MHD Convection Flow of Kuvshinski Fluid Past an Infinite Vertical Porous Plate with Thermal Diffusion and Radiation Effects

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Abstract
The present paper aims at investigating the MHD free convective flow of visco-elastic (Kuvshiniki type) fluid through a porous medium past a semi-infinite vertical moving plate with heat source and Soret effects. The fluid is considered to be gray, absorbing emitting but non scattering medium, and the Rosseland approximation is used to describe the radiative heat flux in the energy equation. A uniform magnetic field of strength B_0 acts perpendicular to the porous surface. The governing partial non-linear differential equations of the flow, heat and mass transfer are transformed into ordinary differential equations by using similarity transformations and then solved by simple perturbation technique. The effects of various flow parameters on velocity, temperature and concentration fields as well as the local friction factor, Nusselt number and Shear wood number are discussed and analyzed through graphs and tables.
Keywords: Kuvshinski fluid, Soret number, Moving plate, Free convention, Laminar flow.

1. Introduction

There are many fluids in industry and technology whose behavior cannot be explained by the classical linearly viscous Newtonian model. The departure from the Newtonian behavior manifests itself in a variety of ways: non-Newtonian viscosity, stress relaxation, non-liner creeping, development of normal stress differences, and yield stress [1]. The Navier-stokes equations are inadequate to predicted the behavior of such type of fluids, therefore many constitutive relations of non-Newtonian fluids are propose by [2]. These constitutive relations gives rise to the differential equations, which, ingeneral are more complicated and higher order than the Navier-Stokes equations. Therefore it is difficult to obtain exact analytical solutions for non-Newtonian fluids [3]. Modeling of the equation governing the behaviors of non-Newtonian fluids in different circum stance is important from many points of view. For example, plastics and polymers are extensively handled by the chemical industry, whereas biological and biomedical devices like hemodialyser make use of the rheological behavior [4]. Ingeneral, the analysis of the behavior of the fluid motion of non-Newtonian fluids tends to be much more complicated and subtle in comparison with that of the Newtonian fluid [5].

Convective heat and mass transfer flow under the influence of magnetic field and chemical reaction arise in many transfer process both natural and artificial in many branches of sciences and engineering applications this phenomenon plays an important role in the chemical industry, power and cooling industry for drying, chemical vapor deposition on surfaces, cooling of nuclear reactors and petroleum industry. Convection flows occurs frequently in nature, as well as due to concentration differences or the combination of these two, for example in atmosphere flows there exist differences in water concentration and hence the flow is influenced by such concentration difference. Chamkha [8] considered unsteady MHD convective heat and mass transfer past a semi-infinite vertical permeable moving plate heat absorption. Ibrahim et al [7] considered the effects of chemical reaction and radiation absorption on unsteady MHD free convection flow past a semi-infinite vertical permeable moving plate with heat source and suction. Heat absorption effect on MHD convective Rivlin-Ericksen fluid flow past a semi-infinite vertical porous plate was investigated by Ravi kumar et al [6]. Recently, Prabhakar Reddy [17] studied the Chemical reaction and thermo diffusion effects on hydro magnetic flow of Rivlin-Erickson fluid in an inclined channel.

Char [12] investigated heat and mass transfer in a hydromagnetic flow of the viscoelastic fluid over stretching sheet. Varsheney and Ram Prakesh [11] have discussed MHD free convective flow of a Visco-elastic (Kuvshinski type)dusty gas through a porous medium induced by the motion of a semi-infinite flat plate moving with velocity decreasing exponentially with time. Kumar et.al [10] have studied MHD free convection flow of a visco-elastic (Kuvshinski type) dusty gas through a porous medium with source/sink. Arvind kumar Sharma [16] studied the effect of Kuvshinski fluid on double diffusive convection and radiation interaction on unsteady MHD flow over a vertical moving porous plate with heat generation and Soret effects. The effect of Kuvshinski fluid on MHD free convection flow with heat and mass transfer past a vertical porous plate was studied by Gurudatt Sharma [15]. Mukesh Chandra shakya [14] have discussed the effect of Hall current on MHD free convective flow of a Kuvshinski type dusty gas through a porous medium with source/sink. convective flow of a visco-elastic (Kuvshiniki type) dusty gas through a porous medium induced by the motion of a semi-infinite flat plate moving with time and heat source was studied by Singh [9] et.al. Recently, Vidyasagar [13] investigated, the

MHD convection boundary layer flow of radiation absorbing Kuvshinski fluid through porous medium.
Inspite of all these studies the effect of Kuvshinski fluid on unsteady MHD free convection with chemical reaction and radiation has received more attention. Hence the main objective of the present investigation is to study the effect of Kuvshinski fluid on unsteady MHD free convective flow past a vertical moving porous plate with thermal radiation, heat source, chemical reaction and thermal diffusion effects.

2. Mathematical formulation

Consider an unsteady two dimensional flow of a laminar, viscous, incompressible eclectically conducting, radiating and chemically reacting Kuvshinski fluid through porous medium past a semi-infinite vertical moving plate. According to the coordinate system $x^* -$ axis is taken along the vertical porous plate in the up word direction and $y^* -$ axis normal to it. The fluid is assumed to be gray, absorbing-emitting but non-scattering medium. The radiative heat flux in the $x^* -$ direction is considered negligible in comparison with that in the $y^* -$ direction. A uniform magnetic field is applied perpendicular to the fluid flow direction and assumed that an induced magnetic field is neglected. Viscous and Darcy resistance terms are taken into account. The fluid properties are assumed to be constant except that the influence of density variation with temperature and concentration has been considered in the body-force term. The level of foreign mass is assumed to be low, So that the Dufour effect is neglected. Also assume that the Dissipation effects are neglected. Under the above assumptions and invoking the Boussinesq approximation, the boundary layer equations governing the flow, and mass transfer of a visco-elastic fluid can be written as

$$\frac{\partial v^*}{\partial y^*} = 0 \tag{1}$$

$$\left(1+\lambda^* \frac{\partial}{\partial t^*}\right)\frac{\partial u^*}{\partial t^*} + v^*\left(\frac{\partial u^*}{\partial y^*}\right) = \nu \frac{\partial^2 u^*}{\partial y^{*2}} + g\beta\left(T^* - T_\infty^*\right) + g\beta^*\left(C^* - C_\infty^*\right) - \left(1+\lambda^* \frac{\partial}{\partial t^*}\right)\left(\frac{\nu}{k^*} + \frac{\sigma B_0^2}{\rho}\right)u^* \tag{2}$$

$$\frac{\partial T^*}{\partial t^*} + v^*\left(\frac{\partial T^*}{\partial y^*}\right) = \frac{k}{\rho c_p}\frac{\partial^2 T^*}{\partial y^{*2}} - \frac{1}{\rho c_p}\frac{\partial q_r^*}{\partial y^*} + \frac{1}{\rho c_p} Q\left(T^* - T_\infty^*\right) \tag{3}$$

$$\frac{\partial C^*}{\partial t^*} + v^*\left(\frac{\partial C^*}{\partial y^*}\right) = D\frac{\partial^2 C^*}{\partial y^{*2}} + K_l\left(C^* - C_\infty^*\right) + D_T \frac{\partial^2 T^*}{\partial y^{*2}} \tag{4}$$

