

HEAT AND MASS TRANSFER IN MHD MICROPOLAR FLUID FLOW OVER A STRETCHING SHEET WITH THERMAL CONDUCTIVITY UNDER THE IMPACT OF HEAT SOURCE AND CHEMICAL REACTION

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Abstract

This study explores heat and mass transfer in magnetohydrodynamic (MHD) micropolar fluid flow over a stretching sheet. The analysis incorporates the effects of thermal conductivity under the impact of heat source and chemical reaction, radiation and thermophoresis to evaluate their influence on the system comprehensively. It is anticipated that the surface temperature will fluctuate by power law. The mass, energy, angular momentum, and concentration conservation equations are in effect. The governing nonlinear partial differential equations (PDEs) are transformed using the similarity transformation technique into nonlinear coupled ordinary differential equations (ODEs) set. The subsequently linked nonlinear ordinary differential equations are numerically solved using the shooting technique and the approach of the fourth-order R-K technique. Symbolic computational software such as MATLAB, the solver `bvp4c` syntax examines the behavior of the relevant physical parameters. A graphic illustration of the results of variant dimensionless parameters on the rate, temperature, and concentration supports the present study. Additionally, according to the numerical impacts, the thermal boundary thickness rises with increasing thermal conductivity parameters and decreases with increasing radiation parameters. Again, it is noticed that the Nusselt and Sherwood rise and fall as they grow. Furthermore, increasing the mass suction parameter and Prandtl number reduces the fluid temperature in both solutions. The radiation parameter and the surface temperature parameter have the impact of increasing the value of the Nusselt number. In contrast, the thermal conductivity parameter has the opposite effect on the Nusselt number.

Keywords: Heat source; MHD; Micropolar fluid; Radiation parameter; Thermal Conductivity

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Introduction

Non-Newtonian fluids are widely used in the engineering and persistence fields. No one relation can adequately capture the properties of non-Newtonian fluids. Applications such as foams, sugar solutions, apple sauce, clay, soaps, lubricants, etc., show the properties of non-Newtonian fluids. The researchers give descriptions of many models of non-Newtonian fluids. Co-polymerized fluids with irregular molecular architectures that affect a viscous medium are categorized as micropolar fluids. These fluid gyratory micro-sized particles introduce new nuances to the ergonomics and mechanics of modern high-tech engineering. The extraction of polymeric materials, sludge and blood flows, crude oil, liquid rainfall, and fluids with bar-like elements are a few particular micropolar fluids. Hoyt and Fabula (1964), Vogel and Patterson (1964) have investigated fluids containing small amounts of polymeric extracts, and they observed that both of these liquids exhibit a decrease in skin friction around a inflexible body. As a result, Eringen (1967; 1972) developed the constitutive equations for the thermo-micropolar fluid theory as well as the theory of micropolar liquids. Micropolar liquids are crucial in the relationship between non-Newtonian fluid dynamics and microstructure. They also provide significant insights into the Navier-Stokes equation. Each fluid element contains two sets of degrees of freedom, known as translator degrees of freedom, which are responsible for rotation and stretch as well as rate, according to this theory, which allows the elements to have self-determining intrinsic spins and homogeneous deformation by Ahmadi (1976).

They display both rotational momentums simultaneously, unlike classical fluids, which show the translational momentum of micropolar fluids. Additionally, translational However, because of the variety of fluid properties, no single constitutive standard can apprehend all non-Newtonian liquids seen in nature; as a result, several non-Newtonian fluid models, like the Casson fluid model, have been established. Ostwald de-Waele fluid power law Chen *et al.* (2011) studied the Maxwell, Jeffery, and micropolar fluids.

Łukaszewicz (1999) and Rahman (2009) have dissected its uses in a variety of industrial processes, including polymer extrusion, unique lubricant flow, colloidal suspensions, and metallic plate cooling in a water bath, have piqued academics' interest in exploring it. A comprehensive examination of the science and industries of micropolar fluids. Micropolar fluids located in dust clouds, liquid crystals, animal blood, polymeric fluids, fluid

suspensions, and other materials have all been studied by Hayat *et al.* (2011). The numerical investigation of MHD limit layer non-Newtonian micropolar liquid caused by an exponentially bent stretching sheet was bent and evaluated by Shi *et al.* (2021). Ramanuja *et al.* (2022; 2023) discussed radiation effects of Newtonian/non-Newtonian fluids through porous medium.

In terms of thermal radiation and chemical reactions, this work investigates the mixed MHD convective of a micropolar fluid flow across a stretched surface through varying thermal conductivity. Flow features such as concentration, microrotation, temperature fields, and velocity are evaluated to modify relevant parameters. When heat is generated or absorbed by injection or suction, chemical reaction, the effects of temperature-dependent and thermal radiation, and thermal conductivity on the mass and heat transfer (MHD) of a micropolar liquid across a stretched surface undergoing constant motion are considered. Symbolic computational software such as MATLAB, the solver bvp4c syntax examines the behavior of the relevant physical parameters. The additional effects are analyzed using component analysis and graph planning. The achievements of this work are extremely relevant, both theoretically with respect to the mathematical modeling of non-Newtonian fluid flow with heat transfer in engineering systems and with respect to engineering cooling applications.

