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Research Article

Steady Three-Dimensional MHD Mixed Convection Couple Stress Flow of Hybrid Nanofluid with Hall and Ion Slip Effect

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The heat transfer ratio has some important applications in industries and the engineering sector. In this model, the authors used the hybrid nanofluid because the heat transfer ratio of hybrid nanofluid is more as compared to the base fluid; the key objective of this research work is to boost up the heat transfer ratio, for example, to regulate the energy is possible only by adding the heat transmission mechanism in the flow model. The current research paper investigates the steady 3D MHD mixed convection couple stress flow of hybrid nanofluid with hall and ion slip effect. The objective of the current research work is to increase the heat consignment ratio, which is the demand of the manufacturing and engineering sector, this type of flow has some important applications in the industries sector and engineering sector for the purpose of cooling and hotness effect, also hotness and cooling play some important role in daily life. To transform the nonlinear partial differential equation to a nonlinear ordinary differential equation we used the defined similarity transformation. The transform nonlinear ordinary differential equations are solved by an approximate analytical method. The important obtained results are presented in the graphs. The influence of different parameters such as couple stress parameter, mixed convection parameter, nanoparticle volume friction, Hall parameter, magnetic field parameter, thermophores parameter, Eckert number, and prandtl number are taken over graphs. The C_f(skin friction coefficient), Nu(nusselt number), convergence control parameter, and comparison of the present work with the published work are described in the form of tables.

1. Introduction

Nanotechnology produced massive consciousness amongst the researchers due to its wide possibility of applications in different branches of science and technology. The important use of the research on nanotechnology is to boost heat transfer entertainment. To enhance the heat transfer ratio different approaches are used for regular fluid. The energy demand is the key aspect of the research in the recent decade and the experts are working to develop new ideas for the rapid gaining of energy at low cost. The small size metal and nonmetal particles in size (1–100 nm) are used in the base liquids to increase the thermal efficiency of the liquids called nanofluids. These nonmetal small size particles belong to various group of carbons and are rapidly being used in the field of manufacturing, Bio-engineering, solar collector, heat exchanges and so on. The stable dispersion of the smaller sized particles in the base liquids improve the thermal efficiency in the form of colloidal solution. The anticipated aspects for nanofluids in the enhancement of heat depend on the (i) toxicity, (ii) thermal properties, (iii) settle with base solvents, (iv) stable chemically, (iv) accessibility, and (vi) price. Conceivable nanomaterial applicants are metal, metal oxides, and carbon materials. These materials become the main focus of research from both theoretical and experimental perspectives, specifically, the chemistry of graphitic carbon. The discovery of graphene macromolecules has extended the domain of the carbon community at a rapid pace and unlocked the investigation of the vast group of 2-dimensional materials. Several researchers work on the combination of solid and liquid for the improvement of ratio. Choi and Eastman [1] for the first time studied the enhancing thermal conductivity of fluids with nanoparticles in the proceedings of 1995. Buongiorno [2] studied the convective heat transport in nanofluids in 2006. Makinde and Aziz [3] studied boundary layer flow of a nanofluid past a stretching sheet with a convective boundary condition. Rana and Bhargava [4] they study flow and heat transfer of a nanofluid over a nonlinearly stretching sheet. Khan and Pop [5] studied boundary-layer flow of a nanofluid past a stretching sheet in 2010. Makinde et al. [6] studied MHD flow of a variable viscosity nanofluid over a radially stretching convective surface with radiative heat in 2016. Besthapu et al. [7] studied mixed convection flow of thermally stratified MHD nanofluid flow over an exponentially stretching surface with viscous dissipation effect in 2017. Acharya et al. [8] used a stretching surface to study ramification of variable thickness on MHD TiO_2 and Ag nanofluid. Acharya et al. [9] used equivalent plates to study pressing flow of nanofluid. Das et al. [10] used a shrinking sheet to study onset of nanofluid in presence of heat source/sink. Ishfaq et al. [11] used a extending surface to discuss estimation of boundary layer flow of a nanofluid. Rana et al. [12] used a pours sheet to investigate mixed convective boundary layer flow of a nanofluid numerically. The researchers take more interest in magneto-marangoni convection, which is produced due to the surface tension. The purpose behind this is some important application such as, scattering of thin liquid layer, atomic reactor, the processing of semiconductor, dynamic use in the welding process, crystal growth, material science, varnish, silicon melt, and many more. The other important application of marangoni convection is fine art mechanism, for instance pigment on the ground. Postelnicu et al. [13] studied the effect of marangoni convection. Al-Mudhaf and Chamkha [14] with the help of porous medium investigated the marangoni convection effect. Wang [15] using series solution method to study the influence of marangoni convection. Chen [16] discussed the inspiration of marangoni convection. Magyari and Chamkha [17] using high magnitude of Reynolds number (Re) to discuss the inspiration of marangoni convection. Zheng et al. [18, 19] studied the MHD marangoni-convective along with the thermal gradients. Aly and Ebaid [20] used laplace transform to study marangoni flow over a permeable surface. Ellahi et al. [21] used ethylene glycol base nanofluid to study different shapes of nano-scale materials. Chen et al. [22] used permeable media to study marangoni convective. Sheikholeslami and Chamkha [23] and Bilal et al. [24] studied Darcy-forchheimer hybrid nano fluid flow with mixed convection past an inclined cylinder. Hybrid nanofluid in the field of sciences and technology is highly applicable. They studied novel kind known as hybrid nanofluid flow for some useful application in manufacturing. [27–31]. The thermal conductivity of EG (ethylene glycol) is little as compared to the other nanofluid. The required demand of heat transfer ratio for current technologies, the wide requirement for thermal energy cannot be satisfied by usually used fluids. The heat transfer ratio of the base fluid is growing when the base liquids are mixed by adding minor shaped particles [32] Thus they increased thermal possessions usual fluids advanced strong interest of researchers to more research. CNTs (carbon nanotubes) are defined as the tube shaped objects, finished of carbon, having nanometer size diameters. Due to the strong bonding between carbon atoms, CNTs are unique. CNTs are classified either single-walled (SWNTs) or multi-walled (MWNTs) nanotubes. Different structures of CNTs nanoparticles, for example, physical, electrical, optical, and thermal, intensified the applications of nanofluids in engineering process containing nano and microelectronics, biosensor, ultracapacitors, atomic reactors, gas storing, textile engineering, display of flat plates, medicinal tools, and many more. Normally used in the energy sector and nanoscience [33] copper oxide water was studied by Kandasamy et al. [34], carbon nanotube/water by Animasaun et al. [35], heat transfer enrichment by carbon nanotube by Aman et al. [36], the investigation of Fe_3O_4/water by Raza et al. [37], the investigation of magnetite-ferrium oxide Fe_3O_4 by Muhammad et al. [38], Al_2O_3/water by Qasim et al. [39], and the study nanofluid flow over a stirring surface by Hussanan et al. [40]. Amirsom, et al. [41] studied three-dimensional bioconvection nanofluid flow from a bi-axial stretching sheet with anisotropic slip. Bég et al. [42] studied double-diffusive radiative magnetic mixed convective slip flow with Biot and Richardson number effects. Uddin et al. [43] studied radiative convective nanofluid flow past a stretching/shrinking sheet with slip effects. Tuz Zohra et al. [44] studied magnetohydrodynamic bio-nano-convective slip flow with Stefan blowing effects over a rotating disc. Uddin et al. [45] studied numerical solution of bio-nano-convection transport from a horizontal plate with blowing and multiple slip effects. Uddin et al. [46] studied computation of bio-nano-convection power law slip flow from a needle with blowing effects in a porous medium. Ma et al. [47] studied Numerical Simulation of Water–Silt Inrush Hazard of Fault Rock: A Three-Phase Flow Model. Ma et al. [48] studied Solid grain migration on hydraulic properties of fault rocks in underground mining tunnel: Radial seepage experiments and

