MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Environmental Effects and Spacecraft Protection (6)

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

Dr. Marika Belardo
CIRA Italian Aerospace Research Center, Capua, Italy
Ms. Paola Spena
Italy
Mr. Giovangiuseppe Giusto
Italy
Dr. ROBERTO SCIGLIANO
CIRA Italian Aerospace Research Centre, Italy
Dr. Giuliano Marino
CIRA Italian Aerospace Research Centre, Italy
Ms. Stefania Cantoni
CIRA Italian Aerospace Research Centre, Italy
Dr. Felice De Nicola
Italy
Dr. Lorenzo Cavalli
Petroceramics SpA, Italy
Dr. Max Valle
Petroceramics SpA, Italy

AN ITALIAN TECHNOLOGY FOR LSI-BASED CMC CONTROL SURFACES FOR RE-ENTRY VEHICLES

Abstract

Since the late 1970s C-fiber reinforced SiC materials have been developed for space applications, and in particular for TPS of re-usable spacecraft, such as the Buran. Control surface of re-entry systems are subjected to a harsh environment during the hypersonic atmospheric re-entry phase: high aerothermal loads and large thermal gradients between the outer surface of the vehicle and the internal environment, including cold structure and avionics, as well as the connections between hot control surfaces and the much cooler actuators inside the vehicle. C/SiC material is one of the best option for TPS and hot structure control surface due to its low weight, good structural performance, minimal thermal expansion mismatch problems, and a good thermal margin. In the manufacturing process of C/SiC materials, C fibers have to be embedded into a SiC matrix. In practice, SiC matrix is built up inside a fiber preform. The most commonly used processes to build the matrix inside the preform are: Chemical Vapour Infiltration (CVI), Polymer Infiltration and Pyrolysis (PIP) and Liquid Silicon Infiltration (LSI). The fabrication technology that has been selected and will be presented in this work is based on LSI, exploited by an industrial team specialized in high performance braking system manufacturing, allowing for low cost and reduced development time w.r.t. CVI and PIP. Despite some commonalities between brakes and thermal protection systems environments, different thermo-mechanical requirements, and final shape and dimensions, as defined by CIRA, impose a specific customization of the process. Our joint team is therefore assessing the following aspects:CFRP “green” manufacturing with long C-fibres or C-fabrics instead of short fibres preforms as normally used for braking devices; pyrolysis of CFRP preform made of long C-fibers (shrinkage, polymeric precursors); siliconization of pyrolized preform made with long C-fibers; additional surface treatment for oxidation protection in low-pressure environment. Besides the manufacturing issues, the design of the control surfaces requires significant know-how in structural analysis and design, material testing and qualification of components. Thanks to the development team own heritage all these aspects are covered. The present paper describes all the technical on going activities related to the development of the abovementioned technology, with the aim to demonstrate the achievement of an adequate technology readiness level to be exploited within the frame of the Space Rider Program, focused on the ESA next space system with re-entry, and in-orbit experimentation capability.