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Radiation-conduction effects on MHD Buongiorno's modelnanofluid flowover a permeable stretching surface in the presence of heat source

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Abstract
In the present analysis, MHD flow of Buongiorno's model nanofluid past a stretching sheet is considered. In addition to that thermal radiation and first order chemical reaction are incorporated in the energy and solutal concentration equation respectively. The Effects of these parameters affects the heat transfer phenomena due to the presence of Brownian and thermophoresis parameters.Suitable similarity transformation is used to transform the governing PDEs to nonlinear coupled ODEs. Runge-Kutta fourth order numerical method is employed for these transformed equations along with shooting technique. The characteristics of different parameters on the flow phenomena are obtained and presented via graphs. The numerical computation for the rate of shear stress, rate of heat and mass transfer are obtained and shown in Tables-1. For the validation of present work, we have compared with earlier established result and found to be in good agreement.
Keywords:*MHD Nanofluid; stretching surface; chemical reaction; numerical approach.*

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I. Introduction

A fluid which is created by solid particles of whose dimensions are less than 100 nm is called as Nanofluid. The performance of heat transfer in nanofluid flow phenomena is characterizes by alow thermal physical phenomenon. Additionally, the classical fluids like alkene one among the foremost fashionable and applicable ways for increasing the constant of heat transfer.''Nanofluid" was first employed by Choi and Eastman [1] which is themixture of nanoparticles and base fluid. Generally, metal or oxides are used for nanofluids.The different aspects and variations of different parameters of nanofluids were discussed in Das et al. [2].A mathematical model of MHD flow with slip in presence of radiation effectwas proposed by Uddin et al. [3]. Bujurke et al. [4] discussed the heat transfer over a stretching sheet in second order fluidwith constant surface temperature.Borrelli et al. [5]and Ashraf and Ashraf [6] examined themagnetic effect on MHD stagnation-pointflow of a micropolar fluid. Freidoonimehr et al. [6] studied the MHD free convection flow of nanofluidover a vertical surface with porosity parameter. Moreover, Jafari and Freidoonimehr [7] discussed on the MHD flow over a stretching surface in the presence of the uniform magnetic field which is applied normally to the surface. Akbar [8] analysed the peristaltic flow in a diverging nanotubes with heat transfer phenomena.Pattnaik and Biswal [9, 10] investigated the MHD free flow in presence of porous media with magnetic and porosity parameter. Mishra et al. [11-14]investigated theeffects of chemical reaction and double stratification on MHD free convection and stagnation-point flowpast a stretching sheet. Joule heating effect and variation of viscous dissipation on MHD Jeffery nanofluid flow in presence/absence of multi-slip boundary conditions have been studied byThumma and Mishra [15]. Makinde and Mishra [16] studied the effect ofradiative heat flux on MHD nanofluid flowover a stretching surface with. Jena et al. [17] considered a MHD Jeffery fluid flow through porous media and analyzed the effect of chemical reaction. Hayat et al. [18] considered an upper convected Maxwell fluid and derived the series solution past a porous stretching plate. Second grade fluid over a stretching sheet for axi-symmetric flow and heat transfer was studied by Hayat and Sajid [19]. Makinde and Olanrewaju [20] considered a convective surface boundary condition in their study to visualize the effect of buoyancywhen the flowpast a vertical plate. Subhashinia [21] studied buoyancy effects which assisting/opposing flows on mixed convection boundary layer past a vertical surface. Ramesh et al. [22] considered a non-Newtonian MHD nanofluid flow in the presence of heat generation/absorption. Vajravelu [23, 24] investigated different fluid flows over a nonlinearly stretching sheet. Both Sanjayanand and Khan [25] and Abel and Mahesha [26] verified the MHD viscoelastic boundary layer flow over a stretching sheet. Mohanty et al. [27, 28] investigated numerically the heat transfer and chemical reaction effect respectively on MHD viscoelastic boundary layerflow past a stretching sheet through porous media. Mishraet al. [29-34] studied different fluid flows of MHD with heat transfer phenomena, porous media, chemical reaction effect and Soret effects with Oldroyd and micropolar fluid along a stretching sheet.

Influenced by above mentioned literature it is our objective to study the heat transfer effect on MHD nanofluid flow in the presence of heat source and chemical reaction. The non-dimensional governing equations are numerically and the outcomes of the results are validate with existing literature.

Nomenclature

u, v	fluid velocity component in x, y direction	k	thermal conductivity
x, y	vertical and horizontal coordinate	h_1	heat transfer coefficients
h_2	nanoparticle mass transfer coefficient	σ	electrical conductivity
B_0	magnetic field	f	self-similar velocity
ρ	fluid density	θ	non-dimensional temperature
υ	kinematic viscosity	ϕ	non-dimensional concentration
k_p^*	porosity parameter	η	scaled boundary layer coordinate
T	fluid temperature	M	magnetic parameter
K_p	non-dimensional porosity parameter	α	thermal diffusivity
τ	relative heat capacity	$\mathrm{P_r}$	Prandtl number
c_p	specific heat at constant pressure	N_b	Brownian motion parameter
$(\rho c_p)_p$	heat capacity of the nanoparticle	N_t	thermophoresis parameter
$(\rho c_p)_f$	heat capacity of the base fluid	S	non-dimensional heat source
C	fluid concentration	L_e	Lewis number
D_B	Brownian diffusion coefficient	f_w	suction parameter
D_T	thermophoretic diffusion coefficient	Bi_θ	thermal Biot number
T_∞	ambient temperature	Bi_ϕ	concentration Biot number
$\mathrm{T_w}$	convective surface temperature	C_f	rate of shear stress
q_r	thermal radiative heat flux	Nu_x	local Nusselt number
Q	heat source	Sh_x	local Sherwood number
k_c^*	chemical reaction parameter	τ_w	skin friction
C_∞	ambient concentration.	q_w	heat flux at the surface
C_w	concentration at the sheet	q_m	mass flux at the surface
u_w	velocity of the sheet	Re_x	local Reynolds number
K_c	non-dimensional chemical reaction parameter	v_w	suction velocity

1. Mathematical Formulation

We have considered an incompressible electrically conducting Nanofluid flow over a vertical stretching surface in the presence of uniform magnetic field,porosity parameter, thermal radiation, nonuniform heat source/sink with chemical reaction (Fig.1). The flow occurs due to various reason but we have considered the case of linear stretching of the sheet. Again, we have considered the convective thermal and nanoparticle concentration boundary conditions. The flow domain is $y > 0$. The sheet is stretched along vertical direction with fixed origin with velocity as $u_w(x) = ax$. We have taken, the Brownian motion and thermophoresis into consideration in the transport equations. Depending on the study very negligible Reynolds number and viscous dissipation induced magnetic field has been neglected. General physical properties of the fluid are considered.

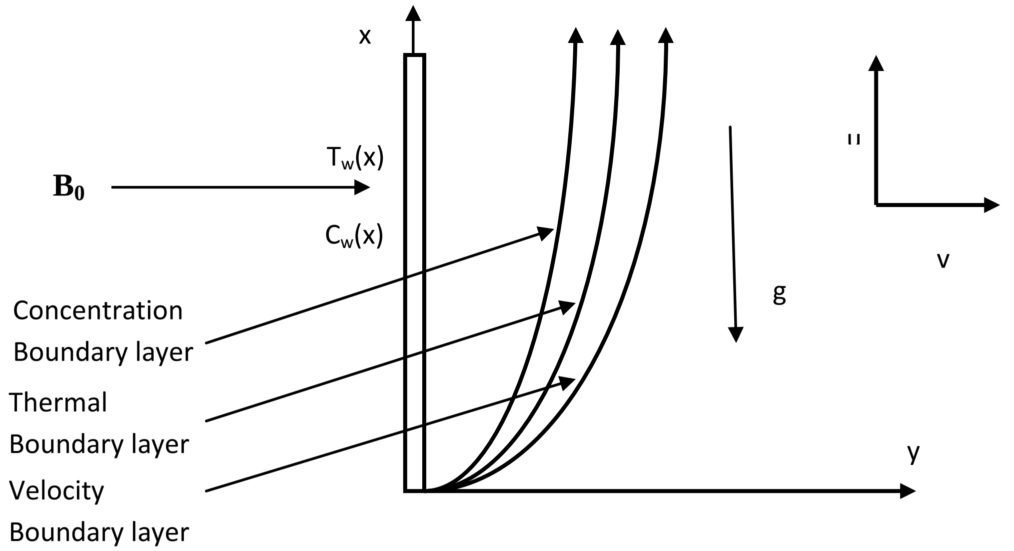

Fig.1 Schematic diagram

The governing equations can be written as follows:

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

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \nu\frac{\partial^2 u}{\partial y^2} - \left(\frac{\sigma B_0^2}{\rho} + \frac{\upsilon}{k_p^*}\right)u \tag{2}$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2} + \tau\left[D_B\frac{\partial C}{\partial y}\frac{\partial T}{\partial y} + \frac{D_T}{T_\infty}\left(\frac{\partial T}{\partial y}\right)^2\right] - \frac{1}{\rho c_p}\frac{\partial q_r}{\partial y} + \frac{Q}{\rho c_p}(T - T_\infty) \tag{3}$$

$$u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = D_B\frac{\partial^2 C}{\partial y^2} + \frac{D_T}{T_\infty}\frac{\partial^2 T}{\partial y^2} - k_c^*(C - C_\infty) \tag{4}$$

where $\upsilon = \dfrac{\mu}{\rho}, \tau = \dfrac{(\rho c_p)_p}{(\rho c_p)_f}$

The respective boundaryconditions which can be implemented in the flow are:

$$u = u_w(x), v = v_w, -k\frac{\partial T}{\partial y} = h_1(T_w - T), -D_B\frac{\partial T}{\partial y} = h_2(C_w - C), \text{ at } \quad y = 0 \tag{5}$$

$$u \to 0,\ T \to T_\infty,\ C \to C_\infty, \quad as \quad y \to \infty \tag{6}$$

The similarity variable and dimensionless functions are taken into consideration as:

$$\eta=\left(\frac{a}{\nu_f}\right)^{\frac{1}{2}}y,\psi(x,y)=\left(\nu_f a\right)^{\frac{1}{2}}xf(\eta),\theta(\eta)=\frac{T-T_\infty}{T_w-T_\infty},\phi(\eta)=\frac{C-C_\infty}{C_w-C_\infty}\tag{7}$$

The radiative heat flux introduced by Rosseland approximation [35] is taken into consideration to simplify equation (3) as:

$$q_r=-\frac{4\sigma^*}{3K^*}\frac{\partial T^4}{\partial y}\qquad \text{where } T^4=4T_\infty^3T-3T_\infty^4$$

$$\frac{\partial q_r}{\partial y}=-\frac{16T_\infty^3\sigma^*}{3K^*}\frac{\partial^2T}{\partial y^2}$$

Now Eqs. (2)–(4) became,

$$f'''(\eta)+f(\eta)f''(\eta)-f'(\eta)^2-\left(M+\frac{1}{K_p}\right)f'(\eta)=0\tag{8}$$

$$(1+N_r)\theta''(\eta)+P_r\left(f(\eta)\theta'(\eta)+N_b\theta'(\eta)\phi'(\eta)+N_t\left(\theta'(\eta)\right)^2+S\theta\right)=0\tag{9}$$

$$\phi''(\eta)+\mathrm{P_r}\,L_ef(\eta)\phi'(\eta)+\frac{N_t}{N_b}\theta''(\eta)-\mathrm{P_r}\,K_cL_e\phi=0\tag{10}$$

where $M=\dfrac{\sigma B_0^2}{\rho a},K_p=\dfrac{ak_p^*}{\nu},N_r=\dfrac{16T_\infty^3\sigma^*}{3K^*k},\mathrm{P_r}=\dfrac{\upsilon}{\alpha},S=\dfrac{Q}{\rho ac_p}$

$$L_e=\frac{\upsilon}{D_B},K_c=\frac{k_c^*}{a},N_t=\frac{\tau D_T(T_w-T_\infty)}{\upsilon T_\infty},N_b=\frac{\tau D_B(C_w-C_\infty)}{\upsilon}$$

So the boundary conditions are reduced as:

$$f(0)=f_w,f'(0)=1,\theta'(0)=-Bi_\theta(1-\theta(0)),\phi'(0)=-Bi_\phi(1-\phi(0))$$

$$f'(\infty)\to 0,\theta(\infty)\to 0,\phi(\infty)\to 0$$

$$f_w=-v_w/\sqrt{\upsilon a},Bi_\theta=\sqrt{\upsilon a}(h_1/k),Bi_\phi=\sqrt{\upsilon a}(h_2/D_B)\tag{11}$$

2. Physical quantities

The physical quantities which are studied in this paper are as follows:

$$C_f=\frac{\tau_w}{\rho u_w^2},Nu_x=\frac{xq_w}{k(T_w-T\infty)},Sh_x=\frac{xq_m}{D_B(C_w-C_\infty)}$$

$$\tau_w=\mu\left(\frac{\partial u}{\partial y}\right)_{y=0},q_w=-k\left(\frac{\partial T}{\partial y}\right)_{y=0},q_m=-D_B\left(\frac{\partial C}{\partial y}\right)_{y=0}\tag{12}$$

Applying the non-dimensional transformations (7) we have,

$$\mathrm{Re}_x^{1/2}C_f=f''(0),\mathrm{Re}_x^{-1/2}Nu_x=-\theta'(0),\mathrm{Re}_x^{-1/2}Sh_x=-\phi'(0),\mathrm{Re}_x=xu_w(x)/\nu\tag{13}$$

II. Results and discussion

Electrically conducting Buongiorno’s model nanofluid flow is considered in the present study.This section elaborates the physical significance of involving parameter characterizes the flow phenomena those are presented via graphs. Figs.2-4 show the variation of magnetic parameter (M) and porosity parameter (K_p) in velocity, temperature and concentration profiles respectively. Fig.2 is the evidence of the decrease in the velocity graph for increasing magnetic parameter. These decreases in velocity profile also noticefor the presence $(K_p=0.5)$ and absence $(K_p=100)$ of porous matrix. The resistive force, Lorentz force is to slow down the flow over the surface. Thus this force opposes the motion of the flow and hence the thickness of velocity near boundary layer gets decreased. Since the porous matrix resiststhe flow, a further decrement is marked in the velocity profile. Another interesting fact is that without magnetic field $(M=0)$ and porous medium $(K_p=100)$, the velocity attains its maximum. The present result is well agrees with the result of [36]. Fig.3shows that temperature profile get enhanced for the increasing values of magnetic parameter (M) both in the presence and absence of porous medium. It is observed that transverse magnetic field, which opposes the velocity profiles shown in Fig.2, overshoot the temperature profile. So an increment in the temperature profile has been observed. The porous matrix favours the enhancement of fluid temperature as well as thickness of the thermal boundary layer. Similar characteristics in concentration profiles are marked due to the interaction of magnetic parameter and porous matrix as shown in Fig. 4. Fig.5 presents the effect of heat source/sink parameter both in presence and absence of porous matrix. It is clear to observe that a bigger amount of heat energy is stored up in the thermal boundary layer in presence of heat source which leads to increase in fluid temperature at all points in thermal boundary layer whereas heat sink has an reverse effect to retards the temperature profile significantly. The presence of porous matrix also enhances the fluid temperature. Figs.6 and 7 show the effect of thermophoresis parameter (N_t) on temperature profiles. N_t enhances the fluid temperature and concentration profiles. This is due to the gradual enhancement in nano-particles percentage with (N_t). Generally, increase in (N_t) produces a force which leads to move the nano-particle from the hotter to colder region and soa gain in heat transfer rates observed. Figs. 8 and 9 show the effect of Brownian parameter (N_b) on the thermal and solutaldistributions respectively. From Fig.8, it can be examined that N_b enhances the temperature profile significantly. This enhancement produces a force which allows the nanoparticles from hotter area to colder region. As a result, it gives rise to the thermal boundary layer thickness and hence temperature of the nanofluid increases. From Fig.9, it is observed that for large N_b, nano-particle concentration profile decreases significantly. The thickness of the solutal boundary layer and the solutal concentration decreases when the Brownian motion takes place in the nanofluid. This is due to the rise of Brownian motion parameter (N_b) .Fig.10 depicts the influence of Lewis number on concentration profile. The ratio of both the diffusivity of thermal and mass defines the Lewis number. It characterizes the fluid flows when both heat and mass transfer occurs simultaneously. Increase in Lewis number means decrease in mass diffusivity. As a result the fluid concentration decreases. Therefore increase in Lewis number decreases the fluid concentration significantly. The effect of Biot number (heat transfer) is depicted in Fig. 11. It is remarked that increase in Biot number increases the temperature of the fluid. It is due to the fact that Biot number occurs because of the thermal slip in the thermal boundary layer. Hence, as the temperature difference between the plate and the ambient state decreases then Biot number increases significantly resulted in overshoot in the temperature profile. Similar observation is marked in Fig. 12. Thus increase in Biot number (solutal transfer) the concentration boundary layer increases. Fig. 13 exhibits the effects of solutal reactant on the distribution of concentration. In the present case we have considered by taking three distinct cases such as $(K_c>0)$, $(K_c=0)$ and $(K_c<0)$ in the presence/absence of porous material. It is noteworthy that presence of generative chemical reaction $(K_c<0)$ enhances the solutal distributionin both the presence/absence of porous whereas destructive retards it significantly. The absence of chemical reactionreflects the case of earlier study [36]. Effect of suction $(f_w>0)$ /injection $(f_w<0)$ in the presence/absence of porous matrix on the temperature and concentration profiles is shown in Figs. 15 and 16 respectively. It is interesting to note that fluid temperature and concentration decreases when suction increases. However, effect is reversedfor injection. It is also observed that inclusion of porous matrix enhances both the temperature and concentration of the nanofluid in their corresponding boundary layers. Finally, fluid temperature gets enhanced throughout the thermal boundary layer with the increasing value of radiation–conduction parameter which displays in Fig.17. It is clear to note that the due to radiation certain amount of energy stored up which motivate toenhance the temperature of nanofluidat all points in the corresponding boundary layer.