Problem Formulation

Fluid thermal conductivity $k(T)$ as a function of temperature that is linear predicted to fluctuate in the following form:

$$k(T) = k_{\infty}[1 + b(T - T_{\infty})] \quad (1)$$

Here $b < 0$ for fluid such as lubrication oils, $b > 0$ for air, b be the constant depending on the nature of the fluid, k_{∞} be the ambient thermal conductivity, T_{∞} free stream temperature. And fluid such as water T be the temperature and assume a constant two-dimensional flow of electrically an incompressible, conducting an electrically conducting non-Newtonian micropolar fluid in the existence of radiation exposed to a magnetic field transverse across a temperature-variable, semi-infinite stretching plate. In Figure 1. the y – axis is oriented perpendicularly to the direction of the slot (z – axis). The x – axis indicates in the direction of

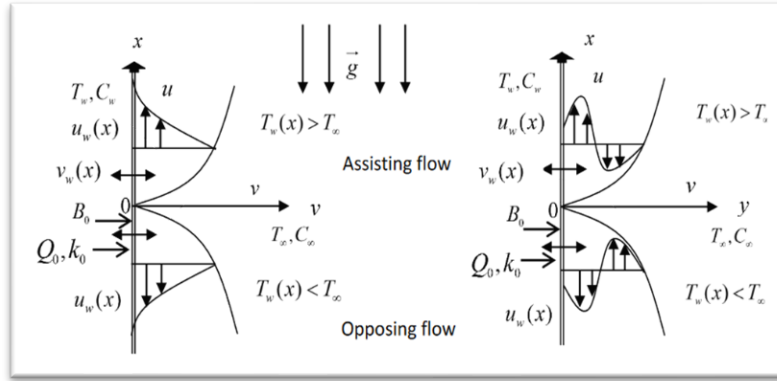


Figure 1. Physical Model

motion and is oriented along the constant stretching plate. Which is why the continuous stretching plate points. The joule heating and the induced magnetic field are taken for granted except for liquid thermal conductivity, a linear temperature function; the fluid effects are considered constant.

Then, the leading equations for the scenario can be mentioned as follows continuity, momentum, angular momentum, energy, and concentration under the standard boundary layer approximations as tracks Damsch *et al.* (2009);

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (2)$$

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = -\frac{1}{\rho} \frac{\partial p}{\partial y} \left(v + \frac{k_1}{\rho} \right) \frac{\partial^2 u}{\partial y^2} - \frac{\sigma B_0^2 u}{\rho} + k_1 \frac{\partial N}{\partial y} + g\beta_c(T - T_\infty) + g\beta_T(T - T_\infty) \quad (3)$$

$$G_1 \frac{\partial^2 N}{\partial y^2} - \frac{\partial u}{\partial y} - 2N = 0 \quad (4)$$

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \frac{k}{\rho c_p} \frac{\partial^2 T}{\partial y^2} + \frac{Q_0}{\rho c_p} (T - T_\infty) - \frac{1}{\rho c_p} \frac{\partial q_r}{\partial y} \quad (5)$$

$$u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = D \frac{\partial^2 C}{\partial y^2} - Kr^*(C_w - C_\infty) - \frac{\partial(CV_T)}{\partial y} \quad (6)$$

Here u be the velocity component of the x – direction, and v be the velocity component of the y – direction. Acceleration due to gravity be $-g$, in the y – direction B_0 be the forced magnetic field externally, density of the fluid be the ρ , characteristic of the fluid constant be the S , heat generation coefficient be the $Q_0 > 0$, absorption coefficient be the $Q_0 < 0$, electrical conductivity be the σ . In the y – direction the radiative heat flux be q_r , The temperature of the fluid inside the

thermal boundary layer, the plate temperature and the fluid temperature in the free stream be T, T_w , and T_∞ , the corresponding species concentration be the C, C_w , and C_∞ , $N=0$ near the wall implies that the concentrated particle flows such that the microelements near the wall surface cannot rotate Jena and Mathur (1981). Angular velocity or N be the components of microrotation whose rotation is in the direction of the xy – plane, In this case, $G_1 > 0$ microrotation constant, thermophoretic velocity be the V_T , thermal conductivity be the k , thermal and concentration expansion coefficients be the β_T and β_c , chemical reaction Kr^* rate, $Kr^* = 0$ be the no reaction, $Kr^* > 0$ be the destructive reaction, $Kr^* < 0$ be the generative reaction, specific heat at constant pressure be the c_p . The effects of chemical reactions and thermophoresis are represented, respectively, by the second and third terms on the RHS of concentration Equation (6);

The following are suitable boundary situations for the model mentioned above:

$$\begin{aligned} u = U_w = ax, v = v_0, \sigma = 0, C = C_w, T = T_w, \\ N = -n \frac{\partial u}{\partial y} \text{ at } y = 0 \\ u = 0, v = 0, T = T_\infty, C = C_\infty, \sigma = 0, \\ N \rightarrow 0 \text{ at } y \rightarrow \infty \end{aligned} \quad (7)$$

Here v_0 be the suction/injection velocity, velocity of the stretching sheet $U_w = ax$ with the shrinking constant $a > 0$.

It is expected that the wall temperature follows the following power-law as it varies along the plate:

$$T_w = \beta x^\gamma + T_\infty \quad (8)$$

Here T_w be the variable temperature at the sheet, γ and β be the surface temperature parameter is constants.

