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Magnesium blood nanoparticles mixed with Powell-Eyring fluid embedded in a stratified medium

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ABSTRACT
Recently, researchers have been focusing on the treatment of diseases caused by magnesium deficiency. Hypomagnesaemia is caused by a lack of magnesium in the blood, which is a further stimulus for various diseases such as vomiting, sleepiness, nausea, loss of appetite and so on. To compensate for this deficiency, magnesium is injected as a nanoparticle into the blood (base fluid). To convey this magnesium deficiency the Powell-Eyring (Magnesium-Blood) nanofluid flow is deformed by the linearly stretchable sheet near the stagnation point in the presence of an inclined magnetic field and joule heating. Here, we also found thermal stratification and nonlinear thermal radiation. The resulting equations are converted to dimensionless form using similarity transformations and solved by the bvp4c method. Graphs and tables are used to investigate the impact of relevant factors on the flow profile. The non-linear radiative parameter is enhanced, resulting in a decrease in blood flow temperature and an increase in heat transfer. As the malting parameter is increased, we see a decrease in temperature and an increase in the velocity of magnesium blood flow. Enriched magnesium nanoparticles are added to medicine to benefit patients, depending on their health conditions.

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KEYWORDS
Thermal stratification; magnesium-blood nanofluid; nonlinear radiation; Eyring-Powell model; melting rheology

Nomenclature

(u_0, v_0)	velocity components (m s^{-1})
(x_0, y_0)	Cartesian coordinates (m)
U_∞	free stream velocity (m s^{-1})
U_w	stretching velocity (m s^{-1})
T	temperature (K)
ϕ_0	volume fraction of the nanofluid
T_m	melting surface temperature (K)
α	angle of inclination
T_∞	ambient temperature (K)
σ_{nf}	electrical conductivity of the nanofluid (Ω^{-1}m^{-1})
B_0	magnetic field ($\Omega^{1/2}$m^{-1}s$^{-1/2}$kg$^{1/2}$)
k_{nf}	thermal conductivity of the nanofluid (Wm^{-1}K^{-1})
σ_b	Stefan–Boltzmann constant (Wm^{-2}K^{-4})
k_b	mean absorption coefficient (m^{-1})
T_0	reference temperature (K)
μ_{nf}	nanofluid's dynamic viscosity (kg m^{-1} s^{-1})
$(\rho c_p)_{nf}$	nanofluid heat capacitance (Jm^{-3} K^{-1})
ρ_{nf}	density of the nanofluid (kg m^{-3})

1. Introduction

Nanofluids are smart fluids that may enhance mass and heat transpor, and have much use in engineering and industries such as biomedicine, manufacturing and electronics. Presently, several investigators and researchers rewarded enough consideration of these techniques and methods which were helpful in the improvement of heat transfer on various heat exchanger methods. This investigator advanced the recent kind of fluid known as nanofluid to achieve those demands. The nanofluid was the fluid that included nanometer-sized particles called nanoparticles. Oxides, metals, carbon nanotubes and carbides were the highest familiar nanoparticles working on nanofluids. The nanofluids were useful and had a wide range of uses, containing fuel cells, temperature controls, microelectronics, gas ventilating chimneys, pharmaceutical procedures, heating systems, heat dissipation, cross-breed powered machines, etc. The deficiency of metal (Magnesium) in animals detail stern diseases such as character alters, muscle spasms, loss of appetite weakness, tremors, sleepiness and seizures mainly for children, etc. (Fiorentini et al. 2021; Ismail, Ismail, and Ismail 2018; Odler et al. 2021; Rude 1998). For equivalence-like deficiency magnesium nanoparticles are inserted into blood. The deficiency of magnesium through non-Newtonian nanofluid flow by the vicinity of the stagnation point was considered by Farooq et al. (2022). Khan et al. (2021) considered the dynamics of transient blood conveying gold nanoparticles by the absence of entropy generation and Lorentz force. Algehyne et al. (2023) studied thermal convective magneto-hydrodynamic flow on the water-placed micropolar nanofluid extensive Ag and CuO nanoparticles through the stagnation point region on the surface. Bhatti et al. (2022) examined the interruption of magnesium oxide and gold nanoparticles generating among vertical parallel plates into viscous dissipation and joule heating. Sagheer, Farooq, and Hussain (2023) inspected the

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effect on the heat source and viscous dissipation of the Maxell nanofluid model across the linearly stretching surface. Ghadikolaei et al. (2023) examined heat transfer and laminar flow and heat on the single-phase green nanofluid by the liquid heat sink. Sachica et al. (2022) analysed the mixed convective heat transfer on alumina-water nanofluid flow previous to the isothermal circling cylinder. Interesting studies involving nanofluids can be found in Refs. (Abolbashari et al. 2014; Das et al. 2015; Ouni et al. 2023; Khan et al. 2023; Yahaya et al. 2023; Yao et al. 2023).