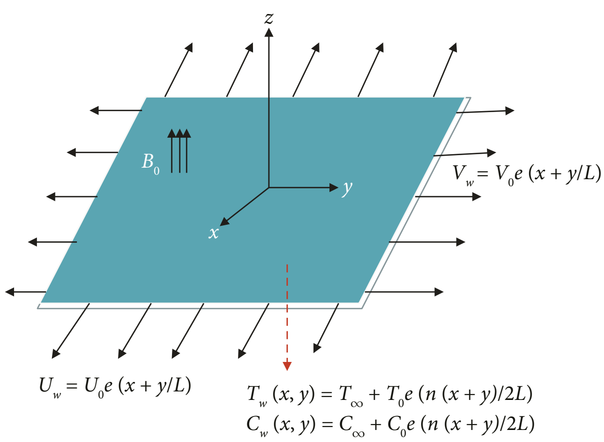

FIGURE 1: Geometry of the flow problem.

verification of permeability prediction. Li et al. [49] studied Insights into Controlling Factors of Pore Structure and Hydraulic Properties of Broken Rock Mass in a Geothermal Reservoir. Key objective of this study is to recover the heat transmission relation, as we know the heat transfer ratio of hybrid nanofluid is more as compare to the base nanofluid nanofluids. For the first time, the steady of 3D MHD mixed convection couple stress flow of hybrid nanofluid with hall and ion slip effect is investigated analytically. The similarity transformation nonlinear partial differential equations is used to convert nonlinear ordinary differential equation. The model nonlinear differential equations have been analysed by approximate analytical method. The impact of different developing results has been inspected with the help of figure and tables. Following contribution show the innovation of the present research article. For the first time, the analytical 3D mixed convection couple stress flow of hybrid nanofluid over an extending surface is considered.

2. Mathematical Formulation

Consider 3D time independent incompressible mixed convection flow of Te_2O_3 + MWCNTs + H_2O and SWCNTs $+H_2O$over an exponentially spreading surface in two lateral directions. The sheet is set at $z = 0$ and the flow is restricted at $z \geq 0$. Due to the applied magnetic field B_0 the fluid is electrical conducted, which is applied in z direction and perpendicular to the xy-plane. Under the supposition of small magnetic Reynolds number the induced magnetic field is ignored. $U_w(x, y) = U_0 e^{(((x+y)/L))}$ is the velocity of the sheet in the x direction and $V_w(x, y) = V_0 e^{(((x+y)/L))}$is the velocity of the sheet in the y direction where U_0 and V_0 are constant and the temperature of the sheet is given as $T_w(x, y) = T_\infty + T_0 e^{(n(x+y)/2L)}$ as shown is Figure 1.

The universal Ohm's law along with Hall and ion slip values is as follows:

$$J' = \sigma(E + (V \times B)) - \frac{\omega_e \tau_e}{B_0}(J' \times B) + \frac{\omega_e \tau_e \beta_i}{B_0^2}(J' \times B) \times B. \quad (1)$$

In equation (1), $J' = (J'_x, J'_y, J'_z)$ represents current density vector, the intensity of the electric filed is denoted by E, the velocity vector is denoted by V, the magnetic field is denoted by B, the cyclotron frequency is denoted by ω_e, and the electrical collision time is denoted by τ_e. All the assumption for mathematical model is describes in Thammanna, et al. [50]. The standard boundary layer supposition the equation governing the continuity, momentum, and energy is as follows:

