SHSLBM simulation of nanofluid thermal convection at high Rayleigh numbers

Yuan Ma[a,b,*] and Zhigang Yang[a,b,c]
[a] Shanghai Automotive Wind Tunnel Center, Tongji University, No.4800, Cao'an Road, Shanghai, China, 201804
[b] Shanghai Key Lab of Vehicle Aerodynamics and Vehicle Thermal Management Systems, No.4800, Cao'an Road, Shanghai, China, 201804
[c] Beijing Aeronautical Science & Technology Research Institute, Beijing, China, 102211
[*] Present the paper at the Conference.

ABSTRACT

A new method called simplified and highly stable lattice Boltzmann method (SHSLBM) was used to simulate the nanofluid natural convection and heat transfer in a square enclosure with a heating obstacle at high Rayleigh numbers. There are four fins on the heating obstacle to affect the flow pattern and heat transfer performance. SHSLBM is based on the lattice Boltzmann framework. The effects of Rayleigh number ($1\times10^6 \le Ra \le 1\times10^9$), nanoparticle volume fraction ($0 \le \phi \le 0.05$) and length of fin ($0.1 \le h \le 0.3$) on the flow pattern, temperature distribution and heat transfer characteristics were illustrated and analyzed. The benchmark simulation results were performed for the validation of method and the results showed the SHSLBM is reasonably accurate and it's suitable to solve the present problem. Three kinds of flow patterns (steady symmetry, unsteady symmetry and unsteady asymmetry) can be observed at various Rayleigh numbers, i.e. at ϕ = 0.01, when the *Ra* increases from 1×10^6 to 1×10^9, the transitions of flow regime from steady symmetry state to unsteady asymmetry state occur. The ϕ and *h* also affect the flow pattern significantly. At higher ϕ, the flow inside the enclosure is steadier and the effect of *h* on the flow pattern varies at different *Ra*.

Keywords: SHSLBM; High *Ra*; Nanofluid; Fin; Natural convection; Heat transfer