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

Author: Mr. XIANG ZHANG
China Academy of Launch Vehicle Technology(CALT), China

DESIGN AND EXPERIMENTAL ANALYSIS OF A THREE-SEGMENT SANDWICH STRUCTURE NOSE CONE FOR HYPERSONIC VEHICLE WITH A COMPARE STUDY OF NUMERICAL SIMULATION EXPERIMENTAL METHOD

Abstract

It is well acknowledged that stationary point is the part that suffers the most severe aerodynamic heating of the hypersonic vehicle during the re-entry period. If the aircraft nose cone ablates, it will affect the aerodynamic shape and the stability of the aircraft. In addition, non-ablative property is important for the nose cone of reusable hypersonic vehicle. In view of the thermal environment characteristics and thermal insulation requirements of the head cone, a new design strategy (a three-segment sandwich structure) is proposed in this paper. The first part near the stagnation point is made of Ultra High Temperature Material; the middle part is made of C/C; and the last part is made of SiO_2/SiO_2 for thermal insulation. The middle part and the last part are wrapped by C/SiC shell and the three parts are connected by CMC bolts. There are two test samples prepared in the experiment, which has different first parts by using C/C and Ultra High Temperature Ceramic (UHTC) respectively and the other parts were the same. These two samples are subjected to in a re-entry simulation testing in the plasma arc tunnel FD-17 of CAAA/ Peking with same parameters which the maximum heat flow exceeded 1.3MW/$m^2$and last 600 seconds. In terms of the sample made of C/C, the maximum temperature of stationary point reached 2187°C with some of ablation, while in terms of the sample made of UHTC, the maximum temperature of stationary point reached 1507°C without ablation. Meanwhile, according to the nozzle inlet parameters and the position of the nose cone test sample in the arc tunnel, the numerical simulation analysis was carried out. Under the complete gas with chemical reaction circumstance, CFD method has been used to obtain the surface pressure, enthalpy and other parameters distribution of the nose cone, calculate the temperature distribution of the sample, and compare with the experimental results. It has been shown that the maximum temperature of the sample made of C/C reached 2187°C, while the other sample's maximum temperature reached 1474°C, which reflect very similar result to the arc tunnel experiment. In summary, based on the above experiments, it is proved that the three-segment sandwich structure nose cone by using UTHC as the first part material has better performance in the heat insulation and ablation resistance aspects, and the numerical simulation can be the reference for the arc tunnel experiment.