III. Conclusion

Electrically conducting Buongiorno's model nanofluid flow of past over a stretching sheet is considered in the present paper. Inclusion of thermal radiation and first order chemical reaction enriches the said work for the enhancement of heat transfer properties of nanofluid flow. The important findings are listed below:

- Presence of porous matrix also favorable to enhance the fluid temperature as well as thickness of the thermal boundary layer.

- Heat sink has retarding effect on the temperature profile whereas source enhances it.
- Thermophoresis parameter is favorable to enhance the fluid temperature and concentration profiles.
- An increase in Lewis number means decrease in mass diffusivity resulted in to decrease the fluid concentration.
- An increase in suction decreases both the fluid.
- Remarkable increase in temperature is observed as an increase in thermal radiation.

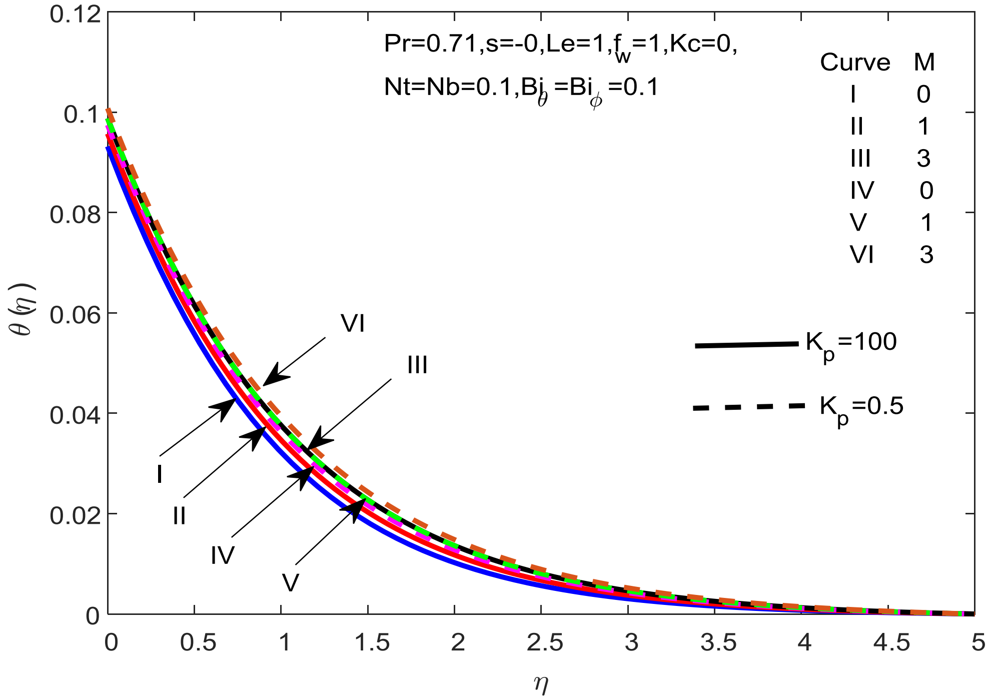

Fig.3 Effects of M and K_p on Temperature Profile

