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DETERMINATION OF THE NEAR-WALL RADIATIVE PROPERTIES OF A NUMERICALLY GENERATED PACKED BED

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Nowadays, porous media play an important role in many industrial applications [1]. In the field of chemistry or energy for example, porous media are heated at very high temperatures: the radiative heat transfer can be the predominant mode of heat transfer. As a result, attention has been paid to model the radiative transfer in heterogeneous media. The exact calculation of the radiation field within a heterogeneous medium is impossible because of the computational cost. Therefore, a common strategy consists in replacing the heterogeneous medium with a realistic homogeneous medium, the radiative properties of which remain to be determined.

This problem has been tackled by many authors [2]. Most authors use a parameter identification method: they determine parameters by comparison of experimental data or simulation results with a transfer model often assuming Beer's law validity [3–5]. In heterogeneous media however, this hypothesis is rarely valid. Recently, a new method has been proposed by Tancrez et al. to characterize the radiative properties of a priori non-Beerian porous media, the only limitation of their theory being the assumption of geometric optics validity [6]. This method has then been extended to anisotropic statistically homogeneous media [7–9].

In the perspective of radiation heat transfer modeling whithin tubular reactors in the chemical industry, near-wall heat transfer has recently been studied [10]. Indeed, since the extinction coefficient is closely linked to the morphology of the medium, the porosity gradient induced by the wall can impact the radiative flux. The goal of this work is to fully characterize the near-wall morphology and the radiative properties of a packed bed composed of spherical particles.

To this end, the following approach has been retained. First, a packed bed bounded by a set of walls has been numerically generated using a commercial software. Then, in order to characterize the morphology of the numerically generated porous medium, the porosity profiles have been calculated. Those profiles are in agreement with the experimental results and correlation of Du Toit et al. [11]. The extinction, scattering and absorption cumulative distribution functions have been calculated with a stochastic Monte Carlo method and the radiative properties have then been determined when possible. The porous medium is heterogeneous and anisotropic near the wall: it has been demonstrated that, as expected, Beer's law is not valid and thus the extinction coefficient can not be defined. As a consequence, the radiative transfer equation (RTE) which is implicitly based on Beer's law can not be used. A generalized radiative transfer equation (GRTE) has been proposed by Taine et al. to treat this case [12, 13]. In the near future, this GRTE will be integrated (using a Monte Carlo technique) to quantify the radiative fluxes in particular in the vicinity of the walls. Finally the influence of a porosity gradient on the radiative transfer will be investigated.

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