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AN IMPROVED HEAT TRANSFER RATES PREDICTION METHOD OVER BLUNT NOSE BODY IN LUNAR EXPLORATION PROGRAM

Abstract

Blunt nose body with sharp corner is a kind of important configuration in lunar exploration program. The reentry capsule and lots of thermal protective material sample are both of such configuration. It is important to get accurate heat transfer rates on this kind of configuration for the thermal protection system design. However, there were few valid theories can solve this problem perfectly. The famous Fay-Riddle expression gives the heating rate of stagnation-point, leaving the velocity gradient to be specified alone. But for this kind of configuration, getting velocity gradient itself is a difficult work. Lees and Zoby, et al. have developed different integral expressions under the assumption of "local similarity" of compressible boundary layer. Unfortunately, as will be seen in this paper, this assumption is generally not satisfied within corner region. Boundary-layer analysis is another valid method to solve this kind of problem. Taking "nonsimilarity" into account, this method can give accurate result. The only drawback of this method is that the input parameter cannot be easily specified. Numerical simulation of Navier-Stokes equations is another promising method. However, it is much time consuming, and most of all, it is still a challenge and need special treatment to give accurate hypersonic heating rates over very blunt nose body. In this paper, the method based on both of the boundary-layer analysis and numerical simulation of Euler equations is further developed. The input data of nonslmilar compressible boundary-layer analysis is given by inviscid CFD solver with certain smoothing process. For the sensitivity of boundary-layer analysis to the velocity perturbation within stagnation region, an assumption of linear velocity distribution is adopted to give smooth and accurate results. The method described above is only valid for axisymmetric flow. With the idea of axisymmetric analogue, the method can be easily extended to the case with angle of attack. Finally, several test cases were conducted, the results showed great agreement with viscous CFD solver, while the computing cost is very cheap.