Determination of Dynamic Dispersion Coefficients for Particles Flowing in Different Geometries

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Abstract

Recently, nanoparticles have attracted significant attention and shown a great potential for enhancing oil recovery. Dispersion coefficients are usually obtained by fitting breakthrough curves to solute experiments; however, solutes and particles disperse differently. Using the moment analysis method and Green's function, mathematical formulations have been developed to determine dynamic dispersion coefficients for passive and reactive particles flowing in a circular tube and parallel-plate fracture with fully-developed laminar flow under different source conditions across the full-time scale. The newly proposed formulations have been verified by agreeing well with the random walk particle tracking simulations. At early times, particle dispersion coefficient is not only controlled by source condition, but also negatively correlated with the center-of-mass velocity. After the critical time, source effect is negligible and all dispersion coefficients converge to the values obtained through the extended Taylor theory. Compared to particles flowing in a 3D circular tube, dispersion coefficients in a 2D parallel-plate fracture are always larger for a uniform planar source; however, this is not always true for a point source. The relationship between particle size and dispersion coefficient for passive particles varies with time where they are positively correlated if Peclet number is larger than its critical value; otherwise, they are negatively correlated. Using 0.02 as the critical value for the relative difference in dispersion coefficient, axial-diffusion effect is negligible for passive solutes at long times when Peclet number is smaller than 50; however, this is not applicable for passive particles. For reactive particles, at long times, both reaction rate and enter-of-mass velocity increases in magnitude as Damköhler number increases (while it is opposite for dispersion coefficient); however, at early times, they are not sensitive to Damköhler number. Subsequently, the newly developed models have been extended to match experimental measurements with a good accuracy.

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