Thermal radiation was the three practices it granted about the transfer of thermal energy among applicable temperatures. This electromagnetic development diffusion levels against drugs were represented as thermal radiation. The factors like the temperature of the material communicate radiation differing against ultraviolet into distant-range infrared. The thermal radioactive material was applied to industry where large-temperature differences were enforced such as polymer production, thermal furnaces, rubber manufacturing, nuclear power stations, etc. The analysis of Ag-TiO_2 hybrid nanofluid through the porous wedge into viscous dissipation and heat radiation was investigated by Kho et al. (2023). That free convective chemically reacting influence of the Buongiorno-nanofluid flow with the stretching aggressive Riga plate by double stratification was considered by Shamshuddin et al. (2023). Raza et al. (2021) analysed the linear thermal radiation impact of the Williamson fluid flow within the curvilinear coordinate system. Anjum et al. (2023) examined steady 3D flow on cross-nanofluid-containing microorganisms due to Lorentz force. Mandal et al. (2022) reported this entropy generation on bioconvection flow by nanofluid consisting of gyrotactic microorganisms through the radiaitve apt cylinders. Aly et al. (2022) studied the hybrid nanofluid flow on incompressible wall jets into mass transportation and thermal radiation.

Eyring-Powell was a significant non-Newtonian fluid in industrial areas, biological technology or manufacturing. Trivial model to cite include processes requiring boiling and bubbles, custards, plastic foam processing, mud and tooth paste. Aziz et al. (2021) examined the characteristics of volumetric entropy generation and convective heat transport on Powell-Eyring hybrid nanofluid through the horizontal permeable stretching surface. Bhattacharyya et al. (2022) presented peristaltic transport on Eyring-Powell fluid over a non-uniform medium. Avramenko, Kovetskaya, and Shevchuk (2022) elucidated the heat transfer and fluid flow by Eyring-Powell fluids on the boundary layer through the flat surface. Patil and Kulkarni (2022) discussed the triple diffusive quadratic connected convective non-Newtonian nanoliquid flow through the affecting vertical plate by the absence of diffusing liquid hydrogen and oxygen. More studies are in Refs. (Anjum et al. 2022; Çolak, Shafiq, and Sindhu 2022; Hayat et al. 2012, 2013; Hayat, Shafiq, and Alsaedi 2015; Hayat, et al. 2015; Hussain and Khan 2022; Irfan et al. 2022; Khan 2022, 2023a, 2023b; Khan, Culham, and Makinde 2015; Khan, Makinde, and Khan 2016; 2020a, 2020b, 2020c, 2020d, 2021a, 2021b, 2022a, 2022b; Makinde, Khan, and Khan 2017; Makinde, Mabood, and Ibrahim 2018; Rasool et al. 2020; Rehman et al. 2017; Rehman, Malik, and Makinde 2018; Sarkar and Makinde 2022; Shafiq and Sindhu 2017; Shafiq et al. 2020, 2021, 2022a, 2022b, 2022c; Sindhu and Atangana 2021; Sindhu, Shafiq, and Al-Mdallal 2021; Tabrez and Khan 2022; Waqas et al. 2022).

Solidification meltings were an important phenomeno in heat transfer inspired many investigators as a result of their widespread physical application in the heat exchanger, thermal protection heat engines, disciples of thermocouples, welding processes; latent heat thermal energy storage and crystal development. Al-Shuwaili et al. (2023) scrutinised the solidification processes and melting on phase change materials within the triples-tube heat storage unit. The heat transfer and melting characteristics of the multi-walled carbon nanotube within the square duct into the vertical undulated wall were studied by Gupta, Mishra, and Singh (2022). Punniakodi et al. (2022) analysed the melting on step change material on the horizontal container by applying multi-heat transfer tubes. Few recent articles on the topic can be studied in Refs. (Butt et al. 2023; Hosseini and Dehaj 2022; Hussain and Sheremet 2023; Kong et al. 2023; Kumar and Sharma 2022; Maleki and Pourahmad 2023).

This principal argument of the investigation was to analyse the effect on Powell-Eyring nanofluids by that stagnation point flow along this given magnetic field. The blood was held by base fluid and magnesium (Mg) nanoparticles were popularised on it. At present, they studied blood by Powell-Eyring fluid being that fluid form illustrates the properties of shear-thinning fluids. That was as well significant in signing the blood reverse shear thinning performance restraint into greater shear stress. As an illustration, the heart employs greater shear stress of that blood to attack this channel. That glossy flows more rapidly when the shear thinning nature prohibits blood clotting in the veins. This effect on nonlinear thermal radiation, joule heating and that high realistic property on melting heat transfer were replaced for consideration of the heat transfer. To the best of their ability, no analysis had been expressed that sheds light on the noticed problems. Hence, they believe their unique access would supply the key to higher the essential data on like flow that following use different health problems.

2. Statement of the problem

Consider that incompressible flow, steady flow on Powell-Eyring nanofluids by that stagnation point flow into a given magnetic field by the angle α constrained into stretching sheet. This property by melting was held for examination for analysing the heat transfer. Joule heating, viscous dissipation, linear thermal stratification and effect were popularised into the temperature profile. An illustration of this model is given in Figure 1. Where, x_0- and y_0-axes were elected and perpendicular by this plate, correspondingly, and that plate was considered to be affected by the velocity $u_0 = c_0 x_0$, here $(a_0 > 0)$ was the constant and x_0 as the coordinate consistent with the melting surface. Again, this investigation on heat transport by the examined model was investigated by the connected impacts on melting heat and nonlinear thermal radiation.

