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Free convection in a triangle cavity filled with a porous medium saturated with nanofluids with flush mounted heater on the wall

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ABSTRACT

Steady-state free convection heat transfer behavior of nanofluids is investigated numerically inside a right-angle triangular enclosure filled with a porous medium. The flush mounted heater with finite size is placed on the left vertical wall. The temperature of the inclined wall is lower than the heater, and the rest of walls are adiabatic. The governing equations are obtained based on the Darcy's law and the nanofluid model proposed by Tiwari and Das [1]. The transformed dimensionless governing equations were solved by finite difference method and solution for algebraic equations was obtained through Successive Under Relaxation method. Investigations with three types of nanofluids were made for different values of Rayleigh number Ra of a porous medium with the range of $10 \leq Ra \leq 1000$, size of heater Ht as $0.1 \leq Ht \leq 0.9$, position of heater Y_p when $0.25 \leq Y_p \leq 0.75$, enclosure aspect ratio AR as $0.5 \leq AR \leq 1.5$ and solid volume fraction parameter ϕ of nanofluids with the range of $0.0 \leq \phi \leq 0.2$. It is found that the maximum value of average Nusselt number is obtained by decreasing the enclosure aspect ratio and lowering the heater position with the highest value of Rayleigh number and the largest size of heater. It is further observed that the heat transfer in the cavity is improved with the increasing of solid volume fraction parameter of nanofluids at low Rayleigh number, but opposite effects appear when the Rayleigh number is high.

1. Introduction

Heat and fluid flow in cavities filled with porous media are well-known natural phenomenon and have attracted interest of many researchers due to its many practical situations. Among these insulation materials, geophysics applications, building heating and cooling operations, underground heat pump systems, solar engineering and material science can be listed. These are reviewed in several books: Pop and Ingham [2], Bejan et al. [3], Ingham and Pop [4], Nield and Bejan [5], Vafai [6,7], Vadasz [8] and in the papers by Varol et al. [9], Varol et al. [10] and Basak et al. [11,12].

A technique for improving heat transfer is using solid particles in the base fluids, which has been used recently. The term nanofluid, first introduced by Choi [13], refers to fluids in which nano-scale particles are suspended in the base fluid. He suggested that introducing nanoparticles with higher thermal conductivity into the base fluid results in a higher thermal performance for the resultant nanofluid. It is expected that the presence of the nanoparticles in the nanofluid increases its thermal conductivity and therefore, substantially enhances the heat transfer characteristics of the nanofluid [13]. Use of metallic nanoparticles with high thermal conductivity will increase the effective thermal conductivity of these types of fluid remarkably. However, the increase in the thermal conductivity depends on the shape, size and thermal properties of the solid particles [14]. It must, however, be noted that heat transfer enhancement by means of nanofluids is still a controversial issue. Contradictory studies have also been reported in the literature, which argue that the dispersion of nanoparticles in the base fluid may results in a considerable decrease in the heat transfer [15,16]. It has been demonstrated that the augmentation or mitigation of the heat transfer found in the numerical studies depends on the existing models used to predict the properties of the nanofluids [17,18]. Buongiorno [19] noted that the nanoparticle absolute velocity can be viewed as the sum of the base fluid velocity and a relative velocity (that he calls the slip velocity). He has shown that in the absence of turbulent effects, it is the Brownian diffusion and the thermophoresis that are important and he has written down conservation equations based on these two effects. There are several numerical and experimental studies on the forced and natural convection using nanofluids related with differentially

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