ADVANCED ABLATION CHARACTERIZATION AND MODELLING (ABLAMOD)

Ali Guelhan
German Aerospace Center, Linder Hoehe, 51147 Cologne, Germany, Ali.Guelhan@dlr.de

Ablative thermal protection materials are a key technology for current and future space exploration missions. However, the mission feasibility is determined by the materials available, and the development of new materials is performed, essentially, by an iterative trial-and-error process. This is due to the absence of validated predictive models for ablative material behaviour – models are tuned to bulk material properties from tests. For each new material, this tuning has to be redone because the models are not of sufficiently high fidelity to be able to make even small extrapolations. This means that materials cannot be designed to a specification to fulfil the needs of a particular mission.
In order to describe physical processes of the ablation correctly, the European FP7 project ABLAMOD with the partner organizations DLR, Airbus Defence&Space, Avio, Amoroim, Fluid Gravity Engineering, AIT, OGI, CIRA, VKI and University of Stratchlyde has been formed. The aim of the European FP7 project ABLAMOD is to make a substantial step towards a predictive model of an ablative thermal protection system by incorporating aspects of high fidelity mesoscale ablator physics within a modular framework. In order to successfully develop such physics modules, the understanding of the fundamental processes occurring within the ablative materials must be improved [1,2]. To this end, three major ablation materials, i.e. carbon base, silicon based and cork based ablators, need to be tested in well characterized in long duration high enthalpy facilities using both standard instrumentation and advanced measurement techniques. These advanced spectroscopic techniques lead to a significant improvement in the detailed characterisation of the material behaviour at the mesoscale level. Both virgin and char version of the materials have been thermally characterized and the internal structure has been scanned by means of computer tomography (CT) [3]. First thermal characterization tests showed some unknown uncertainty sources, which are under investigation [4].

In parallel using the state-of-the-art knowledge of ablator physical processes, modules for the specific phenomena like internal gas flow, radiation, gas transport properties and gas-surface interaction have been developed. Computed Pitot pressure and heat flux profiles using simplified thermal non-equilibrium model show a reasonable agreement with the experimental data in the arc heated facility L3K. The computer tomography data allowed to study the microstructure of all three type ablator materials before and after charring. This data has been directly used for DSMC modelling (Figure 1) [3,5]. The coupling of new modules with the one dimensional baseline ablation code FABL is in preparation. It has been noticed that a direct coupling between the DSMC code, which is used for the rebuilding of internal flow, and the FABL code is not possible [6]. Therefore the ABLAMOD coupled simulation approach considers both direct coupling but also using the look-up tables. Improvements made in the physical description of the ablative materials and advantages of the new simulation environment will be validated against the dedicated experimental data with well-defined uncertainties.

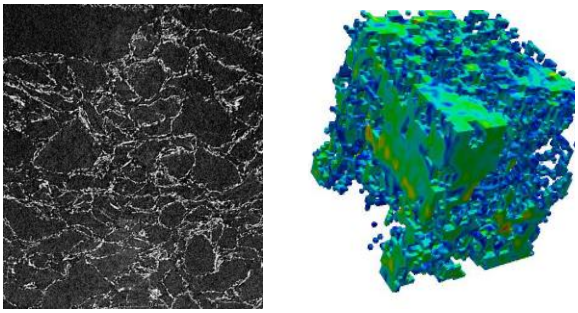

Figure 1: Measured microstructure of cork based ablator sample with the CT (left) and DSMC mesh created from measured CT scan (right).

[1] Ali Gülhan; ABLAMOD, Advanced Ablation Characterization and Modelling, HYDRA Workshop, San Sebastian, February 27 2015.

[2] Gregory Pinaud & Ali Gülhan; ABLAMOD, Advanced Ablation Characterization and Modelling, European project description, 6th Ablation Workshop, Urbana Champaign, IL, April 10-11th 2014.

[3] Erhard Kaschnitz; CT characterization of material samples, ABLAMOD Progress Meeting 3, 30.06.2014, Waterloo, Belgium.

[4] Wolfgang Hohenauer; Pre-test Characterisation of Samples Thermo-Physical Properties, ABLAMOD Progress Meeting, 20.01.2015, Capua, Italy.

[5] Craig White, Thomas Scanlon, Richard Brown and Viola Renato; Permeability of Ablative Materials to Rarefied Gases, ABLAMOD Progress Meeting, 20.01.2015, Capua, Italy.

[6] Emma Johnson; FABL Basics, ABLAMOD Progress Meeting, 20.01.2015, Capua, Italy.