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THE THREE-DIMENSIONAL DYNAMIC NUMERICAL SIMULATION OF STAR-SHAPED GRAINS IN HYBRID ROCKET MOTORS

Abstract

The three-dimensional dynamic numerical simulation of complex-shaped grains is a key issue that restricts the performance prediction of hybrid rocket motors in practical applications. A simplified and updated model for the combustion surface is proposed for the first time, and the changes in flow field structure and performance parameters during the operation of a star-shaped grain in hybrid rocket motors are obtained. It is worth noting that as the port expands, the high-temperature zone inside the port changes from an "m" shape to an "n" shape. The main reason is that the distance between the vortices on both sides of the symmetry plane of the star channel gradually increases. The influence of two vortices on the flow of oxidizer inside the star channel is reduced. The accuracy of the model is verified by the firing tests of the hybrid rocket motors. The hybrid rocket motors adopt a solid polyethylene grain as fuel and a liquid 98% hydrogen peroxide as oxidizer. The results show that the deviations in chamber pressure and thrust are less than 0.3% and 3.0%, respectively. Furthermore, the grain is scanned by computer tomography after the firing test, and the area of the port is obtained through image processing. The deviation between the simulated and experimental area of the port is less than 3.1%. The accuracy of this model has been verified from the above two aspects. This dynamic model lays a good foundation for the three-dimensional dynamic numerical simulations of more complex-shaped grains in the future, which contributes to achieving more accurate performance prediction of the hybrid rocket motors.