DETERMINATION OF VOLUMETRIC RADIATIVE PROPERTIES OF CARBONACEOUS FIBROUS MEDIA

Atin Kumar[1], Jérôme Vicente[2], Yann Favennec[1], Benoit Rousseau[1]

[1]Université de Nantes, CNRS, LTeN Nantes, UMR 6607, F-44000 Nantes, France
[2]Aix Marseille Université, CNRS, IUSTI, Marseille cedex 13, 13453, France

Heat transfer via thermal radiation can be a dominant mode of heat transfer in porous material exposed to very high temperature. Highly porous rigid carbon felt used in thermal protection systems such as insulation of high temperature furnaces, heat shields of space re-entry vehicles, etc., is prone to radiative heat transfer. These materials consist of long fibers with microscopic diameters. The fibers are randomly positioned within volume and oriented along Z-plane. Designing and optimizing heat transfer through such complicated porous media can be leveraged by appropriate determination of radiative properties within the volume and contributing (textural) factors [1]. Motivated by this fact, volumetric radiative properties such as absorption (α), scattering (σ) and extinction (β) coefficients and their possible special dependencies will be determined for a set of material with varying porosity, diameter and orientation of fibers.

Firstly, morphological and textural properties of the material were determined from High Resolution X-Ray Tomography (HRXRT) which provides a stack of gray level images. These images were further processed in *iMorph*, an in-house open source morphological tool to determine properties such as mean diameter and local orientation of fibers, porosity, volumetric surface and mean intercept length between fibers. Further, these properties were used to create virtual fibrous materials (based on Random Sequential Adsorption (RSA) method) with various diameters, orientation and porosity.

Secondly, the Radiative Distribution Function Identification (RDFI) method was used to determine volumetric radiative properties. In this method, the rays are launched from a number of points which are uniformly distributed in void space and their direction is uniformly chosen within 4π steradian sphere inside the volume. Depending on medium if it is beerian or non-beerian and assuming that the geometric optical approximation is valid, RDFI can be used with confidence to determine volumetric radiative properties of the porous medium with opaque solid phase (for a set of optical indices) and transparent fluid phase [2].

Current communication is focused on determining volumetric radiative properties of (virtual) fibrous media using the RDFI method. Representative Elementary Volume (REV) was computed for porosity and radiative properties along with their interdependency. In addition, the dependence of radiative properties over textural parameters to optimize radiative heat transfer in fibrous media will be presented.

[1] Jaona Randrianalisoa, Sophia Haussener, Dominique Baillis and Wojciech Lipiński, "Radiative characterization of random fibrous media with long cylindrical fibers: Comparison of single- and multi-RTE approaches," Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 202, November 2017, Pages 220-232.

[2] Yann Dauvois, Denis Rochais, Franck Enguehard and Jean Taine, " Statistical radiative modeling of a porous medium with semi transparent and transparent phases: Application to a felt of overlapping fibres,", International Journal of Heat and Mass Transfer, Volume 106, 2017.