SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 3 (3C)

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EFFECT OF DUST PARTICLES ON SPACE VEHICLES ENTERING MARS AT HYPERSONIC SPEEDS

Abstract

In the Martian atmosphere heavy storms occur, which transport dust particles even into the higher atmosphere, i.e. up to 40 km of altitude. These particles have a size up to 20μm and consist of silicon oxides and iron oxides. They may affect the heat load on the heat shield during atmospheric entry. In this present study, these additional loads due to impingement of solid particles in hypersonic entry flows in Martian atmosphere are investigated. The Euler-Lagrangian approach is used for the solid particles moving in hypersonic Martian entry flows. For the simulation, the program SINA (Sequential Iterative Non-equilibrium Algorithm) previously developed at the Institute of Space Systems of the University of Stuttgart is used. SINA is a Navier-Stokes Code for the numerical simulation of viscous hypersonic plasma flows in thermochemical non-equilibrium. For the Martian atmospheric chemistry model, only carbon dioxide (CO2) as the main species is taken into account because the Martian atmosphere consists of 95.3% CO2. Considering that the entry velocity at the Mars is usually around 5-7 km/s, the dissociation of CO2 has to be taken into account. Therefore, a five species model (carbon dioxide (CO2), molecular oxygen (O2), carbon monoxide (CO), oxygen (O) and carbon (C)) is implemented in the code. The solvers for the two phases, the gaseous phase and the particle phase, interact with each other through one-way or two-way coupling. The model for the effect of the flowfield gas on a particle includes drag force and particle heating. An adequate model for the drag force computation is implemented in the model in order to take into account transitional and rarefied flows. The heat transfer model of the particle consists of convective heating and radiation cooling. The radiative heating from the gas to the particle is not taken into account because this model is not yet available in SINA. The phase change of the particle due to high temperature of the flowfield is also considered. Convective heat fluxes onto the surface of the particle and its radiative cooling are discussed. The resulting particle temperatures under different conditions and for varying particle sizes are presented. The mass loss and as a consequence the decrease in particle size due to high temperature is explained. Finally, heat fluxes onto the wall of an entry vehicle due to impingement of particles are computed and compared to the heat fluxes from the gas phase.