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Industrial & Engineering Chemistry Research

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pubs.acs.org/IECR

Laminar Mixed Convection in Inclined Triangular Enclosures Filled with Water Based Cu Nanofluid

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ABSTRACT: This paper presents the results on mixed convection in an inclined lid-driven triangular enclosure filled with water based Cu nanofluid. The enclosure is cooled at the inclined surface and simultaneously heated at the base surface. The vertical wall is adiabatic and moving at a constant speed. The governing equations are solved numerically by the Galerkin finite element method. The effects of parameters such as the Richardson number, nanoparticle volume fraction, and tilt angle on the flow and thermal fields as well as the heat transfer rate of the heated surface are taken into account. The overall heat transfer rate of the heated surface is characterized by the average Nusselt number at the heated surface. It has been observed that the effects of the tilt angle and solid volume fractions are significant on the flow and thermal fields. Besides, an optimum value for the solid volume fraction is found, which results in the maximum heat transfer rate at the considered values of the Richardson numbers. The rate of the increase of the average Nusselt number is slow for higher values of the tilt angle while it is much quicker for lower values of the tilt angle.

1. INTRODUCTION

The problem of convection (forced, mixed, or natural) in a two-dimensional cross sectional heated triangular enclosure is of great interest to the computational fluid dynamics community for their practical applications such as attic space heating or cooling of electronic equipment, and solar air heaters.[1−6]

Previous studies were mostly performed on the different flow systems in triangular enclosures. Basak et al.[7] numerically studied the phenomena of natural convection in a right-angled triangular enclosure. The objective of their study was to examine the flow and thermal fields with comprehensive study of heat transfer estimate for natural convection in a triangular enclosure. Omri et al.[8] analyzed natural convection flows using a control volume finite element method in the isosceles triangular cavities. Chen and Cheng[9] numerically studied the effects of lid oscillation on the periodic flow pattern and convection heat transfer in a triangular cavity. Kent et al.[10] investigated natural convection in different triangular enclosures with boundary conditions representing the wintertime heating of an attic space. Varol et al.[11] numerically analyzed natural convection heat transfer in a triangular enclosure with a flush mounted heater on the wall. They used the finite difference method in their computations. The authors found that both the position and location of the heater affect the flow circulation and heat transfer in the enclosure. Later, Varol et al.[12] made a numerical study of natural convection heat transfer from a protruding heater located in a triangular enclosure. Koca et al.[13] analyzed the effect of Prandtl number on natural convection heat transfer and fluid flow in triangular enclosures with localized heating. The authors found that both flow and temperature fields are affected by the change of Prandtl number, Rayleigh number, and the location and length of the heater. Basak et al.[14] investigated the effects of uniform and nonuniform heating of inclined walls on natural convection flows within an isosceles triangular enclosure using a penalty finite element method with biquadratic elements. They observed that nonuniform heating produces higher heat transfer rates at the center of the walls than is the case with uniform heating.

Nanofluids are a new class of fluids, which consist of a base fluid in the presence of nanoscale materials.[15] The convective heat transfer feature of nanofluids is affected by the thermophysical properties of the base fluid and nanoparticles. The function of a meticulous nanofluid for a heat transfer intention can be dealt with quite accurately by modeling the convective transportation in the nanofluid.[16] In recent years, convective heat transfer using nanofluids has received attention because of the promising prospect of nanofluids in enhancing heat transfer. Khanafer et al.[17] numerically studied natural convection of copper−water nanofluid in a two-dimensional enclosure. The authors found that, at any given Grashof

Received: June 9, 2011
Revised: January 21, 2012
Accepted: February 7, 2012
Published: February 7, 2012