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AEROTHERMAL ANALYSIS OF ULTRA HIGH TEMPERATURE CERAMICS FLYING TEST BED

Abstract

Large convective heat fluxes on the leading edges of a re-entry vehicle ask for innovative materials that can stand temperature larger than 2000 K. A class of materials that seems able to sustain such temperatures is the Ultra High Temperature Ceramic (UHTC). SHS program, being developed by CIRA, is aimed to test UTHC materials in real re-entry conditions and to use the collected data to make correlations among on-ground and in-flight experimental measurements and numerical results in order to improve the Technology Readiness Level related to vehicle heat shields. In-flight experimentation on UHTC materials is already foreseen in the ESA program - European eXPErimental Re-entry Testbed (EXPERT). In this program, a capsule will carry out, among several scientific payloads devoted to study the main aspects of the hypersonic flight, the Sharp Hot Structures (SHS) payload consisting in two instrumented UHTC winglets. A new opportunity was given, in the frame of the Australian SCRAMSPACE program aimed to develop synergies between international aerospace research centres in order to increase space related technologies. As for the EXPERT experiments, CIRA designed two UHTC winglets to be positioned on the Australian re-entry vehicle for scramjet experimentation. The purpose of the present paper is to assess the aerodynamic and aerothermal loads that the winglets have to withstand during the in-flight experimentation and the change in the heat loads on the re-entry vehicle due to the presence on the winglets themselves. The aerothermal loading conditions that the flying test bed has to withstand during flight have been evaluated through engineering relationship of the heat flux profile along the trajectory. Hence, the time history of heat flux is considered in order to define the freestream conditions at which, according to a trajectory-based approach, dedicated two-dimensional and three-dimensional CFD computations have been performed to help in the winglet design and in the choice of the payloads positions. These computations allowed obtaining the heat transfer coefficients for thermo-structural analysis in order to verify the temperature level achieved by the winglets and, above all, to cope with re-entry vehicle safety requirements.