MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advanced Materials and Structures for High Temperature Applications (4)

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HYBRID ABLATIVE/CERAMIC THERMAL PROTECTION SYSTEM: MISSION PROFILE, MATERIALS SELECTION, INTERFACE DEVELOPMENT AND VERIFICATION APPROACH

Abstract

The FP7 project HYDRA refers to the development of a hybrid thermal protection solution, where a low density ablator is attached on top of a thermo-structural ceramic core. The project aims to design, integrate and verify a robust and lightweight thermal shield solution for atmospheric earth re-entry. The consortium combines ten European institutions ,including end-users, material providers, and relevant research institutes and universities.

The main advantage of a hybrid heat-shield is based on the capability of the thin ablative top layer of bearing high thermal loads, while the tough ceramic composite underneath provides structural support, as well as the stability of the shape of the Thermal Protection System (TPS). Since, these heat loads are characterized by a peak profile the ablator can dissipate the high heat loads during the peaking time. For that, a comparatively rather thin layer of ablative material is thought to be sufficient. Another asset comes from the reliability and safety point of view: The underneath ceramic core offers extra thermal protection, in case of failure or underestimated design of the ablative external protections.

The approach contains:

(1) The compilation of a set of requirements and specification from two envisaged missions: the CST/ARV from low earth orbit re-entry and the CSTS from low lunar orbit.

(2) Material selection and procurement, including an up-to-date state of the art of materials with an analysis of previous hybrid concepts (I.e. SEPCORE© and SPA) and a material trade-off, resulting in two ablators (carbon fibre/phenolics and cork/phenolics) and two types of ceramic matrix composites (C/SiC and C/C-SiC).

(3) TPS assembly. The first stage is focused on the ablator/ceramic interfacial study, to select the most suitable high temperature adhesive and application parameters (surface roughness, adhesion strength, adhesive capillarity, adhesive rheology, etc…). The assembly includes both test probes and breadboard construction.

(4) Modelling and simulation. Two approaches at different levels are considered: a) Pyrolysis model of the ablator, based on a local pyrolysis model (aided by computed tomography) and b) a further extension to perform a complete-system thermal analysis.

(5) Testing and verification. A full material testing plan has been designed and is currently ongoing: thermal and mechanical characterization of the single materials, verification of the integrity of the ablator/ceramic joints (by thermal shock and vibration test) and finally an overall thermal performance assessment including thermal shock testing and testing in a relevant environment in a plasma wind tunnel.

For more details see www.hydra-space.eu