Brewster (1992) has the following appearance by providing a less radiative heat flow than Roseland's approximation.

$$q_r = -\left(\frac{4\sigma_s}{3k_e}\right) \frac{\partial T^4}{\partial y} \quad (7)$$

Here k_e be the indicate absorption coefficient, on T_0 reference temperature T^4 term and avoid the higher power situations as part of Taylor's series, σ_s is the "Stefan-Boltzmann", therefore getting higher T^4 .

$$T^4 \simeq 4T_0^3 T - 3T_\infty^4 \quad (8)$$

When Equation (7) is explored, Equation (8) has the following form:

$$q_r = -\left(\frac{16\sigma_s T_0^3}{3k_e}\right) \frac{\partial T}{\partial y} \quad (9)$$

Equations (7) to (9) using Equation (5) can be reduces

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \alpha \frac{\partial^2 T}{\partial y^2} + \frac{Q_0}{\rho c_p} (T - T_\infty) + \frac{16\sigma_s T_\infty^3}{3\rho c_p k_e} \frac{\partial^2 T}{\partial y^2} \quad (10)$$

Now V_T be the thermophoretic velocity, this can be expressed as Mills *et al.* (1984) and appears in Equation (5);

$$V_T = -kv \frac{\nabla T}{T_{ref}} = -\frac{kv}{T_{ref}} \frac{\partial T}{\partial y} \quad (11)$$

Here reference temperature be the T_{ref} , thermophoretic coefficient be the k with range from the values 0.2 to 1.2 as stated by Batchelor and Shen (1985); and described by Talbot *et al.* (1980) based on their theory.

$$k = \frac{2C_s \left(C_t K_n + \frac{\lambda_g}{\lambda_p} \right) [1 + K_n (c_1 + c_2 e^{\frac{-C_3}{K_n}})]}{(1 + 3C_m K_n) [1 + 2\frac{\lambda_g}{\lambda_p} + 2K_n C_t]} \quad (12)$$

Here K_n be the Knudsen number, c_1, c_2, c_3, C_t, C_m are the constants, λ_p and λ_g be the diffused particles and the thermal conductivities of the liquid. τ be the thermophoretic parameter can be explained as follows by Mills *et al.* (1984):

$$\tau = -\frac{k(T_w - T_\infty)}{T_{ref}} \quad (13)$$

Characteristic values of τ be the 0.01, 0.05, and 0.1 equivalent to approximate $-k(T_w - T_\infty)$ values of equal to 3K, 15K, and 30K for a reference temperature of $T_{ref} = 300K$.

Introducing a stream function Ψ as the continuity Equation (2) is reflexively contented by the C-R Equations, η be the similarity variable

$$u = \frac{\partial \Psi}{\partial y} \quad \text{and} \quad v = -\frac{\partial \Psi}{\partial x}$$

The subsequent non-dimensional values are presented in order to write the boundary conditions and the governing Equations (3), (4), (6), and (10) in dimensionless form:

$$u = axf'(\eta), v = -\sqrt{av}xf(\eta) \quad \text{where} \quad \eta = \sqrt{\frac{a}{v}}y,$$

$$\psi = (av)^{\frac{1}{2}} xf(\eta)$$

$$\theta(\eta) = \frac{(T - T_\infty)}{(T_w - T_\infty)}, \quad \phi(\eta) = \frac{(C - C_\infty)}{(C_w - C_\infty)} \\ N = \left(\frac{a^3}{v}\right)^{\frac{1}{2}} x\omega(\eta) \quad (14)$$

Given the nonlinear partial differential Equation (14), and Equations (3), (4), (6), and (10) reduce to the following non-dimensional into the following ordinary differential equations after Eringen (1967; 1972) analysis

$$(1 + K)f''' + f''f + Gc\phi + \theta Gr + g'K - f'M = 0 \quad (15)$$

$$\omega''G - (f'' + 2\omega) = 0 \quad (16)$$

$$\left(1 + \frac{3R}{4}(1 + S\theta)\right)\theta'' + \frac{3R}{4}Pr(f\theta' + \delta\theta) = 0 \quad (17)$$

$$\phi'' + \phi'Sc(f\phi' - \tau\theta') - \phi Sc(\tau\theta'' - Kr) = 0 \quad (18)$$

Where water be the $0 \leq S \leq 0.12$, air be the $0 \leq S \leq 6$ and lubrication oils for $-0.1 \leq S \leq 0$ given by Postelnicu (2012);

$$M = \frac{\sigma B_0^2}{\rho a}, G_1 = \frac{K_1}{\rho}, G = \frac{G_1 a}{v}, Pr = \frac{\mu c_p}{k}, \\ R = \frac{k k_e}{4\sigma_s T_\infty^3}, Sc = \frac{v}{D}, Kr = \frac{Kr^* v}{Da}, \\ S = b(T_w - T_\infty), \delta = \frac{Q_0}{(\rho c_p) a}, \\ Gr = \frac{\beta g (T_w - T_\infty)}{au}, Gc = \frac{\beta g \rho (T_w - T_\infty)}{au} \quad (19)$$

Here magnetic parameter, coupling constant parameter, microrotation parameter, Prandtl parameter, radiation parameter, thermal conductivity, heat generation and absorption parameter, chemical reaction parameter Schmidt number.

Where permeability of the permeable surface $f_w = \frac{v_0}{\sqrt{av}}$ which is injection for negative and suction for positive.

The transformed equivalent dimensionless boundary situations are:

$$\begin{aligned} f(0) &= f_w, \quad \theta(0) = 1, \quad f'(0) = 1, \quad \phi(0) = 1, \\ f'(\infty) &= 0, \quad g(\infty) = 0, \quad \phi(\infty) = 0, \quad g(0) = 0, \\ \theta(\infty) &= 0 \end{aligned} \quad (20)$$

