SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 1 (3A)

Author: Dr. Mario De Stefano Fumo
CIRA Italian Aerospace Research Centre, Italy

Dr. Pietro Catalano
CIRA Italian Aerospace Research Centre, Italy
Dr. Burkard Esser
DLR, German Aerospace Center, Germany
Dr. Ali Gülhan
DLR, German Aerospace Center, Germany

NUMERICAL MODELLING OF THE CO2-N2 HYPERSONIC FLOW FOR SIMULATIONS OF MARS ENTRY CONDITIONS

Abstract

In the frame of research activities on future Mars exploration missions, large effort has been devoted to prediction of aero-thermal environment encountered by space vehicle entering the Mars atmosphere. In particular, determination of aero-thermal loads in such severe environments is one of the most challenging problems in the vehicle design. The thermo-chemical modelling of Martian atmosphere is more complex by thermodynamic point of view compared to Earth atmosphere due to massive presence of a polyatomic specie as CO2 and due to the low level of pressure and density expected. The present work deals with CFD simulations of Mars entry vehicle and Plasma Wind Tunnel test probe geometries. The focus is on the comparison between different thermo-chemical models and correlation with experimental and flight data. Flow around Pathfinder probe is computed with a C-O-N system model and compared to the results achieved by the classical Park model and to flight data. Simulations of the flow inside the nozzle of L2K DLR facility with Mars simulated atmosphere will be discussed. Nozzle exit fluid dynamic conditions are applied to a test probe geometry. A mixture of 97% of CO2 and 3% of N2 is modelled for these test cases. Correlation with freestream conditions at the exit nozzle and with the probes stagnation pressure and heat flux are reported. Considering the different materials of the probes, the effect of surface catalysis has been taken into account to correctly predict the heat fluxes. Computations have been carried out by a commercial code with a number of "ad hoc" developed user defined functions for taking into account thermal non-equilibrium and surface catalysis modelling. Results show the capability of the considered models for the aeroheating analysis of the future Mars entry vehicle.

Acknowledgments

The work presented in this paper has been partially performed within the project SACOMAR (Technologies for Safe and Controlled Martian Entry) funded by European Commission under Grant agreement no. 263210