THE AM^{3}aC^{2}A PROJECT: MULTISCALE APPROACH FOR MODELING CMC AND UHTCMC MATERIALS FOR REUSABLE COMPONENTS FOR AEROSPACE

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The recent results of Space X in terms of reusable systems has revitalized the research and development on technologies related to reusable spacecrafts. One of the critical technologies when dealing with space transportation systems are the thermal protections system and hot structures materials that have to withstand the harsh environment of the hypersonic flight.

In Europe, in the last thirty years C/SiC solutions have been developed during different re-entry spacecraft projects (X-38, EXPERT, IXV) with the operative requirement of a single mission at temperatures up to 1700° C (Fig. 1). To date, their use is under qualification in the frame of ESA Space Rider project with the reusability requirement.

Another more recent solution is the material class of the UHTCMC. These materials are mainly based on matrices of metal borides reinforced with carbon fibers and aim to reach operating temperatures above 2000°C. Recent works demonstrated their potential for for use as thermal protections and hot structures for hypersonic vehicles and re-entry systems.

The design of high temperature CMC and UHTCMC structures for re-usable systems shall solve a series of significant critical issues due to the complex behavior of the orthotropic materials characterized by multiple modes of damage often interacting. Furthermore, the degradation of the mechanical characteristics of the material subject to mechanical and thermal cycling conditions in space environment and hypersonic flight in oxidizing environment. For these reasons, the design approach is presently based on very conservative criteria and in parallel extensive experimental activities are needed to certify materials and components.

The main purpose of the AM^{3}aC^{2}A project, funded by the Italian Space Agency, is the development of an integrated approach of experiments and numerical non linear modelling for the definition of a design methodology to be specifically applied to CMC and UHTCMC components for reusable space transportation systems.