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THE CIRA EFFORT TOWARD A FAST AEROTHERMAL DESIGN ENVIROMENT TOOL

Abstract

The design of hypersonic and re-entry vehicles requires an assessment of the aerodynamic and aerothermodynamics environments the vehicle will experience during the re-entry flight. Due to the huge amount of kinetic and potential energies of the 'falling vehicle', the design and sizing of thermal protection system (TPS) play a key role, because it protects the vehicle and payload from the intense heat resulting, in the boundary layer, from the 'aero breaking' process. Computational Fluid Dynamics (CFD) can be used to compute the flow field around the vehicle providing a High-Fidelity estimates of the surface quantities involved in the TPS design (e.g. temperature, heat flux, pressure and skin friction). Obviously, this can't be made for each point of the descent trajectory, as would be required for example to assess the way in which the heat loads propagates on the surfaces and in the vehicle's structure, in a time accurate framework. In this paper, the CIRA effort on developing an in-house tool is illustrated. It relies on a combination of CFD and engineering methodology whose aim is the definition of an aerothermodynamic environment to be used for designing the TPS of hypersonic vehicle. The code input are data comings from a large database of CFD solutions previously obtained using CFD codes. filling a test matrix defined by Mach number (M), angle of attacks (AoA) and Reynolds number (Re), taken from the USV3 flight envelope. Those data are synthesized and transformed within an in-house software that couple proper orthogonal decomposition (POD) techniques and a kriging interpolator. Thus the tool allows to compute a new solution simply asking for the desired Mach, AoA and Re avoiding CFD. A cross-validation of the results, are shown along with comparisons with some existing techniques recently applied in designing Flight Test Vehicles, such as the NASA X-33 and CEV Orion Capsule. evidencing pros and cons of the proposed method. In order to demonstrate the capabilities of the above tool, some results will be shown, such as the time history of surface map of temperature and integrated heat load which are useful to choose and size the TPS materials, respectively. Furthermore, contour maps of some representative quantities, such as pressure, skin friction, and heat flux are provided as well. The main advantage of the developed tool is its flexibility: efficient, fast, adaptable at each trajectory and vehicle's shape change, and hopefully reliable, due to the physics-based interpolation methods.