INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.

Thesis Title: Numerical Investigations of Incompressible Buoyancy-driven Flows over Wide Parametric Ranges using Lattice Boltzmann Method

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SHORT ABSTRACT

This thesis presents a comprehensive exploration of the Lattice Boltzmann Method (LBM) applied to buoyancy-driven flow in a single fluid phase. Using the D2Q9 lattice and the LBGK method in two dimensions, the developed LBM codes showcase remarkable performance across diverse problem sets. Rigorous validation exercises ensure the accuracy and realism of parameterizations. The research begins with validations through simulations of benchmark isothermal and thermal flow problems, followed by the application of the thermal lattice Boltzmann method (TLBM) to study natural convection, including non-Boussinesq simulations.

Key findings include the increasing significance of fluid friction in entropy production beyond a critical Rayleigh number (Ra). The thesis delves into the dynamics of buoyancy-driven flow in confined spaces, shedding light on fluid behavior induced by density differences. It examines mixed convection problems on three configurations, revealing insights into influential parameters such as inclination angle (ϕ), aspect ratio (AR), and velocity ratio.

Furthermore, the study extends to investigate the impact of nanofluids on the thermal-hydraulic behavior of natural circulation loops (NCLs), aiming to optimize performance by reducing entropy generation. Various thermal boundary conditions, including isothermal, constant heat flux, linearly increasing, linearly decreasing, and sinusoidal heat flux, are explored. Results indicate that sinusoidal heat flux conditions enhance convective heat transfer through fluid mixing, while linearly decreasing flux conditions exhibit the highest fluctuation in entropy generation.

Overall, this research contributes valuable insights into the dynamics of buoyancy-driven flows in confined spaces and the optimization of thermal-hydraulic systems using nanofluids. It provides a unified approach to investigate complex phenomena, offering potential avenues for improving the efficiency and performance of fluid systems in diverse applications.