The corresponding boundary conditions are

$$u^* = u_p^*, T^* = T_w^* + \varepsilon\left(T_w^* - T_\infty^*\right)e^{n^* t^*}, C^* = C_w^* + \varepsilon\left(C_w^* - C_\infty^*\right)e^{n^* t^*}, at\; y^* = 0$$
$$u^* \to 0, T^* \to T_\infty^*, C^* \to C_\infty^* \; as\; y^* \to \infty \tag{5}$$

Where u^* and v^* are the velocity components in x, y directions respectively, g is the gravitational acceleration, ν is the kinematic viscosity, σ is the electrical conductivity, λ^* is the coefficient of Kuvshinski fluid, T^*, C^* are the fluid temperature and concentration, T_w^*, C_w^* are the temperature and concentration of the fluid at the wall and T_∞^*, C_∞^* are the free stream temperature and concentration of the fluid. D_T is the thermal diffusivity, K_l is the reaction rate constant, k is the thermal conductivity, c_p is the specific heat at constant pressure, q_r^* is the radiative heat flux and u_p^* is the direction of fluid flow. In addition it is assumed that the temperature and concentrationat the wall are exponentially varying with time.
Assume that the suction velocity normal to the palte is constant. So, eqn (1) gives

$$v^* = -V_0 \tag{6}$$

The local radiant for the case of an optically thin gray fluid is expressed as

$$\frac{\partial q_r^*}{\partial y^*} = -4a^*\sigma(T_\infty^{*3} - T^{*4}) \tag{7}$$

Where a^* is the absorption constant and σ is the Stefan-Boltzmann constant respectively. We assume that the temperature difference within the flow are sufficiently small such that T^{*4} may be expressed as a linear function of temperature. This is accomplished by expanding in Taylor series about T_∞^* and neglecting higher order terms, thus

$$T^{*4} \cong 4T_\infty^{*3}T^* - 3T_\infty^{*4} \tag{8}$$

By using equation (7) and (8), into eqn (3), we get

$$\frac{\partial T^*}{\partial t^*} + v^*\left(\frac{\partial T^*}{\partial y^*}\right) = \frac{k}{\rho c_p}\frac{\partial^2 T^*}{\partial y^{*2}} + \frac{16a^*\sigma T_\infty^*}{\rho c_p}\left(T_\infty^* - T^*\right) + \frac{1}{\rho c_p}Q\left(T^* - T_\infty^*\right) \tag{9}$$

Introducing the following dimensionless variables, and parameters as follows

$$u = \frac{u^*}{U_0}, v = \frac{v^*}{V_0}, y = \frac{y^*V_0}{v}, \theta = \frac{T^* - T_\infty^*}{T_w^* - T_\infty^*}, \phi = \frac{C^* - C_\infty^*}{C_w^* - C_\infty^*}, t = \frac{t^*V_0^2}{v}, u_p^* = u_pU_0$$

$$n = \frac{n^*v}{V_0^2}, Gr = \frac{vg\beta\left(T_w^* - T_\infty^*\right)}{V_0^2U_0}, N = \frac{\beta^*\left(C_w^* - C_\infty^*\right)}{\beta\left(T_w^* - T_\infty^*\right)}, M = \frac{\sigma B_0^2 v}{\rho V_0^2}, K = \frac{K^*V_0^2}{v^2}$$

$$H = \frac{Qv}{\rho c_p V_0^2}, Kr = \frac{K_l v}{V_0^2}, R = \frac{16a^*\sigma v T_\infty^{*3}}{\rho c_p V_0^2}, \Pr = \frac{\mu c_p}{k}, Sc = \frac{v}{D}, Sr = \frac{D_T\left(T_w^* - T_\infty^*\right)}{v\left(C_w^* - C_\infty^*\right)},$$

$$\lambda = \frac{\lambda^*V_0^2}{v}, M_1 = M + \frac{1}{K}. \tag{10}$$

Substituting the above non-dimensional variables into equations (9), (2) and (4) we get,

$$\left(1 + \lambda\frac{\partial}{\partial t}\right)\frac{\partial u}{\partial t} - \frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + Gr(\theta + N\phi) - \left(1 + \lambda\frac{\partial}{\partial t}\right)M_1 u \tag{11}$$

$$\frac{\partial \theta}{\partial t} - \frac{\partial \theta}{\partial y} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} - R\theta + H\theta \tag{12}$$

$$\frac{\partial \phi}{\partial t} - \frac{\partial \phi}{\partial y} = \frac{1}{Sc}\frac{\partial^2 \phi}{\partial y^2} + Kr\phi + Sr\frac{\partial^2 \theta}{\partial y^2} \tag{13}$$

Where Gr is the thermal Grashof number, N is the Buoyancy ratio, M is the Magnetic filed parameter, K is the Permeability parameter, H is the heat source parameter, R is the thermal radiation parameter, Kr is the Chemical reaction parameter, $\Pr$ is the Prandtl number, Sc is the Schmidt number, Sr is the Soret number and λ is the visco-elastic parameter.

