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DESIGN CONCEPTS AND NUMERICAL SIMULATION ON THE SOLID PROPELLANT MICROTHRUSTER FOR CUBESAT

Abstract

The solid propellant microthruster is definitely a new class of micropropulsion system for the future microspacecraft, such as pico/nano-satellite and cubesat etc. It presents many advantages over other propulsion systems such as lesss system complexity, easy to controlling, no moving parts, and no propellant leakage possibility. The miniature of the system is not simply reductions in size, manufacture and capability of the normal size one.

The matrix arranged solid propellant microthruster is a feasible way to overcome the one-shot limitation of it and has been used in many applications such as interception missiles, KKVs etc. The application of microthruster in cubesat is not mearly the shrinking in size of a normal sized one. To exploring the influence behavier of size effection, a 5mm chamber diameter subscaled microthruster and a 3-D printed 3×3 array with 2.6mm diameter chamber have been designed and tested. The numeric simulation using CFD coupled heat transfer was performed to illustrate how the scale affects its performance compared with the fire test. The internal flow of chamber and nozzles is computed by solving the fluid governing equations with finite volume method. The heat convection parameters at the chamber case and nozzle section are used as the inflow boundary conditions for the simulations. The results showed that the small scale of computational model causeed the Knudsen number to be an important factor to be considered. The flow in some part of the nozzle appears obvious break on temperature and velocity, it was an obvious influence of the microthruster dimensions on heat transfer and boundary layer effect, which reduces the effective exit diameter and the thrust.

The fire test of a standalone prototype microthruster was conducted to validate the numerical simulation conclusion. The theoretical specific impulse of the propellant was 255s. The efficiency, as well as matching capability between the ignitor and the main charge, was 84.3% calculated from the F-t curve shown in Fig.8. The size of the microthruster mainly affects the flow fields, heat transfer process between gas and nozzle cases, thus causes great loses of the microthrusters' efficiency.