Application of Lattice Boltzmann Method to Different Boundary Conditions in a Two Dimensional Enclosure

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Abstract : Lattice Boltzmann Method has been advantageous in simulating complex boundary conditions and solving for fluid flow parameters by streaming and collision processes. This paper includes the study of three different test cases in a confined domain using the method of the Lattice Boltzmann model. 1. An SRT (Single Relaxation Time) approach in the Lattice Boltzmann model is used to simulate Lid Driven Cavity flow for different Reynolds Number (100, 400 and 1000) with a domain aspect ratio of 1, i.e., square cavity. A moment-based boundary condition is used for more accurate results. 2. A Thermal Lattice BGK (Bhatnagar-Gross-Krook) Model is developed for the Rayleigh Benard convection for both test cases - Horizontal and Vertical Temperature difference, considered separately for a Boussinesq incompressible fluid. The Rayleigh number is varied for both the test cases (10^3 ≤ Ra ≤ 10^6) keeping the Prandtl number at 0.71. A stability criteria with a precise forcing scheme is used for a greater level of accuracy. 3. The phase change problem governed by the heat-conduction equation is studied using the enthalpy based Lattice Boltzmann Model with a single iteration for each time step, thus reducing the computational time. A double distribution function approach with D2Q9 (density) model and D2Q5 (temperature) model are used for two different test cases-the conduction dominated melting and the convection dominated melting. The solidification process is also simulated using the enthalpy based method with a single distribution function using the D2Q5 model to provide a better understanding of the heat transport phenomenon. The domain for the test cases has an aspect ratio of 2 with some exceptions for a square cavity. An approximate velocity scale is chosen to ensure that the simulations are within the incompressible regime. Different parameters like velocities, temperature, Nusselt number, etc. are calculated for a comparative study with the existing works of literature. The simulated results demonstrate excellent agreement with the existing benchmark solution within an error limit of ± 0.05 implicates the viability of this method for complex fluid flow problems.

Keywords : BGK, Nusselt, Prandtl, Rayleigh, SRT
Conference Title : ICFMA 2020 : International Conference on Fluid Mechanics and Applications
Conference Location : Tokyo, Japan
Conference Dates : April 23-24, 2020