3D Lattice Boltzmann sub-grid particle method for microfiltration

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Computational fluid dynamics (CFD) is a powerful tool to investigate microfiltration. Modeling suspension flow can provide detailed information about cake formation and concentration polarization effects. However, working with fully resolved particles [1] takes a lot of computer resources.
In this contribution, we present a simulation method for sub-grid particles with typical radius of 0.1x grid size. The fluid flow is solved on a coarse grid, while the particle behavior is handled in more detail on a smaller time scale. The separation of different time and length scales assures fast and accurate results.

A Lattice Boltzmann model for fluid flow through porous media [2] was extended with moving particles. Lattice Boltzmann is a powerful modeling technique and has been successful in the simulation of fluid flow in complicated geometries, porous media and multi-phase flow. The drag force on the particles is calculated by the Ergun equation and is coupled to the fluid by a body force term. The excluded volume of the particles is taken into account. The particle-wall and particle-particle interactions are handled by soft spring interations [3] or the lubrication force theory [1].

The code was validated by calculating the pressure drop over a packed bed with random placed stationary particles, to check if the implementation of the body force and excluded volume were alright. Subsequently, simulations were performed with moving particles. Test simulations consisted of 2000 particles on an 8x5x5 lattice. The model works well for dilute suspension flow and dead-end filtration, which will be illustrated by animations.

In the future, the particle-particle interactions will be improved for concentrated suspension flow and cake layers with close packing. Eventually, the model will be adapted to cross-flow microfiltration and used for optimization of process parameters, such as cross flow velocity, transmembrane pressure and the module geometry.

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References

[1] Ladd A., Verberg R., Lattice Boltzmann simulation of particle-fluid suspensions, *J. Stat. Physics* **104** (2001) p.1191.
[2] Guo Z., Zhao T., Lattice Boltzmann model for incompressible flows through porous media, *Phys. Rev. E.* **66** (2002) 036304.
[3] Patankar N., Joseph D., Modeling and numerical simulation of particulate flows by the Eulerian-Lagrangian approach, *Int. J. Multiphase Flow* **27** (2001) p.1659.