A NUMERICAL STUDY ON HEAT TRANSFER FOR MHD FLOW OF RADIATIVE CASSON NANOFLUID OVER A POROUS STRETCHING SHEET

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***Abstract*— The current study deals with the heat transfer of the steady two-dimensional MHD Casson nanofluid flow over a non-linearly stretched porous sheet associated with viscous dissipation, chemical radiate parameters and thermal radiation. Using the appropriate similarity transformation, the non-linear partial differential equations are transformed into a system of coupled non-linear ordinary differential equations which are further numerically solved using a MATLAB built-in solver bvp4c (Boundary value problem of fourth-order). The comparison reveals an excellent agreement which proves the validation of the numerical approach. The effect of various MHD parameters on the velocity, temperature and nanoparticle concentration are discussed graphically whereas its impact on heat and mass transfer rate are shown in tabular form as Nusselt number and Sherwood number respectively. Enhancement in temperature profile is observed as a result of the increased value of the radiation parameter and Brownian motion parameter. In this study, both Newtonian and non-Newtonian cases are studied separately for each parameter. Moreover, this study demonstrates, when a porous sheet is stretched non-linearly under chemical and thermal radiation, the Casson nanofluid controls the temperature and nanoparticle concentration better than the Newtonian nanofluid.**

***Keywords*— Non-Newtonian, Casson nanofluid, Porous stretching sheet, Viscous dissipation, Chemical radiate, Steady flow.**

I. INTRODUCTION

Thermal capabilities of engineering industrial processes mainly revolve around the heat transfer quality of the fluid. The ability of heat transfer is increased by the increase in thermal conductivity. Convectional fluids have very low thermal conductivity, as a result, it cannot be used for ultra-high cooling processes. As a result of their high thermal conductivity, nanofluids are used in place of base fluids as working fluids these days. Choi (1995) was the first researcher to discover that the suspended nanoparticles in the base fluid could enhance the thermal conductivity. Lee *et al.* (1999) examined the thermal conductivity of several metal oxides and discovered that shape and size both played major roles in increasing the thermal conductivity of the nanofluid. Wang *et al.* (1999) explored the viscosity of Al2O3-water and CuO-water and found that 3% volume concentration of Al2O3-water nanofluid enhanced thermal conductivity up to 30%. Eastman *et al.* (2001) by their study conclude that the addition of copper nanoparticles with less than 1% volume fraction in ethylene glycol could increase the thermal conductivity up to 40%. Later on, many investigators (Xuan and Li, 2003) had revealed that by adding 1-5% of nanoparticles in the base fluid could enhance more than 20% of thermal conductivity. Buongiorno (2006) sought to explain the rise in the thermal conductivity of the nanofluid by pointing out two slip mechanisms i.e., Brownian motion of the particles and thermophoresis for effective enhancement of thermal conductivity of the base fluid. Nield and Kuznetsov, (2009) discussed the influence of Brownian motion and thermophoresis on a horizontal boundary layer of porous medium saturated by a nanofluid. Khan and Pop (2010) explored the problem of steady two-dimensional laminar fluid flow of a nanofluid over a stretching flat plate. Different scholars investigated the nanofluid flow on different model and presented some notable results, as some of them in reference (Rana *et al.*, 2012; Makinde *et al.*, 2018)

Pandey and Kumar (2017), studied the flow of Cu-water nanofluid over a porous stretching cylinder under thermal radiation, viscous dissipation and slip conditions. Joshi *et al.* (2021) investigated the heat and mass transfer of hybrid nanofluid over a bidirectional porous stretching sheet under the effect of chemical reaction and heat generation. Singh *et al.* (2021) made a numerical investigation to study the flow of micropolar nanofluid over a stretchable surface under chemical reaction and heat absorption/generation. Upreti *et al.* (2021) also used a numerical approach to study about the heat transfer of Sisko nanofluid over a stretchable Darcy – Forcheimer porous medium under thermal radiation. Very recently Upreti *et al.* (2020) and Pandey and Upreti (2021) have investigated heat transfer efficiency of nanofluids.

Non-Newtonian fluid is widely used in many industrial and technological sector, such as paint, glues, dissolved polymers, asphalts and biological solutions. Non-Newtonian fluids does not comply with Newton's law of viscosity i.e., where shear stress is not directly proportional to the gradient of velocity. For e.g.- Juice of apple, blood, honey, fluid, oils, cream, toothpaste, etc. Hady *et al.* (2011) and Cheng (2012) analyzed the non-Newtonian nanofluid over a porous vertical plate and porous vertical truncated cone. The natural convection of non-Newtonian nanofluid along a preamble cone which was vertical was analysed by Rashad *et al.* (2011). Mabood *et al.* (2015) explored the heat and mass transfer of MHD