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Aerothermal Analysis of the Brazilian 14-X Hypersonic Aerospace Vehicle at Mach Number 7

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Abstract : The Prof. Henry T. Nagamatsu Laboratory of Aerothermodynamics and Hypersonics, at the Institute for Advanced Studies designed the Brazilian 14-X Hypersonic Aerospace Vehicle, which is a technological demonstrator endowed with two innovative technologies: waverider technology, to obtain lift from conical shockwave during the hypersonic flight; and uses hypersonic airbreathing propulsion system called scramjet that is based on supersonic combustion, to perform flights on Earth's atmosphere at 30 km altitude at Mach numbers 7 and 10. The scramjet is an aeronautical engine without moving parts that promote compression and deceleration of freestream atmospheric air at the inlet through the conical/oblique shockwaves generated during the hypersonic flight. During high speed flight, the shock waves and the viscous forces yield the phenomenon called aerodynamic heating, where this physical meaning is the friction between the fluid filaments and the body or compression at the stagnation regions of the leading edge that converts the kinetic energy into heat within a thin layer of air which blankets the body. The temperature of this layer increases with the square of the speed. This high temperature is concentrated in the boundary-layer, where heat will flow readily from the boundary-layer to the hypersonic aerospace vehicle structure. Fay and Riddell and Eckert methods are applied to the stagnation point and to the flat plate segments in order to calculate the aerodynamic heating. On the understanding of the aerodynamic heating it is important to analyze the heat conduction transfer to the 14-X waverider internal structure. ANSYS Workbench software provides the Thermal Numerical Analysis, using Finite Element Method of the 14-X waverider unpowered scramjet at 30 km altitude at Mach number 7 and 10 in terms of temperature and heat flux. Finally, it is possible to verify if the internal temperature complies with the requirements for embedded systems, and, if is necessary to do modifications on the structure in terms of wall thickness and materials.

Keywords : aerodynamic heating, hypersonic, scramjet, thermal analysis
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