From the rate field, the skin friction through the plate can be received, we can directly compute the combine stress coefficient at the plate wall using the angular velocity field in the boundary layer, Nusselt number and Sherwood number It is displayed in a non-dimensional system by

$$\begin{aligned} C_f &= \frac{K(N)_{y=0} + (\mu + k) \frac{\partial u}{\partial y}}{\frac{1}{2} \rho U_0^2} = -2 Re_x^{\frac{1}{2}} \left(1 + \frac{1}{\beta} \right) f''(0), \\ C_w &= \frac{\frac{\gamma}{K} \left(\frac{\partial u}{\partial y} \right)_{y=0}}{\gamma U_0^3 (2K v^2)} = Re_x^{-1} \omega'(0) \\ Nu_x &= \frac{\frac{4\sigma(\partial T^4)}{3k(\partial y)} - k(\frac{\partial T}{\partial y})}{k(T_w - T_\infty)} = Re_x^{\frac{1}{2}} \left(1 + \frac{4}{3} R \right) \theta'(0), \\ Sh_x &= \frac{-D(\frac{\partial C}{\partial y})_{y=0}}{U_0 C_\infty} = (Re_x^{\frac{1}{2}}) \phi'(0) \end{aligned}$$

Where Re_x be the local Reynolds number $Re_x = \frac{U_0 x}{\nu}$

Results and Discussion

We have examined the heat and mass transfer in MHD in this article. Specifically, we have examined

the governing principles of an electrically conducting non-Newtonian micropolar fluid flow across a stretching sheet with thermal conductivity under the effect of a heat source and chemical reaction; Equation (15) to Equation (18) with boundary situation Equation (20) were numerically by via the 4th order Runge-Kutta scheme with shooting method. Symbolic computational software such as MATLAB, the solver bvp4c syntax examines the behavior of the relevant physical parameters. The sections that follow discuss the current study: The non-Newtonian micropolar fluid models for two-dimensional flow's mathematical components are covered in Section 2; the study's problems, conclusions, and possible findings are covered in Section 4; Section 3 provides a conceptual framework and a graphical interpretation of the data gathered. The numerical results of the significant parameters are displayed through graphs in this section to evaluate the consistency and accuracy of our solutions.

We were conceded out by computations taken $1 \leq R \leq 3$, $1 \leq M \leq 3$, $10 \leq \tau \leq 3.0$, $0.1 \leq S \leq 1.0$, $0.2 \leq Ec \leq 1.0$, $0.0 \leq \delta \leq 1$, $0.0 \leq Kr \leq 1.0$. Numerical simulations are used to get the findings, which consider several non-dimensional controlling parameters impact on parameters. The skin-friction coefficient, plate couple stress, Nusselt number, Sherwood number, and numerical estimation methods which are correspondingly proportionate to are $f'(0)$, $g'(0)$, $\theta'(0)$, $\phi'(0)$ additionally arranged, and their numerical values are shown in a level arrangement.

Figures (2) to (4) illustrate the rate, microrotation, temperature and concentration profiles for different values of the f_w suction parameter correspondingly. It is noticed from these Figures (2) to (4) that as the f_w suction parameter enlargements. The temperature, velocity, and concentration as well as the thicknesses of their boundary layers are all

