CHAPTER 4

MAGNETISED HYBRID NANOFLUID ON A HORIZONTAL SURFACE

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4.1 INTRODUCTION

Nanofluids are fluids containing nano-sized particles suspended in a base medium, typically a liquid. They have engineered materials with unique properties and are being explored for a variety of applications. Nanofluids have fascinated the research community's interest since their introduction by Choi and Eastman (1995). Nanoparticles in fluid create a new class of fluids with novel properties not found in their base, carrier, or medium. This is due to the big surface area presented by the nanoparticles, which encourages particles to interact with their environment differently than they would in bulk form. The nanoparticles in nanofluids often affect their thermal conductivity, viscosity, and other properties, providing opportunities for novel applications. When introducing nanofluids, Choi and Eastman (1995) used the terms "amorphous and semi aqueous colloidal particles in a liquid." "nanofluids" quickly replaced this term, which describes the new class.

Researchers have paid increasing attention to nanofluids in recent years. This is due to their top performance in the heat transfer mechanism. For instants, Mahat et al. (2018) utilised the Keller-box technique to study the flow of a viscoelastic nanofluid via a cylinder with viscous dissipation present. It is revealed that the temperature and heat transmission are impacted by viscous dissipation. Later he, expended the work by contrasting the two boundary circumstances—constant heat flow and convective boundary conditions, respectively. The analysed of cooling applications by using the finite difference method has been deeply investigated by Hanif (2021). Adnan et al. (2022) studied the heat transport of a nanofluid made of silver and nanodiamond nanomaterials. It is observed that both have high thermal performance characteristics.

There are lots of researchers interested in studying the applications of nanofluids in engineering and industry. Keeping this view, Khattak et al. (2020) examined nanofluids' applications as a heat exchanger's coolant. They reported the unique features of nanofluids, heat transfer mechanism and heat transfer enhancement. Louis et al. (2022) have reported on a critical assessment of nanofluid uses in double-pipe heat exchangers. According to reports, the primary factors influencing the heat transmission coefficients of nanofluids are their viscosity and thermal conductivity. Several recent significant studies in this regard such as Hanif and Shafie (2022c), Riehl and Mancin (2022), Abbas et al. 2022 and Hanif and Shafie (2022b).

Another interesting effect that attracts the interest of most researchers is Magnetohydrodynamics (MHD). To gain a better understanding of how a fluid moves in a magnetic field, MHD is studied. In MHD, magnetic fields generate currents in moving conducting fields, causing the fluid to polarise and the magnetic field to shift. MHD is widely used in practical applications such as heat exchangers, power pumps and generators. Hanif et al. (2021), numerically discussed the entropy analysis of MHD hybrid nanofluid past a vertical cone. Mahat et al. (2022), showed an investigation of an MHD viscoelastic fluid with nanoparticles across a horizontal circular cylinder. Using the finite difference approach, Saqib et al. (2020), examined the MHD Fractional Cattaneo-friedrich flow of Maxwell fluid. Recent publications that are related to MHD are Hanif and Shafie (2022a), Jalili et al. (2022), and Kotha et al. (2020).

The mechanisms of heat transmission brought on by thermal radiation—which projects thermal radiation onto the region of interest—have been studied by researchers in recent years. As the temperature of a material increases, it emits electromagnetic radiation that varies with its characteristics. Thermal radiation results from the heat being generated within a material. For instance, a thermal radiation source can be an electric heater, a paper plate manufacturer, a metallic piece that needs to be cooled, an electric chip manufacturer, or a petroleum pump. The fluid flow across a stretched, curved sheet with radiation was examined by Anantha Kumar et al. (2020). The effect of radiation in the rotational flow of a hybrid nanofluid in three dimensions was statistically explored by Asghar et al. (2022).

A hybrid nanofluid at stagnation point flow with a thermal radiation effect was considered by Dawar et al. (2022) across a flat plate. MHD hybrid nanofluids via moving surfaces with radiation impact were investigated by Zainal et al. (2021) utilising the MATLAB solver (bvp4c). A thorough investigation has been shown by Hanif et al. (2023) on the use of heat radiation in material engineering for a scenario beyond a permeable cone. Later, in 2022c, extended the application to the petroleum industry for a Maxwell nanofluid. Wahid et al. (2022), Hanif, (2021), and Mabood et al. (2022) have conducted more in-depth studies on heat radiation.

4.2 UNSTEADY FLUID FLOW WITH HEAT AND MAGNETIC EFFECTS

An unsteady two-dimensional fluid flow due to pressure gradient in the presence is the problem to be addressed. The considered fluid is a mixture of Fe_3O_4-Cu and water that is moving at $V = (y, z, t)\hat{i}$ over a permeable horizontal plate. Furthermore, the impacts of heat radiation and magnetic field are encountered. Based on these presumptions, the governing equations are: