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AERODYNAMIC HEATING SIMULATION OF EXOMARS DESCENT MODULE DM-16

Abstract

Aerothermodynamic environment along an entry trajectory has been calculated for the ExoMars Descent Module DM-16 – a space vehicle, planned for launch in 2016. The vehicle enters into the Martian atmosphere with a velocity of about 6 km/sec, consequently one of major design challenges of the mission is the spacecraft aeroshell which protects it from high aerodynamic heating during the flight. Accurate prediction of aerothermal environments is needed to select a type of thermal protection system and determine its size. High enthalpy flow conditions specific to atmospheric entry cannot be fully modeled in ground test facilities. Using of high-fidelity computational fluid dynamics (CFD) simulation is therefore an important part of space vehicle design process. The CFD flow solvers employ different numerical methods and incorporate various real-gas chemical kinetics and transport properties. Thus a problem of verification of numerical algorithms and validation of chemistry and transport models used in CFD solvers is of great importance. In the present work a problem of axisymmetric hypersonic flow over the ExoMars DM-16 is considered. The numerical flowfield solution is obtained in the framework of the Navier-Stokes equations which are expanded with conservation equations for masses of chemical species and vibrational energy of CO2 molecules. An implicit iterative scheme was used for the numerical solution of the Navier-Stokes equations. In more details the numerical method and the thermo-chemical model are described in [1, 2]. The Martian atmosphere is supposed to be 97% of CO2 and 3% of N2 in mass. In calculations 19 chemical reactions are accounted for taking place between 10 chemical species. The effects of different surface catalytic conditions and of CO2 vibrational relaxation on aerodynamic heat flux to the vehicle surface are studied. Comparison with computational results of other authors is made.

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