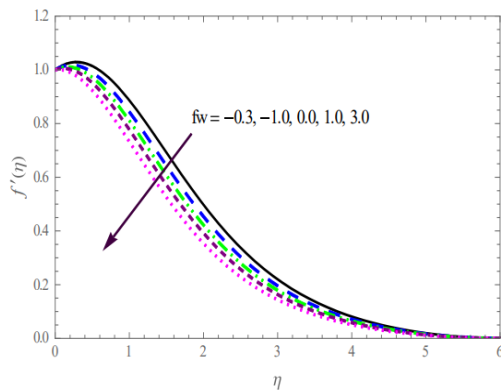


Figure 2. Impact of f_w on velocity

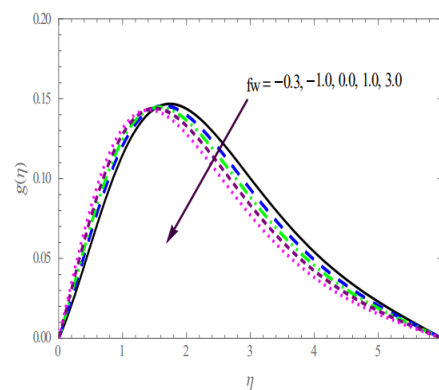
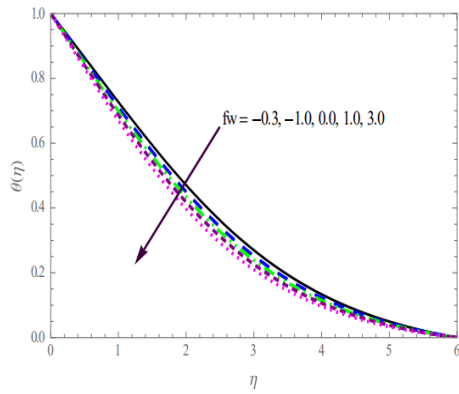
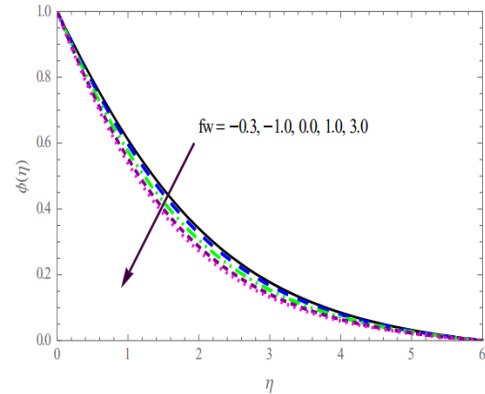
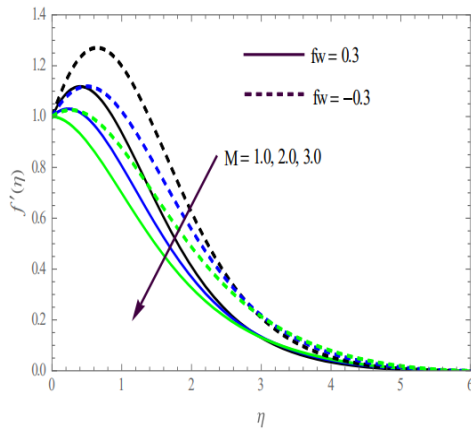
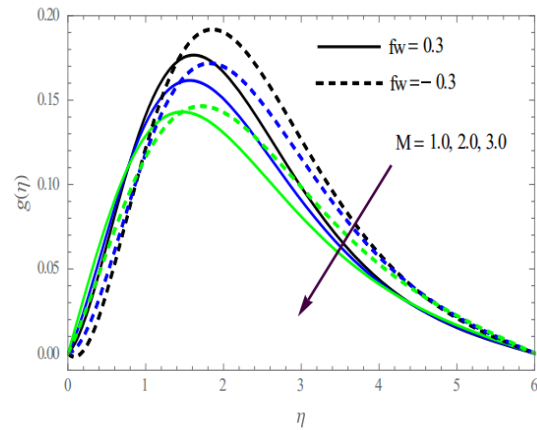
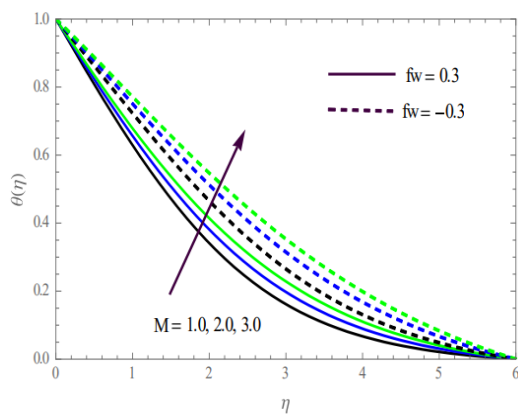
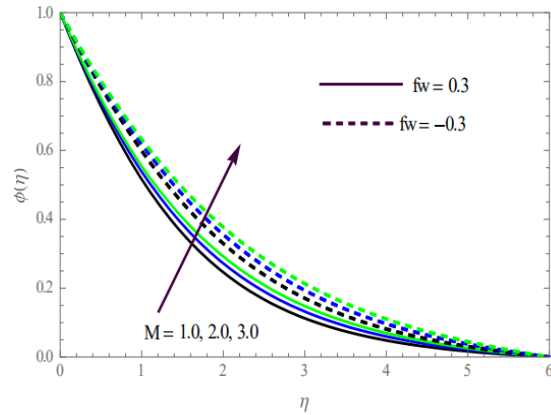


Figure 3. Impact of f_w on microrotation

Figure 4. Impact of f_w on temperatureFigure 5. Impact of f_w on concentrationFigure 6. Impact of M on velocityFigure 7. Impact of M on microrotationFigure 8. Impact of M on temperatureFigure 9. Impact of M on concentration

declining. However, the microrotation increases close to the plate and subsequently declines away from it.

The effects of the magnetic field parameter M on temperature, concentration, microrotation, and velocity are displayed in Figures (6) to (9). A drag-

like force known as the Lorentz force is created when there is a magnetic field existing, and it acts in the opposite direction of the fluid's velocity rises. Moreover, as M rises, the boundary-layer thickness falls and the thermal boundary-layer thickness rises. Additionally, it is noticed in exposed from Figure 5