This ambient temperature was assumed to be higher than this surface temperature, i.e. $T_\infty > T_m$. Magnesium nanoparticles were delayed on base fluid, i.e. this blood. These governing equations into enforcement on that boundary layer similarity

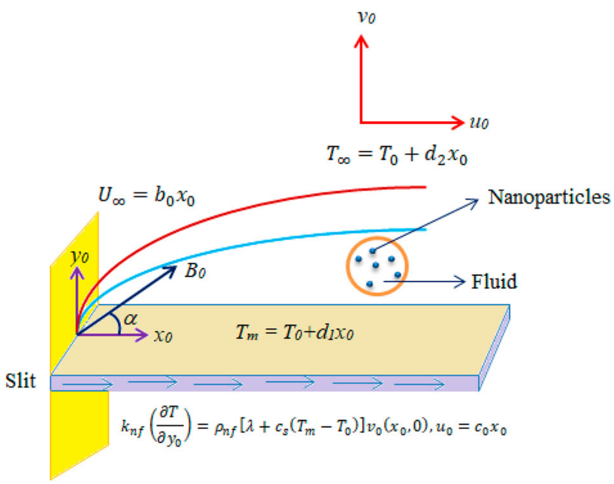

Figure 1. Physical sketch of the flow model.

were taken by following (Farooq et al. 2022):

$$\frac{\partial u_0}{\partial x_0} + \frac{\partial v_0}{\partial y_0} = 0, \tag{1}$$

$$\begin{aligned}\rho_{nf}\left(v_0\frac{\partial u_0}{\partial y_0} + u_0\frac{\partial u_0}{\partial x_0}\right) - U_\infty\frac{dU_\infty}{dx_0} &= \left(\mu_{nf} + \frac{1}{\beta C_1}\right)\frac{\partial^2 u_0}{\partial y_0^2} - \frac{1}{2\beta C_1^3}\left(\frac{\partial u_0}{\partial y_0}\right)^2 \times \frac{\partial^2 u_0}{\partial y_0^2} \\ &\quad - \sigma_{nf}B_0^2\sin^2(\alpha)(u_0 - U_\infty),\end{aligned} \tag{2}$$

$$\begin{aligned}(\rho c_p)_{nf}\left(v_0\frac{\partial T}{\partial y_0} + u_0\frac{\partial T}{\partial x_0}\right) &= k_{nf}\frac{\partial^2 T}{\partial y_0^2} + U_\infty\frac{dT_\infty}{dx_0} - \frac{1}{6\beta C_1^3}\left(\frac{\partial u_0}{\partial y_0}\right)^4 \\ &\quad + \frac{16}{3}\frac{\sigma_b}{k_b}\frac{\partial}{\partial y_0}\left(T^3\frac{\partial T}{\partial y_0}\right) + \left(\mu_{nf} + \frac{1}{\beta C_1}\right)\left(\frac{\partial u_0}{\partial y_0}\right)^2 \\ &\quad + \sigma_{nf}B_0^2\sin^2(\alpha)(u_0 - U_\infty)^2,\end{aligned} \tag{3}$$

Performed in accordance with the boundary conditions:

$$\begin{aligned}&u_0 = U_w(x_0) = c_0 x_0,\ T = T_m = T_0 + d_1 x_0, \\ &k_{nf}\left(\frac{\partial T}{\partial y_0}\right) = \rho_{nf}[\lambda + c_s(T_m - T_0)]v_0(x_0, y_0),\ at\ y_0 = 0,\end{aligned} \tag{4}$$

$$\begin{aligned}&u_0 = U_\infty(x_0) = b_0 x_0, \\ &T = T_\infty = T_0 + d_2 x_0, as\ y_0 \to \infty.\end{aligned} \tag{5}$$

The transformed PDEs are:

$$\xi = y_0\sqrt{\frac{c_0}{\upsilon_f}},\ u_0 = c_0 x_0 h'(\xi),$$
$$v_0 = -\sqrt{c_0\upsilon_f}h(\xi),\ \theta(\xi) = \frac{T - T_m}{T_\infty - T_0}. \tag{6}$$

This continuity Equation (1) was complete although Equations (2)–(3) come:

$$\begin{aligned}&(B_2 + \varepsilon)h''' - \varepsilon\delta h''' h''^2 + B_1 hh'' - B_1 h'^2 \\ &- B_3 Ha\sin^2(\alpha)(h' - A) + A^2 = 0,\end{aligned} \tag{7}$$

$$\begin{aligned}&B_5\left[1 + \frac{Nr}{B_5}\{1 + 3\theta(\theta_w - 1) + 3\theta^2(\theta_w - 1)^2 + \theta^3(\theta_w - 1)^3\}\right]\theta'' \\ &+ \frac{Nr}{B_5}[3\theta'^2(\theta_w - 1) + 6\theta\theta'^2(\theta_w - 1)^2 + 3\theta^2\theta'^2(\theta_w - 1)^3] \\ &- B_4\Pr(\theta h' + s_1 h' - h\theta') + \Pr Ec\left[(B_2 + \varepsilon)h''^2 - \frac{1}{3}\varepsilon\delta h''^4\right] \\ &+ B_3 Ha\,Ec\,\Pr\,\sin^2(\alpha)(h' - A)^2 = 0,\end{aligned} \tag{8}$$

