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The Significance Of The Temperature Jump On Steady MHD Free Convection Viscous Dissipating Fluid Past A Vertical Plate With Dufour And Soret Effects In Porous Medium

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Abstract
The creation of thermal interface materials (TIMs) must take temperature jumps into consideration. It is possible to minimize heat dissipation in electrical equipment like CPUs, power electronics, and LED lighting by comprehending and controlling temperature jumps at the TIM interface. In the present study, the effect of temperature jumps past a moving vertical plate in a porous medium with the Soret and Dufour effect in the presence of thermal radiation is investigated. By similarity transformation, the governing partial differential equations are reduced into a system of ordinary differential equations and then solved by MATLAB'S bvp4c solver. The impacts of the various embedded essentials parameters such as the temperature slip parameter, Soret number, and Dufour parameter on the distribution of the velocity, temperature, and concentration as well as the skin friction coefficients, Nusselt number, and Sherwood number are presented and analyzed. It has been discovered that as the thermal slip parameter increases, the velocity and concentration profile also decreases

Keywords: Free convection, Soret, and Dufour, temperature jump

Introduction

Many studies have been published on flows across vertical plates under various conditions. Porous media are abundant in chemical engineering systems. They have many uses in science and technology. Satish Molli and KishanNaikoti(Molli & Naikoti, 2020) explored unsteady electrically conducting, incompressible, heat and mass transfer MHD free convective fluid flow with Cu-nanoparticles over a vertical plate embedded in a porous medium and variable boundary conditions. The presence of porous media increases the flow resistance and leads to a reduction in the thickness of the thermal boundary layer. The effect of porous media on boundary layer reduction is substantial. M. Veera Krishna, N. Ameer Ahamad, and Ali J. Chamkha(Krishna, Ahamad, & Chamkha, 2020) studied hall and ion slip effects on unsteady MHD-free convective rotating flow over an exponentially accelerated tilted plate fixed in a saturated porous medium with the effects of tilt angle, variable temperature, and concentration. A low permeability reduces the fluid velocity within the flow area occupied by the fluid. The velocity, therefore, increases as the permeability parameter increases across the fluid section.Asma Khalid, Ilyas Khan, Arshad Khan, and SharidanShafie(Khalid, Khan, Khan, & Shafie, 2015) investigated the unsteady MHD-free flow of a Kasson liquid through an oscillating vertical plate with constant wall temperature in a porous medium. The resistance of the porous media decreases, the momentum development of the flow regime increases, and finally the velocity field increases. K. Javaherdeh, Mehrzad Mirzaei Nejad, and M. Moslemi(Javaherdeh, Nejad, & Moslemi, 2015) investigated the free convective heat and mass transfer of MHD flows through vertically moving plates in porous media. The author concluded that an increase in the density of porous media increases the resistance to guide the flow.Asmahani Nayan, Nur Izzatie Farhana Ahmad Fauzan, Mohd Rijal Ilias, Shahida Farhan Zakaria, and Noor Hafizah Zainal Aznam(Nayan, Fauzan, Ilias, Zakaria, & Aznam, 2022) explore the adjusted magnetohydrodynamics (MHD) stream of cross breed nanofluid over an upward plate through a permeable medium utilizing Keller box strategy. The velocity profiles decrease as the porous medium increases, as shown in the figure. Porosity increases permeability, which in turn increases fluid flow in the supposed porous medium. M.C. Raju, S.V.K. Varma, and B. Seshaiah(Raju, Varma, & Seshaiah, 2015) performed a study of fully developed viscous dissipative, magnetohydrodynamic, steady free convective heat transfer flow over an infinite vertical porous plate in the presence of the induced magnetic field. As the magnetic parameter increases, the velocity decreases. In the previous literature survey, the effects of thermal radiation on the fluid flow past an infinite vertical plate have been analyzed by a few researchers. The study of the effects of thermal radiation is acknowledged.

By employing an implicit finite-difference method, M. A. Abd El-Naby, Elsayed M. E. Elbarbary, and Nader Y. Abdelazem(El-Naby, Elbarbary, & Abdelazem, 2003) investigate the effects of radiation on magnetohydrodynamic (MHD) unsteady free-convection flow past a semi-infinite vertical plate with variable surface temperature in the presence of a transversal uniform magnetic field. as the radiation parameter F rises, the transient velocity and temperature rise. M. Veera Krishna (Krishna, 2021) used the Laplace transform to investigate the effects of Hall and ion slip on the radiative magnetohydrodynamic (MHD) rotating flow of viscous electrically conducting Jeffrey fluid over an infinite vertical flat porous surface using ramped wall velocity and temperature, as well as an isothermal plate. The temperature distribution across the entire fluid region is expanded as a result of an increase in the thermal radiation parameter.In the presence of a magnetic field, V. Rajesh and S. Vijaya Kumar Varma (Rajesh & Varma, 2009) investigate the effects of thermal radiation and mass transfer on unsteady free convection flow past an exponentially accelerated infinite vertical plate of varying temperatures. In both cooling and heating the plate, the velocity decreases in tandem with the magnetic parameter. Using the finite element method, Yanala Dharmendra Reddy, B. Shankar Goud, and M. Anil Kumar (Y. D. Reddy, Goud, & Kumar, 2021) seek to determine the role of MHD transient laminar flow, thermal radiation, and heat absorption, in the occurrence of an infinite vertical plate with chemical reaction. The temperature and fluid velocity decrease when the radiation parameter is raised. As a result, ramped and isothermal plates' fluid temperatures and velocity tend to drop as a result of thermal radiation.A mathematical treatment of the Casson fluid model is developed by K. Ramesha, Arshad Riazb, and Zahoor Ahmad Darc(Ramesh, Riaz, & Dar, 2021). The model takes into account the effects of a porous medium, thermal radiation, a magnetic field, Joule heating, boundary slip conditions, and viscous dissipation between two horizontal parallel plates in various circumstances. Temperature increases with increasing radiation parameter values. Thermal and velocity slip effects on a non-Newtonian two-phase flow through a horizontal channel are investigated by Hina Firdous, S M Husnine, Farooq Hussain, and Mubbashar Nazeer (Firdous, Husnine, Hussain, & Nazeer, 2020). Radiation increases as the temperature profile decreases.The existence of the concentration gradient has induced the Dufour effect in the fluid. Furthermore, some concentration is sensitive to the temperature gradient which generates the Soret effect in the fluid. Next, the literature review about the Soret and Dufour effect on free convection flow over a vertical plate is acknowledged.

