SPH based study of confined microflows characterized by abrupt changes in cross-sectional area

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ABSTRACT

In this paper, we investigate the application of the SPH method to the computation of flows in channels with sudden expansion or contraction. Numerical modeling with SPH involves the treatment of flowing matter as distinct mass points, leading to discretization of the Navier-Stokes equations (or other appropriate PDEs) and providing great flexibility to handle large deformations. The computational methodology exhibits similarities with other particle methods, such as Molecular Dynamics (MD), Dissipative Particle Dynamics (DPD), Smooth Dissipative Particle Dynamics (SDPD). A brief discussion on the scales where these methods are appropriate is presented.

In this work, two widely used solvers are used: LAMMPS-SPH [1], [2] and DualSPHysics [3]. The LAMMPS environment albeit mostly intended to MD simulations near the atomic scale, provides a fully parallelized framework for particle simulations, such as SPH. The DualSPHysics Navier Stokes solver has been mainly developed for coastal engineering problems. It originates from the open-source SPHysics software and is a popular choice for carrying out simulations with millions of particles, opening the field for large real-life simulations at manageable computational time.

We have studied microchannel flows of variable cross section. Sudden expansions or contractions, of the order of 50%, generate strong discontinuities in the flow field. Flow models based on various boundary conditions (for example, Periodic/Fixed BCs, Inflow-Outflow BCs, Dynamic Boundary Conditions (DBCs) and modified DBCs) and their implementations are presented in the context of 2-D and 3-D simulations. Results are compared with analytical solutions, if available, or other numerical solutions for the problems under study. Minor artifacts may be observed near the wall corner discontinuities, but, overall, it is suggested that SPH captures the main flow characteristics and achieves very good accuracy [4].

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