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A linearised model for calculating inertial forces on a particle in the presence of a permeate flow. (English) Zbl 1421.76240

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Summary: Understanding particle transport and localisation in porous channels, especially at moderate Reynolds numbers, is relevant for many applications ranging from water reclamation to biological studies. Recently, researchers experimentally demonstrated that the interplay between axial and permeate flow in a porous microchannel results in a wide range of focusing positions of finite-sized particles [the first author and the third author, "Inertial particle dynamics in the presence of a secondary flow", Phys. Rev. Fluids 2, No. 4, Article ID 042201, 7 p. (2017; doi:10.1103/PhysRevFluids.2.042201)]. We numerically explore this interplay by computing the lateral forces on a neutrally buoyant spherical particle that is subject to both inertial and permeate forces over a range of experimentally relevant particle sizes and channel Reynolds numbers. Interestingly, we show that the lateral forces on the particle are well represented using a linearised model across a range of permeate-to-axial flow rate ratios. Specifically, our model linearises the effects of the permeate flow, which suggests that the interplay between axial and permeate flow on the lateral force on a particle can be represented as a superposition between the lateral (inertial) forces in pure axial flow and the viscous forces in pure permeate flow. We experimentally validate this observation for a range of flow conditions. The linearised behaviour observed significantly reduces the complexity and time required to predict the migration of inertial particles in permeate channels.

MSC:

76T20 Suspensions
76D05 Navier-Stokes equations for incompressible viscous fluids

Keywords:

microfluidics; multiphase and particle-laden flows; particle/fluid flow

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