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Computational Code for Solving the Navier-Stokes Equations on Unstructured Meshes Applied to the Leading Edge of the Brazilian Hypersonic Scramjet 14-X

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Abstract : An in-house C++ code has been developed, at the Prof. Henry T. Nagamatsu Laboratory of Aerothermodynamics and Hypersonics from the Institute of Advanced Studies (Brazil), to estimate the aerothermodynamic properties around the Hypersonic Vehicle Integrated to the Scramjet. In the future, this code will be applied to the design of the Brazilian Scramjet Technological Demonstrator 14-X B. The first step towards accomplishing this objective, is to apply the in-house C++ code at the leading edge of a flat plate, simulating the leading edge of the 14-X Hypersonic Vehicle, making possible the wave phenomena of oblique shock and boundary layer to be analyzed. The development of modern hypersonic space vehicles requires knowledge regarding the characteristics of hypersonic flows in the vicinity of a leading edge of lifting surfaces. The strong interaction between a shock wave and a boundary layer, in a high supersonic Mach number 4 viscous flow, close to the leading edge of the plate, considering no slip condition, is numerically investigated. The small slip region is neglecting. The study consists of solving the fluid flow equations for unstructured meshes applying the SIMPLE algorithm for Finite Volume Method. Unstructured meshes are generated by the in-house software ‘Modeler’ that was developed at Virtual’s Engineering Laboratory from the Institute of Advanced Studies, initially developed for Finite Element problems and, in this work, adapted to the resolution of the Navier-Stokes equations based on the SIMPLE pressure-correction scheme for all-speed flows, Finite Volume Method based. The in-house C++ code is based on the two-dimensional Navier-Stokes equations considering non-steady flow, with nobody forces, no volumetric heating, and no mass diffusion. Air is considered as calorically perfect gas, with constant Prandtl number and Sutherland's law for the viscosity. Solutions of the flat plate problem for Mach number 4 include pressure, temperature, density and velocity profiles as well as 2-D contours. Also, the boundary layer thickness, boundary conditions, and mesh configurations are presented. The same problem has been solved by the academic license of the software Ansys Fluent and for another C++ in-house code, which solves the fluid flow equations in structured meshes, applying the MacCormack method for Finite Difference Method, and the results will be compared.

Keywords : boundary-layer, scramjet, simple algorithm, shock wave
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