Simulation of Convection in a Ventilated Square a Cavity with Periodic Heating Condition Using the Lattice Boltzmann Method with Multiple Relaxation Times (LBM-MRT)

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Abstract:

In this work, a laminar fluid flow and convective heat transfer, based on the lattice Boltzmann method with multiple relaxation times (LBM-MRT), was simulated. The D2Q9 and D2Q5 models were implemented for the velocity and temperature fields respectively, to solve the momentum and energy conservation equations. The physical model used is a two-dimensional ventilated square cavity with a periodic thermal condition, the left wall is heated with sinusoidal time-dependent temperature, the right wall is fixed at a cold temperature, the other walls are kept adiabatic. The cavity is ventilated by two diagonally opposite openings, the ventilating fluid is air (Pr=0.71). The hydrodynamics of the air flow and heat transfer were controlled with the amplitude of the periodic temperature condition, the Richardson number and the Reynolds number with the respective variation ranges: amp =0 and 0.4, $0.005 \leq Ri \leq 6.$, and Re=100 and 400. The results obtained in terms of streamlines, isotherms and the heat transfer rate, expressed by the average Nusselt number, presented as a function of time and for a settling period, show the significant effect of these different parameters on the flow and thermal structure fields and the transfer rate. A comparison with the case of the constant hot temperature condition was made to quantify the difference in the transfer rate. between the two cases. The results reveal that the magnitude of temperature warming represents a significant effect factor that minimizes the cooling demand and gives a remarkable improvement over the differential heating of vertical walls of a displacement ventilated square cavity.

Keywords:

LBM-MRT, Periodic heating, Ventilated cavity, thermal comfort.