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EMISSIVITY CHARACTERIZATION OF CARBON SILICON CARBIDE COMPOSITES FOR TPS THOROUGH PLASMA WIND TUNNEL TESTS: EXPERIMENTAL VALIDATION

Abstract

The properties of a thermal protection system (TPS) have crucial impact on the success of a re-entry mission and the proper design of a space vehicle. It is widely accepted that for the design of a heat shield gas/surface interactions must be accurately characterized in order to correctly quantify the aerothermodynamic heating. TPS are mainly cooled by radiation, which prevents the temperature of the surface material to exceed its melting point. This capability of radiative cooling is strongly dependent on the chemical and on the optical properties of coating. This work reports the result of in-situ measurements of emissivity conducted in the Plasmatron facility at the von Karman Institute for Fluid Dynamics on CMC samples, and SEM and EDX characterizations devoted to analyze the surface chemical features. The Plasmatron is a high enthalpy wind tunnel in which plasma is generated by electromagnetic induction and blown in the form of a jet inside a test chamber at sub-atmospheric pressure. The facility provides an ideal environment to reproduce the aerothermal heating experienced by a spacecraft re-entering a planetary atmosphere. The flight boundary layer chemistry is duplicated around a thermal protection system model, ensuring a similarity between the flight and ground stagnation-point heat flux. Infrared pyrometers are used to record the front surface temperature of the specimens. As two-color instruments they provide an output value independent on emissivity. An infrared radiometer is used as an additional front surface information source providing as output the integrated thermal radiation over the 0.6 to 40 μm wavelength range. The plasma to which the materials are exposed is characterized by copper

calorimetric and Pitot water-cooled probes. Three experiments were performed under a dissociated air flow. The first covered short exposure emissivity measurement (300 sec) at different pressure and surface temperature conditions. The second experiment, analogous to the first, was dedicated to long exposure testing (780 sec). Finally, the last test was dedicated to assess the oxidation behavior of the material, by applying heat fluxes above 1 MW/m^2.