AEROTHERMOCHEMISTRY CHARACTERIZATION OF THERMAL PROTECTION SYSTEMS

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Reusable aircrafts entering the Earth atmosphere at hypersonic speed have to be opportunely protected by thermal protection systems, in order to resist to the extreme aerothermal heating, developing around the vehicle. Depending on the flight conditions, the dissociated species composing the surrounding gas undergo recombination reactions, enhanced or inhibited by the catalytic efficiency of the surface. Catalysis phenomena act together with radiation (driven by emissivity) and oxidation, determining the incoming heat flux to the heat shield. Those phenomena are identified together as *gas/surface interactions*.

The characterization of gas/surface interactions, through ground testing, is a fundamental step in the design process of a heat shield. At the von Karman Institute for Fluid Dynamics the simulation of a reacting flight environment is performed in the Plasmatron facility, an inductively-coupled plasma generator, able to provide high enthalpy, clean flow, ideal for thermal protection materials characterization. The Local Heat Transfer Simulation methodology allows the similarity between the subsonic and hypersonic case.

This thesis represents a comprehensive study of superalloy and silicon carbide-based thermal protection systems. Intrusive and optical measurements techniques are combined to characterize the material and the environment to which they are exposed. Experimental data are postprocessed by means of a boundary layer model that allows to rebuild the aerothermochemistry conditions simulated during ground testing. Surface temperature from 1200 up 2200 K and above are investigated, in low pressure environments between 1300 and 2000 Pa. This allowed to build databases of optical properties and catalycities, supporting the aerothermal design of heat shields.

The behavior of catalycity and emissivity properties is explained, taking into account diffusion/reaction processes and the role of surface oxidation. Uncertainties on catalycity data are calculated by spectral methods and a sensitivity analysis of the different assumptions adopted is performed.

The effect of catalycity discontinuities, occurring at interfaces of different materials, is simulated on dedicated ground experiments.

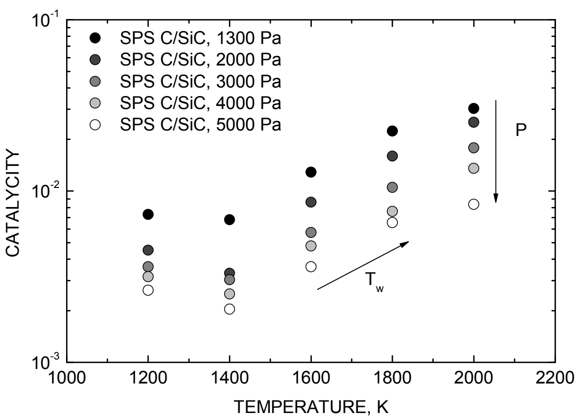

Figure 1 : C/SiC TPS catalycity database (γ versus temperature and pressure)

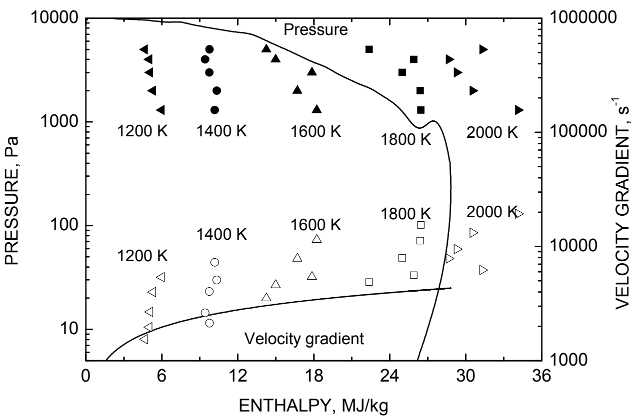

Figure 2 : Extrapolation to flight of ground experiments (points : Plasmatron data, lines : IXV trajectory)