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

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = \nu_{hnf}\frac{\partial^2 u}{\partial z^2} + g\left[\beta_t (T - T_\infty) + \beta_c (C - C_\infty)\right] + \frac{\sigma_{hnf} B_0^2}{\rho_{hnf}\left(\alpha_e^2 + \beta_e^2\right)}.(\beta_e v - \alpha_e u) - \frac{\nu_{hnf}}{\rho_{hnf}}\frac{\partial^4 u}{\partial y^4}, \quad (3)$$

$$u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = \nu_{hnf}\frac{\partial^2 v}{\partial z^2} - \frac{\sigma_{hnf} B_0^2}{\rho_{hnf}\left(\alpha_e^2 + \beta_e^2\right)}.(\beta_e u + \alpha_e v) - \frac{\nu_{hnf}}{\rho_{hnf}}\frac{\partial^4 u}{\partial y^4}. \quad (4)$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} + w\frac{\partial T}{\partial z} = \alpha\frac{\partial^2 T}{\partial z^2} - \frac{1}{(\rho C)_{hnf}}\frac{\partial q_r}{\partial z} + \frac{Q_0}{(\rho C)_f}(T - T_\infty) + \tau\left[\left(\frac{D_T}{T_\infty}\right)\left(\frac{\partial T}{\partial z}\right)^2\right]. \quad (5)$$

u, v, w shows the velocity components, ρ_{hnf} shows density of the hybrid nanofluid, ν_{hnf} shows kinematic viscosity of the hybrid nanofluid, α shows thermal conductivity, g represent gravitational acceleration, x shows distance along the surface, and y shows the distance perpendicular to the surface. The boundary conditions for the defined flow problem are as follows:

$$u = U_w,\ v = V_w,\ w = 0,\ T = T_w, \text{at } z = 0. \quad (6)$$

$$u \longrightarrow 0,\ v \longrightarrow 0,\ T \longrightarrow T_\infty, \text{as } z \longrightarrow \infty. \quad (7)$$

The Radiative heat flux q_r is as follow:

$$q_r = \frac{4\sigma^* \partial T^4}{3k^* \partial y} = -\frac{16\sigma T^{3\,*}}{3k^*}\frac{\partial T}{\partial y}. \quad (8)$$

In equation (8), σ^* shows Stefan–Boltzmann constant and k^* shows the mean absorption coefficient, the similarity transformations are defined as follows:

$$u = U_0 e^{(x+y/L)} f',\ v = U_0 e^{(x+y/L)} g',$$
$$w = -\sqrt{\frac{\nu_{hnf} U_0}{2L}} e^{(n(x+y)/2L)} (f + \eta f' + g + \eta g'). \quad (9)$$
$$T = T_\infty + T_0 e^{(n(x+y)/2L)},\ \eta = \sqrt{\frac{U_0}{2\nu L}} e^{(n(x+y)/2L)} z.$$

Using equation (9) in equations (2)–(6), equation (9), satisfied (2), identically transformed equations (3)–(6) to the following nonlinear ordinary differential equations.

$$\frac{1}{(1-\phi_1)^{2.5}(1-\phi_2)^{2.5}\left[(1-\phi_2)\left(1-\phi_1+\phi_1\rho_{s_1}/\rho_f\right)+\phi_2\rho_{s_2}/\rho_f\right]}f''' - 2(f'+g')f' + (1-\phi_1)^{2.5}(1-\phi_1)^{2.5}(f+g)f'' + \lambda(\theta+Nr\phi) + \frac{M}{\left(\alpha_e^2+\beta_e^2\right)}(\beta_e g' - \alpha_e f') - Kf^{v} = 0. \tag{10}$$

$$\frac{1}{(1-\phi_1)^{2.5}(1-\phi_2)^{2.5}\left[(1-\phi_2)\left(1-\phi_1+\phi_1\rho_{s_1}/\rho_f\right)+\phi_2\rho_{s_2}/\rho_f\right]}g''' - 2(f'+g')g' + (1-\phi_1)^{2.5}(1-\phi_1)^{2.5}(f+g)g'' - \frac{M}{\left(\alpha_e^2+\beta_e^2\right)}(\beta_e f' + \alpha_e g') - Kg^{v} = 0. \tag{11}$$

$$\frac{1}{\Pr}\frac{k_{hnf}}{k_{bf}}\left(1+\frac{4}{3}R\right)\theta'' + \left[(1-\phi_2)\left(1-\phi_1+\phi_1(\rho Cp)_{s_1}/(\rho Cp)_f\right)+\phi_2(\rho Cp)_{s_2}/(\rho Cp)_f\right]Ec(f+g)\theta' - n(f'+g')\theta + Nt\theta'^2 + Q\theta = 0. \tag{12}$$

$$\frac{k_{hnf}}{k_{bf}} = \left(\frac{ks_2+(n-1)k_{bf}+\phi_2(n-1)\left(k_{bf}-k_{s_2}\right)}{ks_2+(n-1)k_{bf}-\phi_2\left(k_{bf}-k_{s_2}\right)}\right) \text{ Where } \frac{k_{bf}}{k_f} = \left(\frac{ks_1+(n-1)k_f-\phi_1(n-1)\left(k_f-k_{s_1}\right)}{ks_1+(n-1)k_f+\phi_1\left(k_f-k_{s_1}\right)}\right). \tag{13}$$

Along with boundary conditions,

$$f(0)=0, f'(0)=1, g(0)=0, g'(0)=c, \theta(0)=1, =1 \text{ for } \eta=0 \quad \mathrm{f}'\longrightarrow 0, \mathrm{g}'\longrightarrow 0, \theta\longrightarrow 0, \text{as } \eta\longrightarrow\infty. \tag{14}$$

$M = 2L\sigma B_0^2/\rho_{hnf}U_w$ shows the magnetic field parameter, $\Pr = \nu_{hnf}/\alpha$ shows prandtl number, $R = (4\sigma^* T_\infty^3/k^* k)$ shows the nonlinear thermal radiation parameter, $\mathrm{Ec} = U_\varpi^2/c_p(T_\varpi - T_0)$ shows Eckert number, $N_t = \tau D_T (T_w - T_\infty)/\alpha_{hnf}T_\infty$ shows the thermophores parameter, K shows couple stress parameter, Q shows heat source parameter, λ shows mixed convection parameter, c shows stretching ratio parameter, η shows independent variable, β_e shows hall parameter, β_i shows ion slip parameter. The skin friction coefficients C_{fx} and C_{fy} and local Nusselt number Nu_x are defined as follows:

$$C_{fx} = \frac{2\tau_{\mathrm{wx}}}{\rho_{hnf}U_w^2}, C_{fy} = \frac{2\tau_{\mathrm{wy}}}{\rho_{hnf}V_w^2}, Nu_x = \frac{xq_w}{k(T_w - T_\infty)}. \tag{15}$$

