SPACE PROPULSION SYMPOSIUM (C4)
Electric Propulsion (4)

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DESIGN AND RESEARCH ON PULSED HIGH THRUST RESISTOJET

Abstract

Introduction

The resistojet is a kind of electrothermal propulsion which is simple in principle but cerates difficult engineering problems. The resistojet which produces high thrust (about 1N) at high specific impulse demands high electric power input and it is hard to implement on board of a medium or small satellite. In this work a new solution of pulsed resistojet is proposed. It uses supercapacitors as a power source. It enables reaching high peak power when the mean power consumption from a satellite power system is low. Application of the pulsed resistojet allows obtaining high thrust for some orbital manoeuvres without necessity of significant modifications of typical platforms of small and medium satellites.

Design and experiments and optimization

The pulsed resistojet can work efficiently only if the heater is characterised by high heat transfer coefficients and low thermal inertia. Many layout and heater options has been investigated in the project. The tested solutions were: high temperature tungsten wires, porous heaters, vibrating heaters, capillary tubes and others. Finally, the directly heated steel tubes were chosen as the best solution. The resistojet must be supplied with very high power for relatively short time. Typical power pulse is about 1 sec long. Delivered energy is about 4000 J. Energy storage device was implemented using supercapacitors. The capacitors bank allows storing of high energy and generation with very high current. The supercapacitors' bank converts energy into power. The numerical simulation of the flow in the tubes allowed estimation of the temperature rise and pressure drop in the system. Also optimisation of the layout of the tube was conducted. The results were implemented in several experimental models of the resistojet which were tested at steady and transient conditions. The experimental data were used to validate a dedicated numerical model. The model is quasi two dimensional model based on mass, momentum and energy balance for the gas flow and metal elements of the resistojet. It accounts for conductive, convective and radiant heat transfer. The validated model was used for optimisation of the system which includes optimisation of the geometry and control algorithm of the capacitor power system.

Summary

The experiments have proven that the concept of the pulsed resistojet powered is correct. In the first version the maximum temperature of the propellant exceed 1000 K, while the optimised design should reach 1200 K and specific impulse about 2000 m/s.