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Advanced Materials and Structures for High Temperature Applications (4)

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FLEXIBLE TPS DESIGN AND TESTING - ADVANCED EUROPEAN RE-ENTRY SYSTEM BASED ON INFLATABLE HEAT SHIELDS (EFESTO PROJECT)

Abstract

The European Union H2020 EFESTO project has been implemented with the main objective to improve the European TRL of flexible Inflatable Heat Shields for re-entry vehicles from 3 to 4/5. In addition to technical progress also the way towards further improvements to TRL 6 shall finally be illustrated with a future In-Orbit Demonstrator (IOD).

Two reference missions with atmospheric entry to Earth and Mars were identified, both of them equipped with a Hypersonic Inflatable Aerodynamic Decelerator (HIAD). For the Mars Application, which is aiming at a payload delivery of about 2500 kg at MOLA +3 km, the mission design resulted in a HIAD with 9 m diameter. For Earth re-entry, a HIAD with a diameter of 4.8 m was selected to safely return the VEGA upper stage AVUM from SSO orbit to ground. For both, Earth and Mars, applications, multidisciplinary design loops led to a fully detailed vehicle design. Based on the mission trajectories, also the associated aerothermodynamic loads and fluxes on the external shape of the system were determined, which were the primary inputs to the design of the flexible TPS and the underlying inflatable structure.

This paper provides an insight of the efforts related to design and testing of the flexible TPS (FTPS) for both applications. For the design of the FTPS advanced flexible materials were selected, some of which never had been considered in Europe before. Several multi-layer layups were identified for each application, each of them allowing to keep the maximal surface temperature below the specified limit of 1800 degrees Celsius. All layups are consisting of outer fabrics layers, that interact with the external environment, and internal insulating layers, blocking heat penetration towards the internal vehicle structure.

The most promising layups have been selected for thermal tests in DLR's arc-heated facilities LBK at flight relevant high-enthalpy test conditions in realistic thermochemical environment. The test approach included tests in stagnation configuration and in wedge configuration. The stagnation tests allowed to characterize the TPS layups' principle capabilities in sustaining a high-enthalpy environment. It was found that the finite catalycity of the outer fabrics provides additional safety margins with regard to fully

catalytic heat fluxes that had been derived from trajectory data and numerical simulation. Due to the low number of testing parameters, the stagnation test results are also well suited for the validation of numerical models. Tests in wedge configuration, however, are closer to application, since the aerothermodynamic loading includes shear loads applied by the flow.

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