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Analysis of Temperature variation in a Mild steel plate using LBM

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Abstract— LBM is a method used for the computations in dynamics of fluid by fluid simulation. In the present study, a square plate (Mild steel plate) of 10 mm X 10 mm dimensions has been selected. The temperature variation and heat flow at different nodes through the plate from its one end to another end would be simulated by giving heat from room temperature to 100° C in MATLAB software, C++ etc. After the simulation process, the results of temperature variation at different nodes will be shown on Tech-Plots in the form graphs b/w temperature and distance from one end of the plate to another end of the plate.

Keywords—***LBM, Modelling, Simulation, Analytical approach.***

I. INTRODUCTION

The Lattice Boltzmann Method, commonly abbreviated to LBM, is a newer numerical method that has been slowly garnering interest in the fluids community since the 90's [3].The method models the distribution of and changes in a density distribution function using the Boltzmann kinetic equation. From this information the velocity profile is determined [6]. This unique approach allows for the modeling of complex flows with, relatively, short computing times and without any filtering.

LBM is a class of computational fluid dynamics (CFD) methods for fluid simulation. Instead of solving the Navier–Stokes equations, the discrete Boltzmann equation is solved to simulate the flow of a Newtonian fluid with collision models such as Bhatnagar–Gross–Krook (BGK)[18]. By simulating streaming and collision processes across a limited number of particles, the intrinsic particle interactions evince a microcosm of viscous flow behaviour applicable across the greater mass [11].

In the past few years, researchers have been using lattice Boltzmann method for simulating and modelling in physical, chemical, social systems including flows in magneto hydrodynamics, immiscible fluids, multiphase flows, heat transfer problems, porous media and isotropic turbulence [5]. Historically, LBM originated from the method of Lattice gas automata (LGA), which was first introduced in 1973 by Hardy, Pomeau and de Pazzis (HPP). In LGA, the term Lattice implies that one is working on a lattice which is dimensional and usually regular. Gas suggests that a gas is moving on the lattice. The gas is usually represented by Boolean particles (0 or 1). Automata indicate that the gas evolves according to a set of rules [9]. In the LGA model, the space, time and particle velocities are all discrete [7]. The iteration of an LGA consists of a collision and propagation step. But, the major drawbacks of the LGA were intrinsic noise, non-Galilean in variance, an unphysical velocity dependent pressure andlarge numerical viscosities. In 1986, Frisch, Hasslacher and Pomeau (FHP) obtained the correct Navier–Stokes equations using a hexagonal lattice. Lattice Boltzmann equations has been used at the cradle of Lattice Gas Automata (LGA) by Frisch et al. to calculate viscosity [16]. To eliminate statistical noise, in 1988 McNamara and Zanetti did away with the Boolean operation of LGA involving the particle occupation variables by neglecting particle correlations and introducing averaged distribution functions giving rise to the LBM[12]. An alternative approach to these computational fluid dynamics simulations was invented in the late 1980s with the lattice gas methods. These methods allowed particles to move on a discrete lattice and local collisions conserved mass and momentum. Because the continuity and Navier Stokes equations are only continuous forms of the mass and momentum conservation statements and method that locally conserves mass and momentum will obey some kind of continuity and Navier Stokes equations and it was shown that the lattice gas methods could be used to simulate (rather noisy) hydrodynamics. However, the lattice gas methods had several drawbacks consisting mainly of their noisy nature and the appearance of some additional terms in the Navier Stokes level equations that limited their success. It was then discovered that instead of discrete particles a density distribution could be adevecting which eliminated the noisiness of the method and allowed for a more general collision operator. This is the lattice Boltzmann method which has been extraordinarily successful for many applications including turbulence, multi-component and multi-phase flows as well als additional applications, including simulations of the Schrodinger equation. We start by introducing the Boltzmann equation and describe how the hydrodynamic equations can be obtained from the Boltzmann equation. We then show how the Boltzmann equation can be simulated by a very simple numerical method leading to the same hydrodynamic equations. Next we extend the lattice Boltzmann method to systems that are not typically described by a Boltzmann equation, namely non-ideal gases and phase-separating multi-component mixtures.

II. REVIEW OF LITERATURE

The Boltzmann equation relates the time evolution and spatial variation of a collection of molecules to a collision operator that describes the interaction of the molecules [1]. It is known that, the Boltzmann equation provides a more efficient presentation of gaseous flows for a whole range of flow regimes than the Navier–Stokes equation. But researchers generally prefer to use the conventional numerical methods (finited difference method, finite volume method, finite element method, etc.) based on the discretization of partial differential equations (Navier–Stokes equations) in continuum regime than solving the Boltzmann equations [4]. This is because solution of the Boltzmann equation is a non-trivial task owing to the complexity of the collision term [6].The development of Lattice Gas Automata (LGA) and Lattice Boltzmann Method (LBM) are the promising methods that use different kind of nonconventional techniques for applications in CFD[8]. The LGA, however, suffered from some drawbacks such as lack of Galilean invariance, statistical noise and unphysical solution (pressure depends on velocity). Investigators overcame the difficulties of LGA through the LBM using the simple model of linearized collision operator based on the Bhatnagar–Gross–Krook (LBGK) collision model [10].The justification for the LBM approach is the fact that the collective behaviour of many microscopic particles is behind the macroscopic dynamics of a fluid and this dynamics is not particularly dependent on the details of the microscopic phenomena exhibited by the individual molecules [13]. It is the solution of a minimal Boltzmann kinetic equation, rather than the discretization of the Navier–Stokes equations of continuum mechanics [15]. It provides stable and efficient numerical calculations for the macroscopic behaviour of fluids, although describing the fluid in a microscopic way.

III. PROBLEM FORMULATION

LBM is a method used for the computations in dynamics of fluid by fluid simulation. In the present study, a square plate (Mild steel plate) of 10 mm X 10 mm dimensions has been selected. The temperature variation and heat flow at different nodes through the plate from its one end to another end would be simulated by giving heat from room temperature to 100° C in MATLAB software, C++ etc. After the simulation process, the results of temperature variation at different nodes will be shown on Tech-Plots in the form graphs b/w temperature and distance from one end of the plate to another end of the plate.

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