The corresponding boundary conditions are

$$u = u_p, \theta = 1 + \varepsilon e^{-nt}, \phi = 1 + \varepsilon e^{-nt} \ at \ y = 0$$

$$u \to 0, \theta \to 0, \phi \to 0 \quad as \ y = 0 \tag{14}$$

3. Solution of the Problem

In order to reduce the above system of partial differential equations to a system of ordinary differential equations in dimensionless form, we may represent the velocity, temperature and concentration as

$$u = u_0 + \varepsilon u_1 e^{-nt} + O(\varepsilon^2)$$

$$\theta = \theta_0 + \varepsilon\theta_1 e^{-nt} + O(\varepsilon^2) \tag{15}$$

$$\phi = \phi_0 + \varepsilon\phi_1 e^{-nt} + O(\varepsilon^2)$$

Substituting eqn (15) into eqns (11)-(13) and equating the harmonic and non-harmonic term and neglecting the higher order terms of $O(\varepsilon^2)$, we obtain the zeroth and first order equations are as follows.

$$u_0'' + u_0' - M_1 u_0 = -Gr\theta_0 - GrN\phi_0 \quad (16)$$

$$\theta_0'' + \Pr\theta_0' - a_0\theta_0 = 0 \quad (17)$$

$$\phi_0'' + Sc\phi_0' + Kr\,Sc\,\phi_0 = -Sc\,Sr\,\theta_0'' \quad (18)$$

$$u_1'' + u_1' - (M_1 - n)(1 - n\lambda)u_1 = -Gr\theta_1 - GrN\,\phi_1 \quad (19)$$

$$\theta_1'' + \Pr\theta_1' - a_1\theta_1 = 0 \quad (20)$$

$$\phi_1'' + Sc\phi_1' + Sc(n + Kr)\,\phi_1 = -Sc\,Sr\,\theta_1'' \quad (21)$$

The corresponding boundary conditions are

$$u_0 = u_p, u_1 = 0, \theta_0 = 1, \theta_1 = 1, \phi_0 = 1, \phi_1 = 1, at\ y = 0$$

$$u_0 \to 0, u_1 \to 0, \theta_0 \to 0, \theta_1 \to 0, \phi_0 \to 0, \phi_1 \to 0, as\ y \to \infty \quad (22)$$

Without going into detail, the solutions of Eqs (16)-(21) subjected to the boundary conditions (22) can be shown to be

$$u = (C_4 e^{-m_6 y} + B_1 e^{-m_1 y} - B_3 e^{-m_3 y}) + \varepsilon e^{-nt}(C_5 e^{-m_5 y} + B_2 e^{-m_2 y} - B_4 e^{-m_4 y}) \quad (23)$$

$$\theta = e^{-m_1 y} + \varepsilon e^{-(nt + m_2 y)} \quad (24)$$

$$\phi = (1 + A_3)e^{-m_3 y} - A_3 e^{-m_1 y} + \varepsilon A_4 e^{-nt}(e^{-m_4 y} - e^{-m_2 y}) \quad (25)$$

4. Results and Discursion

In order to get a physical insight of the problem, the numerical calculations are carried out to illustrate the influence of various physical parameters on the velocity, temperature, concentration, skin-friction, Nusselt number and Sherwood number are presented and analyzed through graphs and tables. Throughout the calculations, the parametric values are chosen as, $n = 0.1, \varepsilon = 0.1, t = 1, u_p = 0.5$ and $N = 2.5$. All the graphs therefore correspond to these values unless specifically indicated on the appropriate graph

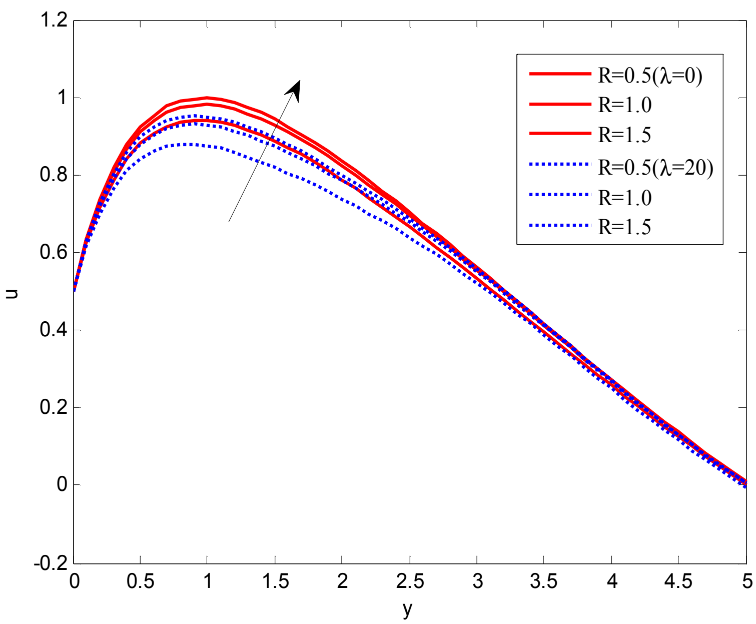

Fig.1. Effect of R on velocity profiles with
$Gr = 2, M = 2, K = 0.5, H = 0.5, Sc = 0.2, Kr = 0.5, \Pr = 0.71, Sr = 0.5, \lambda = 20.$

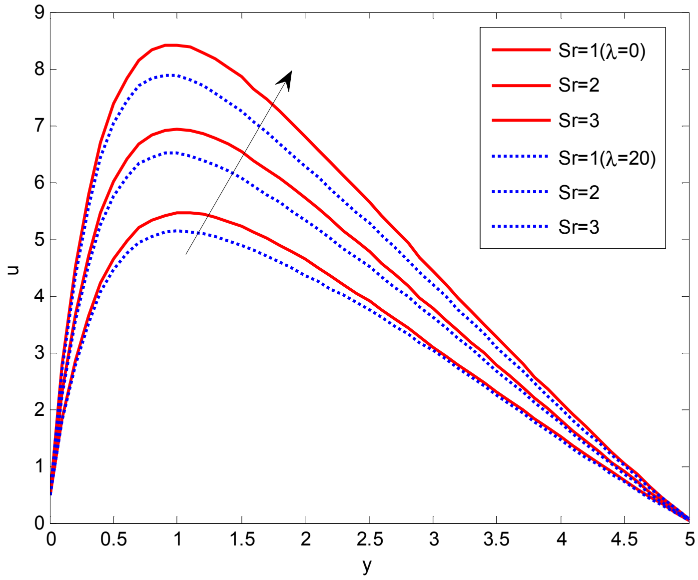

Fig.2. Effect of Sr on velocity profiles with
$Gr = 10, M = 2, K = 0.5, H = 0.1, Sc = 0.2, R = 0.5, Kr = 0.5, Pr = 0.71, \lambda = 20.$

