Pattern Formation in Laminar Flow of Suspensions through Square Channels

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ABSTRACT

Ever since Segre and Silberberg found lateral migration of a spherical particle in laminar pipe flow in 1961, it has been understood that suspension flow in channels exhibits a broad set of non-trivial phenomena. Despite half a century of research, many phenomena are still subject to ongoing investigations. With the rise of microfluidics devices, this topic has made a leap from fundamental science to a wide range of applications, and in turn sparked the interest of many engineers and researchers.

Rectangular or square channels are frequently used in microfluidics devices because they are easier to fabricate than circular pipes. Due to lack of symmetry, such geometries feature several phenomena not found in pipes. Miura et al. [2] found in experiments with very dilute suspensions that there are two sets of equilibrium positions in a square channel: one set close to the channel face centres, and one set close to the channel corners. Further, they found that the face positions are stable for all investigated Reynolds numbers (up to Re=1200), while the corner positions only become stable above Re=260.

We present simulations of suspensions at various solid fractions and Reynolds numbers. We use our software *LBDEMcoupling* [3], a fully resolved coupling between the lattice Boltzmann method (LBM) and the discrete element method (DEM) to conduct these simulations. In the dilute regime, we are able to match the experimental results of Miura et al. As the solid fraction increases, two new effects emerge: At Re < 260, where only the face positions are stable, each of these positions splits up in two sub-positions, one closer to the channel axis and one closer to the channel centre. The particles align in a staggered configuration. At Re > 260, where for dilute suspensions both sets of equilibrium positions are stable, we find that the face equilibrium positions become unstable with increasing solid fraction. Due to interactions, most particles migrate to the more confined, thus more stable corner equilibrium positions. We characterize these newly found positions and discuss possible underlying mechanisms.

REFERENCES

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