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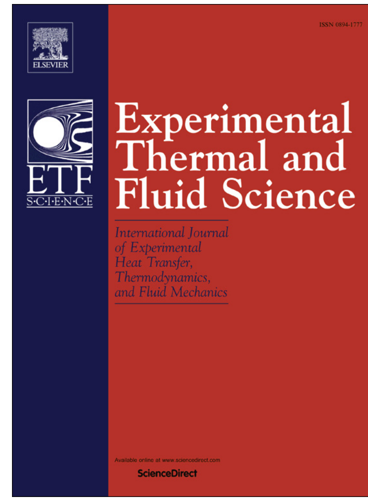

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Experimental and numerical investigation of natural convection in a rectangular cuboid filled by two immiscible fluids

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Abstract

Three-dimensional natural convection in a rectangular cuboid filled by two immiscible fluids of water and air at different liquid height ratios has been studied experimentally and numerically. An uniform flux heater is located on one of the side walls and the other side-walls are insulated with insulator materials. Top and bottom walls are set at a constant cold temperature. Measurements are carried out for different liquid height ratios of AR=0.5, 0.625, 0.75 and 0.875 and Rayleigh numbers of $Ra=1.4\times10^8$, 2.79×10^8, 6.98×10^8 and 8.37×10^8. Height, width and length of the cuboid enclosure are 400mm, 200mm and 400mm respectively. The surface temperatures of the heated wall are measured using the LM-35 electronic sensors while twenty cylindrical watertight slots for inserting the PT100 temperature sensor are placed on midline (Z=0.5) of opposite side wall of the heated wall, so the sensor probe can slides through the slots horizontally. They are distributed on the midline (Z=0.5) as a vertical array with same distances. Also in this paper, a 3D computational work has been carried out to analyze the natural convection numerically. The finite volume approach is utilized for numerical solutions of the continuity, momentum and energy transport equations. The numerical and experimental results are compared and a good consistency was observed. Measurements and numerical results of the temperature distributions between vertical and horizontal walls for different fluid interface height ratios and Rayleigh numbers are presented. The variation of average Nusselt number along the heater with Rayleigh number and liquid interface aspect ratio are obtained. An uncertainty analysis is also done for experimental data.

Keywords: Natural convection; Rectangular cuboid; Immiscible fluids; Experimental; Numerical;

1. Introduction

The natural convection phenomenon heat transfer in enclosures has enormous engineering applications such as Lead-Acid batteries, MEMS devices, heat exchanger and so on.[1-4] As a result of this matter, many researchers carried out some investigations to analyze this phenomenon in cavities with different geometries, boundary conditions and fluids.