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Direct-Forcing Immersed Boundary – Non-Newtonian Lattice Boltzmann Method for Transient Non-Isothermal Sedimentation

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Abstract

In this study a direct numerical simulation methodology for investigating the transient non-isothermal sedimentation of circular particles in non-Newtonian fluids was developed. The combined method of direct-forcing immersed boundary and non-Newtonian lattice Boltzmann method (IB-NLBM) with split-forcing algorithm was used for simulating fluid-particle interactions including the thermal effects. The 4-point diffuse interface scheme was used to link the fixed Eulerian nodes of fluids to the moving Lagrangian nodes of immersed boundary. The effects of added mass due to the particle acceleration were also included in the analysis. The accuracy of the method was successfully validated by comparison of the model predictions with experimental data and earlier numerical results for cold and hot falling particles. The effects of non-Newtonian power-law index and temperature-dependent viscosity of shear-thinning and shear-thickening fluids on settling particles at fixed or varying temperatures for different generalized Archimedes and Prandtl numbers were also investigated. The results for shear-thinning fluids indicated that the effect of temperature-dependent viscosity was more noticeable at higher value of non-Newtonian behaviour index. Furthermore, the differences between the cases of constant and varying particle temperature were more noticeable at higher non-Newtonian behaviour index and larger values of generalized Prandtl number.

Keywords: Immersed boundary–Lattice Boltzmann method, non-Newtonian fluid, non-isothermal sedimentation, temperature-dependent viscosity, diffuse interface scheme

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