The nondimensionless of Skin frication and Nusselt number are as follows:

$$C_{fx}\sqrt{\frac{\mathrm{Re}_x}{2}} = \left(\frac{(1-\phi_1)^{2.5}.(1-\phi_2)^{-2.5}}{(1-\phi_2)\left\{\left((1-\phi_1)+\phi_1.\left(\rho_{s_1}/\rho_f\right)+\phi_2.\left(\rho_{s_2}/\rho_f\right)\right)\right\}}\right)f''(0), \quad C_{fy}\sqrt{\frac{\mathrm{Re}_y}{2}} = \left(\frac{(1-\phi_1)^{2.5}.(1-\phi_2)^{-2.5}}{(1-\phi_2)\left\{\left((1-\phi_1)+\phi_1.\left(\rho_{s_1}/\rho_f\right)+\phi_2.\left(\rho_{s_2}/\rho_f\right)\right)\right\}}\right)f''(0), \frac{Nu_x}{\sqrt{\mathrm{Re}_x}} = -\left(1+\frac{4}{3}R\right)\theta'(0), \tag{16}$$

where $\mathrm{Re}_x = U_w L/\nu_{hnf}$ and $\mathrm{Re}_y = V_w L/\nu_{hnf}$.

3. Method of Solution

Equation (13) is solve analytically by optimal homotopy asymptotic method given below.

$$L'(u(x)) + N'(u(x)) + g_1'(x) = 0, B'(u(x) = 0). \quad (17)$$

L' represents the linear operator, x represent the independent variable, $g_1'(x)$ represents the unknown function, N' represents the nonlinear operator, and $B'(u)$ represents the boundary operator with the help of this method, and we have

$$\begin{aligned} &H(\phi(x), p) = (1-p)[L'(\phi(x,p)) + g_1'(x)] - H(p)[L'(\phi(x,p)) + g_1'(x) + N'(\phi(x,p))] = 0 \\ &B'(\phi(x,p)) = 0 \end{aligned} . \quad (18)$$

The initial solution one for velocity equation and one for temperature equation is obtained from the following equation:

$$\begin{aligned} &L_f' = f''' - f', L_g' = g''' - g', L_\theta' = \theta'' - \theta \\ &f_0(\eta) = 1 - e^{-\eta} \\ &g_0(\eta) = (c - e^{-\eta}) \\ &\theta_0(\eta) = e^{-\eta} \end{aligned} . \quad (19)$$

Liao [25, 26] presented this method to find the residual error so of equations (10)–(13) can be written as follows:

$$\begin{aligned} &\varepsilon_m^f = \frac{1}{n_1+1}\sum_{j_1=1}^{n_1}\left[\kappa_f\left(\sum_{j_1=1}^{n_1} f_1(\eta)_{\eta=j\delta\eta}\right)\right] \\ &\varepsilon_m^g = \frac{1}{n_1+1}\sum_{j_1=1}^{n_1}\left[\kappa_f\left(\sum_{j_1=1}^{n_1} g_1(\eta)_{\eta=j\delta\eta}\right)\right] \\ &\varepsilon_m^\theta = \frac{1}{n+1}\sum_{j=1}^{n}\left[\kappa_\theta\left(\sum_{j=1}^{n} f(\eta)_{\eta=j\delta\eta}, \sum_{j=1}^{n}\theta(\eta)_{\eta=j\delta\eta}\right)\right] \\ &\varepsilon_m^t = \varepsilon_m^f + \varepsilon_m^\theta + \varepsilon_m^g \end{aligned} . \quad (20)$$

4. Results

The following tables and figures show be convergence flow problem.

5. Discussion

The objective of this research paper is to enhance the heat transfer ratio by using hybrid nanofluids. The hard elements dissolve in the base liquid and after its constant diffusion the hybrid nanofluid is produced. The converted nonlinear ordinary differential equation, two for velocity equations and one for temperature equation are solved by optimal homotopy analysis method. The total results of the given flow problem are presented through Figures 2–13, Figure 1 shows geometry of the flow problem, the influence of different parameters on velocity profile both x and y direction are shown in Figures 2–10, the influence of different parameters on temperature profile are shown in Figures 11–13, Table 1 shows the thermo-physical properties of water, CNT*s*and Te_2O_3 nanoparticles, Tables 2 and 3 show the convergence control parameter for both velocity x and y direction, Table 4 shows convergence control parameter for temperature equation of the defined flow problem, Tables 5 and 6 show the influence of different parameter on Skin friction and Nusselt number, respectively, while Tables 7 and 8 show the compression of the present research work and the already publish research work. Table 2 shows the convergence of the defined velocity equation in x direction, from Table 2 we noted that by increasing the number of iteration residual error is decreasing, which show the convergence of the given flow problem, similarly Table 3 show the convergence of the velocity equation in y direction, and Table 4 shows the convergence of the temperature equation. Table 5 shows the impact of $M, K, \lambda, \beta_e, n$ (magnetic field parameter, couple stress parameter, mixed convection parameter, hall parameter, and velocity ratio parameter) on C_f(Skin frication), physically by increasing these parameters the surface frication forces are also increasing, and as a result the C_f(Skin frication) is also increasing as shown in Table 5. From Table 6, we noted that Nu is the increasing function of Q, R, N_t, M (heat source parameter, Reynold, thermophoresis parameter, and magnetic field parameter). Physically increasing these parameters, thermal energy is stored in the system due to the frictional force and as a result Nu is increasing. Tables 7 and 8 show the compression of the present work and already publish work. The variation in couple stress parameter K on velocity along x direction is shown in Figures 2 and 6 along with y direction for both $Te_2O_3 + MWCNTs + H_2O$ and $+H_2O$, from both Figures 2 and 6, we observed that velocity is the decreasing function of couple stress parameter K. This effect occurred due to the production of resistive type forces known as viscous forces, these force increases with the growing size of couple stress parameter K, which face the fluid particles motion. Due to this the motion of fluid drop as a result the velocity profile is decreased and converged to zero. This type of flow has some important application in industries and engineering sector, because such type of flow increases the heat transfer ratio. Figures 3 and 7, shows variation of M (magnetic field parameter) on velocity distribution on both x and y direction for both $Te_2O_3 + MWCNTs + H_2O$ and $SWCNTs + H_2O$. Figure 3 shows the impact of Mon x direction, while Figure 7 shows the impact of Mon velocity profile on y direction, from both Figures 3 and 7 we see that velocity is decreasing

