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INVESTIGATION OF WAGON-WHEEL FUEL GRAIN DESIGN OF HYBRID ROCKET MOTOR

Abstract

Hybrid rocket motor uses liquid oxidizer and solid fuel as propellants. It has become an attractive propulsion system due to its low cost, safety, thrust adjusting, and restart capability. However, its fuel regression rate is significantly lower than that of solid rocket motor for the diffusion controlled combustion, and wagon-wheel fuel grain is widely used for its large burning area. Wagon-wheel fuel grain design plays an important role in the design of the hybrid rocket motor.

The main purpose of hybrid rocket motor fuel grain design is to acquire relationships between burning area and fuel port area with burned thickness of the fuel grain. Based on the uniform fuel regression rate assumption, analytical expressions of the two parameters varying with burned fuel thickness were obtained. According to the quasi-steady assumption and the conservation equation, the interior ballistic calculation model of the hybrid rocket motor with wagon-wheel fuel grain was established.

Fuel grain design was performed with the model established. The hydrogen peroxide (H2O2) and hydroxyl terminated polybutadiene (HTPB) propellant combination was employed in the design. Minimum total impulse and maximum fuel outer diameter were design restrictions. Under certain conditions, geometric parameters were designed for wagon-wheel, double-D, and tube fuel grains. Interior ballistics performances of motors with different fuel types were obtained.

According to the results, wagon-wheel fuel grain can provide larger burning area, higher propellant loading fraction, lower length to diameter ratio, which is benefit for the grain design of large thrust hybrid rocket motor. Variations of oxidizer-to-fuel ratio, combustion pressure and thrust with time of tube fuel grain are more stable. Decreasing diameter of tube and double-D fuel grains can increase the propellant loading fraction. However, the length to diameter ratio increases at the same time.