INERTIA-INDUCED NON-DARCY FLOW THROUGH POROUS MEDIA

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Porous materials are encountered in a diverse range of technical and natural processes. They exhibit complex microstructures typically involving various fluid phases saturating the anisotropic pore space of a solid matrix. While modern, e.g. X-ray tomographic imaging techniques enable the characterization of such microstructures, the fully-resolved modelling of transport processes in porous materials at the technical scale is unfeasible. For instance, the technical scale for superheated fluid flow in geothermal power plants is in the order of kilometers, while pore-channel diameters may be as small as several micrometers. It is thus the engineers interest to use effective macroscale constitutive relationships. The development of such scale-bridging models however requires a detailed knowledge of the pore-scale physics.

The hydrodynamical transport process of interest in our work is filtration, or, in other words, the flow motion of a saturating fluid relative to the solid matrix. Despite its high relevance for technical applications, the pore-scale physics of filtration at finite Reynoldsnumbers, that is, where effects of inertia are dominant, is not well understood. The critical question of interest in our work is: How does the micromorphology of the porous medium affect the laminar-turbulent inertial transition ? The latter motivates our numerical analysis of flow through statistically representative pore-space volumes (RVE) using the novel particle method Smoothed Particle Hydrodynamics[1] (SPH). Using our simulations, we are able to correlate macroscopic effects in terms of the non-linear dependency between pressure loss and filter velocity to the microscopic causes.

Keywords: Turbulent Porous Media Flow, Permeability, Smoothed Particle Hydrodynamics

References:

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