Experimental Data Need for High-Fidelity Material-Response Models

Jean Lachaud (UCSC), Ioana Cozmuta (ERC), Nagi Mansour (NASA Ames)

Objective of the session

Several high-fidelity material-response models are being developed by the hypersonic community. These models require, in addition to the input parameters traditionally used in the state-of-the-art material-response codes, data not currently available - at least in the open literature. The presentations in the session will describe both state-of-the-art experimental techniques and innovative methods in support of model development and data acquisition for high-fidelity models.

In-depth phenomena, high-fidelity models, and required data

As a practical introduction and to provide orders of magnitude, we will describe the in-depth physico-chemical phenomena occurring in a low-density fibrous ablator under conditions relevant to sample return missions. A general high-fidelity model will be presented. The mass, momentum, and energy conservation equations and associated input parameters will be described. The focus will be set on the associated experimental data needed. We will conclude the presentation with a table summarizing the parameters that need to be determined and refer to the contributions of the session that will describe in details specific experimental techniques.

Table of parameters

Symbols (unit)	Properties	Exp. Techniques	Status	Presentations
Conservation of mass				
ε (-)	Open porosity	Pycnometry	SoA	M. Gasch
		Tomography	AM	E. Dickey
$\varepsilon_{mat.}$, ε_{fiber} (kg m^{-3})	Volume fractions	From elaboration	SoA	J. Lachaud
		Tomography, SEM	AD	E. Dickey
$\rho_{mat.}$, ρ_{fiber} (kg m^{-3})	Intrinsic densities	Densitometry	SoA	M. Gasch
		Tomography	AM	E. Dickey
π (kg m^{-3} s^{-1})	Overall Pyrolysis rate	TGA	SoA	J. Feldman
π_i (mol m^{-3} s^{-1})	Pyrolysis rate and species production	TGA + spectrometry	AD	J. White
		FT-IR Spectroscopy	AD	W. Fan
ω_i (mol m^{-3} s^{-1})	Finite-rate chemistry of the pyrolysis gases	Flow-Tube Reactor + spectrometry	AD	J. Marschall
Mass transport				
K (m^2), Fo (-),	Permeability, Forch-	Permeameter	SoA	E. Stokes

β (N)	heimer, Klinkenberg	Tomography + DNS	AM	E. Dickey/J. Lachaud
η(-), Kn	Tortuosity, Knudsen number	Diffusiometer Tomography + DNS	AD AM	E. Stokes E. Dickey/J. Lachaud
Conservation of Energy				
h_{mat}, h_{fiber} (J/kg)	Enthalpy of the solid	DTA/DSC	SoA/AD	J. Feldman
k (W m^{-1} K^{-1})	Effective conductivity	Flash	SoA	J. Feldman

SoA: state-of-the-art / AD: additional data / AM: alternative method.