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Numerical simulation of free convection of nanofluid in a square cavity with an inside heater

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ABSTRACT

In the present paper, free convection fluid flow and heat transfer of various water based nanofluids in a square cavity with an inside thin heater has been investigated numerically. The left and right walls of the cavity are maintained at constant temperature T_c, while its top and bottom walls are insulated. A thin heater with the temperature of T_h ($T_h > T_c$) is located inside the cavity which its location and length is varying. The governing equations were discretized using the finite volume method and SIMPLER algorithm. Using the developed code, a parametric study was undertaken, and the effects of pertinent parameters, such as, Rayleigh number, the position and location of the heater, the volume fraction of the nanoparticles, and various types of the nanofluids on the fluid flow and heat transfer inside the cavity were investigated. It was observed from the results that at low Rayleigh numbers the horizontal positioned heater have higher Nusselt number compared to the vertical positioned heater while at high Rayleigh numbers the position of the heater does not affect the heat transfer rate. For a horizontal heater when it is located in lower half of the cavity, more heat transfer occurs compared to the case of heater located in upper half of the cavity. Moreover, it was found that at high Rayleigh numbers, the Ag–water nanofluid is more effective to enhance the heat transfer rate while at low Rayleigh numbers the type of nanofluids does not affect the heat transfer rate.

1. Introduction

Free convection fluid flow and heat transfer occurs in many engineering systems, such as solar collectors, home ventilation, fire prevention, reactor insulation, power plant, etc. [1]. Different aspects of free convection heat transfer in rectangular cavities have been investigated thoroughly by many researchers [2–6].

Heat transfer from a localized heater inside a rectangular cavity is considered as a model of electronic devices and equipment cooling. An efficient cooling is essential for these electronic equipments and many researchers, have been investigated free convection in cavities with different shapes of heaters. Close et al. [7] conducted a numerical study to observe heat transfer from a vertically located heater in a cavity. They found that gas/vapor mixtures can provide an efficient cooling method for electronic devise problem. Sun and Emery [8] studied conjugate heat transfer inside a cavity with heat source and internal baffle, numerically and experimentally. Their results showed that for a cavity with conductive baffle, heat transfer was a function of baffle conduction, fluid convection and strength of internal heating when the baffle was located near the walls. Uralcan [9] numerically and experimentally, studied free convection heat transfer from heated square localized inside an open cavity. He found that both flow pattern and temperature distribution were affected by the location of the heated square. Oztop et al. [10] using a numerical simulation studied effect of position of a heater in a cavity with cold vertical walls and adiabatic horizontal walls. Their results showed that mean Nusselt number at both vertical and horizontal location position increased with increase in Rayleigh number and length of the heater. Tasnim and Collins [11] investigated the problem of laminar free convection heat transfer in a square cavity with an adiabatic arc-shaped baffle. They found that the degree of flow modification due to blockage of the baffle was enhanced by increase in the shape parameter of the baffle. Abdul Hakeem et al. [12] conducted a numerical study on free convection in a square cavity with discretely heat generating baffles. They found that fluid flow and temperature fields strongly depend on location of the baffles. Also they found that the movement of either the horizontal or vertical plate produced no significant changes in the overall heat transfer rate except when one of them was wall mounted. Kandaswamy et al. [13] numerically studied free convection heat transfer in a square cavity induced by two mutually orthogonal and arbitrarily located baffles. Their results showed that overall heat transfer in the cavity was enhanced for higher value of

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