Electro-Magnetic Effects on Nanofluid across a Stretching Sheet Near a Stagnation point

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1. INTRODUCTION & OBJECTIVE

The analysis of MHD flow is very significant because, the effect of a magnetic field on the flow of electrically conducting viscous fluid has commonly used in many industrial processes, such as crude oil purification, magnetic materials processing, geophysics, production of glass, paper production, and generation of MHD electrical power, etc.

The magnetic field is one of the significant factors that can regulate the cooling rate and to achieve optimal industrial production efficiency. The heat transfer of electrically conductive fluids and Magnetohydrodynamics (MHD) boundary layer flow has various science, industrial and engineering applications, like liquid metals, nuclear(atomic) reactors, aerodynamics, and geothermal engineering.

The electrical field (the space around an electric charge where the electric charge fell by another charge) has primary applications in various fields. The electro-kinetic effects on nanoparticles are important, because the suspension applies a non-uniform field that exerts a force on the nanoparticle.

A nanofluid is a fluid, which contains nanometer-sized particles, and these are called nanoparticles. Nanofluids have enormous properties that make them useful in innumerable applications in heat transfer, including microelectronics, pharmaceutical processes, fuel cells, engine cooling/vehicle thermal management, and hybrid-powered engines, domestic refrigerators, heat exchangers, chiller, machining, boiler flue gas temperature reduction and grinding. Nanofluids are used to increase the thermal conductivity of the base fluids such as propylene glycol, ethylene glycol, water, etc.

The objective of this study is to investigate the effects of magnetohydrodynamics (MHD) and electric fields on heat transfer and fluid flow in a nanofluid over a stretching sheet near a stagnation point. The study aims to understand the impact of various parameters, including magnetic field, electric field, velocity ratio, and nanoparticle volume fraction, on the temperature profile, velocity, skin friction, and mass transfer rates, with potential applications in advanced cooling systems, drug delivery, and energy-efficient industrial processes.

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

The system of ordinary coupled nonlinear differential equations was numerically solved by using the MATLAB bvp4c solver with boundary conditions. To test the accuracy of the present outcomes determined up to 10^{-7} in the absence of some specific parameters, we have compared these numerical results with earlier published work. This gives assurance on the numerical results to be described subsequently.

The current study, the enhancement of the magnetic and electric field on nanofluid near a stagnation point over a stretching sheet. The major outcome of the current study is listed below. The temperature profile decreases on increasing the magnetic field and velocity ratio parameters. If the velocity ratio and magnetic field parameters increases, then the nanoparticle volume fraction decreases. The temperature profile decreases on increasing the velocity ratio and electric field parameters. The nanofluid velocity increased by increasing the electrical field value, but both the magnetic and electrical fields create Lorentz forces resulting in a decrement in the fluid velocity. Skin friction decreases with increasing the velocity ratio parameter. Conversely, increasing electrical field values caused the rise in Skin friction profile. The parameter of the electric field impacts the magnetic field. The Nusselt Number raises on raising both electric field and velocity ratio parameters and thickness of boundary layer momentum diminished. Sherwood number decreases with increasing both electric field and velocity ratio parameters. In the presence of electric field, the Nanoparticle Sherwood Number decreases on increasing the velocity ratio parameter.

Highlights:

- Decrease in temperature profile with increasing magnetic field and velocity ratio parameters-Improved heat management in electronic devices.
- Decrease in nanoparticle volume fraction with increasing velocity ratio and magnetic field parameters-Targeted nanoparticle drug delivery.
- Increase in Nusselt number with increasing electric field and velocity ratio parameters - Advanced cooling systems for aerospace engineering.
- Decrease in skin friction with increasing velocity ratio parameter-Energy-efficient industrial processes.
- Decrease in Sherwood number with increasing electric field and velocity ratio parameters-Optimized mass transfer in chemical processing.
- Increase in nanofluid velocity with increasing electrical field value-Improved thermal management in high-performance systems.

REFERENCES

1. Hsiao KL (2016) Stagnation electrical MHD nanofluid mixed convection with slip boundary on a stretching sheet. Appl Therm Eng 98:850-861
2. Makinde OD, Animasaun IL (2016) Thermophoresis and Brownian motion effects on MHD bio convection of nanofluid with nonlinear thermal radiation and quartic chemical reaction past an upper horizontal surface of a paraboloid of revolution. J Mol Liq 221:733-743.
3. Ibrahim W, Makinde OD (2016) Magnetohydrodynamic stagnation point flow of a power-law nanofluid towards a convectively heated stretching sheet with slip. P I Mech Eng E-J Pro 230:345-354.
4. Ibrahim W (2015) The Effect of Induced Magnetic Field and Convective Boundary Condition on MHD Stagnation Point Flow and Heat Transfer of Nanofluid Past a Stretching Sheet. in IEEE Transactions on Nanotechnology. 14(1):178-186.
5. Turkyilmazoglu M (2012) Exact analytical solutions for heat and mass transfer of MHD slip flow in nanofluid. Chem Eng Sci 84:182-187.
6. Kumaran V, Banerjee AK, Kumar AV, Vajravelu K (2009) MHD flow past a stretching permeable sheet. Appl Math Comput 210:26-32.
7. Abro KA, Chandio AD, Abro IA, Khan I (2019) Dual thermal analysis of magnetohydrodynamic flow of nanofluids via modern approaches of Caputo–Fabrizio and Atangana–Baleanu fractional derivatives embedded in porous medium. J Therm Anal Calorim 135: 2197–2207.

8. Ma Y, Mohebbi R, Rashidi MM, Manca O, Yang Z (2019a) Numerical investigation of MHD effects on nanofluid heat transfer in a baffled U-shaped enclosure using lattice Boltzmann method. J Therm Anal Calorim 135: 3197–3213.
9. Ma Y, Mohebbi R, Rashidi MM, Yang Z (2019b) MHD forced convection of $MWCNT - Fe_3O_4$ /water hybrid nanofluid in a partially heated τ -shaped channel using LBM. J Therm Anal Calorim 136:1723–1735.
10. Seth GS, Ansari MdS, Nandkeolyar R (2011a) Unsteady hydromagnetic Couette flow within a porous channel. Tamkang J Sci Eng 14(1):7–14