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Experimental PIV and interferometric analysis of natural convection in a square enclosure with partially active hot and cold walls

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ABSTRACT

In this paper a PIV and Holographic interferometry measuring campaign on natural convection in a square cavity (side $H = 0.05$ m) filled with air at atmospheric pressure ($Pr = 0.71$) is presented. Two strips (cold and hot) are applied on the vertical sides of the enclosure; tests involve three different configurations, with the hot strip in the middle of one wall, and the cold strip at the bottom, in the middle or at the top of the opposite wall. For each configuration measures are performed with different temperatures of the hot strip. The aim of the paper is to investigate the relation between dynamic and temperature fields and to describe how the flow and the heat transfer inside the cavity are influenced by the temperature of the hot strip and the position of the cold strip. Velocity maps, streamlines maps and interferograms are presented; the average Nusselt number and an expression of *Nu(Ra)* for each configuration are calculated. Results show that the configuration with the cold strip at the top of the wall produces the fastest dynamic field and the highest Nusselt number.

1. Introduction

Natural convection in enclosures plays a major role in a number of applications: cooling of electronic or mechanical systems, solar energy, insulating materials, building design, etc. In most cases knowledge about natural convection is used either to maximize or minimize the heat exchanged in a particular situation.

For this reason, many authors have given particular attention to this kind of phenomenon and different studies have been done, especially in the recent years, both numerically and experimentally.

General description of natural convection, with particular dedication to the knowledge of convection in cavities can be found in references [1–4].

A very large amount of studies is present in literature especially regarding rectangular cavities, with analysis considering different aspect ratios. While numerical methods allow a complete characterization of the cavity (in terms of dynamic and thermal fields), it is rare to find a complete experimental analysis of the cavity. Also, most papers consider configurations where each wall presents a homogeneous condition, either isothermal, adiabatic or with a constant heat flux.

The concern about partially heated or cooled walls is more recent, and also, for a given geometry (for example for square cavities), the number of boundary conditions that can be studied is virtually infinite. This is the reason why literature regarding cavities with partially active walls is still limited: numerical studies involving this particular situations are those by Türkoglu and Yücel [5] and Valencia and Frederick [6] who investigated the effect of heater and cooler position; reference [7] combines the effect of aspect ratio with the effect of heater size and position and also very recent studies dealing with partially heated walls are refs. [8] and [9].

Regarding experimental work, Turner and Flack [10] describe a rectangular cavity with a concentrated hot source, and analyze the temperature field in it through a Wallaston prism schlieren interferometer.

No papers containing both dynamic and thermal experimental investigations have been found for the geometry and boundary conditions analyzed; only a previous papers by Paroncini et al. [11] contains some experimental results concerning natural convection in square enclosures with partially active walls.

In this paper a measuring campaign on natural convection in a square enclosure filled with air is presented. The enclosure has two active strips (hot and cold) on the side walls and is filled with air at atmospheric pressure. Investigation is carried by analyzing temperature and velocity fields at different Ra (obtained by changing the hot strip's temperature, in the range $Ra = 5.5 \times 10^4 \div 2.5 \times 10^5$ for holographic interferometry and $Ra = 5.5 \times 10^4 \div 4.0 \times 10^5$ for PIV) and different positions of the cold strip on the wall. The

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