# Multiphysic Coupling Between Hypersonc Reactive Flow and Thermal Structural Analysis with Ablation for TPS of Space Lunchers

**Authors :** Margarita Dufresne

**Abstract :** This study devoted to development TPS for small space re-usable launchers. We have used SIRIUS design for S1 prototype. Multiphysics coupling for hypersonic reactive flow and thermos-structural analysis with and without ablation is provided by -CCM+ and COMSOL Multiphysics and FASTRAN and ACE+. Flow around hypersonic flight vehicles is the interaction of multiple shocks and the interaction of shocks with boundary layers. These interactions can have a very strong impact on the aeroheating experienced by the flight vehicle. A real gas implies the existence of a gas in equilibrium, non-equilibrium. Mach number ranged from 5 to 10 for first stage flight.The goals of this effort are to provide validation of the iterative coupling of hypersonic physics models in STAR-CCM+ and FASTRAN with COMSOL Multiphysics and ACE+. COMSOL Multiphysics and ACE+ are used for thermal structure analysis to simulate Conjugate Heat Transfer, with Conduction, Free Convection and Radiation to simulate Heat Flux from hypersonic flow. The reactive simulations involve an air chemical model of five species: N, N2, NO, O and O2. Seventeen chemical reactions, involving dissociation and recombination probabilities calculation include in the Dunn/Kang mechanism. Forward reaction rate coefficients based on a modified Arrhenius equation are computed for each reaction. The algorithms employed to solve the reactive equations used the second-order numerical scheme is obtained by a “MUSCL” (Monotone Upstream-cantered Schemes for Conservation Laws) extrapolation process in the structured case. Coupled inviscid flux: AUSM+ flux-vector splitting The MUSCL third-order scheme in STAR-CCM+ provides third-order spatial accuracy, except in the vicinity of strong shocks, where, due to limiting, the spatial accuracy is reduced to second-order and provides improved (i.e., reduced) dissipation compared to the second-order discretization scheme. initial unstructured mesh is refined made using this initial pressure gradient technique for the shock/shock interaction test case. The suggested by NASA turbulence models are the K-Omega SST with a1 = 0.355 and QCR (quadratic) as the constitutive option. Specified k and omega explicitly in initial conditions and in regions – k = 1E-6 *Uinf^2 and omega = 5*Uinf/ (mean aerodynamic chord or characteristic length). We put into practice modelling tips for hypersonic flow as automatic coupled solver, adaptative mesh refinement to capture and refine shock front, using advancing Layer Mesher and larger prism layer thickness to capture shock front on blunt surfaces. The temperature range from 300K to 30 000 K and pressure between 1e-4 and 100 atm. FASTRAN and ACE+ are coupled to provide high-fidelity solution for hot hypersonic reactive flow and Conjugate Heat Transfer. The results of both approaches meet the CIRCA wind tunnel results.

**Keywords :** hypersonic, first stage, high speed compressible flow, shock wave, aerodynamic heating, conugate heat transfer, conduction, free convection, radiation, fastran, ace+, comsol multiphysics, star-ccm+, thermal protection system (tps), space launcher, wind tunnel

**Conference Title :** ICAH 2024 : International Conference on Aerodynamics and Hydrodynamics

**Conference Location :** Sydney, Australia

**Conference Dates :** July 29-30, 2024