International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 4, pp 45-55, April-2023

https://doi.org/10.47001/IRJIET/2023.704007

Analytical Investigation of MHD Casson Fluid Flow Past an Inclined Semi-Infinite Porous Plate with Radiation Absorption and Magnetic Field Effects

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Abstract - **In this paper, an investigation is carried out to explore the effects of radiation absorption and inclined magnetic field on magneto hydrodynamic fluid flow on the velocity and temperature of the fluid. The governing partial differential equations are nondimensionalized using suitable non-dimensional variables and the resulting equations are solved by semi-analytical Adomian decomposition method (ADM). We obtained expressions for the velocity, temperature, and concentration profiles in the form of a series solution. Impacts of involved parameters like magnetic field, heat source, angle of inclination, Grashof number, radiation absorption parameter, Schmidt number, chemical reaction parameter, Eckert number, Prandtl number, Casson parameter and porosity parameter on the velocity, temperature and concentration profiles are presented graphically. Comparison with established work is made and excellent agreement is obtained. This shows the solution obtained using the proposed technique is dependable and accurate.**

Keywords: Adomian Decomposition method (ADM), Similarity Transformation, Velocity profile, Temperature profiles, Variable Suction, Porous plate, MHD, Permeability, Porosity.

I. INTRODUCTION

The convective transfer of mass especially fluid over a heated sloping surface under the influence of magnetic field has fascinated the attention of researchers in contemporary times. This phenomenon has enormous application in many areas of scientific fields as engineering, astrophysics, geophysics such as coolant for nuclear reactors, border controls in aerodynamics, cooling towers and many more. In the physical science especially in chemical and biological sciences, the mass transfer is frequently encountered in the form of mass transition. Whereas, for flow with the presence of concentration gradient, only molecular diffusion takes place. Equally, the study of convective heat and mass transfer has been devoted considerable attention in recent times under several physical parameters and environment specifically in the chemical and manufacturing industries in the preparation of ceramics, glassware, fruit preparation, polymer preparation are good examples. Mahapatra et al. [1] have studied the steady two-dimensional MHD stagnation-point flow of an electrically conducting incompressible viscous fluid. In this study, the sheet is shrunk where the velocity is taken proportional to the distance from the stagnation point and a uniform magnetic field is applied normal to the plane. The study reveals, the velocity component parallel to the sheet is increased in the presence of magnetic field. Also, the magnetic parameter creates a tendency for decrease in the flow to reverse where the flow structure becomes complicated due to the non-alignment of the stagnation point from the stretching sheet. Ahmat and Orthan [2] examined the MHD mixed convective heat transfer flow about a semi-infinite inclined porous plate in the presence of thermal radiation. The fluid in this is assumed to dense and incompressible. Non-similar boundary layer equations obtained after been transformation are solved using Keller box numerical scheme wherein the influence of flow parameters is studied and presented graphically, and good agreement is achieved when result obtained was compared with literature. Mixed convection flow in an inclined enclosure under the influence of thermal radiation and magnetic field has been investigated by Sabyasachi et al [3]. Mahbub and Alamgir [4] have studied the effects of thermophoresis on unsteady MHD free convection heat and mass transfer along an inclined porous plate with heat generation in the presence of magnetic field. Suprava et al. [5] have analysed the radiation and mass transfer effects on MHD flow through porous medium past an exponentially accelerated inclined plate with variable temperature. Heat and mass transfer of natural convective with slanted magnetic field via fractional operator has been considered by Baleanu et al. [6]. Combined effects of inclined magnetic field and chemical reaction on flow over a semi-infinite vertical porous plate through porous medium was studied by Sandeep et al. [7]. Sahin [8] conducted a numerical analysis of the magneto

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hydrodynamics chemically reacting and radiating fluid past a non-isothermal uniformly moving vertical surface adjunct to a porous regime. Thadakamalla and Shankar [9] have examined the effects of inclined magnetic field on the flow, heat, and mass transfer of Williamson nano fluid over a stretching sheet. Rahman and Alam [10] explored the MHD free convective heat and mass transfer flow past an inclined surface with heat generation.