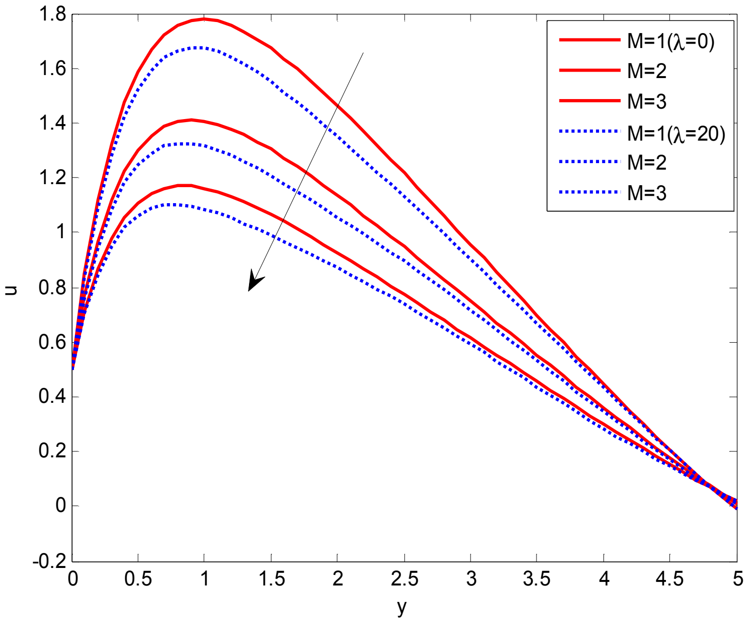

Fig.3. Effect of M on velocity profiles with
$Gr = 2, K = 0.5, H = 0.1, Sc = 0.2, R = 2, Kr = 0.5, Pr = 0.71, Sr = 2,$

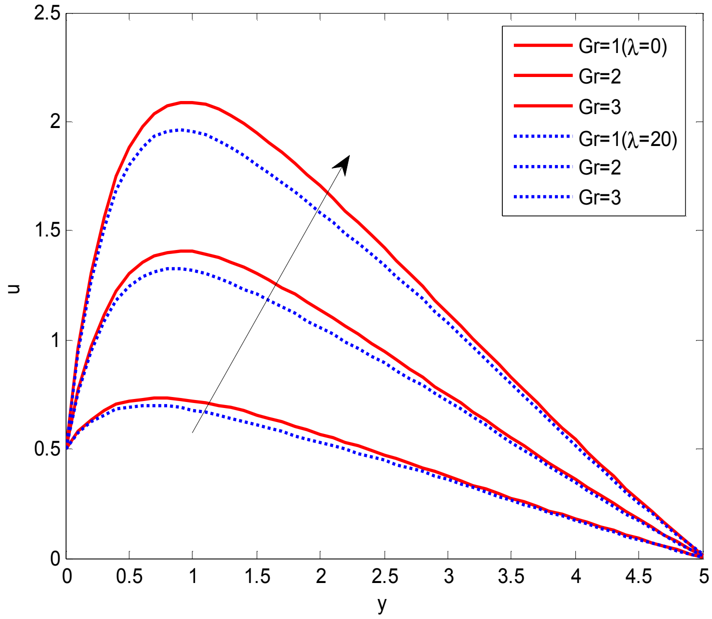

Fig.4. Effect of Gr on velocity profiles with
$M = 2, K = 0.5, H = 0.1, Sc = 0.2, R = 2, Kr = 0.5, Pr = 0.71, Sr = 2.$

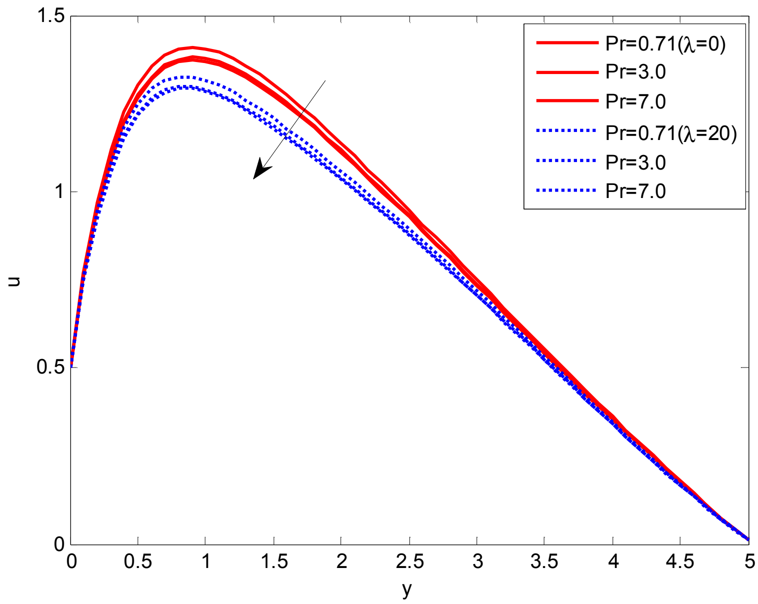

Fig.5. Effect of $\Pr$ on velocity profiles with
$Gr = 2, M = 2, K = 0.5, H = 0.1, Sc = 0.2, R = 2, Kr = 0.5, Sr = 2.$

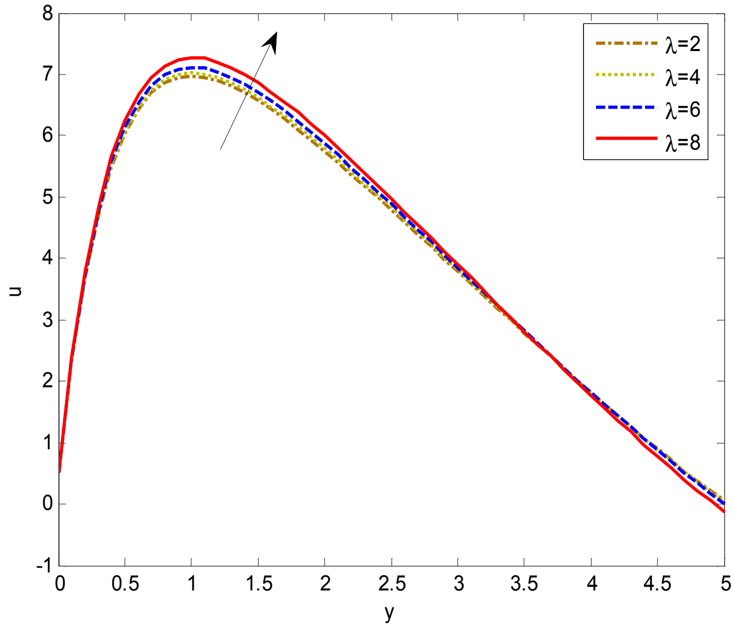

Fig.6. Effect of λ on velocity profiles
with $Gr = 10, M = 2, K = 0.5, H = 0.5, Sc = 0.2, R = 2, Kr = 0.5, Pr = 0.71, Sr = 2.$

