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A comparative study on satellite refueling in electric propulsion systems using organic polymers

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ABSTRACT

In present technology of satellites, Satellites are the highly demanded by their utility in diversified applications. For this application a million dollars of expenditure have been incurred per every year for developing and launching the satellites. This ranges from minimum of 75 million dollars to maximum of 1.5 billion dollars by different countries with life span of satellites from few months to 10 years. The short comes of this life span due to fuel consumption of satellites. This problems in terms of increasing the life span have been answered in the year 8 July 2011 by NASA by introducing different concepts of refueling techniques. These techniques incur 16 percentage of total satellite cost on average to enhance the life span of existing satellites. In this paper we performed a comparative study of different refueling techniques with their basic features with introduction of organic polymers which involves polymers structure, power generation and thruster capabilities. This comparative analysis has been suggested the best possibilities to increase satellite lifespan and save the launching costs.

Keywords— *EMPA, Robotic refuelling, Piezoelectric polymer, Ion thruster, Duel stage propulsion system*

1. INTRODUCTION

For the foreseeable future, access to space will remain very expensive even with tricks like reusing rockets or launching from balloons and giant aeroplanes, it still cost thousands of dollars per kilogram to put something into low earth orbit Once we put something up there and that thing is on its own and hopefully does what it need to until it run out of fuel at which point most satellite are completely Useless and becomes a space debries. This problem somehow has to be solved. So, an invention was) is a NASA Technology demonstration mission with equipment launchers in both brought up which changed whole prospective of astronomy. That is the "Satellite Refueling" the robotic refueling mission (RRM 2011 and 2013 to increase the technological maturity of in-space propellant transfer by testing a wide Variety of potential propellant hardware of new and existing software designs. Total cost of both the satellite and refueling increases and to manufacture a refueling vehicle it cost approx of 15%-16% of satellite manufacturing cost even it is capable of filling 5+ satellites. Hence to overcome this cost problem and to increase the lifespan we have come up with a new idea in field of satellite refueling. Whenever the satellite run out of fuel instead of chemical propellant and Chemical thrusters we can introduce a new organic polymer which can produce electricity when compressed stretched as fuel for ion thrusters. The polymer is developed by swizz researchers of EMPA. This can overcome all the cost, lifespan and speed related problem of a satellite.

2. OUR METHOD

Rockets are the only direct anthropogenic emission sources into the up- per atmosphere. Gaseous rocket emissions include CO, N2, H2, H2O, and CO2, while solid rocket motors (SRM) additionally inject significant amounts of aluminum oxide (Al2O3) particles and gaseous chlorine species into the atmosphere. [1] During this exhaust nitrogen can be recollected and purified and used as a neutral gas propellant for ion thruster. When satellite run out of fuel chemical thruster are shifted by ion thruster and stored propellant can be used for further thrust.

As we know ion thruster is a mode of electric propulsion, we will be raised by a question where we will get a huge amount of electricity source for Ion thruster. As satellite have solar panels to meet their electricity requirements, if we increase the solar panels may help in getting required amount of electricity, but size, weight and cost of satellite increase. Since to overcome this we

can introduce a thin flexible rubber like organic polymer which produce large amount of electricity when it is under any stress which is designed by researcher of EMPA. It is capable of producing electricity even under low stress. Hence it can be used as power source for ion thruster. And an improved vision of this polymer is MCF rubber which can exhibit both piezoelectric effect and photovoltaic effect [2] which is still under research can be used as better polymer for the above case.

