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NUMERICAL AND EXPERIMENTAL RESEARCH ON ABLATION PERFORMANCE OF A CARBON/CARBON COMPOSTIES SOLID ROCKET MOTOR NOZZLE INSERT

Abstract

Nozzle insert is the most important component of a solid rocket motor. Since 1960s, carbon/carbon composite material was used widely. It always sustains thermal load, mechanical load and chemical load. The ablation rules of the nozzle insert, especially the regression rate and mechanism of the throat, is of great importance to maintain the rocket working normally. By adopting theoretical analysis, numerical simulation and experiment, the ablation process of a solid rocket motor nozzle insert made of carbon/carbon composite was investigated. In theoretical aspects, the precise ablation process was proposed. From the point of energy conservation, a balanced equation was set up to describe the complex process on the ablation surface, between the flow field and the solid material. The ablation process was finally divided into two parts, chemical ablation and mechanical erosion. With the help of MSC Marc, a nonlinear analysis commercial software, this process was simulated. Simplified boundary conditions were employed and accurate material properties were chosen to ensure the simulation process effective. The regression rates of the whole ablation surface were analyzed. Results show that the severest ablation part is at the front of the throat, for this part bears both chemical and mechanical impact, compared with the other parts. The average regression rate is about 0.068mm/s. Ground firing test was performed. By using micro-CT technology, the average regression rates of the ablation surface were gained. Comparison between the numerical results and the test results show that the numerical results was larger than the test results by about 20 percent. It was considered that the numerical process ignores the ignition process and the tailing process of the solid rocket motor. As a result, the regression rates should be larger. The numerical analysis was proven effective.