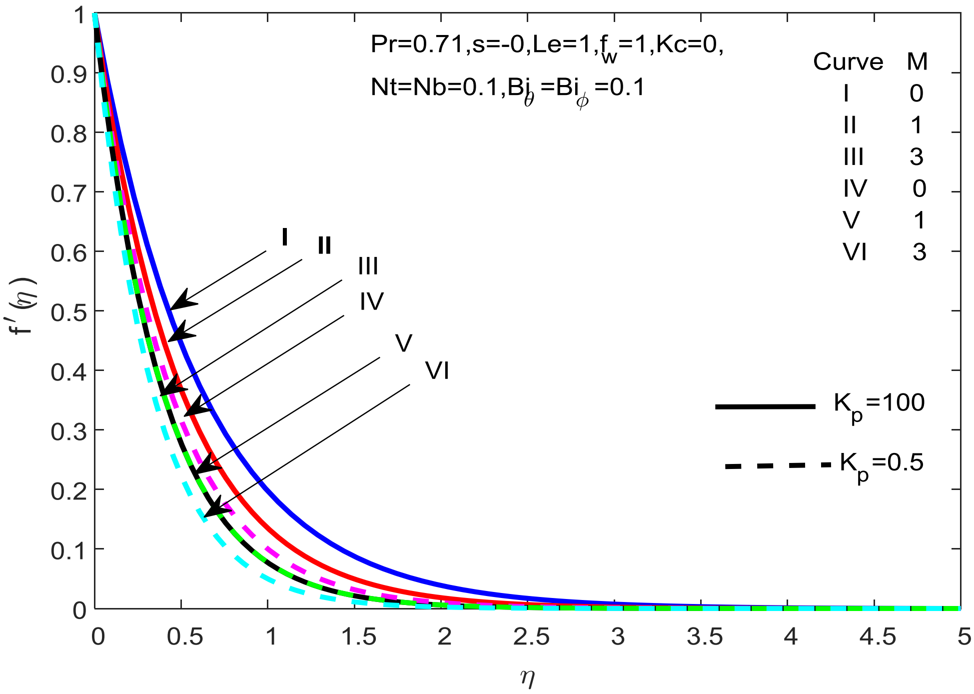

Fig.2 Effects of M and K_p on Velocity Profile

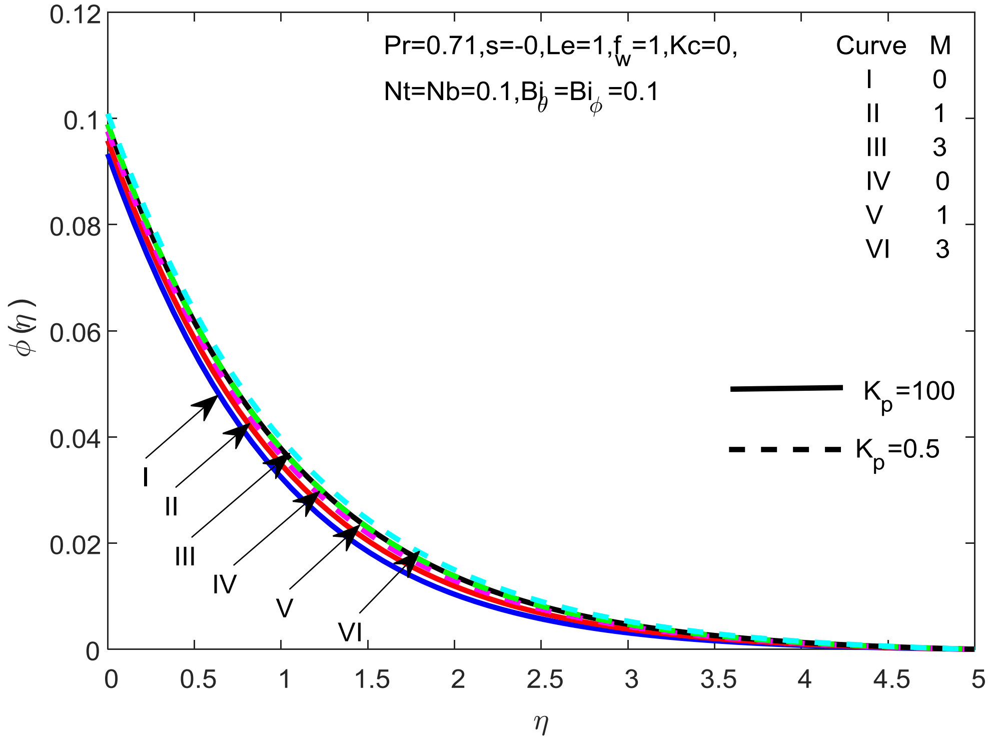

Fig.4 Effects of M and K_p on Concentration Profile

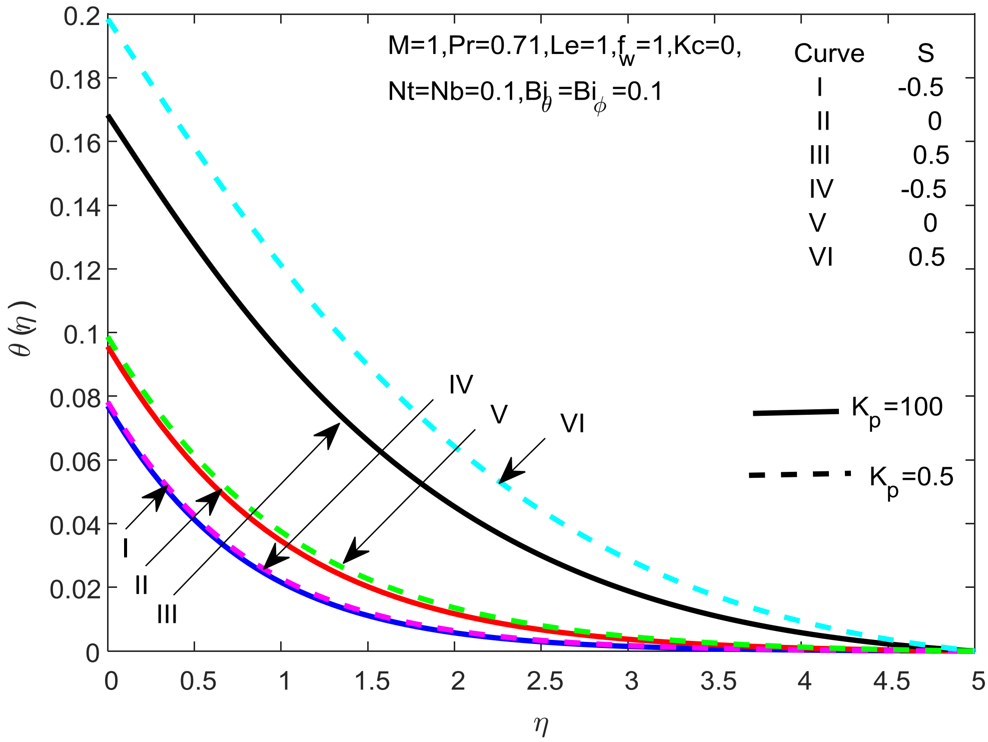

Fig. 5 Effects of S and K_p on Temperature Profile

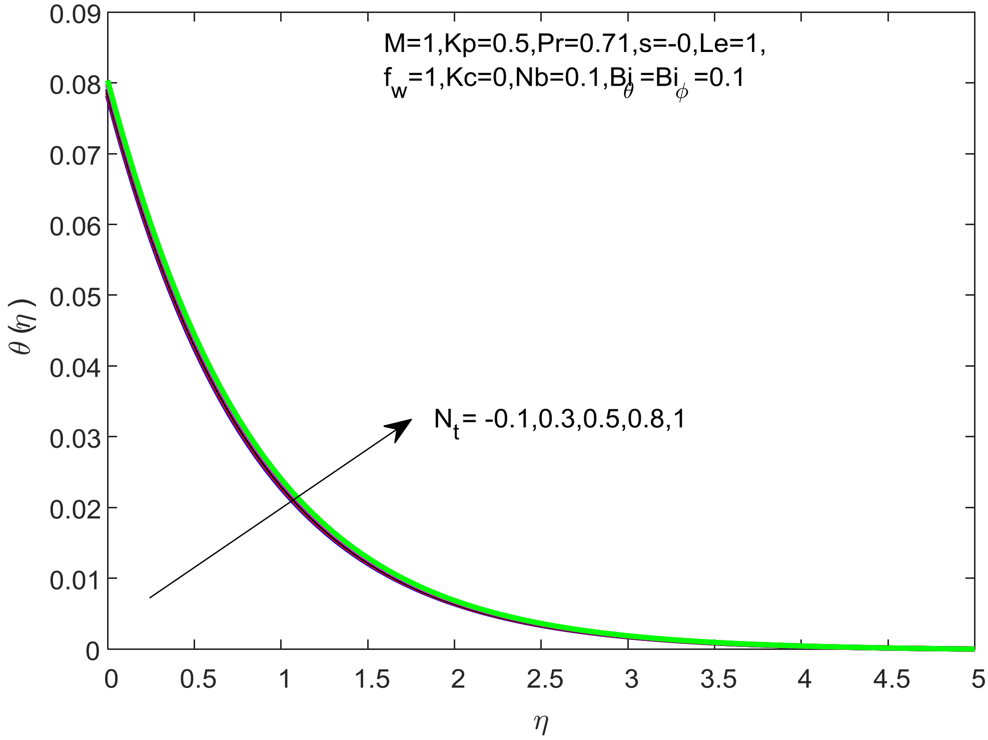

Fig. 6 Effects of N_t on Temperature Profile

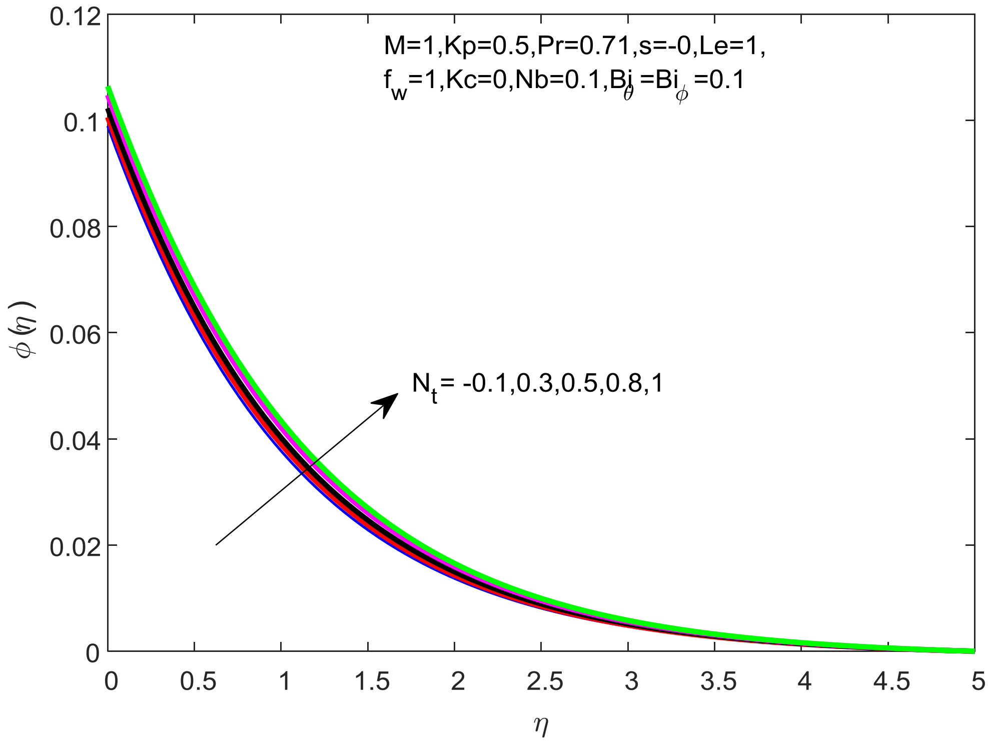

Fig. 7 Effects of N_t on Concentration Profile

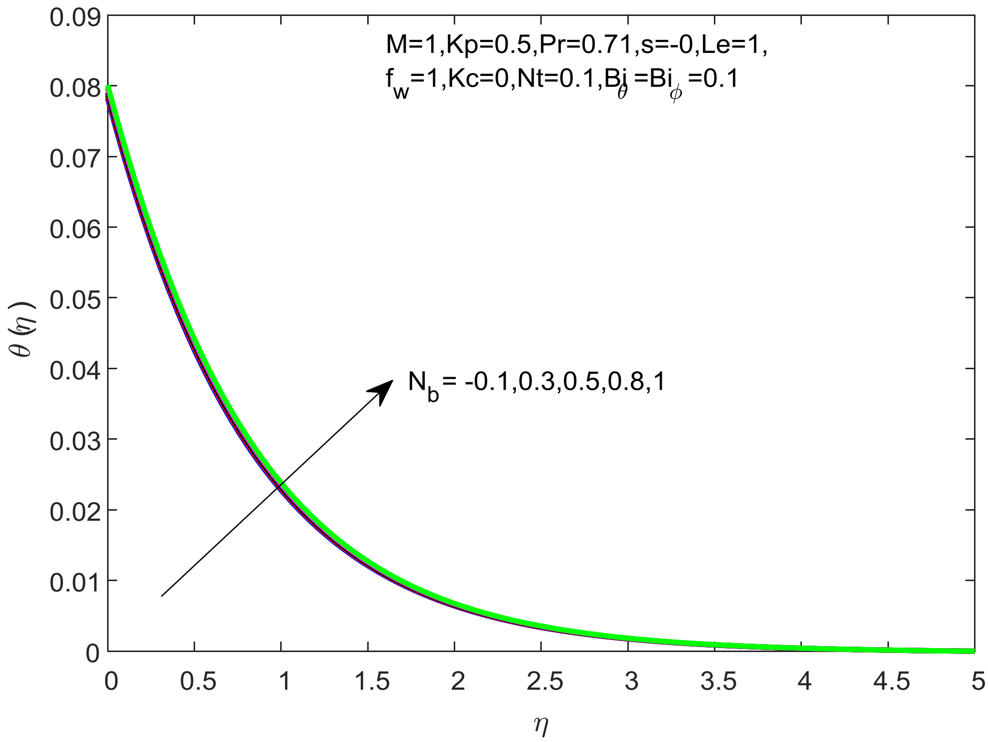

