SPACE PROPULSION SYMPOSIUM (C4)
Poster Session (P)

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NUMERICAL SIMULATION AND TESTING OF H2O2 - LDPE HYBRID ROCKET MOTOR WITH DIAPHRAGM

Abstract

Hybrid rocket motor (HRM) provides several important advantages such as safety, low cost, and throttle characteristics over both solid-propellant and liquid-propellant motors because the solid fuel and liquid oxidizer are separately stored in different phases. However, HRM has problems of lower fuel regression rate and combustion efficiency due to poor mixing between core oxidizer flow and the gasified fuel off the grain surface. The issue becomes worse as the scale increases. Large and volumetric post combustion chamber commonly is used to enhance mixing, while mixer is more effective device to improve mixing and lengthen the residence time of oxidizer and fuel gas inside the motor. The addition mixer located in the grain was originally proposed by Marxman, but the relevant literature data is lack. Dr. Grosse started experimental research on this special topic and carried out a series of tests using liquid nitrous oxide and paraffin. The effect of single-port diaphragm setting at positions ranging from 25% to 100% of tubular fuel grain length on performance and regression were studied through numerical analysis and engine firing in this paper. A numerical simulation model is established coupling the Navier-Stokes equations with turbulence, chemical reactions, solid-fuel pyrolysis and solid-gas interfacial boundary conditions under gas-liquid two-phase flow in 2-D meshes corresponding to the test motor configurations. The tests were conducted in a standard HRM (100mm outer grain diameter, 50mm in port diameter and 500mm in length) with 90% hydrogen peroxide and low density polyethylene (LDPE). The computational results reveal that the port area and position of diaphragm have significant effects on combustion efficiency and regression rate, both of which are increasing compared to the situation without diaphragm, the maximum combustion efficiency is achieved when the diaphragm located in 75% position and the downstream regression rate is about 50% higher compared to the reference. Over 20 corresponding motor firings were conducted for further research of diaphragm effect. The infrared camera thermography system and precision pressure sensor was used to acquire the temperature distribution of exhaust plume and real-time pressure respectively in test. Averaged characteristic velocity and combustion efficiency were determined by acquired experiment data. The experimental data agreed with numerical analysis. It verifies that numerical simulation method is correct. Both experimental and computational conclusions provide compact and efficient guidance for design of the single-port LDPE based HRMs.