Modelling of free surface fluid flow with dispersed particles by means of the lattice Boltzmann method

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ABSTRACT

Numerical simulations of casting processes (which are the target industrial application of this study) include modelling of several physical phenomena. The previously published paper [1] shows that the lattice Boltzmann method is able to accurately simulate the free surface flow during gravity casting into molds of complex geometries. The current study aims at simulations of flow dynamics of the fluid which is filled with rigid particles. This represents a complex physical phenomena as an interaction between the particles and the fluid needs to be considered. This corresponds to casting processes with fillers which are added into the fluid in order to enhance e.g. mechanical properties of the casting.

The free surface flow is simulated using the in-house implemented lattice Boltzmann solver which includes an algorithm capable of modelling surface tension and contact angle effects. The particles are modelled using the Lagrangian description, i.e each of the particles has its own coordinates and velocity. In order to capture the free surface of the incompressible fluid, an algorithm based on the volume of fluid method [2] is adopted. The fluid-structure interaction is performed via immersed boundary method [3, 4], i.e. the velocity of the particles is extrapolated from the fluid's flow field and the forces acting on the particles (inertia, gravity, buoyancy) are transfered into the fluid using a source term.

The main aim of this work is to provide a comparison between numerical simulations and experimental measurements for several three dimensional test cases. A special attention is paid to particle transport and sedimentation under steady as well as unsteady flow conditions. The influence of particle parameters (size, shape, density etc.) on the resulting flow properties is also studied.

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