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Numerical Study of Magneto-Hydrothermal Along a Horizontal Concentric Annulus Deposited by a Ternary Hybrid Nanofluid Formed by Different Types and Shapes of Nanoparticles

NIHAL Necib[1,2*], MOHAMMED. Benkhedda[1,2], EMREHAN. Gürsoy[3], ENGİN. Gedik[4]

[1] Physics Department, Faculty of Sciences, University of M'Hamed Bougara, Boumerdes, Algeria
[2] Coatings, Materials and Environment Laboratory, University of M'hamed Bougara, Boumerdes, Algeria
[3] Department of Energy Systems Engineering, Institute of Graduate Programs, Karabük University, Karabük, Türkiye
[4] Department of Mechanical Engineering, Karabük University, Karabük, Türkiye
*Corresponding author's email: n.necib@univ-boumerde.dz

ABSTRACT

Transport of Heat transfer phenomena related to magneto-hydrothermal for laminar flow forced convection have recently has become an important area of study because of their multi-thermal industrial applications such as electronics cooling, solar collectors, thermal exchangers, medical, and others. The current study aims to analyze the magneto-hydrothermal induced by imposed uniform heat flux at the external cylinder for laminar flow with the presence of three types (Fe_2O_3, CNT, and Gr) and shapes (spherical, cylindrical, and platelet) of nanoparticles inside a horizontal concentric cylindrical annulus. The partials conservations equations continuity, momentum, and energy with the appropriate boundary conditions are solved using ANSYS Fluent software. Single-phase approach is adopted. The originality of this study is to investigate the influence of the magnetic field. The effects of different Hartman numbers (Ha) for one Reynolds number (Re) and single volume fraction (ϕ) on the velocity and temperature profile are comprehensive detail. The results showed a dependence of the ternary hybrid nanofluid flow behavior on both the strength and direction of the magnetic field. The perpendicular position of the uniform magnetic field to the flow direction induces a notable alteration in both hydrodynamic and thermal distribution along the annulus.

Keywords: Laminar, ternary nanofluid, magnetic field, forced convection, annulus.

1. Introduction

Hybrid nanofluids are relatively new class of engineered fluids synthesized by suspending two types of nano-sized particles such as metallic Cu, Ag, Al, oxide metallic TiO_2, Al_2O_3, CuO, or carbon nanotube particles CNT's, MWCNT's with less than 100 nm in a traditional fluid like water or oil, etc. Maxwell [1] was the first to introduce micrometric sized particles into the base fluid. The term "Nanofluid" was invented for the first time by Choi in (1995) [2], at the National Laboratory of Argonne, U.S.A. Nanofluids have a wide range of applications, such as automobile engine electronic devices, refrigeration, and in solar thermal collectors [3,4]. The high thermal conductivity of nanofluids was an innovative way to improve heat transfer. Another technique to boost heat transfer is the application of the magnetic field, this technique has sparked the attention of many researchers [5]. In the present study the main objectif is to explore a magneto-laminar forced convection using a ternary hybrid nanofluid that contains different types and shapes of nanoparticles (Fe_3O_4) with spherical shape, carbon nanotubes (CNT) with cylindrical shape, Graphene (Gr) with platelet shape dispersed in water-based fluid through an annular duct. The investigation is carried out through a numerical simulation, taking into account the effect of Hartmann number.

2. Physical model

The geometry schematic is illustrated in Figure 1, it comprises two horizontal concentric cylinders with 10 and 5 mm for outer and inner diameters respectively, and the length is 100 times the hydraulic diameter D_h. The outer cylinder is subjected to constant heat flux, while the inner cylinder is adiabatic. The hybrid

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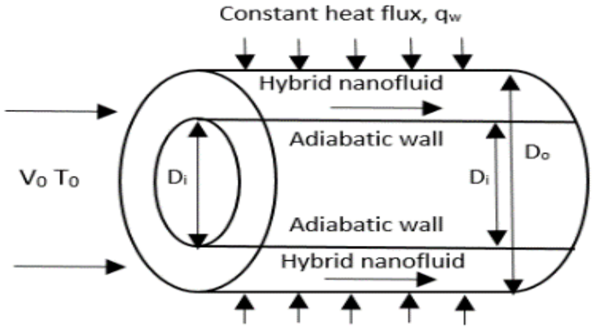
nanofluid enters at a constant axial velocity, v_0, and a constant temperature, T_0.



