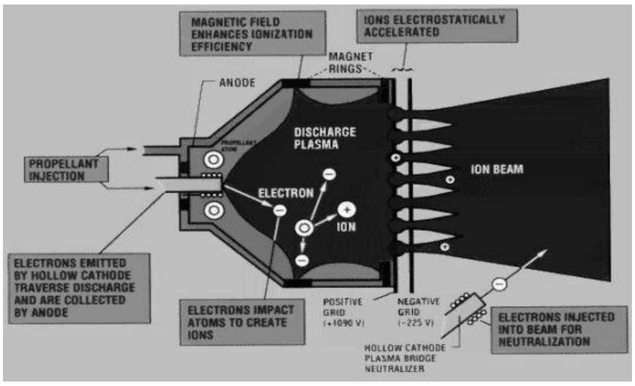

Fig.2 Schematic diagram of Future generation Ionic engines

Propellants used play a major role in ionic engines efficiency thus it should be wisely used. Ionization energy represents a very large percentage of the energy needed to run ion drives. The ideal propellant for ion drives is thus a propellant molecule or atom with a high mass/ ionization energy ratio. In addition, the propellant should not cause erosion of the thruster to any great degree to permit long life; and should not contaminate the vehicle. Recently new propellants are being used as xenon, mercury, bismuth and argon with promising results. Ion thrusters have many applications for in-space propulsion. The best applications of the thrusters make use of the long lifetime when significant thrust is not needed. Examples of this include orbit transfers, attitude adjustments, drag compensation for low earth orbits, transporting cargo such as chemical fuels between propellant depots and ultra fine adjustments for more scientific missions. Ion thrusters can also be used for interplanetary and deep space missions where time is not crucial. Continuous thrust over a very long time can build up a larger velocity than traditional chemical rockets. Since then different missions have been worked upon ionic engines from the world.

VII. FUTURE SCOPE

There are many propellant technologies in the international arena but on the basis of such technologies (may be most advanced) new sophisticated technologies can be emerges, we could imagine all sorts of military or security benefits to having a silent propulsion system with no infrared signature, there have been few rigorous studies of ionic wind as a viable propulsion system. Some researchers have theorized that ionic thrusters, if used as jet propulsion, would be extremely inefficient, requiring massive amounts of electricity to produce enough thrust to propel a vehicle. At MIT researchers have run their own experiments and found that ionic thrusters may be a far more efficient source of propulsion than conventional jet engines. In their experiments, they found that ionic wind produces 110 Newtons of thrust per kilowatt, compared with a jet engine's 2 Newtons per kilowatt. Scientist in this field will achieve the lightest and smallest with economical features if the further using the air and even polluted air for the wind ionic engine.

REFEENCES

[1]E. W. Muller and T. T. Tsong, Field Ion Microscopy Principles and Applications (Elsevier, New York, 1969).
[2]T. T. Tsong, Atom-Probe Field Ion Microscopy (Cambridge University Press, New York, 1990).
[3]D. J. Riley, M. Mann, D. A. MacLaren, P. C. Dastoor, W. Allison, K. B. K. Teo, G. A. J. Amartunga, and W. Milne, Nano Lett. 3, 1455 (2003).
[4]A. Modi, N. Koratkar, E. Lass, B. Wei, and P. M. Ajayan, Nature (London) 424, 171 (2003).
[5]E. Salancon, Z. Hammadi, and R. Morin, Ultramicroscopy 95, 183 (2003).
[6]T. Karabacak, A. Mallikarjunan, J. P. Singh, D.-X. Ye, G.-C. Wang, and T.-M. Lu, Appl. Phys. Lett. 83, 3096 (2003).
[7]J. P. Singh, F. Tang, T. Karabacak, T.-M. Lu, and G.-C. Wang, J. Vac. Sci. Technol. B 22, 1048 (2004).
[8]E. Y. Choueiri. "A Critical History of Electric Propulsion: The First50Years(1906–1956)".http://alfven.princeton.edu/papers/choueiriJPP04a.pdf. Retrieved 2007-11-07.
[9]http://science.nasa.gov/newhome/headlines/prop06apr99_2.htm, April 6, 1999, science.nasa.gov, Ion Propulsion 50 years in the making
[10] Robert H. Goddard - American Rocket Pioneer
[11] "Innovative Engines - Glenn Ion Propulsion Research Tames the Challenges of 21st Century Space Travel". http://www.nasa.gov/centers/glenn/about/fs08grc.html. Retrieved 2007-11-19.
[12](Russian) Native Electric Propulsion Engines Today, Novosti Kosmonavtiki, 1999, No.7
[13] "ESA and ANU make space propulsion breakthrough". Pressrelease.http://www.esa.int/esaCP/SEMOSTG23IE_index_0.html. Retrieved 2007-06-29.
[14]ANU Space Plasma, Power & Propulsion Group (SP3) (2006-12-06). "ANU and ESA make space propulsion breakthrough". *DS4G Web Story*. The Australian National University. Archived from the original on 2007-06-27.http://web.archive.org/web/20070627103001/http://prl.anu.edu.au/SP3/research/SAFEandDS4G/webstory. Retrieved 2007-06-30.
[15]Oleson, S. R., & Sankovic, J. M.. "Advanced Hall Electric Propulsion for Future In-Space Transportation". http://gltrs.grc.nasa.gov/reports/2001/TM-2001-210676.pdf. Retrieved 2007-11-21.
[16]Marcuccio, S.. "The FEEP Principle". http://www.centrospazio.cpr.it/FEEPPrinciple.html. Retrieved 2007-11-21.
[17]Colleen Marrese-Reading, Jay Polk, Juergen Mueller, Al Owens. "In-FEEP Thruster Ion Beam Neutralization with Thermionic and Field Emission Cathodes.
[18] The Proceedings of the Royal Society.

Dr. Umesh Kumar Sharma. M. Sc (Physics) M. Phil (Physics BMI), Ph.D. Nanotechnology, working as Associate Professor and Head, Department of Physics, Eshan College of Engineering Mathura U.P. INDIA. He has 14 years Academic experiences and published 17 research papers in International Journals/conferences and 34 National research papers in National Journals/Conferences/seminars in various fields of Electronics, nanomaterials and nanotechnology and author of 4 Technical books of Engineering. Presently he is working on a project of organic devices in organic electronics; He is the members of International Society of Nanotechnology, International Society of Grephene, and International Council for Nanomaterials. He is Editor/member of Editorial Boards in International Journals IJETR, IJISET,IJAICT,IJETT etc.

Prof. (Dr.) G.Srivastava , B. Tech (Mechanical), M. Tech (Mechanical),Ph.D. (Mechanical) working as Professor & Director at Eshan College of Engineering Mathura U.P. INDIA. He has 24 years Academic & Research experiences and published more than 23 research papers in national and International reputed journals/conferences/seminars in various fields of Materials, Thermal and other field of Mechanical engineering. He has chaired more than 8 National Conferences.