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EXPERIMENTAL INVESTIGATION OF FUEL REGRESSION RATE IN HTPB BASED LAB-SCALE HYBRID ROCKET MOTOR

Abstract

Fuel regression rate, which is an important parameter in the design of hybrid rocket motor, directly affects the internal ballistic performance of the motor. The fuel regression rates of different propellant combinations make difference, and the additives in fuels also have influences on the regression rate, which makes it necessary to carry out experimental investigations for different fuel compositions. In this paper, experimental studies have been performed in lab-scale hybrid rocket motors with hydrogen peroxide (H2O2) oxidizer and hydroxyl terminated polybutadiene (HTPB) based fuels with different additives, and the effects of the metal Mg, Al, aromatic hydrocarbon anthracene and carbon black to the regression rate were investigated. The experimental systems have been set up for the tests, including pressuring system, oxidizer feeding system, test platform, measuring and control system and motor assembly. The oxidizer feeding system was pressurized by high pressure nitrogen, and the oxidizer mass flow rate was controlled by the cavitating venturi tube. The National Instruments measurement device was adopted to acquire the pressure and thrust data, and Programmable Logic Controller was selected to control the igniter and valves in the test. The oxidizer used was H2O2 with a mass concentration of 98%, and the tube fuel grain type was selected with outer diameter of 100mm and length of 500mm. The working time of the tests were about 5 seconds, and the average fuel regression rate of each test was acquired by the variation of the fuel mass and dimension. A series of tests have been performed for different fuel compositions. According to the classic fuel regression rate formula, that the regression rate is directly proportional to the exponential oxidizer mass flux, the coefficients in the formulas of different fuel compositions were fitted by the tests data. The results showed that the effect of metal additives on the fuel regression rate was significant, and it increased with increasing metal content. However, in the case of same metal content, the effect of hydrocarbon anthracene to fuel regression rate was less obvious. In addition, apparent sparks were visible in the flame ejected from the nozzle, which may increasing nozzle erosion and two-phase flow losses. In conclusion, according to the experimental investigation, the fuel regression rate formulas of 98% H2O2 and HTPB based hybrid rocket motors with different additives in fuels have been acquired, which provide effective parameters for performance calculations and motor designs.