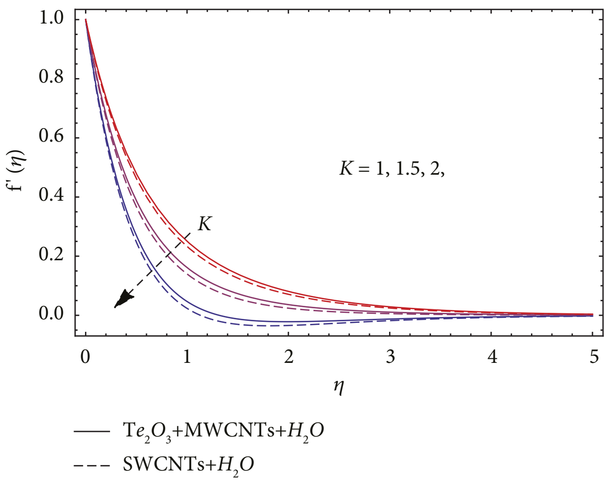

FIGURE 2: Influence of couple stress parameter on velocity profile in x direction.

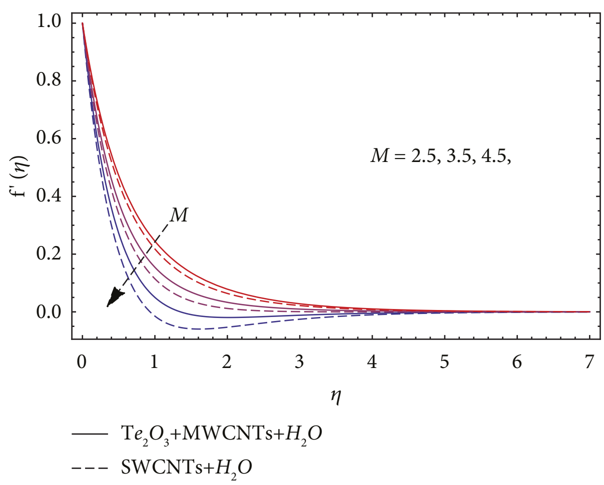

FIGURE 3: Influence of magnetic field parameter on velocity profile in x direction.

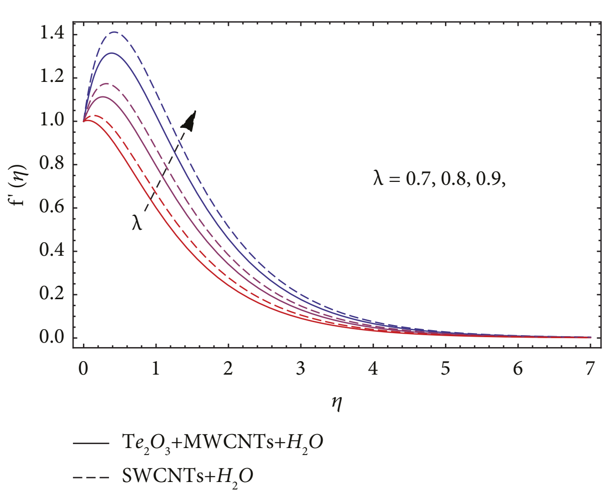

FIGURE 4: Influence of mixed convection parameter on velocity profile in x direction.

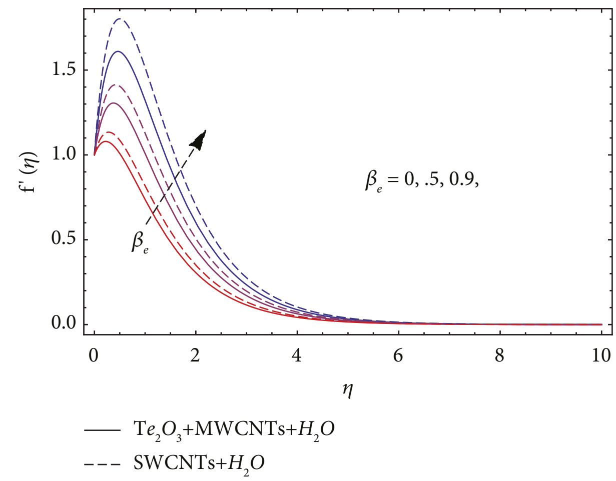

FIGURE 5: Influence of hall parameter on velocity profile in x direction.

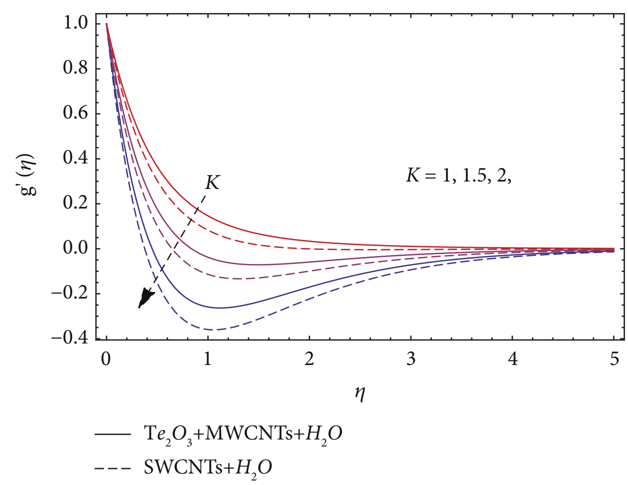

FIGURE 6: Influence of couple stress parameter on velocity profile in y direction.