Similarly, the simultaneous movement of heat and mass transfer in a porous medium been extensively studied due its many applications in several fields of human endeavor. They include nuclear reactor cooling, geothermal reservoirs, porous dryers, enriched oil recovery, thermal insulating, and polymer industries. Sanker Reddy et al. [11] have examined the radiation effects on unsteady MHD free convective heat and mass transfer flow past a vertical porous plate embedded in a porous medium with viscous dissipation. The heat and mass transfer along a vertical plate with variable surface temperature and concentration in the presence of magnetic field have been analysed by Elbashbeshy [12]. Raghanath et al. [13] have studied heat and mass transfer on unsteady MHD flow through a porous medium between two vertical porous plate. Rama and Maheshbabu [14] have investigated unsteady heat transfer flow of Casson fluid through porous medium with aligned magnetic field and thermal radiation. Magneto hydrodynamics heat and mass transfer steady flow of a convective fluid through a porous plate in the presence of diffusion thermo and aligned magnetic field have been considered by Charankumar et al. [15].

Magneto hydrodynamics (MHD) is the study of interaction between a conducting fluid and magnetic field. Have useful engineering applications which include MHD flow meters, MHD pump, MHD power generation. The effect of thermal radiation on the convective heat and mass transfer on a wedge inclined at an angle has also been explored. Rachamalla and Nandylala [16] have examined the heat and mass transfer on MHD convective flow over an infinite vertical porous plate with heat source and chemical reaction. Thermal radiation and inclined magnetic field effects on MHD flow past a linearly accelerated inclined plate in a porous medium with variable temperature has been studied by Mahari and Nayak [17]. Idowu et al [18] obtained a numerical solution for thermal radiation effects and inclined magnetic field of MHD free convective heat transfer dissipative fluid flow past a moving vertical plate with variable suction. Similarly, Abbasbandy et al. [19] have investigated het and mass transfer of thermophoretic MHD flow over an inclined radiative isothermal permeable surface in the presence of heat source/sink. A numerical study has been conducted by on the heat and mass transfer flow of a nanofluid over an inclined plate under enhanced boundary conditions with magnetic field and thermal radiation has been investigated by Sreedevi et al. [20].

The objective of this research is in two-fold. Firstly, to consider a holistic study on convection involving mass and heat transfer through a porous medium flowing through a vertical plate in the presence of inclined magnetic field, chemical reaction, and radiation absorption. They have employed the perturbation method to obtain the solution for the pertinent parameters of the flow. However, in this study, we have added the novelty of considering the effect on the temperature as well as on the concentration gradient using Adomian decomposition method (ADM) in the presence of chemical reaction and radiation absorption. The Adomian decomposition method is an elegant semi-analytical method which gives an approximate analytical solution to a given problem in the form of a convergent series without requiring linearization, restrictive assumption, and perturbation parameter. Numerous applications of this innovative technique to many problems in several areas of science, engineering, finance, chemistry can be found in [21-38].

The rest of the study is organized as follows: The introduction of the useful concepts that characterized the study is given in section 1. The formulation of the problem is given in section 2. In section 3, the governing equations of continuity, momentum, energy, and specie concentration equations are explicitlygiven.Section4 gives the basics of the solution technique, Adomian decomposition method. In chapter 5, the implementation of the solution technique to obtain dimensionless velocity, temperature, and concentration profiles in convergent series form under the influence of the flow parameters is presented. The simulations of the different profiles for variations in the pertinent parameters expressed graphically as well their exhaustive discussions are presented in chapter6. The conclusion of the study is drawn in chapter 7.

II. MATHEMATICAL FORMULATION

We consider a two-dimensional, laminar, viscous, heat absorbing and electrically conducting MHD Casson fluid flowing through an inclined semi-infinite porous plate under the influence of thermal radiation into a porous medium. Assuming the fluid flow along the $x-$direction around$y-$axis. Assuming the fluid flow makes an angle of α in the path of the magnetic field B_0. The slow pace expressed an exponentially increasing rule of smaller disturbances. If the velocity and temperature on the wall as well as the suction differ exponentially with time. The main equations in this analysis are the balance of mass, linear dynamics, energy, and concentration.

