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Particle migration and deposition at the pore scale: Eulerian-Lagrangian approach

Wednesday, 1 June 2022 14:50 (1h 10m)

Solute transport containing particles is essential in various applications, including filtration industry, subsurface contaminant transport in hydrology or environmental engineering, formation damage in the petroleum industry, and subsurface biocolloids or microorganism transport [1-4]. The evolution of pore-scale structure because of particle retention is a complicated process, which is a function of pore-scale heterogeneity and non-linear coupling of particle transport and fluid flow. Deposited particles alter the fluid flow fields at the pore scale, increase pore space heterogeneity, and impair the porosity and permeability of the porous medium. Pore-scale studies enable us to find effective mechanisms during particle transport.

Various modelling approaches were introduced to explain the retention mechanism of particle transport in porous media. Continuum-based numerical models can be used at representative elementary volume to explore solute transport in porous media. By solving the advection-dispersion equation, these models blur microscopic details and employ simplifying assumptions in the averaging process [5]. At the pore scale, the Lattice Boltzmann method (LBM), computational fluid dynamics (CFD), and pore network models (PNM) can be implemented to predict flow field variations. To track particles, the discrete element method (DEM) and Lagrangian CFD approaches are usually coupled with flow field predictors. Coupled methods enable us to study velocity fields, particle trajectory, spatial distributions, and residence time [2, 6].

This study incorporated the Eulerian-Lagrangian approach at the pore scale to investigate the spatial and temporal deposition of solute transport with particles. The velocity field and trajectory of particles were determined by solving the Navier-Stokes and momentum balance equations, respectively. When particle diameter is smaller than image voxel size, handling deposited particles can be challenging because many particles are required to occupy a pore voxel. Pore voxels adjacent to solid voxels are dynamically updated to trapped voxels when particles touching them have a comparable velocity to the adhesion forces of solid surfaces. The model was developed in Python and validated with the experimental data. Using an image-based technique, the portion of retained particles by surface deposition and clogging mechanisms were discriminated during various experimental simulation scenarios. Mean injection velocity, particle size and concentration, surface adhesion forces, and surface roughness are considered as sensitivity parameters. The results show that the role of the clogging mechanism rises by increasing the particle size, particle concentration, and surface adhesion forces much more than surface deposition. Hydrodynamic particle bridging can reduce structure permeability substantially compared to surface deposition. Particle retention at a critical velocity is maximum where the spatial deposition switches from filter cake development to homogenous retention across the structure.

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Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Unsure

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