ABSTRACT

The physics involved in the flow and heat transfer of non-Newtonian fluids is complex due to complex rheological behavior of such fluids. To simulate the flow and heat transfer of such fluids, several computational techniques have been developed. Lattice Boltzmann method (LBM) is a relatively new and efficient computational technique to simulate complex fluid flow and heat transfer. The present dissertation focuses on the application of LBM for the simulation of flow and heat transfer in non-Newtonian fluids inside a cavity driven by the motion of a single wall or multiple walls or by the buoyancy effect. Careful efforts have been taken to check the credibility of the LBM before simulation of each objective of the present thesis.

First, the LBM has been applied for the oscillating lid case to simulate the periodic flow characteristics of Newtonian fluid in a cavity for various Reynolds numbers and frequencies of oscillation. The results show that the development of vortices within the cavity depends strongly on Reynolds number and oscillating frequency. Next, the method is extended to investigate the flow characteristics of power-law fluid flow in a double sided lid driven cavity by modifying the relaxation time in the LBM. The influence of power-law index and Reynolds number on the variation of velocity and center of vortex location of fluid has been analyzed with the help of velocity profiles and streamline plots. Additionally, the effect of speed ratio on the development of vortices in a cavity has been studied.

Further, attempts have been made to extend the application of LBM to simulate viscoplastic fluid flow in lid driven cavities. The influence of Bingham number, Reynolds number, direction of wall motion and aspect ratio on the development of flow phenomena of viscoplastic fluids in lid driven cavities is studied.

Finally, the numerical investigations for steady-state natural convection in a two-dimensional square cavity filled with non-Newtonian power-law fluids by localized heating from below with single and multiple discrete heaters and symmetrical cooling from the side walls have been studied. The multi distribution function thermal LBM model is applied to simulate the flow and temperature fields for a constant Prandtl number at various combinations of power-law index, Rayleigh number, length of the heat source and distance between two heaters. The buoyancy force is incorporated in the collision term of the LBM through Boussinesq approximation. Simulation results are presented in the form of streamlines, isotherms, velocity profiles and variation of Nusselt number on the non-adiabatic walls to probe the momentum and heat transfer characteristics.

Keywords: **Lattice Boltzmann method, non-Newtonian fluids, power-law fluids, Bingham fluids, lid-driven cavity, double-sided lid motion, natural convection, discrete heaters**.