

A Numerical Investigation of Air Intakes for the 14-X Hypersonic Vehicle Scramjet Engine.

Abstract

This work is part of the research and development, at the Institute for Advanced Studies (IEAv, in the Portuguese abbreviation), of the first Brazilian hypersonic vehicle prototype (the 14-X airplane). It presents CFD results and performance calculations of the air intake section of some scramjet engine configurations under several different operating conditions assuming 2D geometries for the inlet and isolator regions of the intake. The reference case considers the vehicle flying at Mach 7 at an altitude of 30 km. In this case, air compression is achieved by two ramps, one of which is the vehicle forebody itself and the other is an inlet compression ramp; the engine cowl satisfies the “shock on lip” condition. From this reference case, several other cases were simulated varying several vehicle operating conditions such as operating altitude, velocity and angle of attack. Besides these, calculations were made for different configurations of the compression geometry by varying the angle of the inlet compression ramp, as well as a case in which the inlet compression is given by two ramps instead of one, while keeping the same compression ratio as in the reference case. The airflow in the inlet and isolator is calculated numerically with the commercial Ansys Fluent software, considering the air as a calorically perfect gas for both inviscid and viscous flows (laminar and turbulent). For both viscous flow models, the reference case has been calculated by considering both adiabatic and cold wall boundary conditions for both constant and temperature-varying air properties such as thermal conductivity, specific heat and dynamic viscosity. For each and every case, important scramjet intake performance parameters have been obtained such as: contraction ratios (internal, effective and geometric), mass flow rate, kinetic energy efficiency and adiabatic energy efficiency, as well as total and static pressures and temperatures, density and velocity.