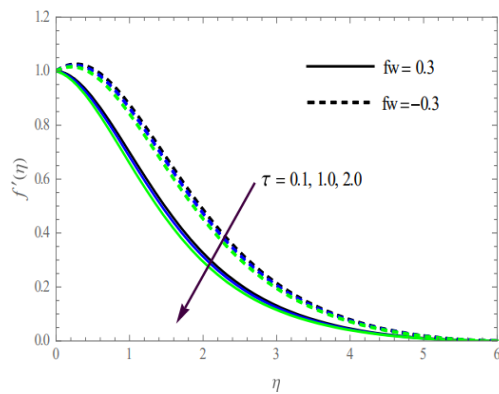


Figure 10. Impact of τ on velocity

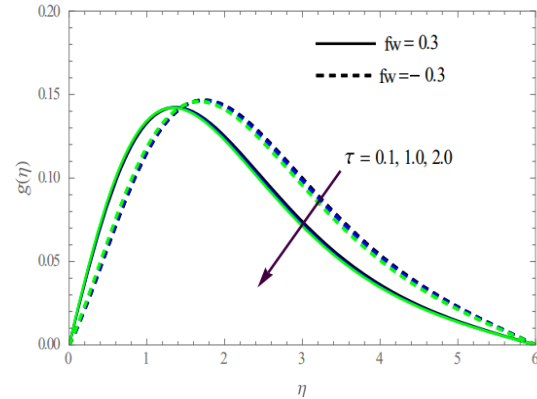


Figure 11. Impact of τ on microrotation

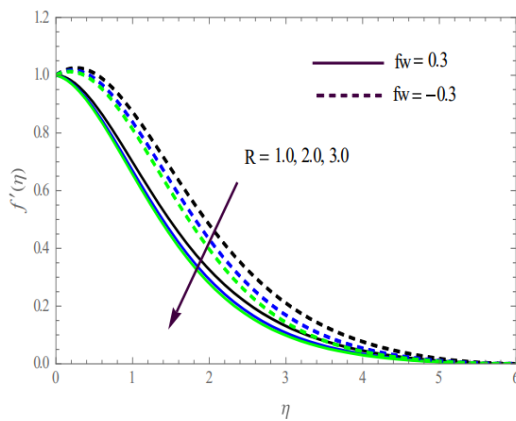


Figure 12. Impact of R on Velocity

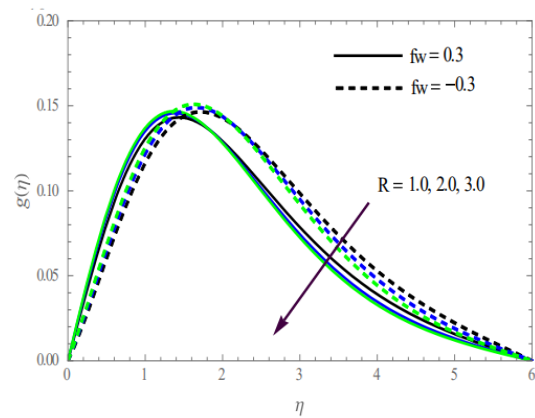


Figure 13. Impact of R on microrotation

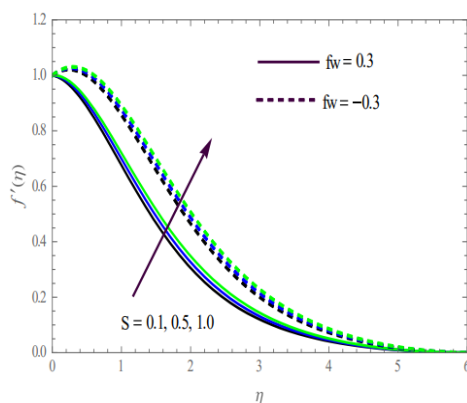


Figure 14. Impact of S on velocity

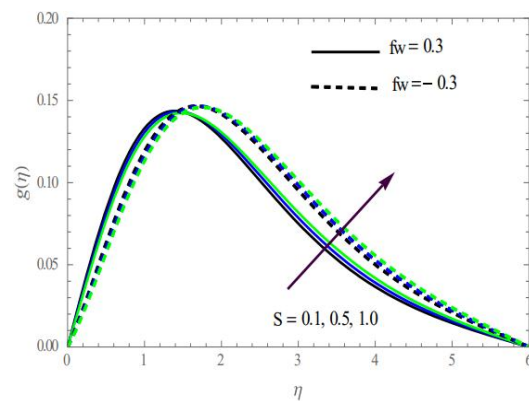
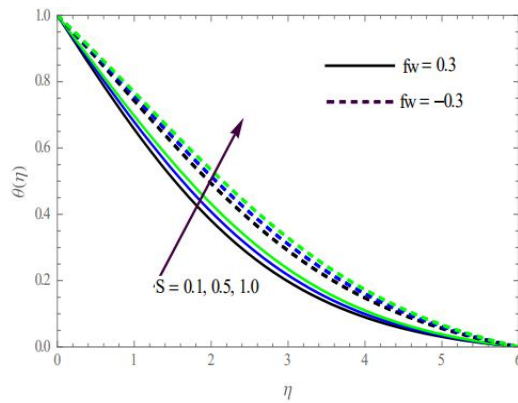
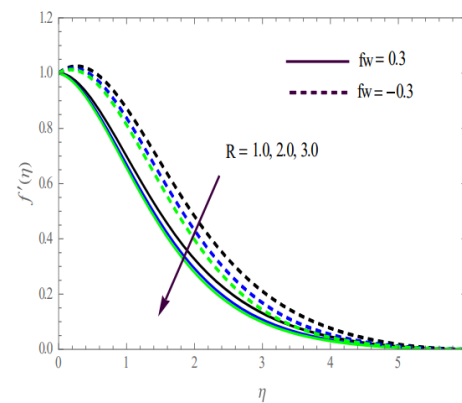
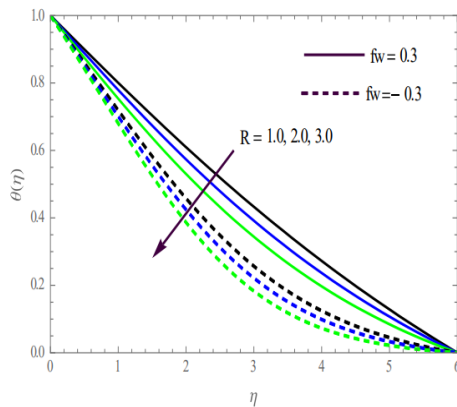
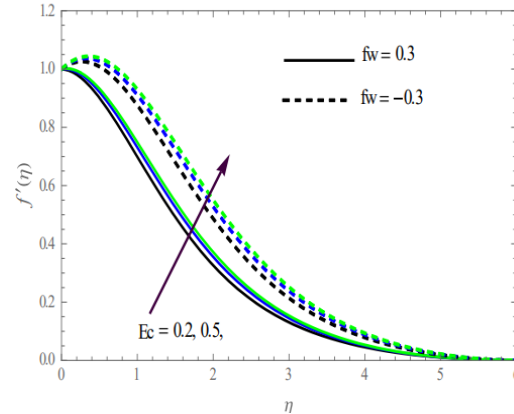


Figure 15. Impact of S on microrotation

that, for equally suction and injection scenarios, the microrotation progressively reductions away from the plate after first rising close to it. It is apparent from Figure 7 that lowers temperature. It is obvious from Figure 8 that the concentration expands with a rise in the magnetic field value.

Figures (10) to (13) show how the thermophoretic parameter τ affects temperature, concentration, microrotation, and rate, respectively. Figure 10 makes it abundantly apparent that as the thermophoretic parameter rises, the fluid rate drops, and thus the thickness of the momentum boundary

Figure 16. Impact of S on temperatureFigure 17. Impact of R on microrotationFigure 18. Impact of R on temperatureFigure 19. Impact of Ec on velocity

layer declines. As illustrated in Figure 11, the microrotation gradually declines for both the suction and injection scenarios after initially increasing closer the surface due to the rise in the thermophoretic parameter τ . It is also clear from Figure 12 that τ lowers temperature. As the values of the thermophoretic parameters rise, the fluid concentration in the boundary layer area drops, as seen in Figure 13. It follows that the concentration boundary layer should change as a result of the thermophoretic parameter.

