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COMPUTATIONAL HEAT TRANSFER FOR THERMAL PROTECTION SYSTEMS IN SPACE APPLICATIONS

Jeremy Mora-Monteros, Nikhil Banerji, Elise Fahy, Sophia Haussener

Laboratory of Renewable Energy Science and Engineering, EPFL, 1015 Lausanne, Switzerland
Correspondence author. Email: sophia.haussener@epfl.ch

ABSTRACT Thermal protection systems (TPS) are employed for spacecraft to survive high temperature conditions during atmospheric re-entry. For space shuttle type entries, ceramic tiles traditionally shield the payload from exposure to high heat fluxes due to their near-zero conductivity. Recent research into use of medium to low density TPS materials brings its own challenges, of which understanding internal radiative heat transfer and the coupling effects between radiation and conduction are two. Analysis of heat transfer in these materials often requires the use of numerical models based on volume averaging methods to satisfactorily account for the multiple scales involved, i.e. the pore scale and the macro scale. The accuracy of these methods relies on the determination of effective radiative properties, which depend on bulk properties, discrete-scale interface boundary conditions and morphology of the porous media. Advanced tomography-based direct pore-level simulations can be used for an accurate determination of these effective properties. The effective properties have to be incorporated into the macro-scale modeling of the TPS, which furthermore has to be coupled to the external flow and radiation fields. Plasma torch and high-flux solar simulator experimentation – operating at similar convective and radiative fluxes as in the real application – can be used to test the accuracy of the modeling assumptions and the modeling results.