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Explicit numerical simulation-based study of the hydrodynamics of micro-packed beds

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Abstract

Knowledge of the hydrodynamic character of micro-packed beds (μPBs) is critical to understanding pumping power requirements and their performance in various applications, including those where heat and mass transfer are involved. The report here details use of smoothed particle hydrodynamics (SPH) based simulation of fluid flow on models of μPBs derived from X-ray microtomography to predict the hydrodynamic character of the beds as a function of the bed-to-particle diameter ratio over the range $5.2 \leq D/d_p \leq 15.1$. It is shown that the permeability of the μPBs decreases in a non-linear but monotonic manner with this ratio to a plateau beyond $D/d_p \approx 10$ that corresponded to the value predicted by the Ergun equation. This permeability variation was best represented by the model of Reichelt (*Chem. Ing. Technik*, **44**, 1068, 1972) and also reasonably well-represented by that of Foumeny (*Intnl. J. Heat Mass Transfer*, **36,** 536, 1993), both of which were developed using macroscale packed beds of varying bed-to-particle diameter ratios. Four other similarly determined correlations did not match well the permeability variation predicted by SPH. The flow field within the μPBs varied in an oscillatory manner with radial position (*i.e.* channelling occurred at multiple radial positions) due to a similar variation in the porosity. This suggests that use of performance models (*e.g.* for heat and mass transfer) derived for macroscale beds may not be suitable for μPBs. The SPH-based approach here may well form a suitable basis for predicting such behaviour, however.

Keywords: Porous media; micro-packed bed; pressure drop; permeability; smoothed particle hydrodynamics (SPH); Lagrangian.

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