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Studying the Temperature Field of Hypersonic Vehicle Structure with Aero-Thermo-Elasticity Deformation

Authors : Geng Xiangren, Liu Lei, Gui Ye-Wei, Tang Wei, Wang An-ling

Abstract : The malfunction of thermal protection system (TPS) caused by aerodynamic heating is a latent trouble to aircraft structure safety. Accurately predicting the structure temperature field is quite important for the TPS design of hypersonic vehicle. Since Thornton’s work in 1988, the coupled method of aerodynamic heating and heat transfer has developed rapidly. However, little attention has been paid to the influence of structural deformation on aerodynamic heating and structural temperature field. In the flight, especially the long-endurance flight, the structural deformation, caused by the aerodynamic heating and temperature rise, has a direct impact on the aerodynamic heating and structural temperature field. Thus, the coupled interaction cannot be neglected. In this paper, based on the method of static aero-thermo-elasticity, considering the influence of aero-thermo-elasticity deformation, the aerodynamic heating and heat transfer coupled results of hypersonic vehicle wing model were calculated. The results show that, for the low-curvature region, such as fuselage or center-section wing, structure deformation has little effect on temperature field. However, for the stagnation region with high curvature, the coupled effect is not negligible. Thus, it is quite important for the structure temperature prediction to take into account the effect of elastic deformation. This work has laid a solid foundation for improving the prediction accuracy of the temperature distribution of aircraft structures and the evaluation capacity of structural performance.

Keywords : aerothermoelasticity, elastic deformation, structural temperature, multi-field coupling
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