Numerical and experimental study of non-Newtonian free surface flow effects using the lattice Boltzmann method

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ABSTRACT

Numerical simulations of free surface flow can be well utilised to simulate the gravity casting processes and to reduce their total costs e.g. by optimising the casting mold desing (including number and position of its inlets and outlets). Implementation of an efficient and precise numerical method is necessary in order to produce a valid numerical solution. The lattice Boltzmann method represents an alternative to classical numerical methods such as finite volume or finite element methods. In our previous work [1] we showed that the lattice Boltzmann method was able to accurately simulate the free surface Newtonian fluid flow in complex geometries. Thanks to its computational efficiency, the lattice Boltzmann method could be seen as an appropriate numerical tool for simulations of gravity casting processes.

Nevertheless, materials which are being casted into the mold usually behave as non-Newtonian fluids (e.g. plastics or resins). Thus this work focuses on numerical simulations of non-Newtonian fluid flow using the lattice Boltzmann method [2, 3] and studies the influence of the non-Newtonian effects on resulting flow field. The free surface flow is simulated using the in-house implemented lattice Boltzmann solver. The free surface is captured by an algorithm based on the volume of fluid method [4]. The non-Newtonian behaviour of the fluid is modelled by the power-law model [2].

The key part of this work provides a comparison between numerical simulations and experimental measurements for various three dimensional test cases. The experimental measurements are performed for several non-Newtonian fluids and used for validation of numerical simulations. The emphasis is put not only on the comparison of numerical and experimental data but also on a study of non-Newtonian fluid behaviour and its influence on obtained results.

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