SPECIAL NANOHOUR

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Beckman Institute - Room 3269

Micro-mechanical modeling of flow through randomly packed beds of spheres: Dispersion, deformation and drying

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The detailed flow field for low Reynolds number flow through random packing of mono-sized spheres is derived. The number of spheres is several thousands and the porosities ranges between 0.4 and 0.6. The system of spheres is divided into smaller volumes with Voronoi diagrams and the flow field is obtained by usage of a dual stream function. The local saturated flow fields are approximated as for close packed spheres and the overall flow pattern is obtained by minimising the dissipation rate of energy. To start with the longitudinal (DL) and transverse (DT) dispersion coefficients are computed by fitting the resulting effluent curve to a 1-D solution of a continuous model and by fitting the numerical concentration profile to an approximate 2-D solution, respectively. The obtained values of DL and DT are in agreement with 3-D experimental data from the literature enabling a study of the effects of pore structure and porosity on DL and DT. Next, flow induced alterations of permeability of random packing of mono-sized spheres is studied. The change of permeability is obtained for elastic deformations of the positions of the spheres using either of two methods. Each sphere is elastically attached to single points or the spheres are connected via an elastic porous network. The results show that the permeability for large random systems increases as a function of velocity and thus the deformation. The alteration is, however, much less than for 2-D cases like parallel cylinders. The relative increase in permeability becomes larger as the porosity increases from 0.4 to 0.6. Finally the model is applied to drying of iron ore pellets showing variation in the distribution of temperature and moisture content in the final phase of drying.

Relevant references

1. Hellström, J.G.I., Frishfelds, V., Lundström, T.S., ”Mechanisms of flow-induced deformation of porous media” Journal of Fluid Mechanics, 664, 220-237 (2010)
2. Frishfelds, V., Hellström, J.G.I., Lundström, T.S., Mattsson, H., ”Fluid flow induced internal erosion of porous media; Modelling of the No erosion filter test experiment” Transport in Porous Media 89, 441-457 (2011)
3. Ljung, A-L, Frishfelds, V, Lundström T.S., Marjavaara, B.D. “Discrete and continuous modelling of heat and mass transport in drying of a bed of iron ore pellets” Drying Technology, 30(7), 760-773 (2012)
4. Jourak, A, Frishfelds, V, Lundström, TS, Herrmann, I, Hedström, A, “The Calculations of Dispersion Coefficients Inside Two-dimensional Randomly Packed Beds of Circular Particles” AIChe Journal 59(3): 1002-1011 (2013)
5. Lundström, T.S., Frishfelds, V., “Modeling filtration of particulate flow during impregnation of dual-scale fabrics” Journal of Composite Materials, 47(15): 1907–1915
6. Lundström, T.S., Hellström, J.G.I., Frishfelds, V., “Transversal flow-induced deformation of fibres during composites manufacturing and the effect on permeability” Journal of Reinforced Plastics and Composites, 32(15): 1129–1135 (2013)
7. Jourak, A, Frishfelds, V, Hellström, JGI, Lundström, TS, “Numerical derivation of dispersion coefficients for flow through three-dimensional randomly packed beds of monodisperse spheres” AIChe Journal (2014)

Coffee and cookies will be served

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