D. Srinivas Reddy, G. Sreedhar Sarma, and K. Govardhan (D. S. Reddy & Govardhan, 2015) have reported the two-dimensional steady-state free convection of heat and mass transfer from vertical surfaces in porous media with viscous dissipation is combined with the Soret effect and Dufour. The temperature profile increases with increasing Soret number.Likewise, N. Ameer Ahammad, M. Veera Krishna (Ahammad & Krishna, 2021) discussed the Soret and Dufour effects on natural convection heat and mass transfer for the unsteady two-dimensional boundary layered flow through a vertical channel/duct with the existence of viscous dissipation and invariable suction. As the Soret number increases, we observe a decrease in fluid temperature across the fluid regime. The Dufour parameter increases monotonically with the temperature distribution. Ime Jimmy Uwanta and Halima Usman (Uwanta & Usman, 2014) studied the combined effects of Soret and Dufour on free convective heat and mass transfer in unsteady one-dimensional boundary layer flow over vertical channels in the presence of viscous dissipation and constant suction. The velocity and concentration profiles are increases as the Soret number increases, whereas the temperature profile within the boundary layer decreases. As the Dufour number increases, the velocity and temperature profiles monotonically increase.B. Chiranjeevi, P. Valsamy, G. Vidyasagar (Chiranjeevi, Valsamy, & Vidyasagar, 2021) reviewed the problem of MHD boundary layer flow studies on moving vertical perforated plates with exothermic and chemical reactions in the presence of heat absorption. As the Dufour number increases, the velocity and temperature increase. Velocity, temperature, and concentration increase with an increasing number of Soret. M. Gnaneswara Reddy and N. Bhaskar Reddy (M. G. Reddy & Reddy, 2010) investigated the interaction of Soret and Dufour effects on steady MHD free convection flow in a porous medium with viscous dissipation. An increase in the Soret number leads to an increase in boundary layer velocity and concentration. The Dufour number increases the velocity and temperature across the boundary layer. A. S. Idowu and B. O. Falodun(Idowu & Falodun, 2019) provided a fantastic description of the Soret-Dufour impact on the MHD heat and mass transfer of Walters-B viscoelastic fluids across a semi-infinite vertical plate spectrum relaxation analysis. Increasing the Soret number increases the velocity profile. As the Dufour number increases, the flow velocity increases.In the previous literature survey, the temperature jump is not considered by the researcher. In the next section, we consider the effects of temperature jumps on MHD that have been studied by several researchers

