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PROSPECTIVE OF THE COMPUTATIONAL THREE-DIMENSIONAL RADIATIVE AEROTHERMODYNAMICS FOR PREDICTION OF THE HEAT PROTECTION SYSTEM OF RETURN SPACE VEHICLES

Abstract

Prediction of the radiative heating of entering space vehicles and study of numerous coupled radiative gasdynamic processes in shock layers at orbital and especially for the super-orbital conditions of return into Earth atmosphere has received renewed interest due to modern plans for a return from Moon and closest planets of the Solar system. In spite on the fact that radiation heat transfer processes, being applied to reentry space vehicles, have been considered more than forty years, the unanswered questions still remaining in the past aerothermodynamic data. The scientific unknowns following from these questions have to be resolved to provide acceptable aerothermodynamic prediction of creating space vehicles of the new generation. Examples of comparison of the numerical simulation results for two- and three-dimensional problems of radiative aerothermodynamics are considered for orbital and super-orbital velocities at a non-zero angle of attack. Brief description of the used radiative gas-dynamic model of physically and chemically nonequilibrium, viscous, heat conductive, and radiating gas of complex chemical composition is presented. Especial attention is devoted to problems of verification and validation of obtained calculated data are discussed. Examples of comparison of the numerical simulation results for two- and three-dimensional problems of radiative aerothermodynamics are considered for orbital and super-orbital velocities at a non-zero angle of attack. Results of three- and two- dimensional calculations of convective and radiative heating of Apollo Command Module and Orion-like spacecraft are considered and compared. Also, these results are compared with experimental and calculated data for entering space vehicles into the Martian atmosphere, such as Pathfinder, Mars Science Laboratory, and Schiaparelli. Calculations were performed with the use of the author's computer platform NERAT(3D,2D)+ASTEROID and with different models of radiation heat transfer, as well as with the use of multi-group spectral models, taking into account most significant radiative mechanisms of absorption and emission. This presentation contains a comparison of obtained numerical simulation results with the flight experimental data, with preliminary theoretical estimations used for the creation of the first superorbital space vehicles, and with analytical correlations for convective and radiative heat fluxes, recently suggested in the literature.