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Author: Mr. JUSTIN CHISM
United States, JC981987@GMAIL.COM

Mrs. TAMARA WRIGHT
United States, TAMATHI@GMAIL.COM

STUDY ON COMPARATIVE PERFORMANCE OF ADVANCED ION PROPULSION ENGINE SYSTEMS

Abstract

This manuscript provides a detailed system analysis from comparative studies performed on innovative ion propulsion systems with conventional ion propulsion systems. Ion propulsion systems achieve higher thrust, higher specific impulse, and enhance the ability to conduct long-range space missions.

Propulsion systems achieve these objectives through engine systems that are capable of generating high specific impulse. The concept of ion propulsion engine systems works on the principle of electric propulsion which creates a high specific impulse utilizing an electric field to focus narrow streams of positively charged particles away from the spacecraft. In ion propulsion engines, the resultant ions are accelerated electrically and beamed out, providing the required thrust. To complete the engine system another source is necessary to provide electrical energy (solar panels or nuclear reactors are current sources under consideration) while ions provide the reaction mass.

The conventional two-stage ion engine system uses three perforated grids attached to a chamber which contains a reservoir of charged particles. Applying high voltage to the first grid and low voltage to the second grid results in an electric arc field difference between the two grids causing the extraction and acceleration of the ions out of the chamber and into space. This method improves fuel efficiency of the thruster by increasing the voltage difference between the grids and expelling the ions at a faster rate.

Recent dual-stage 4-grid ion engine systems eliminate the problem caused by ion acceleration damage by using a two-stage process using four grids. The first stage uses two closely spaced grids operating at very high voltages. The two grids in the second stage are positioned further 'downstream' and are operated at low voltages. This difference in voltage between the grids is responsible for the more powerfully accelerated ions. The test model had a higher voltage difference and an ion exhaust plume that was over four times faster than state-of-the-art ion engine designs. It is also four times more fuel efficient, enabling a more compact engine design than present thrusters.

Finally, the high acceleration of this newest design results in a very narrow ion exhaust plume which diverges by only 3 degrees - five times narrower than previous systems. The fuel for thrust needed for minor orientation correction of spacecraft is greatly reduced. With an adequate supply of electrical power, high power versions of this innovative engine design would provide the required thrust to propel manned spacecraft on long-range missions.