The homotopy perturbation method is used by M.G. Sobamowo and A.T. Akinshilo(Sobamowo & Akinshilo, 2017) to analyze the double-diffusive squeezing unsteady flow of electrically conducting nanofluid between two parallel disks under slip and temperature jump conditions. Temperature distribution increases toward the lower disk and decreases toward the upper disk as the temperature jump effect increases. N. Ghara, S. Das, S. L. Maji, and R. N. Jana (Ghara, Das, Maji, & Jana, 2012) used the Laplace transform to investigate the effects of radiation on MHD free convection flow of a viscous electrically conducting fluid passing through a moving infinite vertical plate with ramped wall temperature.Basant K. Jha, Babatunde Aina, and Sani Isa (Jha, Aina, & Isa, 2015) found an exact solution for the steady fully developed natural convection flow of an electrically conducting, viscous, incompressible fluid in a vertical annular microchannel under the influence of a transverse magnetic field in the presence of velocity slip and temperature jump at the annular microchannel surfaces. Heat transfer from the cylindrical surfaces to the fluid is reduced as rarefaction and temperature jump increase. The effects of velocity slip and thermal slip on MHD boundary layer mixed convection flow and heat transfer of an incompressible fluid past a plate in the presence of suction/blowing by shooting method were investigated by Swati Mukhopadhyay and Iswar Chandra Mandal (Mukhopadhyay & Mandal, 2015). The velocity may rise as a result of enhanced convection currents because of an increase in the effects of the temperature field in the velocity distribution as the mixed convection parameter rises.Basant K. Jha, Babatunde Aina, and A.T. Ajiya(Jha, Aina, & Ajiya, 2015) take into account the fully developed steady natural convection flow of conducting fluid in a vertical parallel plate microchannel in the presence of a transverse magnetic field. By using the control-based finite element method (CVFEM), the temperature jump goes up as the rarefaction parameter goes up, which reduces the amount of heat transfer from the wall to the fluid. The buoyancy effect, from which the flow derives, is reduced by this reduction in heat transfer, resulting in a decrease in the gas velocity far from the wall.The magnetohydrodynamic (MHD) stream and intensity move over a permeable contracting sheet with speed slip and temperature bounce are explored by Liancun Zheng, JiajiaNiua, Xinxin Zhang, Yingtao Gao (Zheng, Niu, Zhang, & Gao, 2012) utilizing HAM. The thermal boundary layer becomes thinner as the Prandtl number and temperature jump parameter values rise. Radiation consequences for MHD streams past an indiscreetly begun vertical plate with variable intensity and mass exchange are concentrated on by U. S. Rajput and S. Kumar by (Rajput & Kumar, 2012) utilizing the Laplace change strategy. They discovered that as the Prandtl number rises, the temperature falls.Rakesh Choudhary and Shalini Jain (Choudhary & Jain, 2021) used the Runge-Kutta fourth-fifth-order Fehlberg method (RKF45) to investigate the effects of temperature jump and concentration slip on inclined MHD bioconvection via porous media past a vertical porous plate. the fluid temperature is higher for injection than for suction. This is because, when fluid is injected, it drags out of the wall, resulting in less fluid on the wall and a higher temperature.Using the finite volume method, ArashKarimipoura, Annunziata D'Oraziob, and Mostafa SafdariShadlooc(Karimipour, D’Orazio, & Shadloo, 2017) wish to model the movement of nanofluids in a microchannel while a magnetic field is present. Greater slip coefficients equate to greater temperature hopping, but Hartmann number effects can be ignored.The interaction of temperature jump effects on MHD free convection flow in a porous medium with viscous dissipation and Soret and Dufour effect has received little attention. Hence, the object of the present is to analyze the temperature jump effects on steady MHD free convection viscous dissipating fluid past a vertical plate with Dufour and Soret effects in a porous medium.

Governing Equations

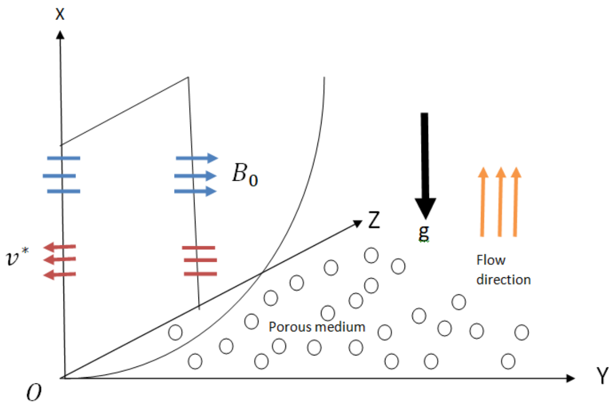

Figure 1: Schematic diagram of porous medium

The flow is supposed to flow through an infinite plate. The x-axis is assumed to be along the surface of the plate and the plate is kept at a constant concentration C_w that is higher than the concentration C of the ambient fluid. Furthermore, a constant temperature T_w that is higher than that of the surrounding fluid temperature T, which is assumed on the surface of the plate. Besides, a constant magnetic field is applied perpendicularly to the plate as demonstrated in Figure 1. Due to the assumption that the fluid is marginally conductive, the magnetic Reynolds number is significantly below one, and the induced magnetic field is insignificant in comparison to the applied magnetic field. Furthermore, it is believed that no applied voltage exists, resulting in the absence of an electric field. Additionally, it is assumed that all fluid parameters are fixed, except the body force term's influence on density change with temperature and concentration. Only the effects of temperature jump, MHD, viscous dissipation, thermal radiation, and the Soret and Dufour effect are taken into account in this study. The governing equations are

Continuity equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \tag{1}$$

Momentum equation

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = v\frac{\partial^2 u}{\partial y^2} + g\beta(T - T_\infty) + g\beta^*(C - C_\infty) - \frac{\sigma B_0^2}{\rho}u - \frac{v}{K'}u \tag{2}$$

Energy equation

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2} + \frac{D_m k_T}{c_s c_p}\frac{\partial^2 C}{\partial y^2} + \frac{v}{c_p}\left(\frac{\partial u}{\partial y}\right)^2 \tag{3}$$

Species equation

$$u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = D_m\frac{\partial^2 C}{\partial y^2} + \frac{D_m k_T}{T_m}\frac{\partial^2 T}{\partial y^2} \tag{4}$$

With the boundary equations:

$$u = ax,\ v = v_0,\ T = T_w + l_1\frac{dT}{dy},\ C = C_w at y = 0$$

$$u \to 0, \quad v \to 0, \quad T \to T_\infty, \quad C \to C_\infty at y \to \infty \tag{5}$$

Where l_1 is the thermal slip parameter.

