Effect of Boundary Condition Applying Type on Heat Transfer Modeling via Double Species Lattice Boltzmann Method

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ABSTRACT

Lattice Boltzmann Method (LBM) is one of mesoscopic particle model approaches for simulating fluid flow numerically. This model has been developed from a Boolean model known as the lattice gas method. In recent decades, the lattice Boltzmann method has become an alternative to the conventional computational fluid dynamics methods for solving Navier-Stokes equations. Anilkumar and Jilani [1] evaluated a natural convection heat transfer enhancement in a closed cavity with partition utilizing Nano fluids. Doghan [2] compared the results of CFD and other softwares for open cavity heated at one wall and we investigated the problem via thermal lattice Boltzmann method (TLBM) in compare to their results.

In TLBM, we use an approximation known as BGK or single relaxation time in Boltzmann equation. The equations are discretized by energy method, reported in literature. The D2Q9 lattice for 2D density and internal energy distribution function used in this case. As the TLBM with single relaxation time has an instability in equations, we use double species thermal lattice Boltzmann for heat transfer modeling so we define new coefficient based on this method. The principle objective of the present study is to solve the velocity and temperature field using two different distribution functions in double species thermal lattice Boltzmann method. The study is carried out for a wide range of Rayleigh numbers. Velocity and temperature distributions as well as Nusselt numbers were obtained for the Rayleigh numbers ranging from 103 to 106 with a Prandtl number around 0.718 for air. Moreover, the Boussinesq approximation is applied to the buoyancy force term. Also we evaluate that the order of derivatives can help us in the accuracy of macroscopic values. So we apply this method for all of boundary conditions same as no slip, constant temperature, adiabatic walls and heat transfer on the walls in two different TLBM model and macroscopic states. We show that applying type of the boundary conditions in both states does not make any difference and based on computer code results, we can use both of them with minimum terms of derivatives.

Results are presented and plotted in the form of streamline and isotherm plots as well as the variation of average Nusselt number at the walls and domain. The results are compared to those of CFD methods referenced through literature. A good agreement is obtained between the current solution and previous works and it shows that we can use double species TLBM with minimum terms of derivatives on a macroscopic and TLBM parameters in boundary conditions discretization. It was demonstrated that all of results have a good independency from the grids and number of mesh cells. So as the TLBM has a proper accuracy in calculation, we can save the time with decreasing the terms and order of derivatives. Finally it was observed that we can solve the first rows and corners of grid (i.e. the nodes on the body) with macroscopic terms then continue for other lattices through TLBM with high accuracy and save the time even more.

REFERENCES

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