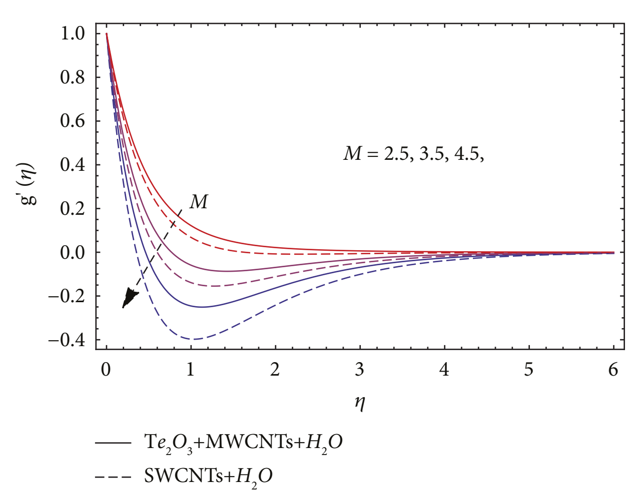

FIGURE 7: Influence of magnetic field parameter on velocity profile in y direction.

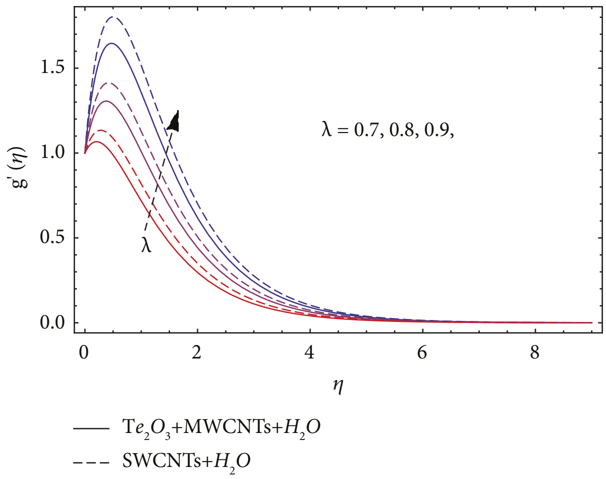

Figure 8: Influence of mixed convection parameter on velocity profile in y direction.

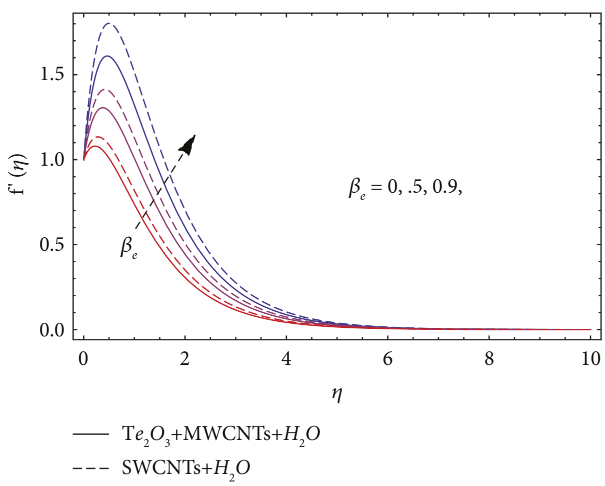

Figure 9: Influence of hall parameter on velocity profile in y direction.

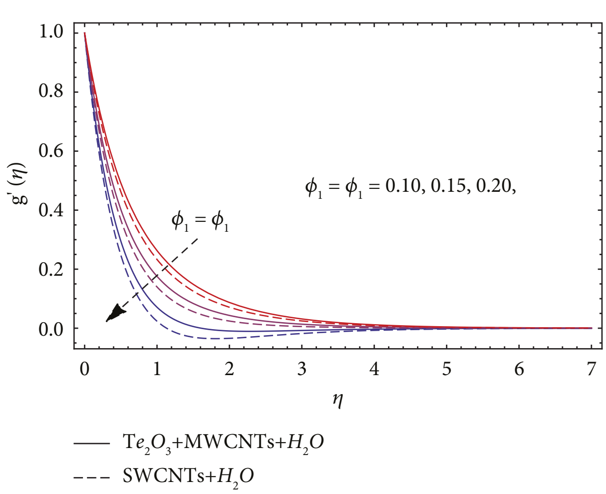

Figure 10: Influence of nanoparticle volume frication on velocity profile in y direction.

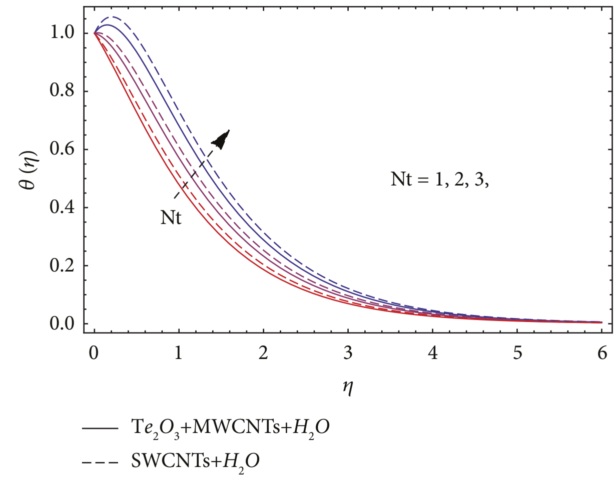

Figure 11: Influence of thermophoresis parameter on temperature profile.