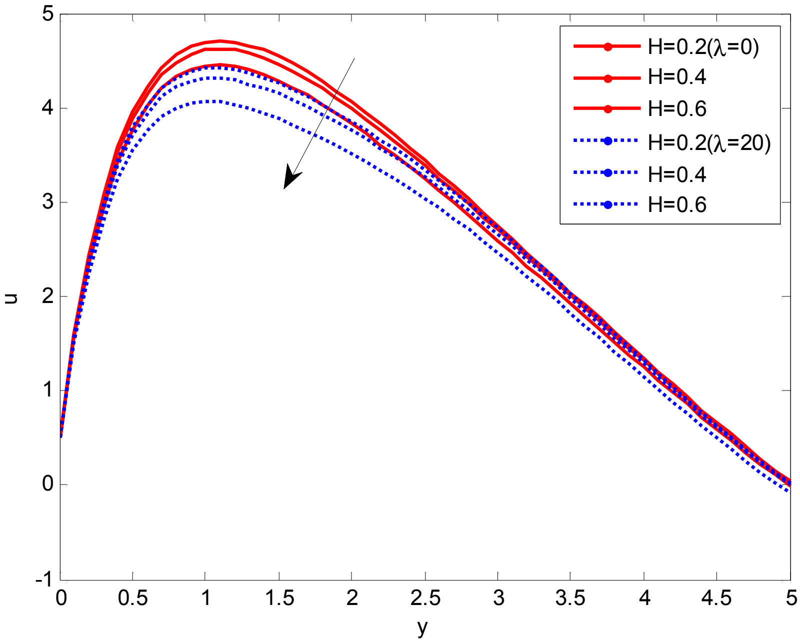

Fig.7. Effect of H on velocity profiles with
$M = 2, K = 0.5, Sr = 2, Gr = 10, Sc = 0.8; R = 2, Kr = 0.2, Pr = 0.71.$

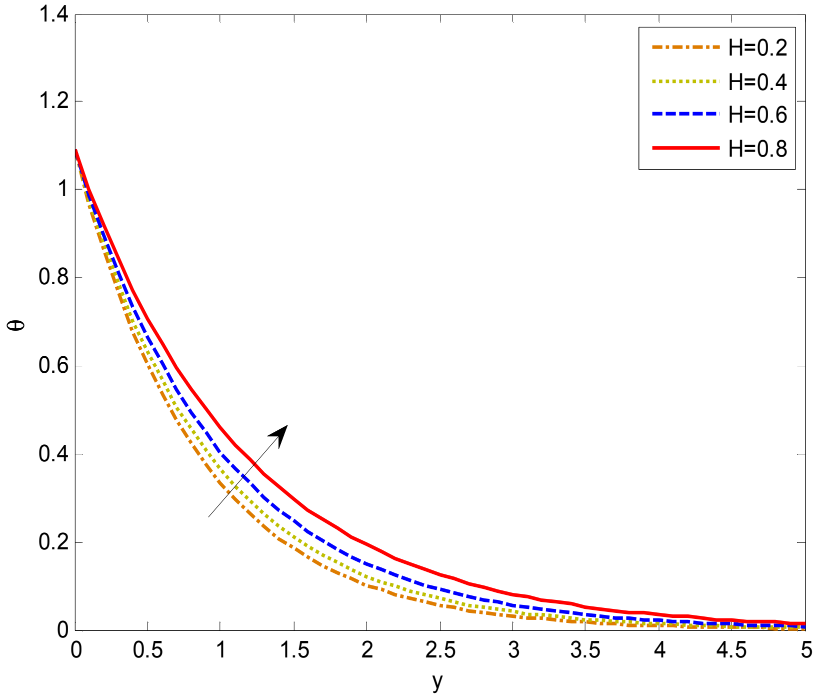

Fig.8. Effect of H on Temperature profiles with $R = 1, Pr = 0.71$.

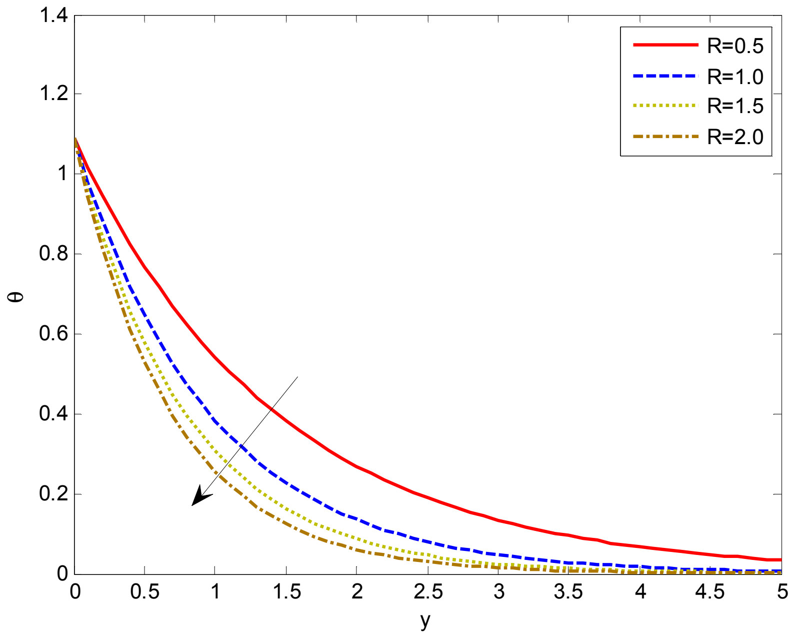

Fig.9.Effect of R on Temperature profiles with $H = 0.5, Pr = 0.71$.