3. Numerical simulation

The finite volume method was used to solve the governing equations with the appropriate boundary conditions using computational fluid dynamics software ANSYS-Fluent.

4. Results and Discussion

Figure 2 shows the axial velocity contours at the outlet of the duct with and without magnetic field. The results are taken for ϕ=5%, and Re=800. As can be seen, in the absence of a magnetic field (Ha=0), the velocity contours exhibit circular pattern. However, when the magnetic field is applied, a noticeable deformation occurs, causing the concentric circles in the middle to split into two parts. This behavior can be attributed due to the influence of the magnetic field.

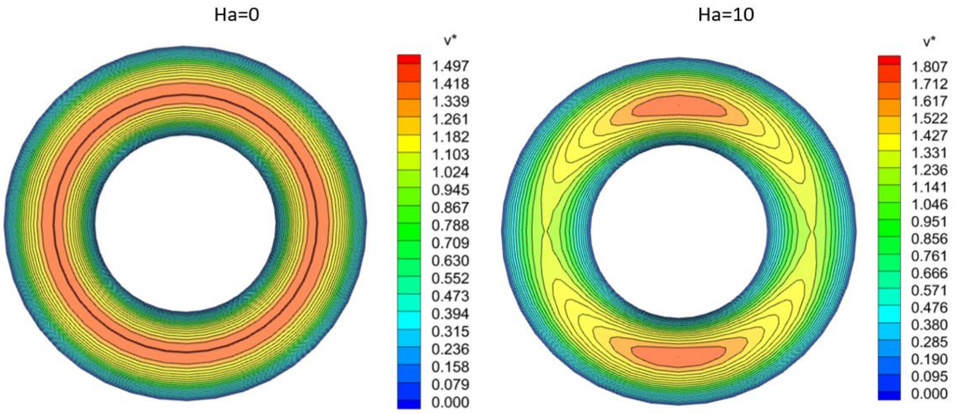


Figure 2: Axial velocity contours at the outlet of the duct for different Hartmann number

Figure 3 shows the 3D isotherms contours for different Hartmann number. At (Ha=0), temperature contours take the shape of concentric circles, which follow a radial and axial stratification. As the magnetic field perpendicular to the fluid flow is applied (Ha=10), a deformation occurs, transforming the circles into ovals. This deformation signifies changes in heat distribution patterns due to the magnetic field's impact on the fluid flow.

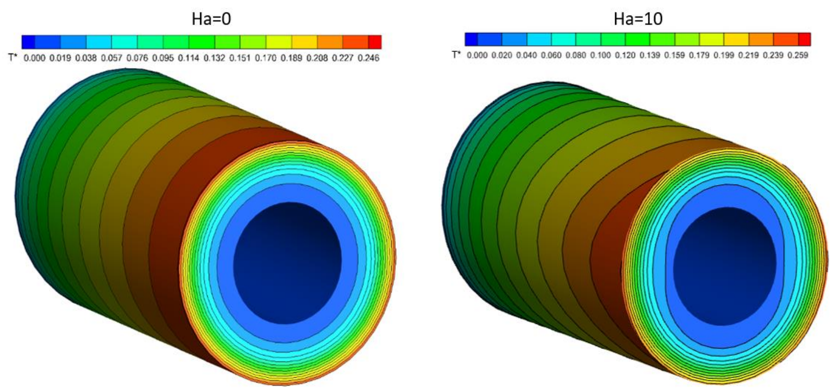


Figure 3: 3D isotherm contours for different Hartmann number

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5. Conclusions

In this study, laminar forced convection heat transfer in a horizontal annular duct filled with ternary hybrid nanofluid containing Fe_3O_4 with spherical shape, CNT with cylindrical shape and Gr with platelet shape disersed in water based fluid is investigated numerically. The obtained results found that applying a uniform magnetic field perpendicular to the flow induces a notable alterations in both hydrodynamic and thermal distribution along the duct.

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