These dimensionless boundary conditions were recorded on the following model:

$$h'(0) = 1,\ \Pr h(0) + \frac{B_5}{B_1}M\theta'(0) = 0,\ \theta(0) = 0, \tag{9}$$

$$h'(\infty) = A,\ \theta(\infty) = 1 - s_1. \tag{10}$$

Pr is the Prandtl number, δ and ε signify the material factors, *M* shows the melting parameter, s_1 performs the stratified thermal parameter,θ_w denotes the temperature ratio parameter, *Ha* signifies the magnetic factor, *Nr* represents the radiation parameter, *A* is the ratio of free stream velocity and *Ec* signifies the Eckert number into stretching velocity. Those parameters were depicted by the following model:

$$\delta = \frac{U_w^2 c_0}{2\upsilon_f C_1^2},\ \Pr = \frac{(\mu c_p)_f}{k_f},\ A = \frac{b_0}{c_0},\ s_1 = \frac{d_1}{d_2},\ \varepsilon = \frac{1}{\beta C_1\mu_f},$$

$$B_2 = (1 - \phi_0)^{-2.5},\ B_1 = (1 - \phi_0) + \phi_0\frac{\rho_s}{\rho_f},\ \theta_w = \frac{T_0}{T_\infty},$$

$$B_3 = \frac{\sigma_{nf}}{\sigma_f},\ \frac{\sigma_{nf}}{\sigma_f} = \frac{(\sigma_s + 2\sigma_f) - 2\phi_0(\sigma_f - \sigma_s)}{(\sigma_s + 2\sigma_f) + \phi_0(\sigma_f - \sigma_s)},$$

$$Ec = \frac{U_w^2}{(c_p)_f(T_\infty - T_0)},\ B_4 = (1 - \phi_0) + \phi_0\frac{(\rho c_p)_s}{(\rho c_p)_f},$$

$$M = \frac{(c_p)_f(T_\infty - T_0)}{\lambda + c_s(T_m - T_0)},\ B_5 = \frac{k_{nf}}{k_f},$$

$$\frac{k_{nf}}{k_f} = \frac{(s_s + 2k_f) - 2\phi_0(k_f - k_s)}{(k_s + 2k_f) + \phi_0(k_f - k_s)},\ Ha = \frac{\sigma_f B_0^2}{\rho_f c_0},\ Nr = \frac{16\sigma_b T_\infty^3}{3k_f k_b}.$$

This skin friction coefficient and local Nusselt number were considered in the following model:

$$C_f = \frac{\tau_w}{\rho_{nf}U_w^2},\ Nu_x = \frac{xq_w}{k_f(T_\infty - T_m)}. \tag{11}$$

where τ_w, q_w are the heat flux and the wall shear stress, respectively.

2.1. Present

$$\tau_w = \left(\mu_{nf} + \frac{1}{\beta C_1}\right)\left(\frac{\partial u_0}{\partial y_0}\right) - \frac{1}{6\beta C_1{}^3}\left(\frac{\partial u_0}{\partial y_0}\right)^3,$$
$$q_w = -k_{nf}\left(\frac{\partial T}{\partial y_0}\right) + q_r\ as\ y_0 \to 0. \tag{12}$$

This unitless model on the upon quantities is as follows:

$$C_f Re_x^{1/2} = (B_2 + \varepsilon)h''(0) - \frac{1}{3}\varepsilon\delta h''(0)^3,$$
$$Nu_x = -\frac{B_5(1 + Nr(\theta_w)^3)\theta'(0)}{Re_x^{-1/2}(1 - s_1)}. \quad (13)$$

That local Reynolds number was established on the model, i.e. $Re_x = \frac{U_w x_0}{\upsilon_f}$.

3. Numerical procedure

The set of nonlinear double differential equations into dimensionless boundaries stated in (7)–(8) found mathematical solutions about velocity, temperature and concentration using this Lobatto IIIa finite difference shooting method bvp4c by computing software MATLAB.