We then introduce the following similarity transformations and dimensionless variables:

$$u = axf', \quad v = -(av)^{\frac{1}{2}}f, \quad \theta = \frac{T - T_\infty}{T_w - T_\infty}, \quad \Phi = \frac{C - C_\infty}{C_w - C_\infty}, \quad \eta = y\left(\frac{a}{v}\right)^{\frac{1}{2}}$$
$$Gr = \frac{g\beta(T_w - T_\infty)}{a^2 x}, \; Gm = \frac{g\beta^*(C_w - C_\infty)}{a^2 x}, \; M = \frac{\sigma B_0^2}{a\rho}, \quad K = \frac{\nu}{aK'}$$
$$\Pr = \frac{\nu\rho c_p}{k}, \; Du = \frac{D_m k_T (C_w - C_\infty)}{c_s c_p (T_w - T_\infty)}, \; Ec = \frac{a^2 x^2}{c_p (T_w - T_\infty)}, \tag{6}$$
$$Sc = \frac{\nu}{D_m}, \quad Sr = \frac{D_m k_T (T_w - T_\infty)}{\nu T_m (C_w - C_\infty)}$$

where θ is the non-dimensional temperature function, ϕ is the non-dimensional concentration, Gr is the thermal Grashof number, $G_m$is the solutal Grashof number, M is the magnetic field parameter, Ec is the Eckert number, Du is the Dufour number, Sc is the Schmidt number, and Sr is the Soret number.

In view of the equation (6), the equations (2), (3), and (4) reduce to the following nondimensional form

$$f''' + ff'' + Gr\theta + Gm\phi - (M + K)f' = 0, \tag{7}$$

$$\theta'' + Prf\theta' + PrDu\phi'' + PrEcf''^2 = 0, \tag{8}$$

$$\phi'' + Scf\phi' + ScSr\theta'' = 0. \tag{9}$$

The corresponding boundary conditions are

$$f = f_w, f' = 1, \theta = 1 + \delta\theta', \phi = 1, \; at \eta = 0,$$
$$f' \to 0, \theta \to 0, \phi \to 0 \; as \eta \to \infty,$$

where δ is the thermal slip parameter. The quantities of industrial and engineering importance are the coefficient of skin friction, Nusselt number, and Sherwood number, which are defined as

$$C_f = Re^{\frac{1}{2}}f''(0), \qquad Nu = -(Re)^{\frac{1}{2}}\theta'(0), \qquad Sh = -(Re)^{\frac{1}{2}}\phi'(0).$$

Using the Bvp4c Matlab solver, the similarity-transformed governing equations (7), (8), and (9) are resolved, Equations (7) until (9) are first reduced to first order Ordinary Differential Equations in order to be solved by applying the bvp4c. First, we let:

$$y_1' = y_2 = f',$$
$$y_2' = y_3 = f'',$$
$$y_3' = -y_1 y_3 - Gry_4 - Gmy_6 + (M + K)y_2,$$
$$y_4' = y_5 = \theta,$$
$$y_5' = -\Pr y_1 y_5 - PrDuy_7' + PrEcy_3^2,$$
$$y_6' = y_7 = \phi,$$
$$y_7' = -Scfy_7 - ScSry_5'.$$

The corresponding boundary conditions are

$$y(0) = f_w, y_2(0) = 1, y_4(0) = 1 + \delta * y_5(0), y_6(0) = 1,$$
$$y_2(1) = y_4(1) = y_6(1) = 0,$$

where f the dimensionless stream function,$f_w = \frac{v_0}{\sqrt{av}}$ is the dimensionless suction velocity and primes denote partial differentiation with respect to the variable η and $\delta = l_1\sqrt{\frac{a}{v}}$ are thermal slip parameters.

The verification and validation table below is done to make sure the results are accurate, trustworthy, and credible. Table 1 shows the validation and verification of numerical solutions of the skin-friction coefficient C_f, Nusselt number Nu, and Sherwood number Sh for $Pr = 0.71, Du = 0.2, Sc =$

$0.6, Sr = 1.0$.

Table 1. Results validation for skin friction C_f, Nusselt number Nu, Sherwood number Sh

Gr	Gm	M	K	f_w	C_f		Nu		Sh	
					M. Gneneswara Reddy, N. Bhaskar Reddy (M. G. Reddy & Reddy, 2010)	Present study	M. Gnaneswara Reddy, N. Bhaskar Reddy(M. G. Reddy & Reddy, 2010)	Present study	M. Gnaneswara Reddy, N. Bhaskar Reddy (M. G. Reddy & Reddy, 2010)	Present study
2.0	2.0	0.5	0.5	0.5	0.82302	0.8355	0.86186	0.8848	0.43622	0.4083
4.0	2.0	0.5	0.5	0.5	1.68650	1.6714	0.90193	0.9246	0.46479	0.4372
2.0	4.0	0.5	0.5	0.5	1.88533	1.9027	0.91883	0.9465	0.47943	0.4578
2.0	2.0	1.0	0.5	0.5	0.49068	0.5046	0.84005	0.8612	0.42136	0.3905
2.0	2.0	0.5	1.0	0.5	0.48781	0.5046	0.83956	0.8612	0.41984	0.3905
2.0	2.0	0.5	0.5	1.0	0.51154	0.5131	1.09368	1.1228	0.47301	0.4426

Results and Discussion

The set of coupled nonlinear governing boundary layer equations in ODE form with the corresponding boundary conditions is solved numerically with the help of bvp4c using Matlab.