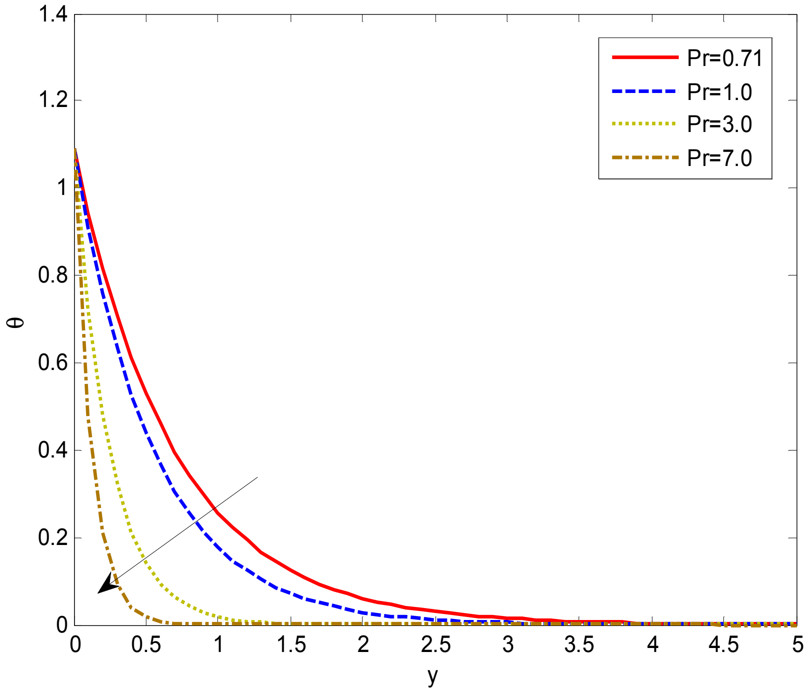

Fig.10. Effect of $\Pr$ on Temperature profiles with $H = 0.5, R = 2.$

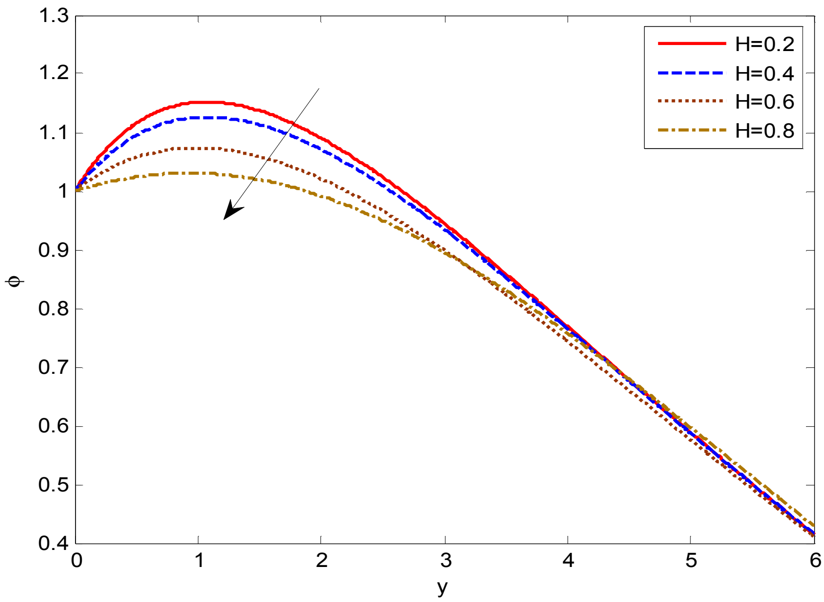

Fig.11.Effect of H on Concentration profiles with $Sc = 0.2, R = 1, Kr = 0.5, Pr = 0.71, Sr = 2.$

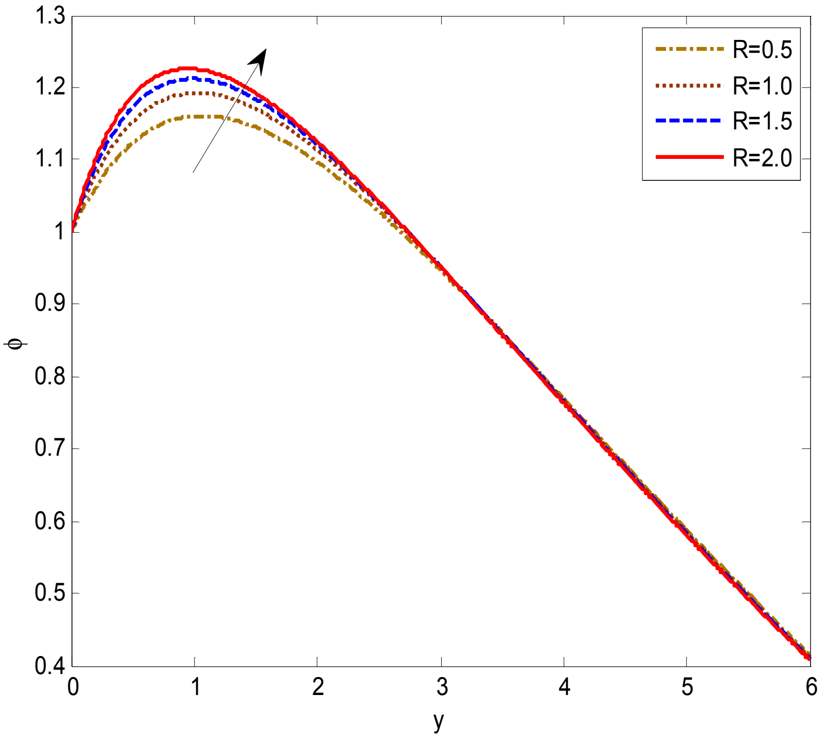

Fig.12.Effect of R on Concentration profiles with $H = 0.1, Sc = 0.2, Kr = 0.2, Pr = 0.71, Sr = 2.$

