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RESEARCH ON THERMOCHEMICAL REACTION MECHANISM AND MODEL OF EPDM INSULATOR UNDER SLAG DEPOSITION CONDITION

Abstract

The Solid Rocket Motor mostly used as power devices of space launch vehicles, and the insulator design becomes one of the key technologies to ensure SRM reliable operation, while the too thick insulator is part of the negative quality of the engine, which performance and reasonable design have great influence on SRM carrying capacity. Therefore, the reasonable choice of insulation material formulations, structural forms and thickness design needs a in-depth understanding of its ablation characteristics and mechanism as a precondition.

Due to the demand for large charge and aspect ratio in overall design of modern heavy launch vehicles, more and more segmented charge SRM configurations with submerged nozzle structure have been widely applied in the basic level power of launch vehicle. However, with the design of segmented charge structure and the use of high metal content composite propellant, strong recirculation flow will occur at the charge section and the back wall cavity of submerged nozzle, resulting in partial condensed particles collided with the insulator wall and form slag under entrainment effect, thereby aggravating the ablation of the exposed wall and aft-dome insulation material, which is very unfavorable for prolonged operation of the SRM.

In this paper, the EPDM insulation materials are used as research object. Firstly, through the theoretical research work, the reasonable capture criterion is selected to simulate the full-scale SRM flow field. Then, based on the geometric and flow similarity rule, we designed the lab-scale device to perform ground firing test which can simulate slag deposition phenomenon, and study the influence rule of ablation rate of EPDM insulator under different melting alumina deposition states. Using EDS and XRD to determine the chemical reaction products of melting layer and charring layer, thermodynamic software analysis was carried out to get thermodynamic equation of alumina and charring layer under SRM operating condition. Using high temperature TG analyzer to carry out the isothermal weight loss experiment of alumina analytical reagent and carbon powders under certain ratio, and obtain the relative kinetic parameters. Finally, the reaction mechanism of the Al-O-C system is given to explain the scientific problem of how dose the charring layer is consumed by high-temperature slag. Then, combined with the reaction mechanism and porous media model, a thermochemical ablation model based on charring layer porous structure was established under the condition of melting alumina deposition, and it was brought into experimental verification and correction.