Macroscopic model for convection/radiation heat transfer in porous media

V. Leroy[1,2], B. Goyeau[1,2] and J. Taine[1,2]

[1]*CNRS, UPR 288, Laboratoire d'Energétique Moléculaire et Macroscopique, Combustion (EM2C), Grande Voie des Vignes, 92290 Châtenay-Malabry, France*
[2]*Ecole Centrale Paris, Grande Voie des Vignes, F-92290 Châtenay-Malabry, France*

ABSTRACT: This study is devoted to the macroscopic modeling of transfer phenomena in porous media subjected to high temperatures. The derivation of the macroscopic model, based on a thermal non-equilibrium, includes the coupling of radiation with the other transfer mechanisms. In order to account for non-Beerian homogenized phases, the radiation model is based on the Generalized Radiation Transfer Equation (GRTE) and under some conditions on the radiation Fourier'law.

The originality of the present upscaling lies to the fact that the *volume averaging method* is applied to the local energy conservation equations where the radiation transfer is included after a *statistical homogenization*. This coupled homogenization mainly raises three challenges.

- First, the physical nature of coupled heat transfers is different. We have to deal with the coexistence of both the material system (where heat conduction and/or convection take place) and the non-material radiation field composed of photons. This radiation field is homogenized using a statistical approach leading to the definition of radiation properties characterized by statistical continuous functions defined in the whole system (cumulated extinction distribution function, cumulated absorption probability, cumulated scattering probability,…).
- The second difficulty concerns the different scales involved in the upscaling procedure. We have shown that the scale separation required in the volume averaging method is compatible with the characteristic length scale of the statistical approach.
- The third challenge lies in the emission modeling which depends on the temperature of the material system. For a semitransparent phase, this temperature is obtained by averaging the local temperature using radiation intrinsic average while a radiation interface average is used for an opaque phase.

This coupled upscaling procedure is applied for different combination of opaque, transparent or semitransparent phases. The different macroscopic models that have been obtained involve several effective transport and radiation properties whose determination can be obtained by solving the associated closure problems that have been derived.