3.1. Let us examine

$$h = \Re_1, \frac{dh}{d\xi} = \Re_2, \frac{d^2h}{d\xi^2} = \Re_3, \frac{d^3h}{d\xi^3} = \Re_3',$$
$$\theta = \Re_4, \frac{d\theta}{d\xi} = \Re_5, \frac{d^2\theta}{d\xi^2} = \Re_5', \quad (14)$$

They obtain the following first-order system:

$$\Re_3' = \frac{-1}{(B_2 + \varepsilon - \varepsilon\,\delta\,\Re_3^2)} \times [B_1\Re_1\Re_3 - B_1\Re_2^2 - B_3 Ha\sin^2(\alpha)(\Re_2 - A) + A^2], \quad (15)$$

$$\Re'_5 = \frac{-1}{B_5[1 + (Nr/B_5)\{1 + 3(\theta_w - 1)\Re_4 + 3(\theta_w - 1)^2\Re_4^2 + (\theta_w - 1)^3\Re_4^3\}]} \times \left\{ \begin{array}{c} \frac{Nr}{B_5}(3(\theta_w - 1)\Re_5^2 + 6(\theta_w - 1)^2\Re_4\Re_5^2 \\ +3(\theta_w - 1)^3\Re_4^2\Re_5^2) - B_4\Pr(\Re_4\Re_2 + s_1\Re_2 - \Re_1\Re_5) \\ +\Pr Ec\left[(B_2 + \varepsilon)\Re_3^2 - \frac{1}{3}\varepsilon\delta\,\Re_3^4\right] \\ +B_3 Ha\, Ec\,\Pr\,\sin^2(\alpha)(\Re_2 - A)^2 \end{array} \right\}, \quad (16)$$

The above equations based on boundary conditions (9–10) were composed into a bvp4c code. This issue was initially determined on the lower domain $[0, L]$ and the value of L was raised continuously so that initial slopes $h''(0)$ and $\theta'(0)$ are independently taken by L. Computations were again made by the simplified finite difference method (SFDM). On that access, the governing system was first linearised into applying Taylor's polynomial and to the comparable algebraic system was acquired into working advancing and central variations. This algebraic system's extensive triangular matrix was calculated by applying the Thomas algorithm.

4. Validation of code

To certify the model's effectiveness, they cited the decreased Nusselt number values about different values of Pr by the existence of nonlinear thermal radiation, apt magnetic field, viscous dissipation and melting heat transfer on clear fluids. These numerical solutions are recorded in Table 2 and related to Abolbashari et al. (2014), Das et al. (2015) and Aziz et al. (2021). This displays the best deals with the past analysis.

Table 1. Thermo-physical properties on blood and silver nanoparticles (Farooq et al. 2022; Khan et al. 2021).

Thermo-physical properties	Blood	Magnesium
k(W/mK)	0.52	156
c_p(J/kgK)	3617	1046.7
σ (S/m)	1090	2.3×10^7
ρ(kg/m^3)	1050	1738

Table 2. Correlation on $-\theta'(0)$ with difference on Prandtl number, and taking $A = 0, \varepsilon = \delta = 0, Nr = 0, M = 0, Ha = 0, Ec = 0, S_1 = 0$, and $\theta_w = 0$.

Pr	Abolbashari et al. (2014)	Das et al. (2015)	Aziz et al. (2021)	Present outcomes
0.72	0.80863135	0.80876122	0.80876181	0.808631534
1.0	1.00000000	1.00000000	1.00000000	1.000000000
3.0	1.92368259	1.92357431	1.92357420	1.923681907
7.0	3.07225021	3.07314679	3.07314651	3.072249821
10.0	3.72067390	3.72055436	3.72055429	3.720673058

5. Results and discussion

Thermally stratified Powell-Eyring fluid conveying magnesium-blood nanoparticles over the stretched surface with an impact on melting heat transfer and nonlinear thermal radiation is considered in this investigation. This thermophysical info on nanoparticles was subjected tn Tables 1–2. This effect of various embedded flow variables such as the magnetic factor, velocity ratio factor, Eckert number, radiation parameter, melting parameter and stratified parameter of flow fields were established into graphs, further depicting the influence on corresponding parameters of friction factor and the Nusselt number. About graphical outcomes, they studied $A = 0.1, \varepsilon = 0.2, \alpha = \frac{\pi}{6}, \delta = 0.2, Ha = 0.4, Nr = 0.1, \theta_w = 1.4, Ec = 0.1, \phi_0 = 3\%$, $M = 0.5$, and $s_1 = 0.1$. This base fluid (blood) was chosen for the issues, that belonged to physical realistic cases in life. This Prandtl number about the blood was held into being twenty one.

This impact on the ratio parameter A on the velocity field $h'(\xi)$ by nanofluid is displayed on Figure 2. The velocity form was analysed and exposed to be computed from A. Therefore, this thickness on that velocity limit layer displays equal recessive and stretching performance by free stream velocity. Moreover, these are not boundary layer as $A = 1$, being that fluids and this wall play by that equal acceleration. About $A < 1$, this velocity was greater by that wall's surfaces, although about $A > 1$, this velocity was greater away against the wall. That was the benefit of observing to stagnation point appear by that intersection on the channel or by these points where veins were blocked or semi-blocked when that plaque of this inside walls that consequence to decreases that blood flow inside of arteries. Anyhow, the pressure was maximal like blockages that result in a stroke or heart attack. They may discover Iclogged arteries over differences on graphs.