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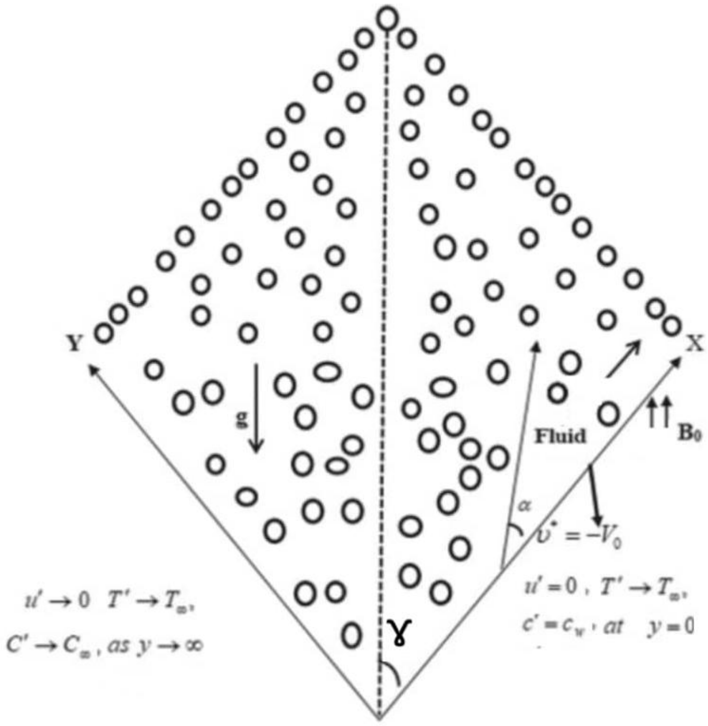

Figure 1: Physical configuration of the problem

$$\frac{\partial v^*}{\partial y^*} = 0, \Longrightarrow v^* = -V_0 > 0 \quad (1)$$

$$v^* \frac{\partial u^*}{\partial y^*} = \nu\left(1 + \frac{1}{\beta}\right)\frac{\partial^2 u^*}{\partial y^{*2}} + g\beta(T^* - T_\infty)\cos\alpha + \frac{\sigma B_0^2}{\rho}\sin^2\gamma u^2 - \frac{\nu u^*}{K^*} \quad (2)$$

$$v^* \frac{\partial T^*}{\partial y^*} = \frac{\kappa}{\rho C_\rho}\frac{\partial^2 T^*}{\partial y^{*2}} + \frac{\nu}{C_\rho}\left(\frac{\partial u^*}{\partial y^*}\right)^2 + \frac{\sigma B_0^2}{\rho}u^{*2} + \frac{Q}{\rho C_\rho}(T^* - T_\infty) + \frac{R^*}{\rho C_\rho}(C^* - C_\infty) \quad (3)$$

$$v^* \frac{\partial C^*}{\partial y^*} = D\frac{\partial^2 C^*}{\partial y^{*2}} - K_1(C^* - C_\infty) \quad (4)$$

The boundary conditions are as follows

$$u^* = 0, C^* = C_w, T^* = T_w \text{ at } y^* = 0$$

$$u^* \longrightarrow 0, C^* \longrightarrow C_\infty, T^* \longrightarrow T_\infty \text{ as } y^* \longrightarrow \infty \quad (5)$$

Using the following non-dimensional numbers:

$$u = \frac{u^*}{v_0}, y = \frac{v_0 y^*}{\nu}, Pr = \frac{\upsilon_\rho C_\rho}{\kappa}, \theta = \frac{T^* - T_\infty}{T_0 - T_\infty}, \phi = \frac{C^* - C_\infty}{C_0 - C_\infty}, Gr = \frac{\nu g\beta\,(T_w - T_\infty)}{\nu_0^3} \quad (6)$$

Putting Eq. (6) into Eqs. (1-4), we obtain the following simplified non-dimensional equations as follows

$$\left(1 + \frac{1}{\beta}\right)\frac{\partial^2 u}{\partial y^2} + \frac{\partial u}{\partial y} - (M^2\sin^2\gamma + K_0)u + Gr\cos\alpha\,\theta = 0 \quad (7)$$

$$\frac{\partial^2\theta}{\partial y^2} + Pr\frac{\partial\theta}{\partial t} + PrEc\left(\frac{\partial u}{\partial y}\right)^2 + PrEcM^2u^2 + PrQ\theta + R\varphi = 0 \quad (8)$$

$$\mathrm{Sc}\frac{\partial^2\varphi}{\partial y^2} + \frac{\partial\varphi}{\partial t} - Kr\varphi = 0 \quad (9)$$