Fig. 8 Effects of N_b on Temperature Profile

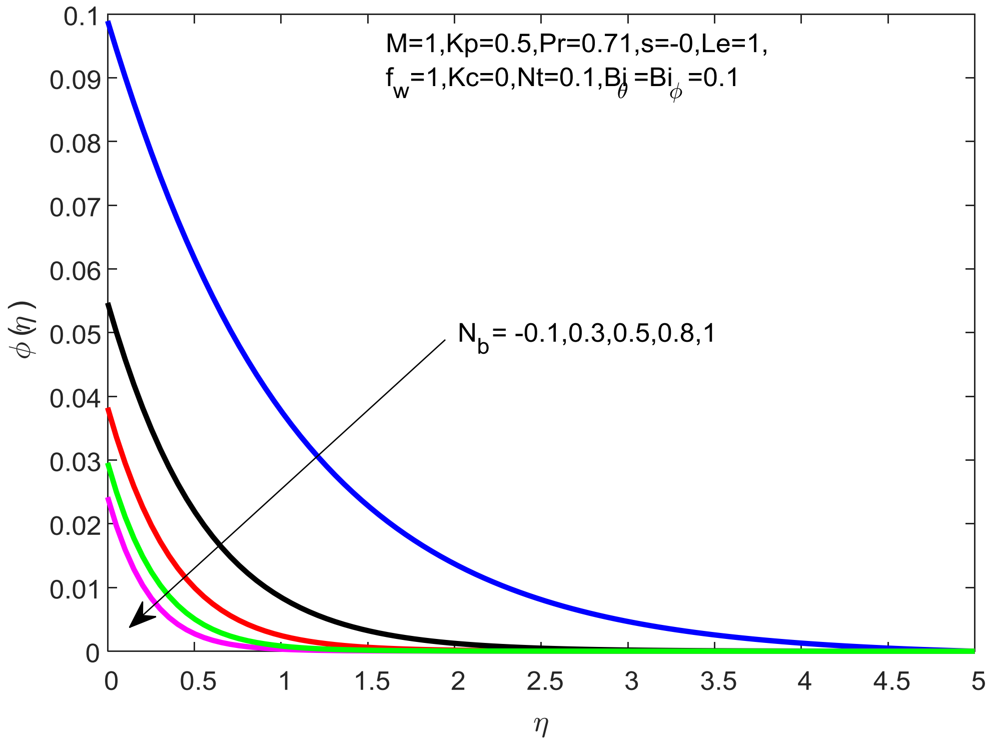

Fig. 9 Effects of N_b on Concentration Profile

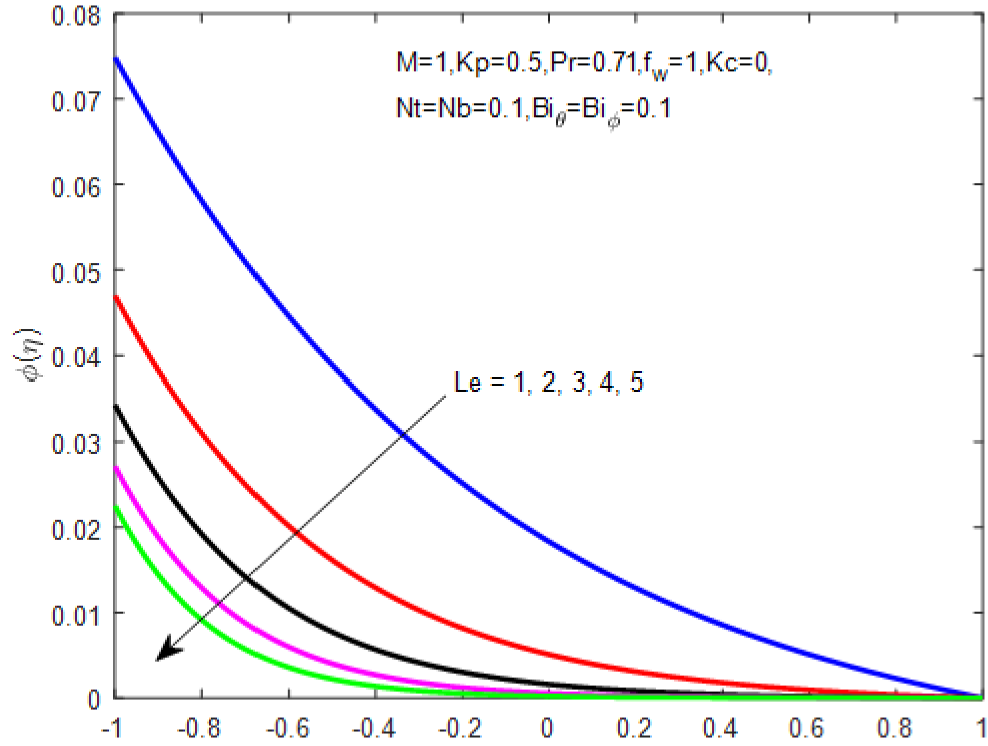

Fig.10 Effects of Le on concentration profile

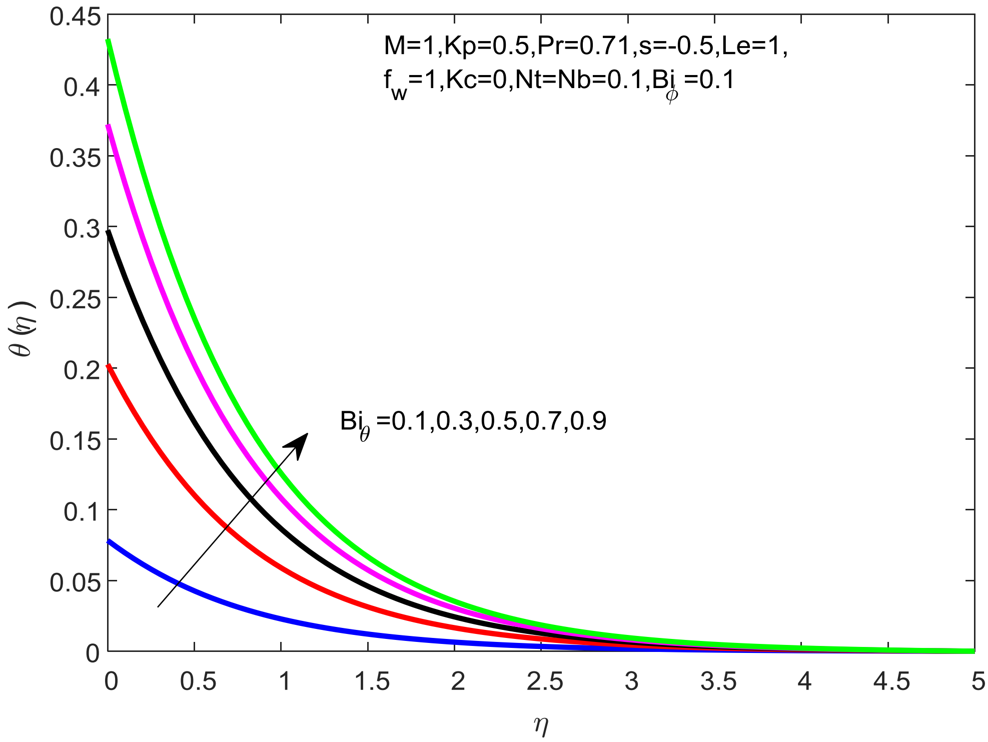

Fig. 11 Effects of Bi_θ on Temperature Profile

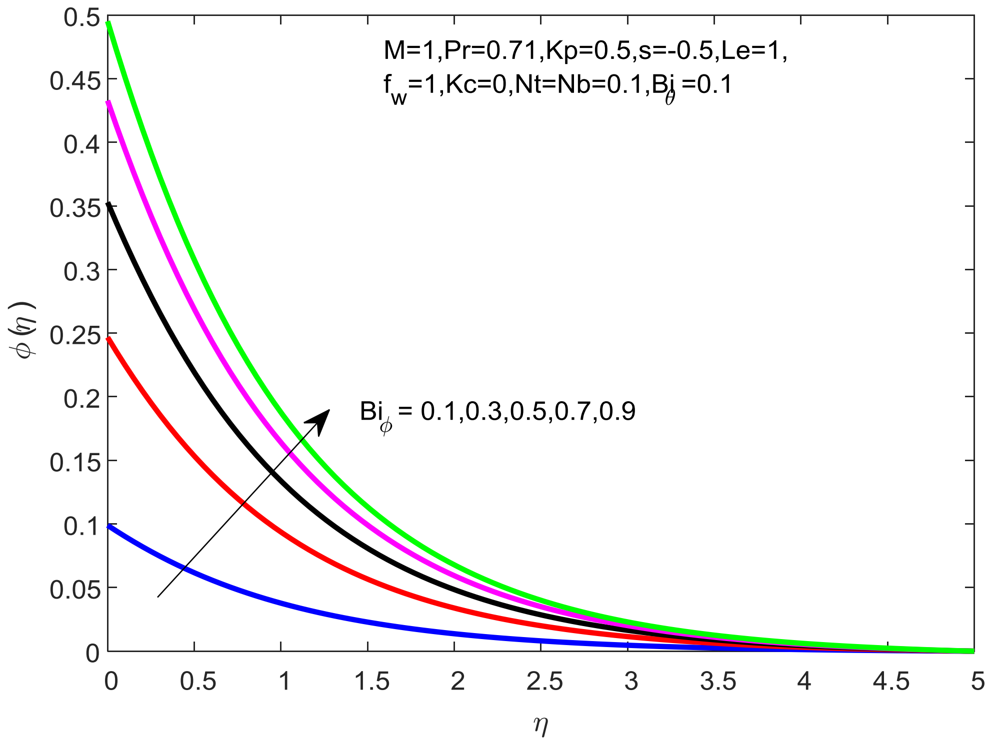

Fig. 12 Effects of Bi_ϕ on Concentration Profile

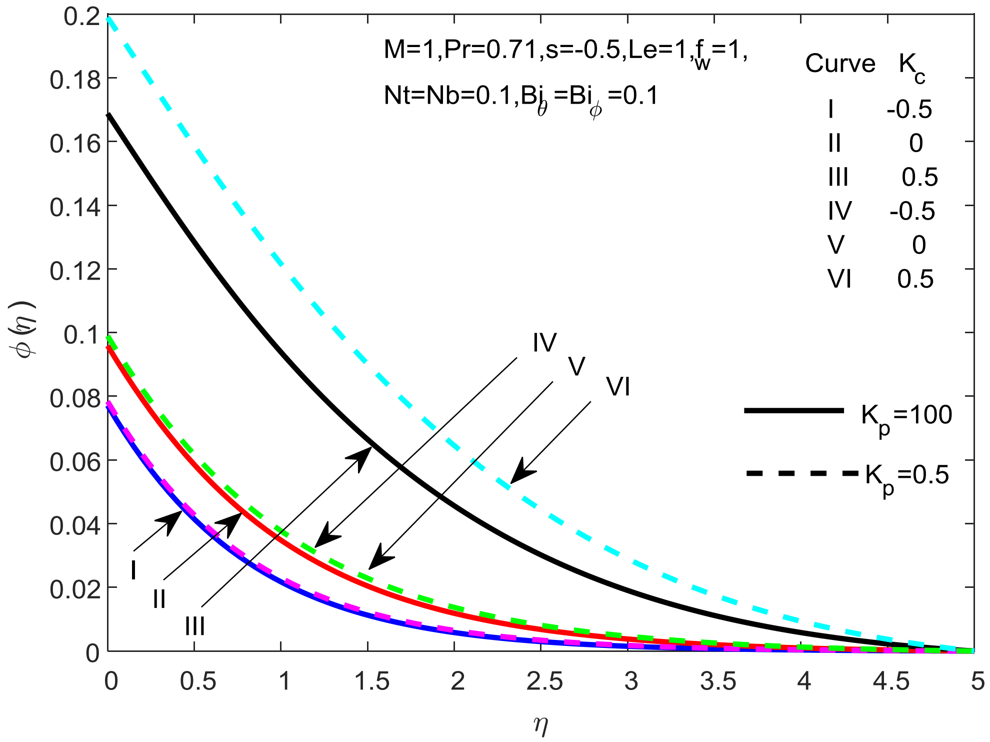

Fig. 13 Effects of K_c on Concentration Profile