This influence on the magnetic parameter Ha on and volume fraction parameter ϕ_0 of the horizontal fluid velocity of this nanofluid is illustrated in Figure 3. Although the magnetic factor Ha was exalted, the thickness and velocity layout on the

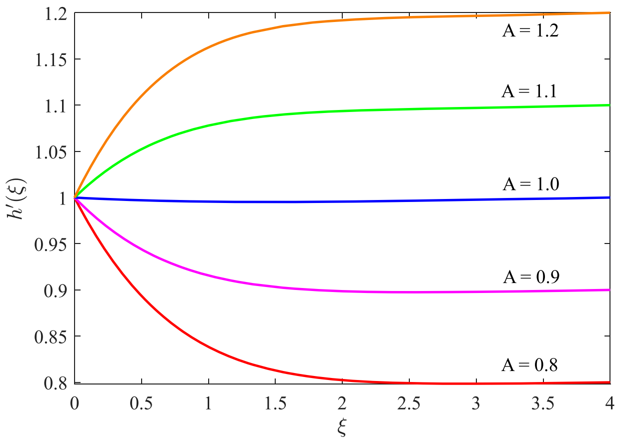

Figure 2. Velocity field about distinct values of A.

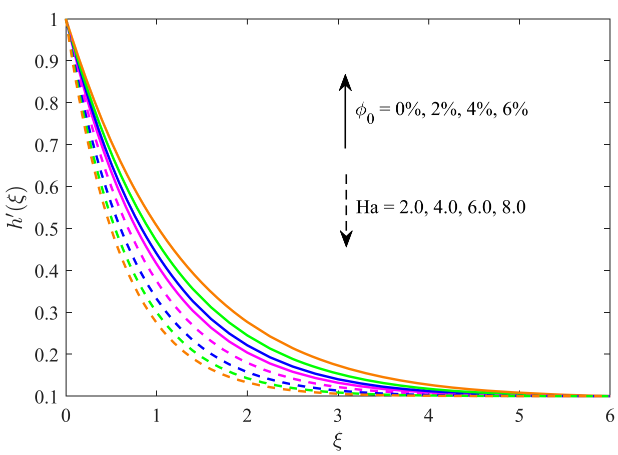

Figure 3. Velocity field about various values of ϕ_0 and Ha.

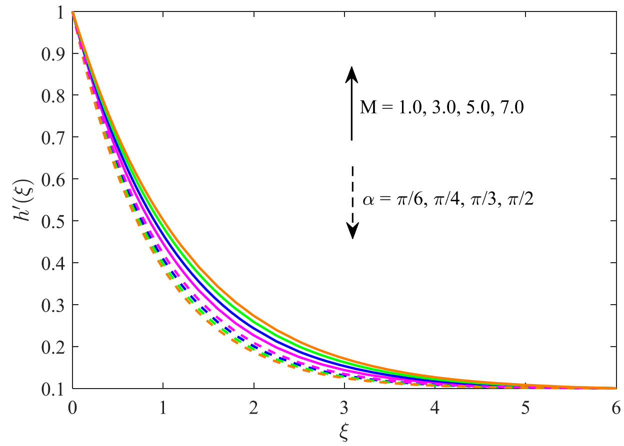

Figure 4. Velocity field about different values of M and α.

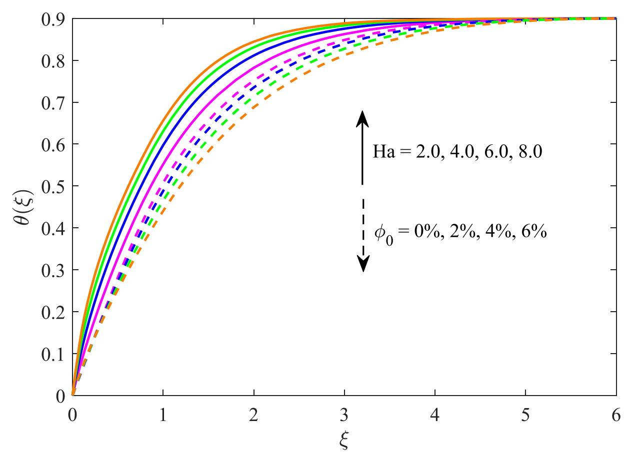

Figure 5. Temperature field about distinct values of Ha and ϕ_0.

boundary layer were decreased. that appears considering the Lorentz force, which gives retarding forces, it performs by drag forces reversed on the flow direction. Hence, collapses the blood motion. Furthermore, it could be noted in the velocity was growing on ϕ_0. It is confirmed that nanoparticles were accountable for a greater rate of heat transfer that consequence to improves the convective flow on nanofluid. Hence, velocity developed regularly. It illustrates that the resumption of magnesium deficiency patient was more corresponding to highly inserted magnesium nanoparticles.

Figure 4 presents the effect on inclination α and melting factor M of this velocity field by a magnesium-blood-based nanofluid. This velocity field decreases as the value of affection α increases resulting in greater Lorentz force and magnetic field. Hence, Lorentz's force reverses that blood flow and finally collapses. Moreover, patients with hypomagnesaemia restore gradually during the transportation of nanofluids. Anyhow, to raise the restoration rate, a magnetic field may be based on that affected region to appeal to the maximal magnesium particles. Furthermore, the improvement in the melting parameter M, this velocity field and similar thickness on that boundary layer enhance.The dominant melting parameter produces the greater convective flow against the cooling surface. Hence, the velocity field developed. That was beneficial to discard the restriction against the inside walls by veins like fats or plaques.

