Pore-scale simulation of granular filtration flows

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Abstract. Granular rapid filtration serves as a purifying treatment step after the sedimentation process in a water treatment system. Despite its conventionality, understanding the complex hydrodynamic behaviour within the filter media with random packing remains challenging. In this study, we explore the use of numerical simulations with idealised configurations as a possible modelling approach. Two numerical configurations are emulated for the clean and clogged filter bed flow conditions, respectively. For the former, numerical domains with 10 and 20 idealised spheres, having 2mm diameters, were designed in OpenFOAM and tested for Darcy flow (Re < 1) and Forchheimer flow (Re > 1). For the latter, the clogged bed condition was emulated by the arrangement of 50-microns spheres around a singular 2mm collector sphere in COMSOL. The number of 50-microns spheres was varied to achieve different specific deposit values, and all configurations were tested at 0.002m/s. The mesh quality for the designed numerical configurations in both cases was examined in details to ensure validity. The simulation results show that the numerical approach is able to reproduce the pressure drop under clean bed condition within approximately 6%. In addition, the simulated pressure drop values for the clogged bed condition are also consistent with the empirical head loss values suggested in the literature.

Keyword: Computational fluid dynamics, granular filter bed, pressure drop, pore-scale