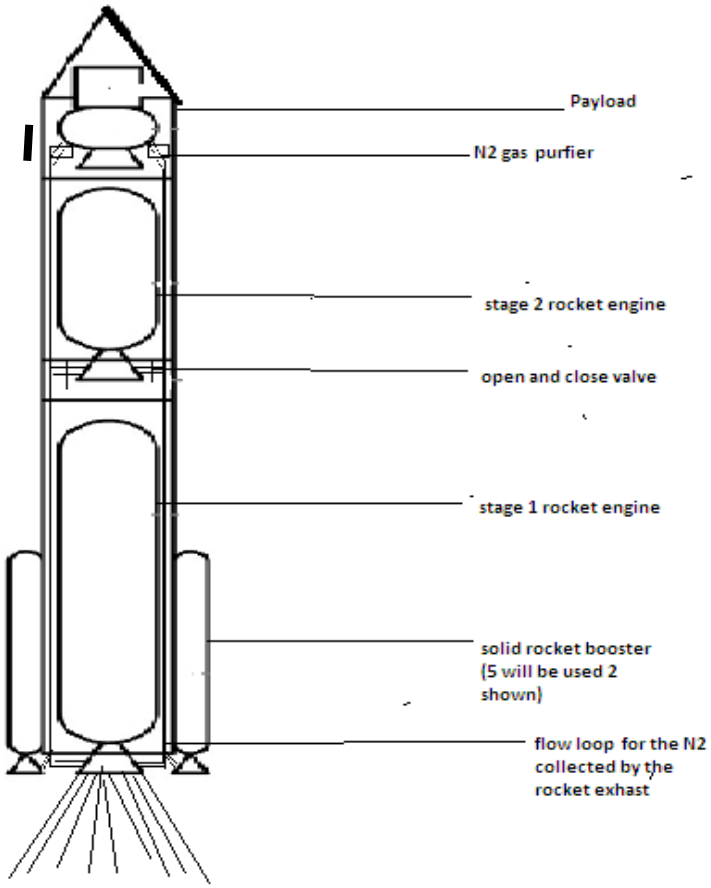

Fig. 1: Diagrammatic representation of 2 stage rocket with assumption way of reusing N2 from exhaust of rocket as fuel to provide some number

2.1 Shifting of thrusters

This system is applicable only if the satellite is designed in a way that a satellite should have two stage of propulsion system which is a composition both chemical and electrical propulsion engine. When chemical engine run out of fuel they get dismantled in a same way as rocket stages are shifted. If these satellites are on the earth's orbit they can be programmed such the dismantled chemical engine can move towards a nearest space station, either being a space debris it can be recycled for further use. This is not possible if the satellite if out of earth's orbit. After the dismantling of the chemical engine the satellite engine is switched to ion thruster.

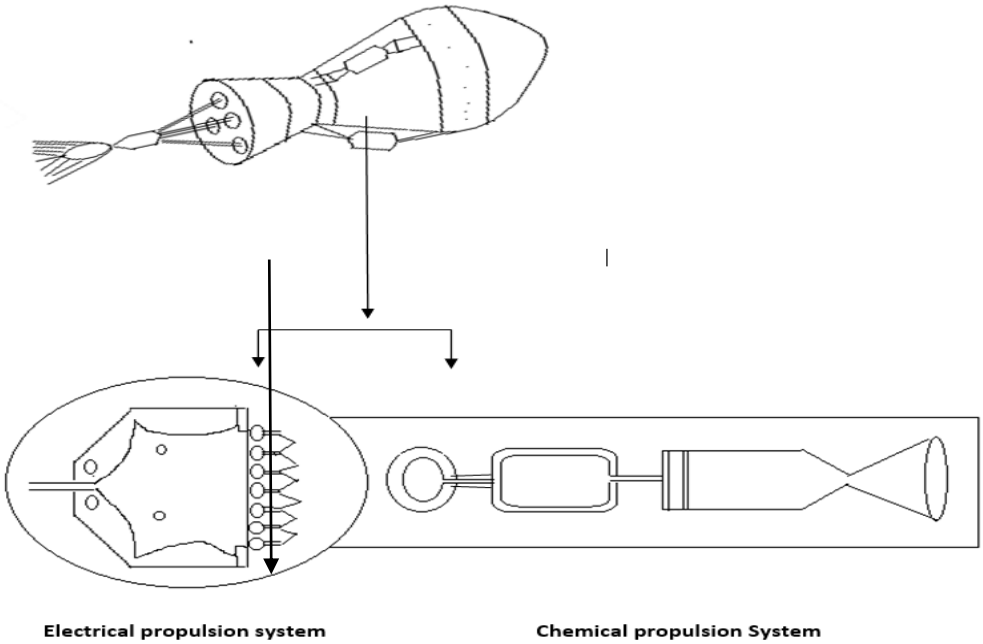

Fig. 2: T.S view of combined designed of electrical and chemical propulsion Assumed to satisfy the introduced propulsion system