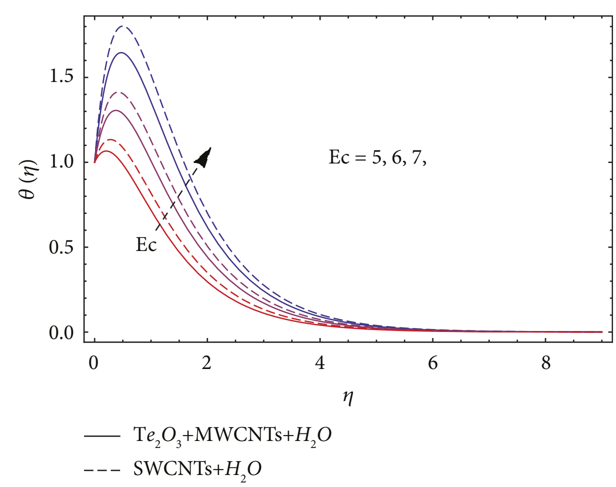

Figure 12: Influence of Eckert number on temperature profile.

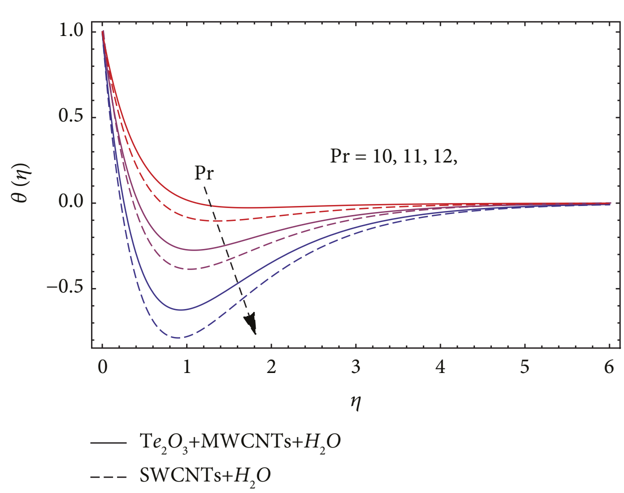

Figure 13: Influence of prenatal number on temperature profile.

Table 1: Thermo-physical properties of water, CNTs, and Te_2O_3 nanoparticles.

	$\rho\,(\mathrm{kg/m^3})$	$C_p\,(\mathrm{j/kgK})$	$k\,(\mathrm{W/mK})$
Pure water	997.1	4179	0.613
SWCNTs	2600	2600	6600
MWCNTs	1600	1600	3000
Te_2O_3	5200	670	6

Table 2: The convergence of the flow problem for velocity equation in x direction, Gul et al. [51].

m	$\mathbf{f}'(\eta)$
5	1.1311×10^{-1}
10	0.4214×10^{-2}
15	2.1613×10^{-4}
20	1.0318×10^{-5}
25	1.0187×10^{-6}

Table 3: The convergence of the flow problem for velocity equation in y direction.

m	$\mathbf{g}'(\eta)$
5	1.0411×10^{-2}
10	3.1214×10^{-3}
15	4.5013×10^{-5}
20	1.1318×10^{-6}
25	3.1187×10^{-7}

Table 4: The convergence of the flow problem for temperature equation.

m	$\theta(\eta)$
5	0.2391×10^{-2}
10	1.3126×10^{-3}
15	0.1218×10^{-4}
20	0.5016×10^{-5}
25	1.1483×10^{-6}

Table 5: The impact of $M, K, \lambda, \beta_e, n$ (magnetic field parameter, couple stress parameter, mixed convection parameter, hall parameter, and velocity ratio parameter) on skin frication for the flow problem.

λ	M	K	β_e	c	C_f
0.1	1	0.80	0.35	0.30	0.7121
0.3	5				0.7313
0.5	9				0.7614
		0.80			0.7901
		0.90			0.8214
			0.45		0.8510
			0.55		0.8840
				0.50	0.9510
				0.70	0.9923

function of M that is increasing magnitude of magnetic field parameter decreases in velocity filed. This impact occurred by the production of resistive types of forces called Lorentz force. These forces improves with the growing strength of M,

Table 6: The impact of Q, R, N_t, M (heat source parameter, Reynold, thermophoresis parameter, and magnetic field parameter) on Nusselt number of the flow problem.

Q	M	R	N_t	Nu
0	7	1	1.5	0.1043
1				0.2615
2				0.2913
	8			0.3227
	9			0.3440
		1.5		0.3712
		2		0.3090
			3.5	0.4210
			5.5	0.4513

Table 7: Comparison table of analytical method and numerical method for velocity equation.

m	Numerical	OHAM	Absolute Error
1	1.0000	1.0000	0.0
2	1.2312	1.2016	3×10^{-3}
3	1.3211	1.2909	3×10^{-3}
4	1.1371	1.3403	3×10^{-3}
5	0.4628	0.4240	2×10^{-2}
6	0.5401	0.5124	2×10^{-3}
7	0.2103	0.2311	-2×10^{-2}
8	0.4912	0.4831	-1×10^{-2}
9	0.6231	0.6009	2×10^{-2}
10	0.6529	0.6811	-3×10^{-3}

Table 8: Comparison table of analytical method and numerical method for temperature equation.

η	Numerical	OHAM	Absolute Error
1	1.0000	1.0000	0.0
2	1.5123	1.4811	3×10^{-2}
3	1.2311	1.2025	3×10^{-2}
4	1.8009	1.7633	4×10^{-2}
5	1.5411	1.5091	4×10^{-2}
6	1.7425	1.7201	2×10^{-2}
7	1.9361	1.9131	2×10^{-2}
8	1.9322	1.9002	3×10^{-2}
9	1.8572	1.8211	3×10^{-2}
10	1.9900	1.9232	7×10^{-2}

which decreases the motion of fluid and converge to zero. This type of flow has some important application in industries and engineering sector, because such type of flow increases the heat transfer ratio. Figures 4 and 8 shows the influence of λ over velocity profile in both x and y direction for both $Te_2O_3 + MWCNTs + H_2O$ and $SWCNTs + H_2O$, Figure 4 show the influence of λon x direction, while Figure 8 show the influence of λ on y direction. From both Figures 4 and 8, we observer that velocity filed is a growing function of λ, that is, the large value of λ increase the velocity profile, this effect is due to the buoyancy impact for both base fluid and hybrid nanofluid. Figures 5 and 9 show variation in β_e on velocity profile for both $Te_2O_3 + MWCNTs + H_2O$ and

