MHD Convection in Vented Channel-driven Cavity with Adiabatic Rod

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1. INTRODUCTION AND OBJECTIVE

The demand for efficient cooling in the electronic industry has put a challenge to traditional cooling methods like natural convection. As a result, mixed convection has emerged as a popular alternative over the years.

Mixed convection, which combines forced and natural convection, is a valuable technique for heat transfer in thermal systems with cavity-like structures. The forced convective flow can be generated by external forces acting on the fluid. In a typical driven cavity, the mixed convective flow arises from two mechanisms: the shearing action caused by wall motion (kinetic force due to forced flow) and the buoyancy-induced flow resulting from thermal gradients (potential force due to density variation).

Moreover, the presence of a magnetic field significantly affects the dynamics of convective flow. When mixed convection and magnetic field coexist, it is referred to as magnetohydrodynamic (MHD) convection [1]. By adjusting the strength of the magnetic field, the heat transfer characteristics can be controlled to meet specific requirements. MHD convection systems find practical applications in various fields, including material processing, liquid metal cooling systems, cooling in quantum machinery, metal casting and solidification processes, nuclear reactors, air-conditioning, microelectronic devices, and spacecraft propulsion. Overall, the utilization of MHD convection offers promising opportunities for enhancing heat transfer in a wide range of industrial applications.

In this study, we investigate the flow structure and heat transfer characteristics within a vented channel-driven cavity. The walls of the cavity are maintained at different temperatures, and an adiabatic rod is positioned vertically downward from the top wall of the channel to redirect the external forced flow towards the interior of the square cavity. Moreover, a magnetic field is applied to the system. To tackle the governing equations, we employ the finite difference method. Nusselt number is considered as the sensitivity for heat transfer. Our investigation focuses on the influence of various governing physical parameters, such as Reynolds, Richardson, and Hartmann numbers.

2. RESULTS AND HIGHLIGHTS

The study yielded significant findings concerning the investigation of flow structure and heat transfer characteristics in the vented channel-driven cavity. The introduction of the adiabatic rod and the application of the magnetic field resulted in pronounced variations in the flow patterns and heat transfer processes. It also examines how changing the height of the adiabatic rod affects heat transfer in the range of Ri from 0.01 to 10. It is observed that heat transfer is significantly improved when an insulated rod is present. The study also suggests that the height of the baffle should be adjusted depending on the direction of the external flow for optimal performance. Add to this, the application of a magnetic field reduces heat transfer and turbulence caused by forced convection in the fluid flow.

REFERENCES

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