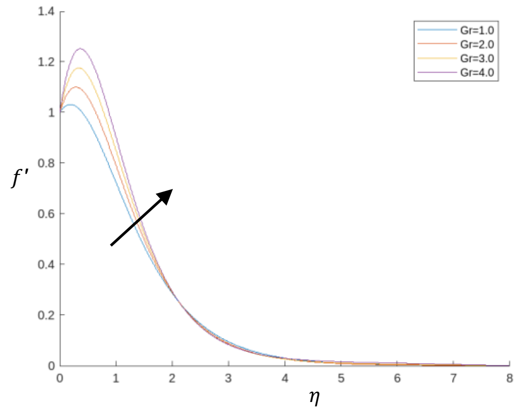

Figure 2 : Velocity profiles for different values of Gr

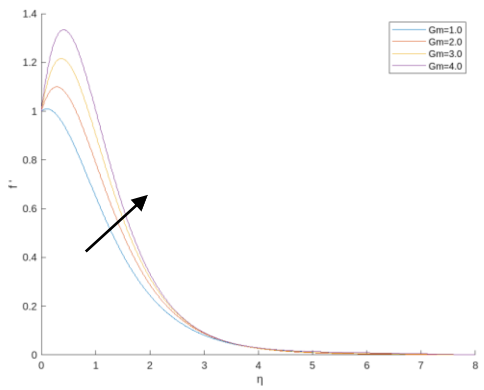

Figure 3 : Velocity profiles for different values of Gm

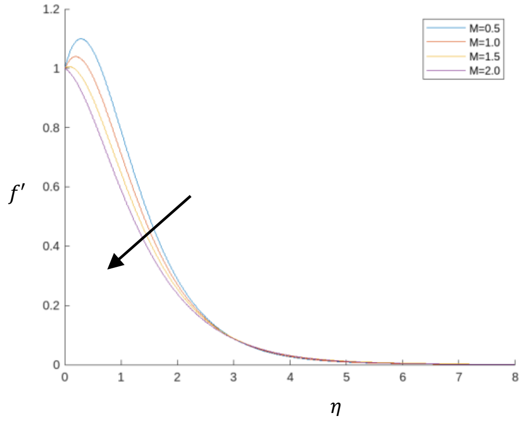

Figure 4 : Velocity profiles for different values of M

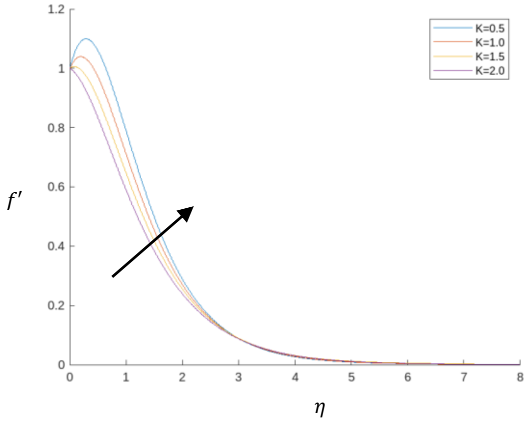

Figure 5 : Velocity profiles for different values of K

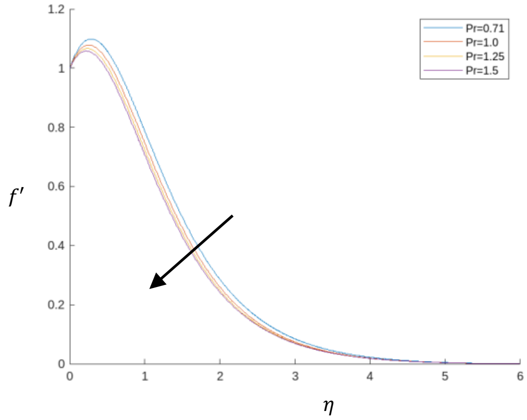

Figure 6 : Velocity profiles for different values of Pr

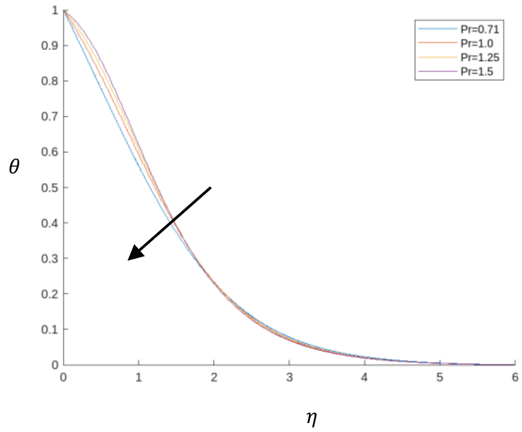

Figure 7 : Temperature profiles for different values of Pr

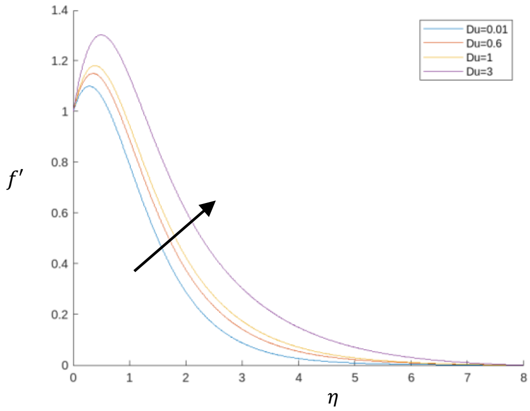

Figure 8 : Velocity profiles for different values of Du

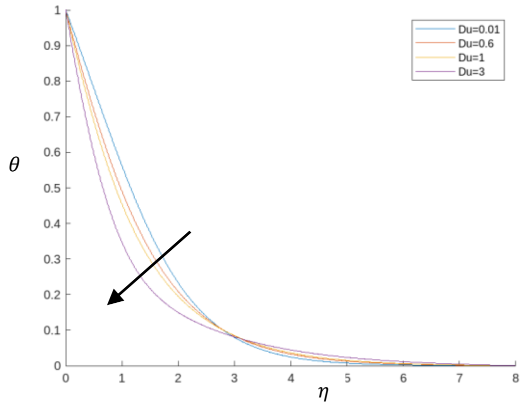

Figure 9 : Temperature profiles for different values of Du

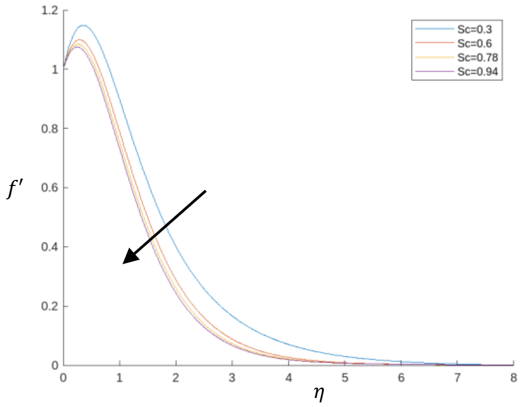

Figure 10 : Velocity profiles for different values of Sc

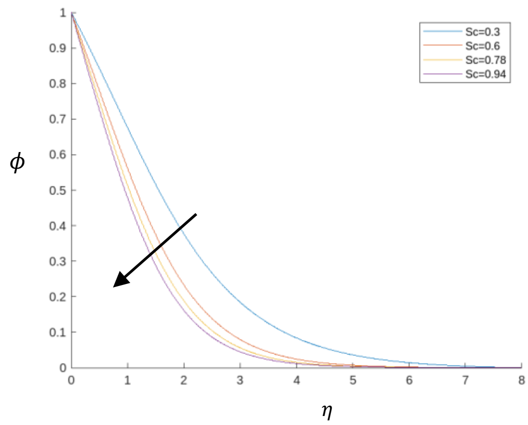

Figure 11 : Concentration profiles for different values of Sc

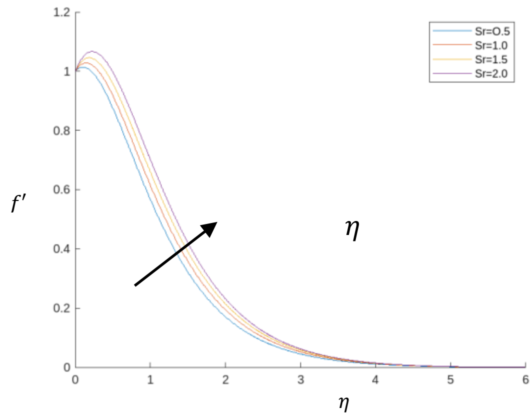

Figure 12 : Velocity profiles for different values of Sr

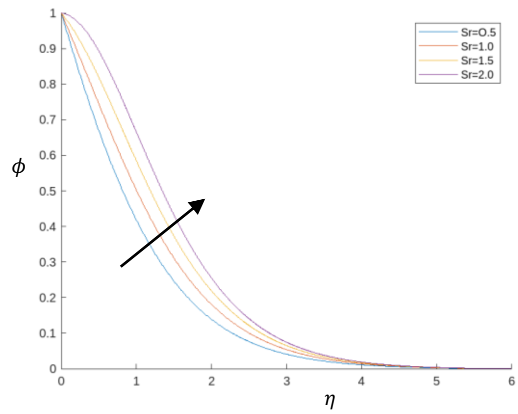

Figure 13 : Concentration profiles for different values of Sr

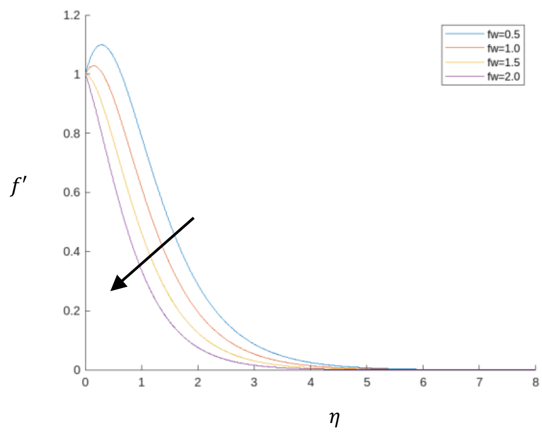

Figure 14 : Velocity profiles for different values of f_w

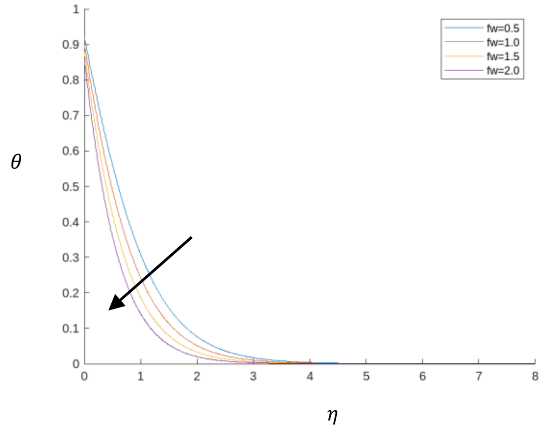

Figure 15 : Temperature profiles for different values of f_w

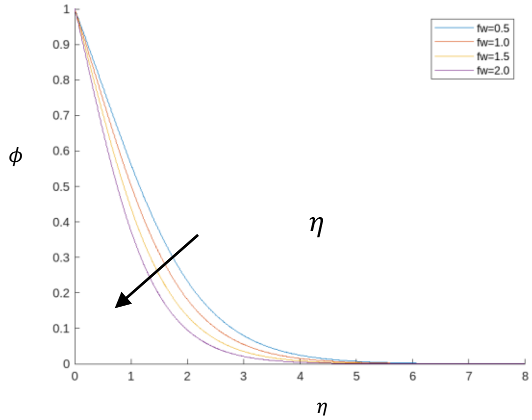

Figure 16 : Concentration profiles for different values of f_w

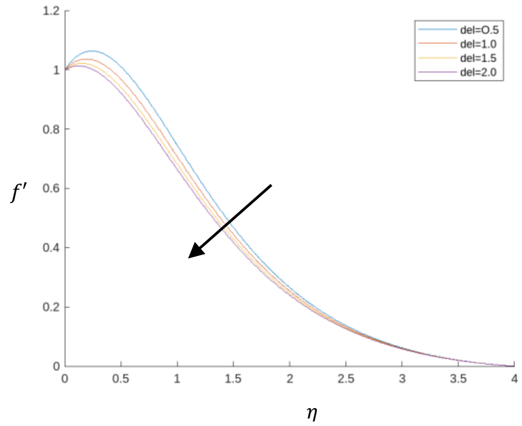

Figure 17 : Velocity profiles for different values of δ

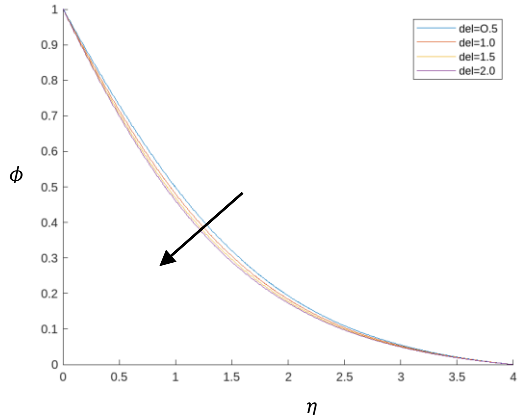

Figure 18 : Concentration profiles for different values of δ

The effect of the thermal Grashof number on velocity is shown in Figure 2. The buoyancy forces become greater as the thermal Grashof number increases, resulting in fluid motion close to the perforated plate. Different densities brought on by changing temperatures are what propel this motion. Due to buoyancy, the fluid near the plate moves upward, this causes the fluid's velocity to