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ANALYSIS ON CARBON-CARBON NOZZLE THERMAL STRESS OF SOLID ROCKET MOTORS

Abstract

Abstract: Nozzle is one of the most important components in solid rocket motor, and carbon-carbon nozzle is developing in recent years. Comparing with common material nozzle, it has simple structure, light deadweight , small inner nozzle contour ablation and high reliability. Carbon-carbon nozzle is formed by several kind of materials and is subjected to the ablation and concussion of the hot gas during working, so its working condition is very severe due to mechanics environment arisen by disparities of thermal expansion coefficients and temperature distributing of materials. Carbon-carbon nozzle is composed of metal shell, integrative three dimension knitting carbon-carbon convergent, throat insert and nozzle divergent, thermal insulation layer. Metal shell is the major bearing loads part, which has high rigidity. Integrative three dimension knitting carbon-carbon convergent, throat insert and nozzle divergent make up of inner nozzle contour, which is subjected to the cautery and concussion of the hot gas, together with back lining thermal insulation layer in order to avoid too high metal shell temperature. The nozzle's geometry, loading and boundary condition, the convection and radiation heat transfer between hot gas and nozzle wall can be considered to be axis-symmetrical, therefore the two dimension axis-symmetrical analysis method can be used to compute the transient temperature filed of nozzle. In order to determine temperature and pressure on nozzle inner contour, the hypotheses have been made as follows: 1) The rocker motor is in steady working state, gas parameter (such as temperature and pressure) do not vary with time; 2) Ablation, denudation of nozzle inner contour are not considered; 3) Particle contact heat transfer is not considered; 4) The radiation between nozzle metal shell and ambience is considered; 5) Convection heat transfer coefficient varying with axial direction in nozzle can be obtained according to experiential formula; According to above-mentioned hypotheses, the effects of the geometry of nozzles and the major factors involved in heat analysis were considered. An axis-symmetrical finite element model (FEM) was established. The transient temperature fields of throat modules and expansion zones were computed under given heat boundary conditions. Then stress analysis was made for the heat structure coupled fields of nozzles with axis-symmetrical loading. Using the FEM method, displacement was treated as an unknown variable, and changes in physical parameters of an anti-ablation layer were considered.

Key words: solid rocket motor; carbon-carbon nozzle; finite element method; transient temperature filed; structure analysis;