Experimental analysis and modeling of non-isothermal transient flows in granular porous media at large Biot numbers

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Numerous green technologies are based on heat and mass transfer in porous media at high temperatures : heat exchangers for thermodynamic solar power plants, biofuel production from biomass, etc.

This type of transfer often involves several non-Darcian effects such as inertial [1], compressibility and unsteadiness effects, and, most importantly, local thermal non-equilibrium effects between the gas and the solid [2] but also sometimes within the solid itself (high Biot number) [3]. Upscaling models have been proposed [4] and have shown to provide acceptable results for an intermittent energy storage system [5]. The complexity of real granular packings and coupled non-darcian effects with non-equilibrium heat transfer in the transient regime require experimental measurements to accurately identify homogenized model parameters. We have developed an experimental setup to measure the non-Darcian parameters in centimetric granular porous media. It consists of a 20 cm diameter, 1 meter long, tube filled with the granular porous medium of interest. Hot gas is blown at the required flow rate and temperature at the inlet of the tube (in the current version, up to 0.5 m/s and 800 K). The temperature evolution of the gas and of the grains are monitored during dynamic heating, steady state and cool-down.

Macroscopic models proposed in the literature [2, 4] have been implemented in the Porous Material Analysis Toolbox based on OpenFoam (PATO) [6], which is released Open Source (www.pato.ac). Parameter estimation is done using advanced multi-objective optimisation, coupling Dakota [7] with PATO. This work illustrates the strategy and presents results in the case of a high temperature, compressible, inertial, and transient flow in a pebble packed bed.

References

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