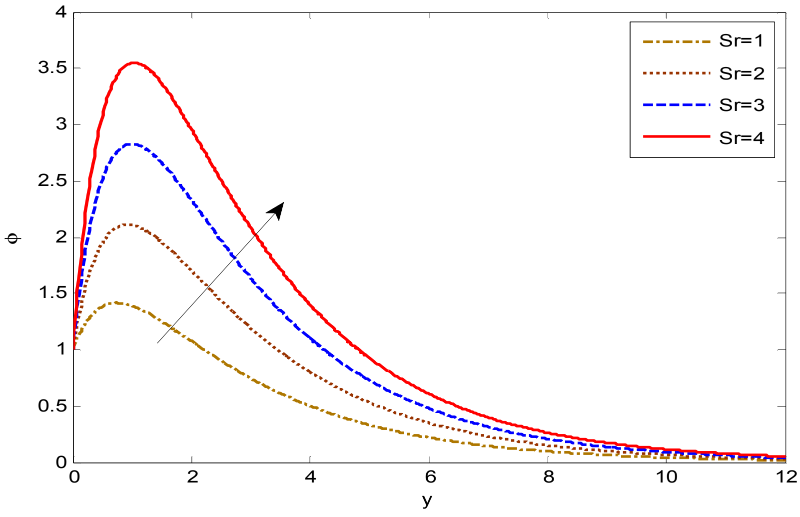

Fig.13.Effect of Sr on Concentration profiles with $H = 0.1, Sc = 0.8; R = 2, Kr = 0.2, Pr = 0.71.$

M	K	H	Sc	R	Kr	Pr	Sr	Newtonian fluid	Visco-elastic fluid
1	0.5	0.1	0.2	2	0.5	0.71	2	9.0432	8.7360
2	0.5	0.1	0.2	2	0.5	0.71	2	7.4428	7.1851
3	0.5	0.1	0.2	2	0.5	0.71	2	6.3288	6.1040
2	**1.5**	0.1	0.2	2	0.5	0.71	2	9.7557	9.4258
2	**3**	0.1	0.2	2	0.5	0.71	2	10.6049	10.2472
2	**5**	0.1	0.2	2	0.5	0.71	2	10.9931	10.6225
2	0.5	**0.2**	0.2	2	0.5	0.71	2	7.1901	7.4477
2	0.5	**0.4**	0.2	2	0.5	0.71	2	7.2007	7.4581
2	0.5	**0.6**	0.2	2	0.5	0.71	2	7.2122	7.4693
2	0.5	0.1	**0.22**	2	0.5	0.71	2	7.8165	7.4693
2	0.5	0.1	**0.30**	2	0.5	0.71	2	9.3698	9.0109
2	0.5	0.1	**0.60**	2	0.5	0.71	2	16.2809	15.6268
2	0.5	0.1	0.2	**1**	0.5	0.71	2	7.5008	7.2453
2	0.5	0.1	0.2	**3**	0.5	0.71	2	7.4022	7.1444
2	0.5	0.1	0.2	**5**	0.5	0.71	2	7.3503	7.0933
2	0.5	0.1	0.2	2	**2**	0.71	2	6.1761	5.9706
2	0.5	0.1	0.2	2	**4**	0.71	2	4.9119	4.7507
2	0.5	0.1	0.2	2	**6**	0.71	2	3.9668	3.8349
2	0.5	0.1	0.2	2	0.5	**0.025**	0.5	3.0894	2.8565
2	0.5	0.1	0.2	2	0.5	**0.71**	0.5	4.4015	4.3086
2	0.5	0.1	0.2	2	0.5	**7.0**	0.5	4.9305	4.8741
2	0.5	0.1	0.2	2	0.5	0.71	**1**	5.4153	5.2674
2	0.5	0.1	0.2	2	0.5	0.71	**3**	9.4702	9.1028
2	0.5	0.1	0.2	2	0.5	0.71	**5**	13.5252	12.9381

Table.1: Numerical values of Skin-friction coefficient (Cf) for Newtonian fluid and Visco-elastic (Kuvshiniki type) fluid

H	Pr	R	Nu
0.2	0.71	2	-1.6765
0.4	0.71	2	-1.6093
0.6	0.71	2	-1.5381
0.1	**0.025**	2	-0.2512
0.1	**0.71**	2	-1.7088
0.1	**7.0**	2	-9.3225
0.1	0.71	**1**	-1.3372
0.1	0.71	**3**	-1.9969
0.1	0.71	**5**	-2.4559

Table.2: Numerical values of Nusselt number (Nu)

H	Pr	Sc	R	Kr	Sr	Sh
0.2	0.71	0.2	2	0.5	2	0.5868
0.4	0.71	0.2	2	0.5	2	0.5586
0.6	0.71	0.2	2	0.5	2	0.5286
0.1	**0.025**	0.2	2	0.5	2	-0.0722
0.1	**0.71**	0.2	2	0.5	2	0.6003
0.1	**7.0**	0.2	2	0.5	2	3.6683
0.1	0.71	**0.22**	2	0.5	2	0.6624
0.1	0.71	**0.30**	2	0.5	2	0.9149
0.1	0.71	**0.60**	2	0.5	2	1.9367
0.1	0.71	0.2	**1**	0.5	2	0.4431
0.1	0.71	0.2	**3**	0.5	2	0.7198
0.1	0.71	0.2	**5**	0.5	2	0.9081
0.1	0.71	0.2	2	**2**	2	0.5177
0.1	0.71	0.2	2	**4**	2	0.4338
0.1	0.71	0.2	2	**6**	2	0.3699
0.1	0.71	0.2	2	0.5	**1**	0.2501
0.1	0.71	0.2	2	0.5	**3**	0.9504
0.1	0.71	0.2	2	0.5	**5**	1.6507

Table.3: Numerical values of Sherwood number (Sh)

Fig.1 illustrates the influence of Radiation parameter R on velocity distribution for Newtonian and Visco-elastic fluids. It is noticed from the figure that the fluid velocity increases with an increase in the Radiation parameter R in both cases. This is because of the fluid considered here which is gray, emitting and absorbing radiation but non-scattering medium.Fig.2 demonstrates the effect of the Soret number Sr on the fluid velocity for both Newtonian and Visco-elastic fluids. Comparing the curves of the said figure it is observed that a growing Soret number Sr increases the fluid velocity and momentum boundary layer thickness. Also it is observed that the boundary layer thickness is thinner for Visco-elastic fluid with the comparison of Newtonian fluid. The effect of Magnetic field parameter M for both Newtonian and Visco-elastic fluids on velocity profiles are shown in fig.3. It is clear that the fluid velocity decreases with an increasing values of M for both cases. Because the transverse magnetic field retards the fluid flow, which is known as Lorentz force. It is also observed that the velocity reaches the maximum peak value at the surface.