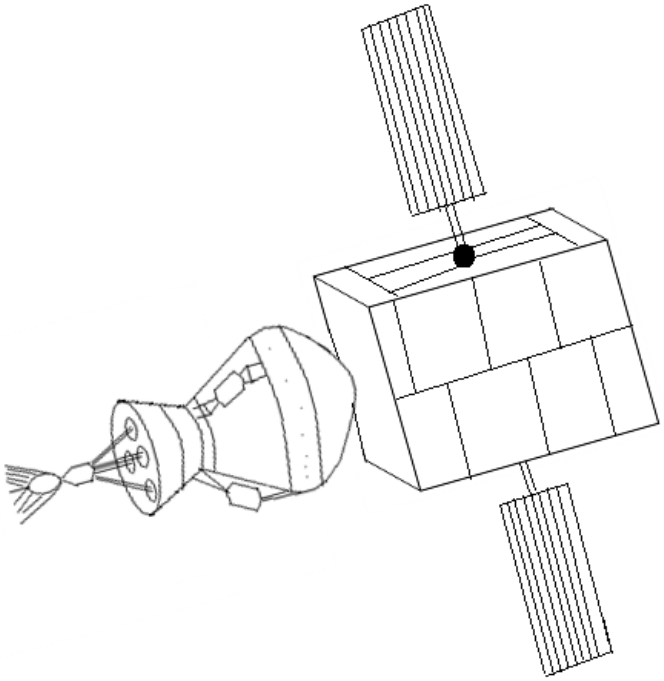

Fig. 3: Design of a double staged propulsion systemic Satellite

2.2 Can N2 be used as a propellant?

As we all know xenon is the most used propellant for ion thruster. Since the Xenon is rare and rather expensive to provide some numbers, 2000h of continuous lifetime testing of a larger ion thruster suitable for orbit rising of Xe gas flow of about 70sccm requires about 50kgs of Xe. Assuming a Xe price of about US $2000per kg, such a campaign would cost about US $100000 just in turns of propellant cost.[3] To overcome this problem and to bring low cost alternative propellant for Xenon –propelled ion thruster. Iodine propellant is proposed based basis on the low ionization potential, the high atomic mass and weight savings associated with strong solid fuel with low vapour pressure [4].by observing this property even nitrogen can be used as the alternative propellant for ion thrusters. And even N2 is also act as inert gas which is the basic need of ion thruster propellants. Because of its less atomic mass large amount of N2 is need as propellant. Which is not effective with respective to other propellant. But in this technique the N2 is obtained from the rocket and satellite exhaust of chemical propulsion system in high amount and free of cost. Hence N2 can be a effective propellant for this system

Table 1

Propellants	Xenon (Xe)	Iodine (I2)	Nitrogen(N2)
Atomic mass	131.29	126.90447	14.0064
1st ionization potential	12.1299ev	10.4513ev	14.5341ev
Vapour pressure	low	low	low

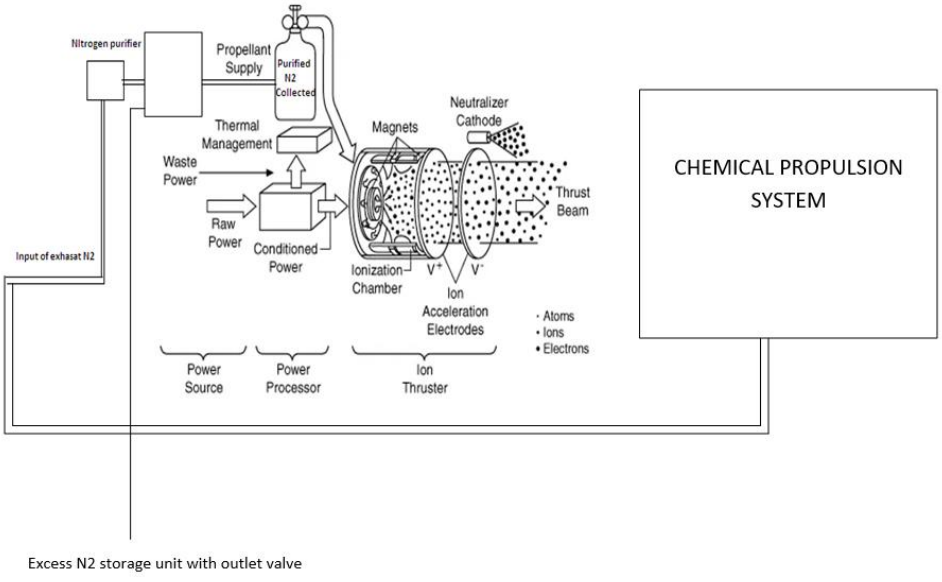

Fig. 3: Diagrammatic representation of mechanism of working of ion thruster with the propellant storage unit and exhaust propellant purifier

2.3 Composition, working and principle of Organic polymer produced by EMPA

This rubber is a composite incorporation of polar nanoparticles and an elastomer. Silicon was used as a prototype, shaping and joining these materials yields a thin, elastic in which the polar moieties of nanoparticles has been randomly oriented. The film is heated until the glass transition temperature of nanoparticles get exceeded and they change from a solid glassy state to rubbery form when it is exposed to a strong electric field orients the polar moieties and these arrangements are frozen by cooling to room temperature this organic polymer has the capability to produce electricity even by sensing the vibration of heart beat. Sensibility of this material can produce large amount of electricity which is required for ion thruster [5]. This material works on the principle of piezoelectric effect. This effect is mostly found in solid crystals. Commonly in crystals the basic unit cell is identical and symmetrically arranged but in piezoelectric material the situation is different. When by applying pressure by squeezing or stretch it result in deformation of structure causing some atoms to come closer and mean while other move away from each other finally resulting in the disturbance in electric neutrality hence a voltage is created among its outer ends. Same phenomenon Take place in the polymer produced by EMPA Researchers.

