Enhancing Thermo-Convection Flow in a Ventilated Cavity Using Electro-Hydrodynamics

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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 an electric field significantly affects the dynamics of convective flow. When temperature gradient and electric field coexist, it is referred to as electro-thermo-hydrodynamics (ETHD) [1]. By adjusting the strength of the electric charge injection, the heat transfer characteristics can be controlled to meet specific requirements. ETHD convection systems find practical applications in various fields, including cooling electronic devices, enhancing microfluidics and heat exchanger efficiency, and improving crystal growth processes. Additionally, ETHD systems find use in biomedical applications like targeted drug delivery and in developing electro-hydrodynamic pumps for reliable, maintenance-free fluid transport. These applications highlight the significant role of ETHD systems in advancing technology and engineering solutions.

The study involved doing numerical experiments to find out how electro-hydrodynamic convection effects on a mixed convection flow within a square cavity, influenced by an opposed flow through two ventilation channels. The left wall was a source of the electric emitter that heats up the wall, having a collector electrode on the opposite wall. The rest of the walls were electrically and thermally insulated. 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 electrical Rayleigh numbers.

2. RESULTS AND HIGHLIGHTS

The study yielded significant findings concerning the investigation of flow structure and heat transfer characteristics in the vented dual-channel-driven cavity. The application of the electric field resulted in pronounced variations in the flow patterns and heat transfer processes. The study reported that electrical activity enhances heat transfer, with an increase of 88% for the low buoyancy at Ri = 0.1, and 25% for the high buoyancy at Ri = 20. While a 52% increase in heat transfer by the Richardson number is made in pure thermal convection, this gain falls to 13% and 2% with medium and strong electrical effects, respectively.

REFERENCES

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