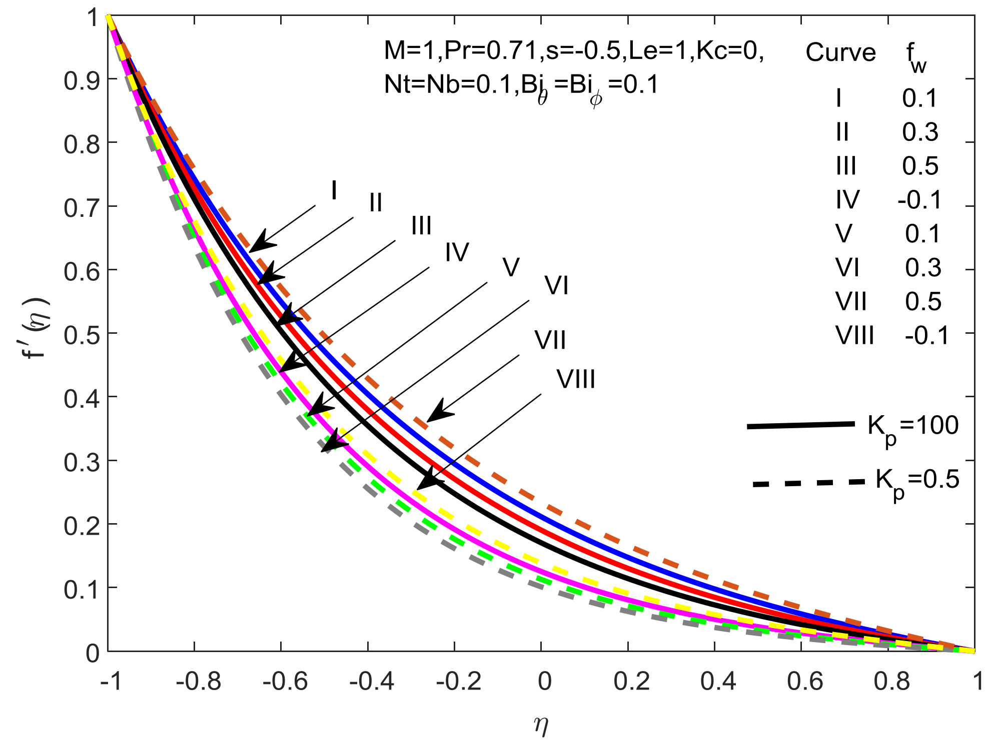

Fig. 14 Effects of f_w and K_p on Velocity Profile

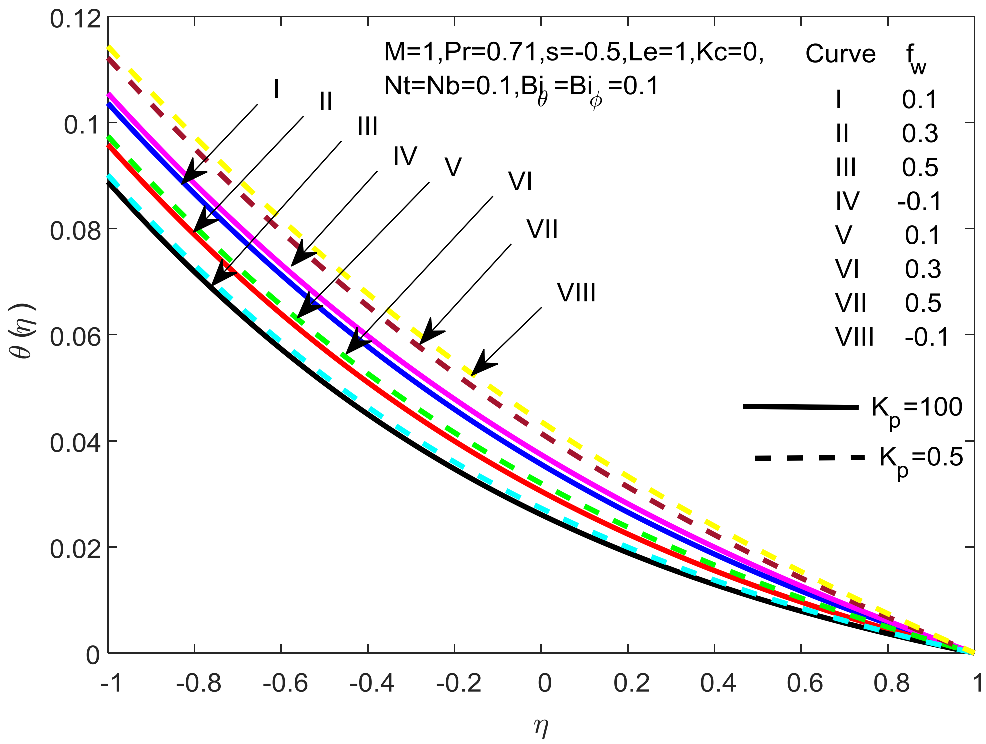

Fig. 15 Effects of f_w and K_p on Temperature Profile

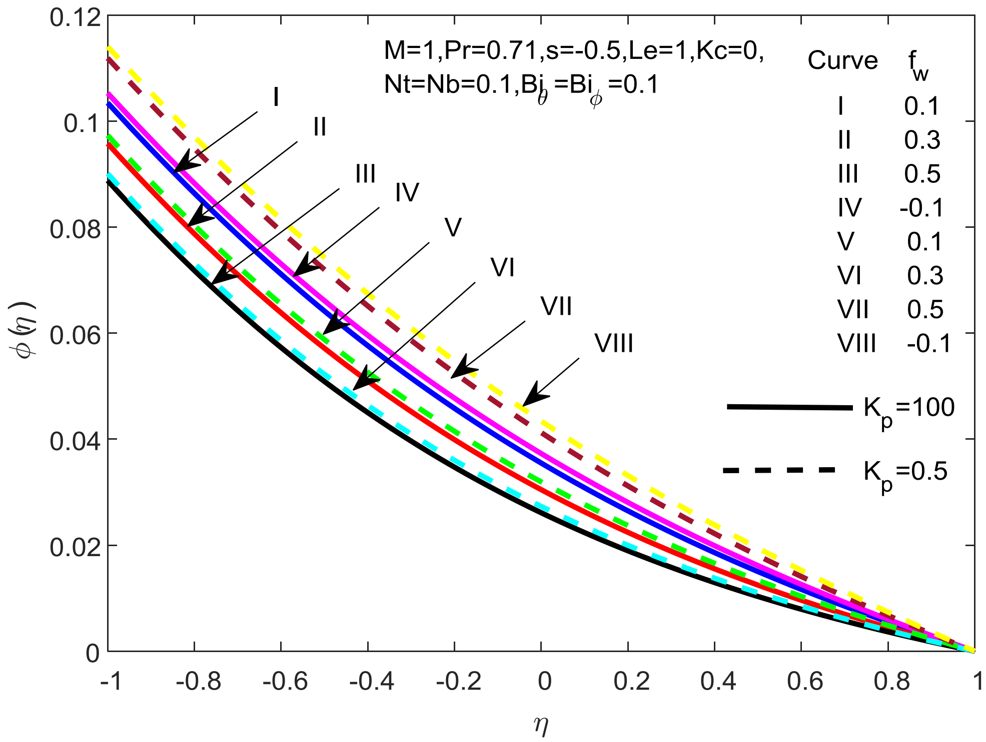

Fig. 16 Effects of f_w and K_p on Concentration Profile

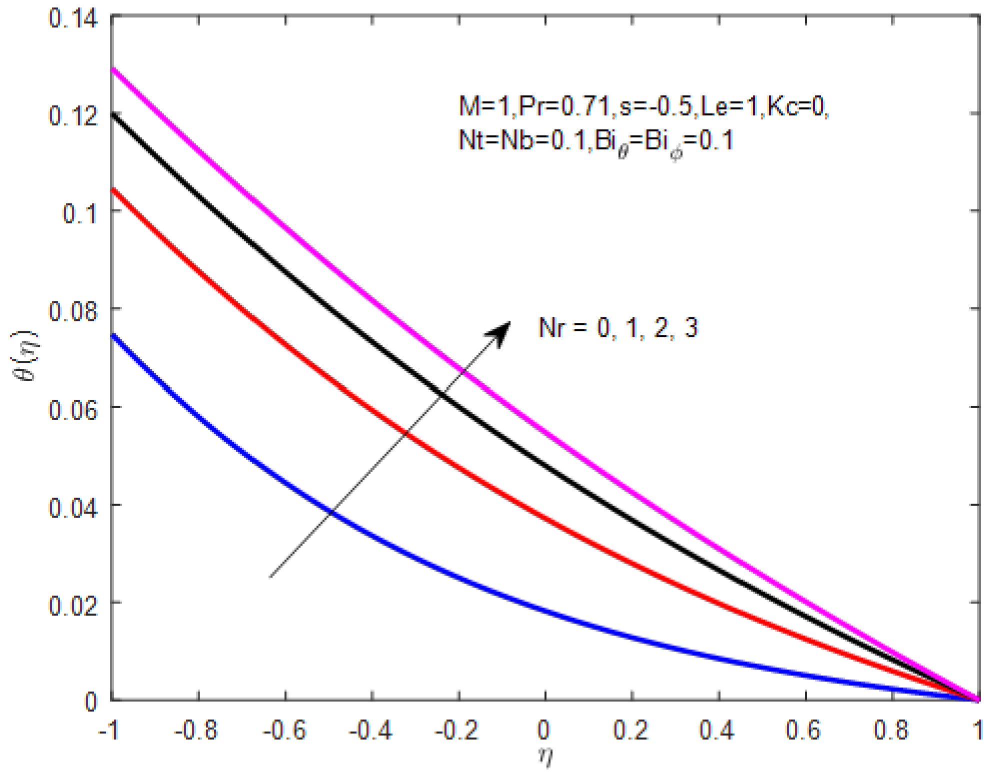

Fig.17. Effect of radiation on temperature profile

References

[1] Choi SUS, Eastman JA. Enhancing thermal conductivity of fluids with nanoparticles. Mater Sci, 231 (1995), 99–105.

