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Natural convective Cu-water nanofluid flow in isosceles triangular cavity with forced free stream cooled sides and localized heated base

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ABSTRACT

The present paper aims to conduct a numerical investigation of the natural convective flow of Cu-water nanofluid in an isosceles triangular-shaped cavity, where an air stream cools the lateral walls while its base is subjected to discrete heating. The governing equations are numerically solved using the finite volume method (FVM) employing ANSYS FLUENT. The results are presented with diverse scopes of pertinent parameters, including non-dimensional heater length (L/H = 0.25, 0.5, and 1), Rayleigh Number (Ra = 10^4, 10^5, and 10^6), nanoparticles volume fraction (φ = 0, 0.03, 0.06 and 0.09), and free stream Reynolds number ($Re_\infty = 10^2, 10^3, 10^4$ and 10^5). The impact of each of these parameters is depicted on the isotherms (θ) lines, stream function (ψ) contours, and the average Nusselt number (Nu_{avg}) plots on the heated lower wall. The findings showed the subsequent enlargements in Nu_{avg} with an increase in Ra by 515 %, L/H by 130 %, Re_∞ by 43 %, and φ by 137 %, indicating an enhancement in the heat transfer rate with these parameters. Besides, extra secondary eddies will be generated inside the cavity when Ra becomes more extensive, while the flow configuration is not influenced by the enlargement of φ, Re_∞, and L/H. The present model findings have been compared with other work from the literature and showed an acceptable agreement with a maximum error of less than 1 %.

1. Introduction

Investigation of heat transfer characteristics and flow field, especially for free convection within enclosures filled with nanoparticles, to improve the thermal systems, is of great function in many engineering applications like electronic appliances' cooling, heat exchangers, solar collectors, nuclear reactor design, cryogenic storage, and industrial furnace design [1–6]. So, many researchers have studied this subject from different aspects. Rahman et al. [7] discussed the influences of enclosure tilt angle and nanofluid volume fraction (φ) on the temperature and flow fields. The amount of heat transmission for the mixed convection was also deemed in their study. Their study was applied to a triangular enclosure with a cooled inclined-wall lid-driven, heated base surface, an adiabatic vertical wall moving at a constant velocity, and occupied with Cu- water nanofluid. Ahmed et al. [8] examined the free convection in a triangular enclosure filled with Cu-water nanofluid. They deemed the inclined enclosure wall cold, the vertical wall insulated, and the base heated partially. The influences of φ, the Rayleigh number (Ra) on streamlines, isotherms' contours, and Nusselt number were taken into account. Selimefendigil and Öztop [9] achieved a numerical investigation of mixed-convective Magnetohydrodynamics (MHD) flow in a triangular enclosure filled with Cu-water nanofluid with a rotating cylinder. They studied the impact of the Grashof number, φ, Hartmann number, and angular velocity of a rotary cylinder on the transfer of heat and flow field. Öztop et al. [10] accomplished a theoretical and experimental review of the free convection flow field and heat transfer inside enclosures of various types with localized heating and filled by a nanofluid or a simple fluid. The influences of location and type of local heat sources and different forms of boundary conditions and cavities on the enclosed heat transfer and flow field were reviewed in their work. Triveni et al. [11] achieved a numerical simulation using the FLUENT package to examine the free convection in a triangular cavity with a right-shaped angle, heated partially from the bottom. They studied the effects of Ra, cold wall positions, and partial heating on the flow field characteristics and temperature profile. Boulahia et al. [12] performed a numerical investigation of mixed-convective nanofluid flow in a square-shaped cavity with two-sided moving walls and heat sources of triangular shape. They considered that the left and right sides of the cavity should be cooled at invariant temperature, while the bottom and upper moving walls should be insulated thermally. They discussed the impact of φ, Richardson number, kind, and size of

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