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THERMAL ANALYSIS OF ADVANCED PLATE STRUCTURES BASED ON CERAMIC COATING ON CARBON/CARBON SUBSTRATES FOR AEROSPACE RE-ENTRY RE-USABLE SYSTEMS.

Abstract

The development of reusable launch vehicle (RLV) must include a significant reduction of the payload transportation costs. One of the most expensive systems for any RLV is the thermal protection system (TPS), which protects the vehicle from the high thermal loads during re-entry. The reusability and on-orbit environment are the key parameters for the design of TPS and its materials. Aim of the work is to analyze a novel coating process based on the alumina base coating applied on a TPS for re-entry application. The proposed treatment is due to preserve the thermo-mechanical properties of a Carbon/Carbon substrate from the detrimental space environment conditions, such as LEO thermal cycles, outgassing due to ultra-high vacuum, Atomic Oxygen and UV irradiation. The experimental measurement of the coefficient of thermal expansion (CTE) is performed in order to evaluate the thermal stress and performance of both the substrate and coating layer. Particular emphasis is devoted to the study of the effect of coating/substrate adhesion, which may result in anomalous mechanical behavior. By the use of the inverse method heat capacity and thermal conductivity are analyzed. A robust numerical approach, such this inverse method, is one of the best for these problems as many parameters concur for the determination of properties. Such approach permits to perform the parametric and structural identification of the model. These procedures are presented including both experimental investigation and methodical-numerical aspects. Special test equipment and the regularizing algorithm for solving the ill-posed inverse heat conduction problem are described. Such approach provides estimating of thermal properties of different types of Carbon/Carbon substrate coating. After thermal conditioning the integrity of the coating and the substrate will be investigated by full microscopy analysis using SEM/EDX techniques. The experimental results are implemented in numerical simulations in order to foresee the overall performance of the material.