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ANALYSIS OF ABNORMAL COMBUSTION PHENOMENON IN A BIPROPELLANT 150N LIQUID ROCKET ENGINE DURING START-UP TRANSIENT

Abstract

A bipropellant 150N rocket engine was conducted the hot fire test in Shanghai Institute of Space Propulsion. The engine throat was severely ablated because of free gas in the propellant feedline and high filling pressure during the start-up transient. The abnormal combustion occurred at the first ignition. The weld seam was first heated to red and then developed downstream. The maximum chamber temperature reached 1800 when working 5.5 s, and the throat was ablated at 8 s. The thrust oscillation was severe and pits appeared in the chamber pressure curve. The gas in the blind cavity between the solenoid valve and liquid discharge valve couldn't be discharged during the vacuum filling. In order to analyze start-up process, the engine head gas entrainment experiment was carried out to verify the influence of the gas in the injector on the engine atomization. ANSYS-Thermal was used to simulate the heat transfer of the thrust chamber. The wall temperature variation along the axial direction and distribution without liquid film were calculated. Without film cooling, the gas convection heat transfer coefficient and recovery temperature of the chamber were first solved, and then the chamber temperature field simulation was carried out by combining with the obtained convective thermal boundary conditions, considering the radiative heat transfer of the outer wall to the environment. The results suggest that: (1)Free gas in the injector will reduce the engine start-up stability. The smaller mixing ratio, the higher supply pressure or chamber pressure will aggravate the instability because of the less free gas bubbles required for the engine to generate thrust oscillation. Under the condition of gas entrainment, the oxidizer or fuel jets will be atomized and developed to cutoff, leading to the cooling jets not hitting the chamber wall surface to form stable liquid film. (2)The simulation results show that the temperature near the throat of the thruster outer wall reaches 1400 C at 5 s without film cooling, which is similar to the throat temperature of the test, but the body temperature of isothermal combustion without film cooling is very difficult to reach 1475 C at 3.839 s. Instability combustion might occur at the front end of the chamber. (3)Assuming that oscillating combustion occurs, the combustion temperature was equivalent to the isostatic combustion temperature, but the combustion pressure rose sharply. After several iterations, the results show that the corresponding combustion pressure is about 3.95 MPa.