$SWCNTs + H_2O$. Figure 5 shows the effect of $\beta_e$on velocity filed in x direction and Figure 9 shows the influence of β_e on velocity filed in y direction. From both Figures 5 and 9, we observe that velocity profile is the growing function of the Hall β_e, that is, the growing value of β_e rise the velocity filed. This impact is due to the inverse relation of β_e and M, that is, by β_e decreeing the M, due to this Lorentz forces is decreasing so as result velocity of both base fluid and hybrid Nano fluid is increasing as shows in Figures 5 and 9, and converge to zero, this type of flow is used in industries sector for Colling effectdecreeing. Figure 10, shows the variation in nanoparticle volume frication $\phi_1 = \phi_2$ on velocity profile for both $Te_2O_3 + MWCNTs + H_2O$ and $SWCNTs + H_2O$, we see that velocity filed is the decreasing function of $\phi_1 = \phi_2$, that is, the increasing magnitude of nanoparticle volume frication $\phi_1 = \phi_2$, decrees the velocity distribution and converges to zero. This effect is produced due to the viscous forces, which increases with the increasing of nanoparticle volume friction and as a result the moment of the fluid particle decreasing, such type of flow Is used in industries sector as a hotness agent, which plays an important role. Figure 11 shows the relation between thermophoresis parameter and temperature profile for both $Te_2O_3 + MWCNTs + H_2O$ and $+H_2O$, we see that temperature filed is the growing function thermophoresis parameter. Therefore, enhancing the thermophoresis parameter heat energy is stored in the system because of the frictional force, which appear in the form of heat and as a result temperature filed is increasing, the uses of this type of flow in industries for the increasing of heat energy so with the help of this flow we can reduced the consumption of energy, which is the required demand of engineering and industries sector. Figure 12 shows the relation between Eckert number and temperature profile for both $Te_2O_3 + MWCNTs + H_2O$ and $+H_2O$. From Figure 12, we see that temperature profile is the growing function of Eckert number. Therefore enhancing the Ecker number heat energy is stored in hybrid nanofluid because of the drug or frictional force which appear in the form of heat and as a result temperature filed is increasing, we can use Ecker number as hotness agent in productions sector to decrees the consumption of energy The uses of this type of flow in industries for the increasing of heat energy so with the help of this flow we can reduced the consumption of energy, which is the required demand of engineering and industries sector. Figure 13 is schemed for Pr on both $Te_2O_3 + MWCNTs + H_2O$ hybrid nanofluid and $SWCNTs + H_2O$ base fluid. It is obvious from Figure 13 that temperature is the decreasing function prandtl number, essentially the viscous diffusion is more than thermal diffusion and consequently, the greater quantity of the Pr decreases temperature filed and converges to zero, prandtl number can be used as a Colling agent in manufacturing sector.

6. Conclusion

The heat transfer ratio of hybrid nanofluid is more as compare to the common nanofluid, due to this consequence the researchers take more interest in hybrid nanofluid nowadays. This paper investigates 3D MHD mixed convection couple stress flow of hybrid nanofluid with hall and ion slip effect analytically. The purpose of this study is to increase the heat transfer ratio with the help of hybrid nanofluid. The present work is found to be very good for the future standpoints because the purpose of this work is the enhancement of heat transfer ratio, in future we will face the shortages of energy sources so with the help of this analysis we gain command on energy feeding, this type of flow problem has some important application in manufacturing field, medical field, auto mobile field for example, the getting of energy is not sufficient, but also to regulate the feastings of energy and this is possible only to support the growth heat transmission liquids . The heat transmission is important in science and technology. In future we will face the problem to adjust the consumptions of energy, in our research article we used hybrid nanofluid which helped in the enhancement of heat transfer ratio which have some important applications, for example, the achievement of energy is not enough, but also to adjust the consumptions of energy and this is possible only to approve the development heat transmission liquids. The heat transmission which is the demand of the industry, for application of nanotechnology and engineers have challenged such huge numbers of application, identifying with heat transmission fluids. Still, with the development of nanometer sized particles and its uses in the heat transfer fluids have overall improved thermal conductivity. The development of heat transport via nanofluid have involved a number of scientist due to a lot of uses in various sectors such as distillation and separation of bio-molecules, biosensors, atomic system cooling, manufacture of glass fiber, thermal storing, in solar water boiler, in field of defense, MRI, thermal absorption process, drag delivery, and transportation (thermal management od vehicle and cooling of engine). The key finding of the present research article are as follows:

(1) The velocity profile along x and $y$direction is increasing by increasing the Hall parameter
(2) The velocity profile along x and $y$direction is decreasing by increasing magnetic field parameter M
(3) The velocity profile along x direction is increasing by increasing mixed convection parameter λ
(4) The velocity profile along x direction is decreasing by increasing the couple stress parameter
(5) The temperature profile is decreasing by increasing prandtl number Pr
(6) The temperature profile is increasing by increasing the thermophoresis parameter Nt
(7) The temperature profile is increasing by increasing Eckert number.

Nomenclature unit

x, y, z: Cartesian coordinates
u, v, w: Velocity components
U_w, V_w: Velocities of the stretching sheet (ms^{-1})
R: Thermal radiation parameter

Q: Heat source
T: Local temperature (C^0)
M: Magnetic field
Nu: Nusselt number
Pr: prandtl number
T_w: Surface temperature (C^0)
B_0: Constant magnetic field
T_∞: Ambient temperature (C^0)
Nb: Brownian motion parameter
Nt: Thermophoresis parameter
C_{fx}: Skin friction coefficient in x-direction
C_{fy}: Skin friction coefficient in y-direction
c: velocity ratio parameter
β_e: Hall parameter
β_i: Ion slip parameter
λ: Mixed convection parameter
ϕ: Dimensionless concentration
θ: Dimensionless temperature.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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