increase. Because the buoyancy-driven motion is strongest there, the greatest velocity occurs close to the perforated plate. The buoyancy forces steadily weaken as the fluid flows away from the plate, and the velocity smoothly decreases. In the end, the fluid velocity will get close to the free stream velocity, which is the velocity of the fluid outside the perforated plate that is unaffected. This happens because the buoyancy effects diminish as the fluid flows farther from the plate and encounters less heat gradient.

Figure 3 presents typical velocity profiles in the boundary layer for different values of the dissolved Grashof number. The fluid velocity increases and the maximum value are more specific due to the increased buoyancy of the species. The velocity distribution reaches a particular maximum value in the vicinity of the plate and then drops off precisely to approach the value of free lines.

For different valuesof the parameter from M, the velocity profiles are plotted in Figure 4. The magnetic field's impact on fluid flow becomes increasingly noticeable as the magnetic parameter rises. The fluid's velocity is gradually decreased by the MHD drag force, which lowers the fluid's velocity profile. When a flow is passing through a porous media, the porous structure itself already hinders the flow and lowers its velocity in comparison to free-stream conditions. The MHD drag force further reduces the fluid velocity in the porous medium when a magnetic field is present. Due to the combined effects of the MHD drag force and the resistance of the porous media, the velocity of the fluid as it moves through the porous medium under the influence of the magnetic field steadily drops. The velocity profile eventually approaches the free stream velocity, which is the fluid's velocity outside of the impact of the porous media and magnetic field.

