Numerical Simulation of Nonequilibrium Flows over Rounded Bodies at Hypersonic Speeds

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The present study focuses on the problem of aerothermodynamics of space vehicles with rounded edges at hypersonic speeds during the flight trajectory. First, the in-house Navier-Stokes solver, UNIC-UNS code, with the slip boundary condition is used to simulate the flows around a sphere-nosed cylinder at different Knudsen numbers and Mach numbers. The simulation results are compared with DSMC computations for validation. It was found that the Navier-Stokes simulations are in good agreement with that of DSMC. Next, the hypersonic flows over the European EXPErimental Re-entry Test-bed (EXPERT) model are simulated for a wide range of flow regimes, which corresponds to the expected descent trajectory with allowance for rarefaction and thermochemical nonequilibrium. Three dimensional CFD analyses are presented for the complete geometry of the capsules in considering the air dissociation and its effects on the flow structure and on the force and thermal loads for the hypersonic ranges of the flight. These fundamental tests pave a road to future studies and to provide the scientific community with qualitative data that can be useful for the preliminary design of hypersonic vehicles.

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