The influence of thermal Grashof number Gr on velocity profiles for both Newtonian and Visco-elastic fluids Visco-elastic fluids are shown in fig.4. From this figure it is clear that the fluid velocity increases with an increasing values of Gr in both cases. It is also noticed that the momentum boundary layer thickness for Newtonian fluid is thicker than that of Visco-elastic fluid and the momentum boundary layer thickness is increases significantly with an increase in Gr .The velocity profiles for different values of Prandtl number Pr for Newtonian and Visco-elastic fluids are presented in fig.5. From this figure it is seen that the velocity decreases with an increase in Pr. Also it is observed that the fluids with lower Prandtl number Pr have thicker boundary layer structures. Fig.6. presents the velocity profiles for different values of Visco-elastic parameter λ. Velocity is found to decrease with the increasing Visco-elastic parameter λ. Increasing nature of the momentum boundary layer thickness with increasing λ is noted. Fig.7 demonstrates the effect of heat source parameter *H* on the fluid velocity for both Newtonian and Visco-elastic fluids. As an output of figures, it is observed that the fluid velocity decreases with an increase in *H* and also the thickness of the momentum boundary layer is decreases.

The effect of heat source parameter *H* on the temperature and concentration distributions are exhibited in figures 8 and 13. From the figure.8 it is noticed that the dimensionless temperature increases for increasing strength of the heat source parameter, So, the thickness of thermal boundary layer increases with heat source parameter. This result is very much significant for the flow where heart transfer is given prime importance. It is also observed from fig.13 that the concentration profiles decreases with an increase in Heat source parameter. The temperature field for various values of the radiation parameter *R* is represented in fig.9 with increasing *R*, the dimensionless temperature profile as well as thermal boundary layer thickness decreases therefore using radiation we can control the flow characteristics and temperature distribution.

Fig.10 displays the effect of Prandtl number $\Pr$ on the temperature profiles with increasing $\Pr$ the temperature profiles decreases. An increase in Prandtl number means a decrease of fluid thermal conductivity which causes a decrease in temperature. The effect of Soret number *Sr* on the concentration profiles is shown in fig.11. From this figure we see that concentration profiles increase with an increasing values of *Sr*, from which we conclude that the fluid concentration rises due to greater thermal diffusion. It is found that the concentration boundary layer thickness increases with an increase in the Soret number. Fig.12 depicts the concentration profiles with Radiation parameter *R*. It is observed that the species concentration increases with increasing values of *R*, also the Solutal boundary layer thickness increases with the increasing values of *R*.

Table.1 depicts the numerical values of Magneatic field parameter M , Permeability parameter K , heat source parameter H , Schmidt number Sc ,Radiation parameter R ,Chemical reaction parameter Kr ,Prandtl number $\Pr$ and Soret number Sr on the Skin-friction coefficient Cf for both Newtonian and Visco-elastic fluids. The local friction factor increases with increasing values of *K, H, Sc, Pr* and *Sr*. While it decrease with the increasing values of *M,R* and *Kr* for both fluids. Also it is noticed that the Skin-friction coefficient increases quickly for larger values of Sc . It is found that the Skin-friction coefficient is very significant for Newtonian fluids. Table.2 demonstrate the effects of heat source parameter H ,Prandtl number $\Pr$ and Radiation parameter *R*,on Nusselt number *Nu* which measures the rate of heat transfer at the surface of the plate. It is found that the heat transfer at the plate is increased by an increase in the heat source parameter H , and it is interesting to note that the reciprocal situation occurs in the case of Prandtl number $\Pr$ and Radiation parameter R .

The effects of heat source parameter H, Prandtl number *Pr*, Schmidt number *Sc*, Radiation parameter *R*, Chemical reaction parameter *Kr* and Soret number *Sr* on the Sherwood number *Sh* are presented in Table.3. It is observed that the Sherwood number increases with an increasing value of $\Pr$,*Sc*,*R* and *Sr*, while it decreases with an increasing values of H ,and Kr .

5. Conclusions

The problem of unsteady MHD free convective heat and mass transfer flow of Kuvshinski fluid past an infinite vertical plate with thermal radiation, Heat source, Radiation and thermal diffusion effects was studied. The dimensionless governing equations are solved analytically by usual perturbation technique. From the present study we can make the following conclusions.

1. Increasing the values of Soret number and Radiation parameter resulted in increases the velocity profiles for both Newtonian and Visco-elastic fluids.

2.An increasing values of Heat source parameter and Radiation parameter the temperature profiles as well as the thermal boundary layer thickness increases but the temperature profiles are decreases with an increasing in Prandtl number

3. The species concentration profiles increases with the increasing values of Soret number. It is clear that the species concentration reaches the maximum value at the plate for larger values of Soret number.

4. The local friction coefficient increases significantly for different values of Schmidt number.

5.The local coefficients of Nusselt number increases with Heat source parameter and it decreases with Prandtl number or Radiation parameter but opposite trend is observed in Sherwood number.

Appendix

$$a_0 = \Pr(R-H), a_1 = \Pr(R-H-n), m_1 = \frac{\Pr+\sqrt{\Pr^2+4a_0}}{2},\ m_2 = \frac{\Pr+\sqrt{\Pr^2+4a_1}}{2}$$

$$m_3 = \frac{Sc+\sqrt{Sc^2-4ScKr}}{2}, m_4 = \frac{Sc+\sqrt{Sc^2-4Sc(n+Kr)}}{2}, A_3 = \frac{Sc\,Sr\,m_1^2}{m_1^2 - Scm_1 + KrSC},$$

$$m_5 = \frac{1+\sqrt{1+4M_2}}{2}, \qquad m_6 = \frac{1+\sqrt{1+4M_1}}{2},$$

$$r_1 = Gr(1-NA_3), r_2 = Gr(NA_4-1), r_3 = GrN(1+A_4), r_4 = GrNA_4$$

$$B_1 = \frac{r_1}{m_1^2 - m_1 - M_1}, B_2 = \frac{r_2}{m_2^2 - m_2 - M_2}, B_3 = \frac{r_3}{m_3^2 - m_3 - M_1}, B_4 = \frac{r_4}{m_4^2 - m_4 - M_2},$$

$$C_4 = u_p + B_3 - B_1, C_5 = B_4 - B_2$$

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