[2] S.K. Das, S.U.S. Choi, W. Yu, T. Pradeep, Nanofluids Science and Technology, John Wiley & Sons, (2008).

[3] M.J. Uddin, O.A. Beg, A.I.Md. Ismail, Mathematical modelling of radiative hyderomagnetic thermosolutal Nanofluid convection slip flow in saturated porous media, Math. Probl. Eng. (2014), 1–11.
[4] N.M. Bujurke, S.N. Biradar, P.S. Hiremath, Second-order fluid flow past a stretching sheet with heat transfer, Z. Angew. Math. Phys. 38 (1987), 653–657.
[5] Borrelli A, Giantesio G, Patria MC. MHD orthogonal stagnation-point flow of amicropolar fluid with the magnetic field parallel to the velocity at infinity. ApplMath Comput,264(2015), 44–60.
[6] Ashraf M, Ashraf MM. MHD stagnation point flow of a micropolar fluid towards aheated surface. Appl Math Mech -Engl Ed,32(1)(2011), 45–54.
[7] Jafari SS, Freidoonimehr N. Second law of thermodynamicsanalysis of hydro-magnetic nanofluid slip flow over a stretchingpermeable surface. J Braz Soc Mech Sci Eng,37(2014), 1245–1256.
[8] Akbar NS. Heat transfer and carbon nano tubes analysis for theperistaltic flow in a diverging tube. Meccanica,50(2014),39–47.
[9] Pattnaik P.K and Biswal T, MHD free convective boundary layer flow of a viscous fluid at a vertical surface through porous media with non-uniform heat source, IJISET 2 (3) (2015), 211-223.
[10] Pattnaik P K and Biswal T,Analytical Solution of MHD Free Convective Flow through Porous Media with Time Dependent Temperature and Concentration, Walailak J Sci & Tech, 12(9) (2015), 749-762.
[11] MishraS R, PattnaikP K, BhattiM Mand Abbas T, Analysis of heat and mass transfer with MHD and chemical reaction effects on viscoelastic fluid over a stretching sheet, Indian J Phys, (2017), DOI 10.1007/s12648-017-1022-2.
[13] Mishra S.R, Pattnaik P.K and Dash G.C, Effect of heat source and double stratification on MHD free convection in a micropolar fluid, Alexandria Engineering Journal, 54, (2015), 681–689.
[14] Mishra S.R, Nayak B and Sharma R.P, MHD stagnation-point flow past over a stretching sheet in the presence of non-Darcy porous medium and heat source/sink, Defect and Diffusion Forum, 374(2017)92-105.
[15] Thumma T and Mishra S.R, Effect of viscous dissipation and Joule heating on magnetohydrodynamics Jeffery nanofluid flow with and without multi-slip boundary conditions, Journal of Nanofluids, 7(3)(2018)516-526.
[16] Makinde O. D and Mishra S. R, On stagnation point flow of variable viscosity nanofluids past a stretching surface with radiative heat, International Journal of Applied and Computational Mathematics, 3(2) (2017)561-578, Springer.
[17] Jena S, Mishra S.R and Dash G.C, Chemical reaction effect on MHD Jeffery fluid flow over a stretching sheet through porous media with heat generation/absorption, International Journal of Applied and Computational Mathematics, 3(2) (2017)1225-1238, Springer.
[18] Hayat T, Abbas Z, Sajid M. Series solution for the upperconvectedMaxwell fluid over a porous stretching plate. Phys LettA 2006;358:396–403.
[19] Hayat T, Sajid M. Analytic solution for axi-symmetric flow andheat transfer of a second grade fluid past a stretching sheet. Int JHeat Mass Transfer 2007;50:75–84.
[20] D.Makinde,P.Olanrewaju,BuoyancyEffectonthermal boundary layeroveraverticalplatewithaconvectivesurface boundary condition,ASMEJ.FluidsEng.132(2010) 044502 (1-4).
[21] V. Subhashinia,N.Samuela,I.Pop,Effectsofbuoyancy assisting andopposing flows onmixedconvectionboundary layer flow overapermeableverticalsurface,Int.Commun. Heat MassTransf.38(4)(2011)499–503.
[22] G.K. Ramesh, A.J. Chamkha, B.J. Gireesha,Magnetohydrodynamic flow of a non-Newtonian nanofluidover an impermeable surface with heat generation/absorption,J. Nanofluids 3 (2014) 78–84.
[23] Vajravelu K. Viscous flow over a nonlinearly stretching sheet, Appl Math Comput 2001;124:281–8.
[24] Vajravelu K, Cannon JR. Fluid flow over a nonlinear stretchingsheet, Appl Math Comput 2006;181:609–18.
[25] E. Sanjayanand, S.K. Khan, On heat and mass transfer in aviscoelastic boundary layer flow over an exponentially stretchingsheet, Int. J. Therm. Sci. 45 (2006) 819–828.
[26] M. Subhas Abel, N. Mahesha, Heat transfer in MHDviscoelastic fluid flow over a stretching sheet with variablethermal conductivity, non-uniform heat source and radiation,Appl. Math. Model. 32 (2008) 1965–1983.
[27] B.Mohanty, S.R.Mishra, H.B.Pattnaik, Numerical investigation of Heat transfer effect on MHD flow of two types of visco-elastic fluid over a stretching sheet through porous media, International Journal on Theoretical and Applied Research in Mechanical Engineering, 3(1) (2014) 68-78.
[28] J. Mohanty, J.K. Das, S.R.Mishra, Chemical reaction effect on MHD Jeffery fluid over a stretching sheet with heat generation/absorption, Modeling Measurement and Control-B, 83(1)(2015)1-17.
[29] S.R.Mishra, S.Baag, A.K.Acharya, Effect of heat transfer on MHD Couette flow in Oldroyd liquid through porous media, International Journal of Applied Mathematics and Mechanics, 5(1)(2016)1-10.
[30] S.R.Mishra, S.Baag, D.K.Mohapatra, Chemical reaction and Soret effects on hydromagnetic micropolar fluid along a stretching sheet, Engineering Science and Technology, an International Journal, 19(4)(2016)1919-1928, Elsevier.
[31] S.R.Mishra, D.Bhukta, M.M. Hoque, Numerical simulation of heat transfer effect on Oldroyd 8-constant fluid with wire coating analysis Journal, Engineering Science and Technology, an International Journal, 19(4)(2016)1910-1918, Elsevier.
[32] S.R. Mishra, B. Nayak, R.P. Sharma, MHD stagnation-point flow past over a stretching sheet in the presence of non-Darcy porous medium and heat source/sink, Defect and Diffusion Forum, 374(2017)92-105.
[33] S.R.Mishra, M.M.Bhatti, Simultaneous effects of Chemical reaction and Ohmic heating with heat and mass transfer over a stretching surface: A numerical study, Chinese Journal of Chemical Engineering, 25(2017)1137-1142, Elsevier.
[34] S.R. Mishra, I. Khan, Q.M. Al-mdallal, T. Asifa, Free convective micropolar fluid flow and heat transfer over a shrinking sheet with heat source, Case Studies in Thermal Engineering, 11(2018)113-119, Elsevier.
[35] M.Q. Brewster, Thermal Radiative Transfer Properties. Wiley,New York, (1972).
[36] H. Ajam, S. S. Jafari, N. Freidoonimehr, Analytical approximation of MHD nanofluid flow induced by a stretching permeable surface using Buongiorno's model, Ain Shams Engineering Journal (2016) https://doi.org/10.1016/j.asej.2016.03.006