CHAPTER

2

MAGNETOHYDRODYNAMICS CU-TIO$_2$ HYBRID NANOFLUID WITH VISCOUS DISSIPATION

Rahimah Jusoh, Zulkhibri Ismail,
Muhammad Khairul Anuar Mohamed, and Nooraini Zainuddin

2.1 INTRODUCTION

Boundary layer flow is often described as a thin layer filled with fluid that is next to a solid object's surface. Within this layer, fluid properties undergo rapid changes because of how the fluid and solid surface interact. Recently, there had many studies on the boundary layer flow across a stretching/shrinking plate due to numerous applications in various industrial and technical sectors. The manufacturing of glass fibre, aerodynamic plastic sheet extrusion, metal spinning, condensation of metallic plates, wire drawing, and hot rolling are a few examples of these uses. Prandtl number (Pr), was a pioneer in presenting the concept of the boundary layer, where he suggested that friction causes the fluid directly in contact with a surface to adhere to it, which is called the no-slip condition. He proposed that the influence of friction was primarily confined to the boundary layer, which is a thin layer near the surface, while the flow beyond this layer was nearly inviscid, akin to the flow discussed for centuries prior (Anderson, 2005). Crane (1970), started the examination of the flow past an elongated plate and offered an analytical answer. Afterwards, abundant academics expanded on the model by considering a variety of conditions.

The exploration of boundary layer flow over stretching and shrinking surfaces holds relevance not just for viscous and non-viscous fluids, but also for nanofluids. The study of boundary layer flow in nanofluids has attracted a lot of attention lately since it has potential applications in many different engineering fields. Nanofluids, which comprise suspended nanoparticles, have the potential to markedly influence the thermal and flow characteristics of the fluid upon their addition. Nanofluid characteristics may be tuned by varying the concentration and size of suspended nanoparticles. The fluid's heat transfer coefficient may be raised by adding nanoparticles, which is beneficial in a variety of applications including heat exchangers, thermal energy storage systems, and the cooling of electronic components.

The boundary layer flow of nanofluids has been explored through numerical simulations and experimental research; the results have demonstrated remarkable possibilities for their applications in a variety of engineering sectors. To improve efficiency and performance, engineering systems may be designed and optimised with the aid of knowledge about the heat transmission and flow properties of nanofluids. Because hybrid nanofluids have the potential to enhance heat transfer in a diversity of applications, including nuclear reactor cooling systems, automobile engines, and electronic device cooling systems, researchers have been spending more time exploring them in recent years. When two or more different types of nanoparticles are combined with a base fluid, a hybrid nanofluid is created. It has been discovered that hybrid nanofluids have superior heat transmission qualities than single nanoparticle nanofluids. Additionally, by adjusting the concentration and kind of nanoparticles utilised, hybrid nanofluids allow for customisation of the fluid's thermal and physical characteristics.

2.2 HYBRID NANOFLUIDS AND RELATED PHENOMENA

This section will guide readers through an exploration of the various works that numerous scholars have conducted on the topic of nanofluids, hybrid nanofluids, magnetohydrodynamics, and viscous dissipation.

2.2.1 Nanofluid and Hybrid Nanofluid

Enhancing the thermal conductivity of a material is a constant goal for scientists and researchers. Traditionally, conventional base fluids have been utilised as heat transfer mediums, yet their efficiency is hindered by their limited heat conductivity. Recognising these limitations has spurred a recent surge of interest in nanofluids as an alternative approach.

Nanofluid is a mixture of tiny solid particles, ranging from 1 to 100 nanometres in size, dispersed within a liquid base like oil, water, or ethylene glycol. These solid particles can be made of various materials such as carbides, metals, graphite, carbon nanotubes, or oxides. According to Choi and Eastman (1995) proposal, adding nanoparticles to the fluid could improve its thermal conductivity. Many industrial, technological, and biological uses of nanofluid exist, such as solar energy generation, geothermal power, drug delivery, industrial cooling, hybrid-powered engines, microchip cooling, and extraction processes. As a result, the nanofluid has received significant interest and has been studied in various aspects such as stability, thermal properties, chemical reaction, magnetisation, and viscosity. When compared to traditional heat transfer fluids, the majority of studies concur that nanofluids significantly improve thermal conductivity performance (Ho et al., 2023; Mehta et al., 2022; Sun et al., 2022).

After then, the research was expanded by simultaneously dispersing two distinct types of nanoscale-sized particles, leading to the creation of "hybrid nanofluid". Two distinct types of nanoparticles are used in this new combination to enhance thermal conductivity and encourage a