The effect of the permeability parameter K on the velocity field is shown in Figure 5. The porous media provides less resistance to the fluid flow as the permeability parameter rises, allowing the fluid to pass through more easily. The velocity profile decreases as a result of the reduced resistance. The fluid experiences fewer obstructions and broader channels as the permeability rises, enabling a more uniform and smooth flow. As a result, the velocity profile is shallower and the velocity drop from the entrance to the output is reduced.

Figures 6 and 7 illustrate the velocity and temperature profiles for different valuesof the Prandtl number. The numerical results show that an increasing effect of the Prandtl number leads to a decrease in velocity (Figure 6). From Figure 7, it is observed that an increase in the Prandtl number leads to a decrease in the thickness of the thermal boundary layer and generally a lower mean temperature in the boundary layer. For this reason, heat can diffuse away from the heated plate more quickly than for higher values of Pr since smaller values of Pr are comparable to increasing the thermal conductivities because the boundary layer is thicker and the rate of heat transmission is decreased in the case of decreasing Prandtl numbers. (M. G. Reddy & Reddy, 2010)

For different valuesof the Dufour number, the velocity and temperature profiles are shown in Figures 8 and 9 respectively. The Dufour number rises, indicating that mass diffusion has less of an impact than heat diffusion. In these circumstances, the velocity profile often rises while the temperature profile falls. The increasing thermal diffusion effects cause the velocity profile to increase. The thermal diffusion becomes more significant as the Dufour number rises, resulting in higher heat transfer between the fluid and the surroundings. Convective effects that improve fluid motion and, as a result, raise the velocity profile can be brought on by this increased heat transfer. On the other hand, the increased heat diffusion is what causes the temperature profile to fall. A more effective heat transmission mechanism results from the thermal diffusion becoming more prominent with a greater Dufour number. As a result, the temperature profile tends to flatten out and the temperature distribution becomes more uniform.