Figure 5 demonstrates the influence of the volume fraction parameter ϕ_0 and the magnetic factor Ha on the temperature field $\theta(\xi)$ of the nanofluid. That temperature profile was raised, though the magnetic parameter was changed. This thickness on the thermal boundary layer again develops continuously. The rate of Lorentz's force improvement to consequence to raise this resistive force about blood motion and alternately produced heat by that blood flow. Hence, blood particles had greater temperature. This improvement on ϕ_0 approach reduced the temperature profile. This direction was also noted in Figure 5. Against those plots, they note that the temperature of magnesium-blood nanofluid was small and related to the pure blood flow as long as less thermal conductivity exists.

The effect of Eckert number Ec and melting factor M on the thermal field is noted in Figure 6 about the nanofluid, especially blood–magnesium. Along with the boost un Eckert number, this temperature distribution regularly enhanced. Actually, that performance was when the drag force among fluid particles transferred mechanical energy along with heat energy. Hence, this temperature field extends. Furthermore, by the melting parameter being inflated, this temperature field evolves the decreasing application. This thickness on the thermal boundary layer raises trough that melting parameter was improved. About the higher melting parameter, the heat plays against to heated fluid into

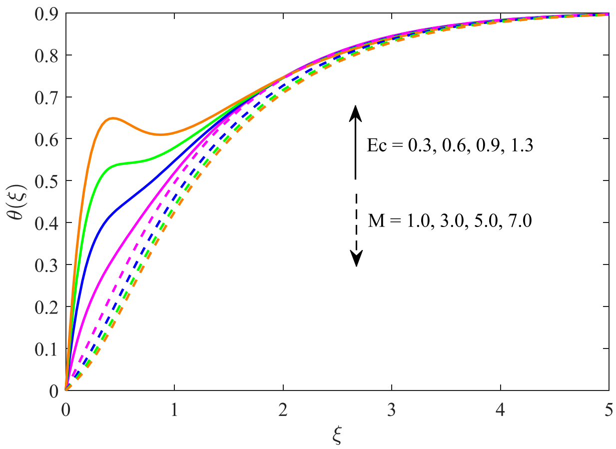

Figure 6. Temperature field about different values of *Ec* and *M*.

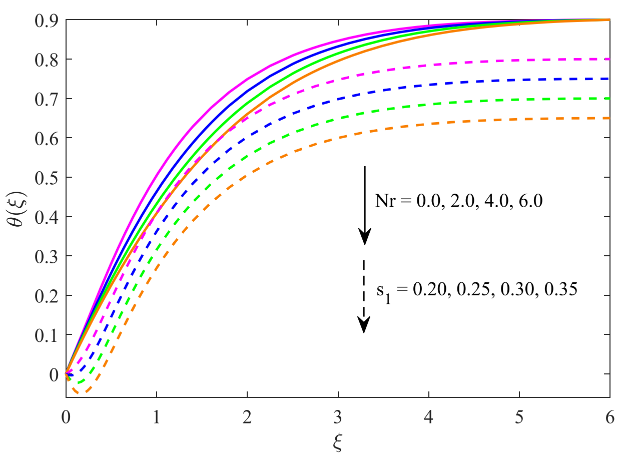

Figure 7. Temperature field about different values of *Nr* and s_1.

this cold wall high fast was accountable for greater heat transfer into the surroundings and lastly results in less temperature. Furthermore, greater heat transfer by the surface of veins shows melting into plaque or fats of the inside walls. Hence, greater melting decreases this barrier to blood flow.

Figure 7 highlights the characteristics of thermal stratification s_1 and radiation factor *Nr* on the thermal field $\theta(\xi)$. It could be shown that temperature distribution decreases by increasing the magnitude of s1. As the stratification parameter increases, different density regions are generated that oppose heat transfer inside the blood. Again, this effect was during the reduction of convective potential among this ambient temperature and sheet surface. Hence, a decrease appears in the blood temperature. Stratification shows the important act by nanoparticles and homogeneous mixtures of blood that prohibit into clog arteries during the non-homogeneous mixtures on blood cells. One can notice from Figure 7 this temperature that similar boundary layer thickness reduces to rise on *Nr*. In this section, the growth of this value of *Nr* similar o the existence of conduction through radiation. The heat loss in this environment increases, reducing the thermal field.

Figure 8 represents the behaviour of the strength of nanoparticle concentration ϕ_0 and malting factor *M* on the fraction factor C_f. The higher values of ϕ_0 and *M* increase the magnitude of

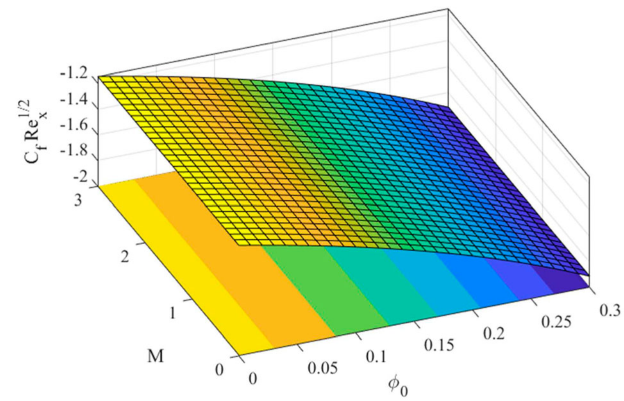

Figure 8. Friction factor about different values of ϕ_0 and *M*.

