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Solar Electric Propulsion: The Future of Deep Space Exploration

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Abstract : The research is intended to study the solar electric propulsion (SEP) technology for planetary missions. The main benefits of using solar electric propulsion for such missions are shorter flight times, more frequent target accessibility and the use of a smaller launch vehicle than that required by a comparable chemical propulsion mission. Energized by electric power from on-board solar arrays, the electrically propelled system uses 10 times less propellant than conventional chemical propulsion system, yet the reduced fuel mass can provide vigorous power which is capable of propelling robotic and crewed missions beyond the Lower Earth Orbit (LEO). The various thrusters used in the SEP are gridded ion thrusters and the Hall Effect thrusters. The research is solely aimed to study the ion thrusters and investigate the complications related to it and what can be done to overcome the glitches. The ion thrusters are used because they are found to have a total lower propellant requirement and have substantially longer time. In the ion thrusters, the anode pushes or directs the incoming electrons from the cathode. But the anode is not maintained at a very high potential which leads to divergence. Divergence leads to the charges interacting against the surface of the thruster. Just as the charges ionize the xenon gases, they are capable of ionizing the surfaces and over time destroy the surface and hence contaminate it. Hence the lifetime of thruster gets limited. So a solution to this problem is using substances which are not easy to ionize as the surface material. Another approach can be to increase the potential of anode so that the electrons don't deviate much or reduce the length of thruster such that the positive anode is more effective. The aim is to work on these aspects as to how constriction of the deviation of charges can be done by keeping the input power constant and hence increase the lifetime of the thruster. Predominantly ring cusp magnets are used in the ion thrusters. However, the study is also intended to observe the effect of using solenoid for producing micro-solenoidal magnetic field apart from using the ring cusp magnetic field which are used in the discharge chamber for prevention of interaction of electrons with the ionization walls. Another foremost area of interest is what are the ways by which power can be provided to the Solar Electric Propulsion Vehicle for lowering and boosting the orbit of the spacecraft and also provide substantial amount of power to the solenoid for producing stronger magnetic fields. This can be successfully achieved by using the concept of Electro-dynamic tether which will serve as a power source for powering both the vehicle and the solenoids in the ion thruster and hence eliminating the need for carrying extra propellant on the spacecraft which will reduce the weight and hence reduce the cost of space propulsion.

Keywords : electro-dynamic tether, ion thruster, lifetime of thruster, solar electric propulsion vehicle
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