The influence of the Schmidt Sc number on the velocity and concentration profiles is shown in Figures 10 and 11, respectively. The ratio of momentum to mass diffusivity is represented by the Schmidt number. The relative efficiency of momentum and mass movement by diffusion in the hydrodynamic (velocity) and concentration (species) boundary layers are consequently measured by the Schmidt number. The concentration reduces as the Schmidt number rises. As a result, the concentration buoyancy effects reduce which lowers the fluid velocity. The velocity and concentration boundary layers are simultaneously reduced along with the velocity and concentration profiles. (M. G. Reddy & Reddy, 2010)

Figures 12 and 13 show the velocity and concentration profiles for different values of the Soret number. It should be noted that an increase in the number of Soret leads to an increase in velocity and concentration in the boundary layer. The boundary layer may experience convective flow patterns as a result of the Soret effect. Thermal diffusion generates fluctuations in the concentration of various components, which results in density discrepancies as the temperature differential gets larger. These disparities in density can cause convective flow, which raises the velocity of the boundary layer (Figure 12). The heat diffusion effect gets higher with a greater Soret number. The temperature differential causes the mixture's various components to separate more clearly as a result. This separation causes concentration gradients to rise, which may result in a buildup of the more diffusive component close to the boundary layer (Figure 13).

Figures 14, 15 and 16 show the effects of suction parameters on velocity, temperature, and concentration, respectively. It has been observed that increases in suction parameters lead to decreases in velocity, temperature, and concentration. Suction functions as a force resisting the flow or as a negative pressure. The strength of the suction force grows along with the suction parameter. A reduction in velocity is the result of the increased suction force counteracting the fluid motion. The suction force draws fluid out of the system, which lowers the flow rate and, in turn, lowers the fluid's velocity. The temperature profile can also be impacted by the suction parameter. The suctioned-out fluid is replaced by possibly warmer surrounding fluid as it is removed. If the fluid being suctioned has a greater temperature, removing it lowers the temperature of the remaining fluid. As a result, a decrease in temperature may result from increasing the suction parameter. The concentration profile is also influenced by the suction parameter. When using suction, it is possible to extract some of the fluid along with any dissolved or suspended particles that are present in the fluid. The final fluid's total concentration falls as a result.

Figures 17 and 18 show the velocity and concentration profiles for different values of the thermal slip parameter,δ. In Figure 17, as the thermal parameter increase, the velocity profile decrease. The momentum transfer between the fluid and the solid surface is interfered with by the temperature jump effect. The velocity of the fluid close to the solid surface is hampered by the greater temperature gradient, which reduces the velocity profiles. From Figure 18, we can observe that the concentration profile decrease as the thermal slip parameter increase. The fluid's ability to diffuse solute particles can be improved by increasing the temperature jump parameter. The solute particles encounter increasing thermal gradients as the temperature rise and get bigger, which increases diffusion. A drop in the concentration gradients and, as a result, a decrease in the concentration profiles can result from this improved diffusion.

Table 2 demonstrates how the thermal slip parameter affects the skin-friction coefficient C_f, Nusselt number Nu, and Sherwood number Sh for Gr=2.0, Gm=2.0, M=0.5, K=0.5, Pr=0.71, Du=0.2, Sc=0.6, Sr=1.0, Ec=0.01, f_w=0.5

Table 2. Quantities of interest with thermal slip parameter

Thermal slip parameter, δ	Skin friction, C_f	Nusselt number, Nu	Sherwood number, Sh
0.5	0.5592	0.5345	0.5688
1.0	0.3975	0.4106	0.6094
1.5	0.2943	0.3339	0.6342
2	0.2224	0.2817	0.6510

From Table 2, it is observed that Skin friction tends to decrease as the thermal slip parameter rises. This is due to the fact that a higher thermal slip parameter suggests a thicker momentum boundary layer, which would result in less momentum transfer and hence lower skin friction. The Nusselt number may drop when the thermal slip parameter increases. This is due to a lower fluid-solid contact implied by a larger slip parameter, which suggests a lower convective heat transfer. The precise relationship, however, relies on the unique system and flow circumstances. The Sherwood number may rise with an increase in the thermal slip parameter. This is because a higher Sherwood number, which is caused by a lower fluid-solid contact, allows for improved mass transport due to a greater slip parameter.

Conclusion

The impacts of the various embedded essentials parameters such as the temperature slip parameter, Soret number, and Dufour parameter on the distribution of the velocity, temperature, and concentration as well as the skin friction coefficients, Nusselt number, and Sherwood number are presented and analyzed. The conclusions of the study are as follows:

1. The velocity increases as the thermal Grashof number and solutalGrashof number increase.
2. The velocity decreases as the magnetic parameter and permeability parameter increase.
3. The velocity increases as the Dufour number increase while the temperature decreases as the Dufour number increase.
4. The velocity and temperature decrease as the Prandtl number and Schmidt number increase.
5. The velocity increases as the Soret number increase and temperature decrease as the Soret number decrease.
6. As the thermal parameter increase, the velocity and concentration decrease.

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