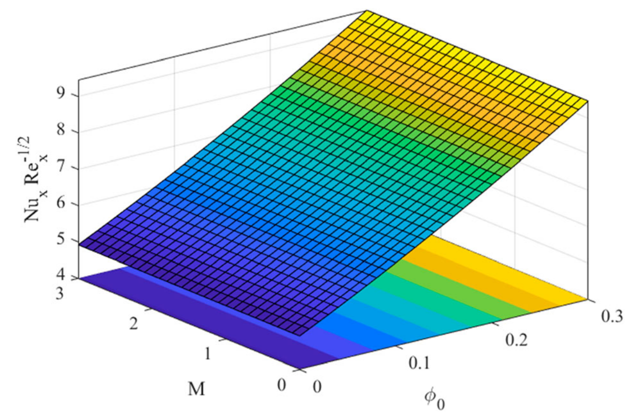

Figure 9. Nusselt numbers about various values of ϕ_0 and *M*.

Table 3. Values of skin friction $C_f Re_x^{1/2}$ and Nusselt number $Nu_x Re_x^{-1/2}$ for $Pr = 21, M = 0.5$ and $\phi_1 = 3\%$.

A	ε	Ha	α	s_1	Nr	Ec	$C_f Re_x^{1/2}$	$Nu_x Re_x^{-1/2}$
0.1	0.2	0.4	$\pi/6$	0.5	0.1	0.1	−1.199159	5.314884
0.2							−1.131140	6.006720
0.3							−1.042878	6.508340
0.1	0.1						−1.144278	5.299743
	0.3						−1.250804	5.330602
	0.5						−1.346259	5.362925
	0.2	0.0					−1.148691	5.509217
		0.3					−1.186723	5.362812
		0.6					−1.223687	5.220273
		0.4	$\pi/4$				−1.247777	5.127254
			$\pi/3$				−1.294738	4.945686
			$\pi/2$				−1.340203	4.769619
			$\pi/6$	0.2			−1.178044	0.402488
				0.4			−1.191694	3.060824
				0.6			−1.207124	8.819795
				0.5	0.0		−1.200731	4.440918
					0.2		−1.197817	6.101465
					0.4		−1.195637	7.475012
					0.1	0.0	−1.204821	6.553551
						0.2	−1.193724	4.120360
						0.4	−1.183475	1.853215

friction factor. As ϕ_0 increases from 0.0 to 0.3, the resultant friction factor increases by 66.68%. Similarly, the melting parameter increases from 0.0 to 3.0, the resultant friction factor increases by 15.81%. The characteristics of ϕ_0 and *M* heat transfer rate are displayed in Figure 9. Significant developments in the heat transfer rate were remarked by developing ϕ_0 and *M*. As ϕ_0 increases from 0.0 to 0.3, the heat transfer rate increases by 92.33%. Similarly, M increases from 0.0 to 3.0, the heat transfer rate increases by 28.71%.

The effect on different physical parameters of physical quantities is given in Table 3. They discovered against the table that the magnitude of friction factor increased for ε, Ha, α, and s_1 although the reverse effect was observed into the improved values of A, Nr and Ec. Heat transfer rate is reduced with an increase in Ha, α, and Ec at the same time they observed the opposite direction on Nu_x into the raise on A, ε, s_1, and Nr.

6. Conclusion

The basic intention of this analysis was to feature the effect on a highly realistic boundary condition, named melting phenomenon was studied to widen that heat transform property. This stagnation point flow on Powell-Eyring fluid into a given magnetic field and nonlinear thermal radiation was held with the account. These inclined PDEs were transformed along the system of ODEs applying this proper comparison transformation. This bvp4c method was applied to the reproduction of the form. These established remarks were observed as follows:

In the absence of magnesium nanoparticles, the magnetic field propagates lazily during the little blood translational velocity. Hence, the patients's discomfort against magnesium would hold high time into regain later put in the medication. Anyhow, the magnetic field would be helpful, if they concentrate this medicine on several particular regions affected by magnesium deficiency. Moreover, this inclination angle again decreases the restoration rate in magnesium deficiency patients. In the region where most attrition on that blood into put in magnesium nanoparticles, a cooling cuff can be applied about thinning on the blood. Moreover, resumption time can reduce the collection of extensive magnesium nanoparticles. The heat transfer rate of magnesium blood nanofluid improved the developed nonlinear radiation parameter. The skin-friction coefficient of blood flow intensifies for growing values of magnetic field strength.

Last but not least, there are much scope in the next analysis by the different system such as viscosity, and thermal conductivity with the help of the various forms as well as different oil-based liquids, i.e. ethylene glycol, kerosene, etc.

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