2.4 Capability of existing ion thruster.

At present condition ion thruster had capability to get a exhaust velocity of 20 to 5 km/s (45000 - 112000 mph),the thrust of 25 to 250 millinewtons (0.090 - 0.8990 Zf) with a efficiency of 65 -80% with the supply of 1-7 Kw (1.3 - 9.4 bp).which is sufficient for a satellite to perform its work[6].

2.5 Why is it better than other refueling techniques?

When we come to refueling concept On-orbit robotic refueling method is most effective one. Which is even under research, how to refuel it without any leakage of fuel during refueling and maintaining particular condition in space which is suitable for refueling [7]. Even if we overcome this the vehicle to carry fuel may cost approx of 55-60% of satellite manufacture cost (this calculation is according to the costliest satellite built to the costliest RRM made). Even if we think same vehicle can refuel many satellites. A new technique was introduced called robotic refueling by constellation method in which required number of satellites are brought in a circular constellation and then they are refueled in a desired and designed way. [8] This technique may reduce the cost but it even cost 16% of satellite manufacturing cost (this is based on 8 satellites Refueled at a same time). These techniques are useful only when they are in the earth orbit. When we take a huge mission to go to mars or Pluto these techniques may not help. Because a refueling vehicle cannot be sent their hence there is a necessity to modify the satellite to refuel itself by its own exhaust when needed and our technique is effective to overcome these entire problems.

2.6 Comparative Study

Table 2

S. No	Name of technique	Limitation of these technique	Advantages of our technique over them
1	On orbit satellite refueling	The manufacturing cost of vehicle is more, it can't be used in long distance missions	The manufacturing Cost is less and can be used for long distance missions
2	Satellite refueling by constellation method	The manufacturing cost of vehicle is less compared to RRM, even it can't be used in long distance missions	The manufacturing little bit less and it can be used for long distance missions
3	Usage of large solar panels (future plan of NASA for its X2 Hall thruster)	It increases the area and weight of the satellite it also increases the cost of installation of solar penal	Our method won't alter the area and weight of the standard satellite. And cost is too less compared to installation of solar penal..

3. LIMITATIONS

- These satellites cannot take voyage near the suns orbit, because the rate of production of electricity of the organic polymer decreases with increase in temperature
- Since they can produce more electricity some of the produced electricity should be eliminated when it exceeds the storage limit
- Pressure or stress applied on polymer must be in a range hence pressure applied on polymer during large trust has to be in a controlled manner.
- We couldn't explain how to extract N2 from the High-speed extract of rocker

4. RESULTS

By observing all the other techniques, this can be the most effective technique which can be a big change in the field of astronomy. By using this system, the cost, lifespan, long range travel capability increases. With slight alter in weight and size of the satellite. By this comparative study of all technique of refueling self on-orbit refueling and use of duel stage propulsion system (electrical and chemical) can be an effective than all other existing techniques

5. REFERENCES

[1] Low coat small- satellite Access to space using hybrid rocket propulsion by Christian Schmierer, Mario Kobald, Konstantain Tomiline, Ulrich Fischer, Stefan Schlechtriem

[2] Flexible organic material which generate electricity produced by EMPA researchers (Dorina Opris) statement

[3] Low coat small- satellite Access to space using hybrid rocket propulsion by Christian Schmierer, Mario Kobald, Konstantain Tomiline, Ulrich Fischer, Stefan Schlechtriem

[4] Iodine as an Alternative Fuel for Electric Propulsion By Richard D. Branam, PhD,Principle Investigator,Assistant Professor of Aerospace Engineering

[5] Taken from the Article published on web by m.econonictimes.com on Nov 12, 2017, 11.07 AM IST
[6] Taken from wikipedia.https://en.m.wikipedia.org/wiki/Ion_thruster
[7] A peer-to-peer refueling strategy using low-thrust propulsion by Atri Dutta∗ and Nitin Arora † and Ryan P. Russell ‡
[8] Peer-to-Peer Refueling for Circular Satellite Constellations by Haijun Shen∗ and Panagiotis Tsiotras†

