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Author: Prof.Dr. Dechuan Sun
School of Aeronautics and Astronautics, Dalian University of Technology, China

NUMERICAL SIMULATION OF THE START PROCESS OF A HAN-BASED MONO-PROPELLANT ROCKET THRUSTER

Abstract

HAN based propellants are potential green propellants used in mono-propellant rocket thrusters. To predict the performance of a HAN based mono-propellant thruster more accurately, the start transient process was separated to two sections. The previous section is the process of propellant filling in the collecting chamber and capillary tubes after the main valve is opened and the next section is the process after the propellant entering the thruster chamber. The filling process of liquid propellant was calculated by VOF (volume of fluid) method. We used pressure inlet boundary condition in calculation and obtained the variation of the mass flow rate at the inlet and the outlet of the tubes. The simulation results can explain the variation of pressure measured by the pressure sensor mounted ahead of the main valve and the calculated filling time agrees well with the test data. The result of mass flow rate at outlet was taken as the inlet boundary condition in the next process. Although the propellant reacts upon contact with the catalytic particles and the reaction time depends on flow and reaction kinetics, it is too complex to establish a simplified model. So this process was neglected and assumed that the liquid propellant change into mixed gas immediately after entering the catalytic bed. Also, the reaction was treated as chemical equilibrium process. The properties and the temperature of the mixed gas were calculated by Gibbs free energy minimization method. The catalytic bed was treated as porous medium and the pseudo homogeneous hypothesis in porous medium was used to calculate the flow and heat transfer in it. Simulation results show that the steady-state pressure slightly greater than the test value. The rise of pressure has two phases corresponding gas filling procedure and temperature rise up of catalytic bed. In thrust chamber, most pressure drop is in catalytic bed where the pressure drop is sensitive with its porosity. The temperature of the thruster's wall surface was also simulated; it is slightly higher than the test data.