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# Natural convection in an inclined quadrantal cavity heated and cooled on adjacent walls

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ABSTRACT

Natural convective flow and heat transfer in an inclined quadrantal cavity is studied experimentally and numerically. The particle tracing method is used to visualize the fluid motion in the enclosure. Numerical solutions are obtained via a commercial CFD package, Fluent. The working fluid is distilled water. The effects of the inclination angle, $\phi$ and the Rayleigh number, Ra on fluid flow and heat transfer are investigated for the range of angle of inclination between $0^\circ \leqslant \phi \leqslant 360^\circ$, and Ra from $10^5$ to $10^7$. It is disclosed that heat transfer changes dramatically according to the inclination angle which affects convection currents inside, i.e. flow physics inside. A fairly good agreement is observed between the experimental and numerical results.



## 1. Introduction

The study of buoyancy-induced flows in enclosures has numerous applications including solar energy collection, nuclear energy, cooling of electronic components, micro-electromechanical systems (MEMS), lubricating grooves, etc. Besides its importance in such processes, due to the coupling of fluid flow and energy transport, the phenomenon of natural convection still remains as an interesting field of investigation and therefore attracts a great deal of researchers.

The existing literature presents a vast number of studies on natural convection in enclosures. However, most of these studies have been related to either a vertically or horizontally imposed heat flux or temperature difference. There is little work regarding natural convection in enclosures with differentially heated neighboring horizontal and vertical walls, e.g. November and Nansteel [1], Ganzarolli and Milanez [2], Aydin et al. [3,4], Aydin and Yang [5], Corvaro and Paronconi [6], Ishihara et al. [7], Ameziani et al. [8].

On the other hand, a great number of studies existing in the literature have been carried out for simple square and rectangular enclosures. As Shiina et al. [9] reported those investigations do not serve us to determine natural convection in real enclosures with more complex geometries such as building systems with complex geometries and energy systems. They studied natural convection in a hemisphere heated from below. Chen and Cheng [10] performed a numerical and experimental study on natural convection inside an inclined arc-shaped enclosure. They emphasized that irregular shaped enclosures had not been sufficiently analyzed yet despite the fact that they have relevance to some engineering applications such as concentrating solar collectors, lubrication systems and air-conditioning devices. Kim et al. [11] studied steady-state natural convection in a meniscus-shaped cavity.

It should be also noted that many of the studies in the open literature are numerical only. In many of these studies, similar geometries are investigated very easily, which are too far from the interest of the practice. In addition, sometimes, additional effects are included in these studies, whose results are to be validated through analytical if available or experimental studies. However, there is scarcity of experimental research when compared enormous number of theoretical ones.

In a recent study, Aydin and Yesiloz [12] studied buoyancy-induced flow and heat transfer mechanisms in a water-filled quadrantal cavity experimentally and numerically. The adjacent walls of the cavity are isothermal at different temperatures, while the curved wall is kept adiabatic. As an extension of that study, the aim of this study is mainly concentrated on the effect of inclination angle on steady state buoyancy-induced flow and heat transfer. The range of $0^\circ \leqslant \phi \leqslant 360^\circ$ of the inclination angle and Rayleigh number range of $10^5$–$10^7$ are considered. To the best knowledge of the authors, this is the first natural convection study on this geometry.

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