The velocity, temperature, and microrotation, profiles for variations in the thermal conductivity parameter S for both suction and injection are shown in Figures (14) to (16). The fluid velocity in the boundary layer region tends to rise when the thermal conductivity parameter rises, as seen in Figure 13. The thermal conductivity parameter thickens the momentum barrier layer, which in turn raises rate, which is the physics underlying the results. As S increases, the microrotation rises near the plate and declines away from the plate, as exposed in Figure 14. One may also detect that the temperature

rises with growing in Figure 15. Thus, the thermal boundary layer thickness is improved by increasing the thermal conductivity parameter S .

The temperature, microrotation, and velocity profiles for variations in the thermal radiation parameter R for both suction and injection are shown in Figures (16) through (18). The fluid velocity in the boundary layer region inclines to rise when radiation parameters R rise, as seen in Figure 16. The underlying physics of the observations is that the thermal radiation thickens the momentum barrier layer, increasing velocity in the process. It is evident from Figure 17 that the microrotation rises near the plate and declines in the opposite direction as it grows. Moreover, Figure 18, illustrations that the temperature distribution rises consistently as thermal radiation parameters rise. Thermal boundary layer thickness is therefore increased by increasing.

Figures (19) to (21) illustrate how temperature, microrotation, and velocity are obstructed by the viscous dissipation parameter, also known as the Eckert number Ec . Figures (19) through (21), in that

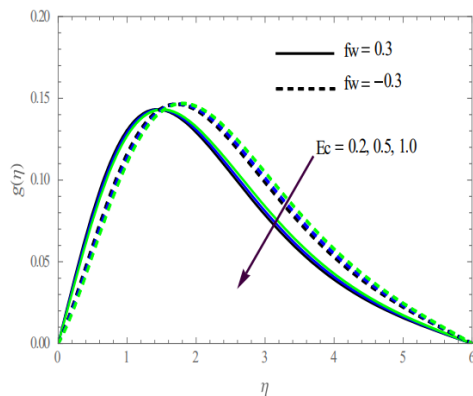


Figure 20. Impact of Ec on microrotation

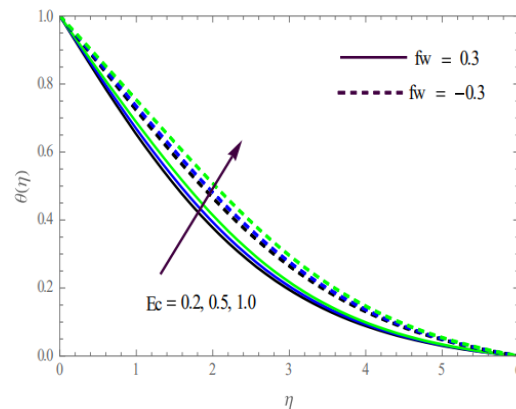


Figure 21. Impact of Ec on temperature

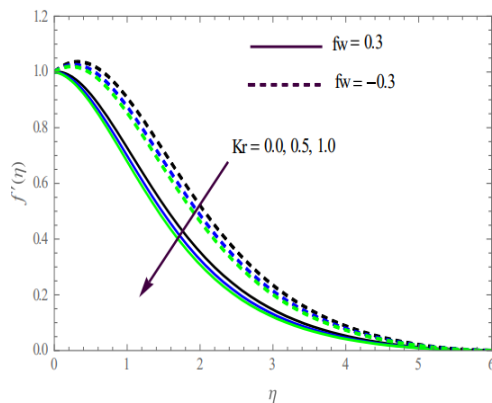


Figure 22. Impact of Kr on velocity

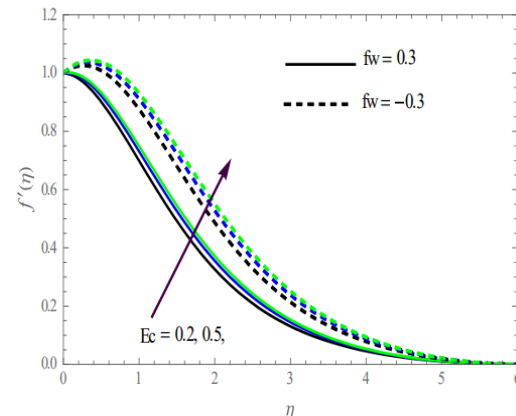


Figure 23. Impact of Kr on microrotation

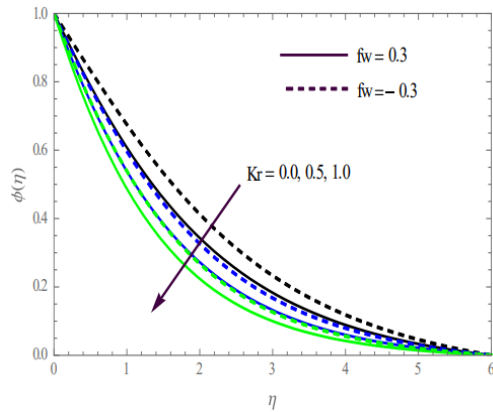
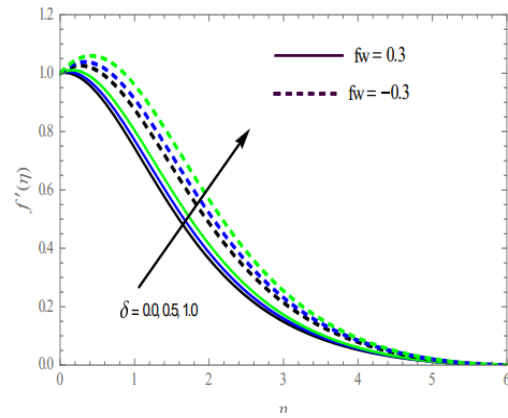
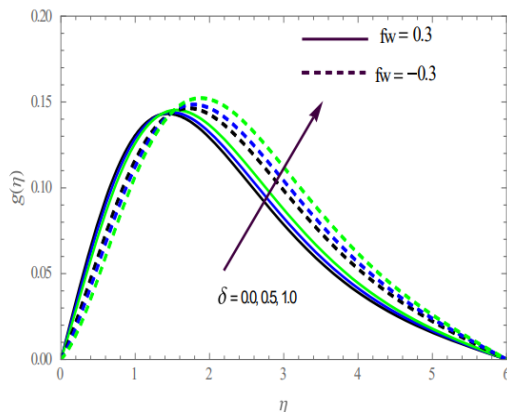
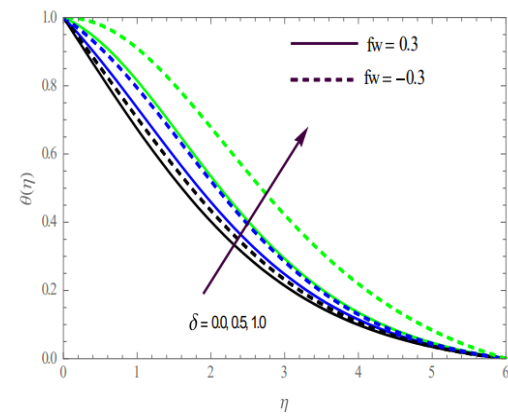
order. Figure 19 expressions that as fluid suction and injection rise, so does the velocity field. Figure 20 illustrates how, with improved liquid suction and injection, the microrotation rises close to the plate and gradually declines away from it. Additionally, Figure 21 demonstrates how the temperature rises as fluid suction and injection values rise.

The dimensionless rate, microrotation, and concentration profiles for a range of chemical reaction parameter values are exposed in Figures (22) to (24). It is obvious from Figure 22 that in both scenarios of constant fluid suction or injection, the velocity declines as the liquid pressure Kr rises. Figure 23 illustrates how, in both situations of constant liquid suction and injection, the microrotation rises close to the plate before declining away from it. Furthermore, it is also obvious from Figure 24 that concentration rises with increasing continuous liquid suction and injection times.

The dimensionless rate, microrotation, and temperature profiles for a range of heat generation/

absorption values are revealed in Figures (25) to (27). It is noticed be established from Figure 25 that the velocity rises with increasing pressure in mutually situations of constant liquid suction or injection δ . Figure 26 illustrates how, for the scenarios of constant fluid suction and injection δ , the microrotation grows, declining near the plate and increasing away from it. Furthermore, it is also evident from Figure 27 that when fluid suction or injection δ is continuous, temperature rises as it does.

The impacts of all pertinent physical parameters on the local skin friction coefficient, couple stress coefficient, the local Nusselt number and the local Sherwood number for both the cases of constant fluid suction and injection are depicted in Tables 1 and 2, respectively. From this table, we can see that the skin friction coefficient rises as Kr , whereas it reduces with the increment in S , R , δ and τ for fluid suction as well as for injection. Couple stresses coefficient increases as M , R , τ and Kr , whereas it decreases with the increment values in

Figure 24. Impact of Kr on concentrationFigure 25. Impact of δ on velocityFigure 26. Impact of δ on microrotationFigure 27. Impact of δ on temperature

S and δ for fluid suction as well as for injection. Nusselt number increases as M , R whereas it decreases with the increment values in M , τ , and Kr for both fluid suction and injection. However, they behave oppositely on the Sherwood number for fluid suction and injection.

Conclusions

The current study contributes to our numerical and physical understanding of the heat and mass transfer in MHD an electrically conducting micropolar non-Newtonian flow over a stretching sheet due to an investigation using thermal conductivity as the heat source and chemical reaction boundary layer flow. In a magnetic field, thermal radiation. Flow appearances such as rate, temperature fields, microrotation, and concentration are evaluated to manipulate relevant parameters. Based on the obtained graphic results, based on the investigator's findings, it may be inferred that:

- The magnetic parameter increases skin friction's value while decreasing the heat transmission pace.
- The radiation and surface temperature parameters increase the value of the Nusselt number.
- The thermal conductivity characteristic has a reverse influence on the Nusselt number.
- Increasing the mass suction parameter and Prandtl number leads to a reduction in fluid temperature in both solutions.
- Increasing the thermophoretic parameter lowers the concentration and local Stanton number within the boundary layer.

Nomenclature

u, v	velocity component
g	Gravity
B_0	Magnetic field
ρ	Density

S	Characteristic of the fluid constant
Q	Absorption coefficient
σ	Electrical conductivity
q_r	Heat flux
T, T_w , and T_∞	Fluid temperature in the free stream
C, C_w , and C_∞	Concentration
N	Angular velocity
γ, β	Surface temperature
T_w	Variable temperature
G_1	Micro rotation constant
k	Conductivity
β_T and β_C	Concentration expansion coefficients
Kr^*	Chemical reaction rate
c_p	Specific heat
R	Radiation
Pr	Prandtl parameter
Ec	Eckert number
$k(T)$	Fluid thermal conductivity

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