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The resulting boundary conditions are

$u = 0, \theta = 1, \varphi = 1,$ at $y = 0$

$u \longrightarrow 0, \theta \longrightarrow 1, \varphi \longrightarrow 1$ as $y \longrightarrow \infty$ (10)

III. BASICS OF ADOMIAN DECOMPOSITION METHOD (ADM)

In this section, we illustrate the fundamentals of the Adomian decomposition method (ADM). We consider a general nonlinear ordinary differential or partial differential operator comprising both linear and nonlinear terms of the form

$$F\big(u(x)\big) = g(x) \quad (11)$$

Decomposing the linear term in Eq. (11) into the form $L + R$, where L is easily invertible and usually the highest order derivative among the linear terms, whereas R is the remain of the linear operator of order less than L. However, for singular problems, L is the combination of the singularity term and the highest order derivative.

Rewriting Eq. (11) in operator form, we have

$$L(u(x)) + R(u(x)) + N(u(x)) = g(x)$$

$$L(u(x)) = g(x) - R(u(x)) - N(u(x)) \quad (12)$$

While $N(u(x))$ is a nonlinear term and $g(x)$ is the source term.

Applying the inverse operator L^{-1}on both sides of Eq. (12), we obtain

$$L^{-1}(Lu(x)) = L^{-1}\big(g(x)\big) - L^{-1}(Ru(x)) - L^{-1}(Nu(x)) \quad (13)$$

The definition of L^{-1} depends on the type of the differential equation. For instance, in initial-value problems, L^{-1} is given as a sequence of definite integrals from 0 to x. Similarly, if L is an nth order operator, then L^{-1} is the n −fold integration operator,

$$L^{-1}\big(Lu(x)\big) = u_0(x) - \sum_{n=0}^{m-1} \frac{u^{(n)}(x_0)}{n!}(x - x_0)^n \quad (14)$$

However, for boundary-value problems, the indefinite integrals are used such that

$$L^{-1}\big(Lu(x)\big) = u_0(x) - \sum_{n=0}^{m-1} \frac{\alpha_n}{n!} x^n \quad (15)$$

The integration constant, α_n is obtained using the given boundary condition. Suppose L is second- order differential operator, then the inverse operator, L^{-1} is a two-fold indefinite integral

$$L^{-1}(.) = \int_0^x \int_0^x (.) dxdx$$

$$u(x) = \phi_0(x) + g(x) - L^{-1}R(u(x)) - L^{-1}N(u(x) \quad (16)$$

Where g(x) is the term obtained from integrating the source term and ϕ_0 from the given conditions

Now rewriting the solution and nonlinear terms as decomposition series of the form

$$u(x) = \sum_{n=0}^{\infty} u_n(x) \quad (17)$$

Similarly, the nonlinear term can be determined by an infinite series of the Adomian polynomials.

$$N(u_0, u_1, u_2, \dots, u_n) = \sum_{n=0}^{\infty} A_n \quad (18)$$

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Then the so-called Adomian polynomials $A_n^{'s}$ are obtained from the formula

$$A_n = \frac{1}{n!}\frac{d^n}{d\lambda^n}[N(\textstyle\sum_{k=0}^{\infty}\lambda^k u_k)]_{\lambda=0},\ n = 0,1,2,3 \quad (19)$$

Putting Eq. (10) into Eq. (9), we obtain the solution as decomposition series of the form.

$$\textstyle\sum_{n=0}^{\infty} u_n(x) = u(x) = \varphi_0(x) + g(x) - L^{-1}R(\sum_{n=0}^{\infty} u_n(x)) - L^{-1}N(\sum_{n=0}^{\infty} A_n(x)) \quad (20)$$

Where $u_0(x) = \phi_0(x) + g(x)$ is the zeroth component of $u_n(x)$

The subsequent members of the series are obtained recursively using

$$u_{k+1} = -L^{-1}R\big(u_k(x)\big) - L^{-1}(A_k(x)),\ k \geq 0 \quad (21)$$

Then exact solution of the problem is the limit of the recursive relation

$$u(x) = \lim_{n\to\infty} \textstyle\sum_{k=0}^{n} u_k(x) \quad (22)$$

IV. IMPLEMENTATION OF ADM

Writing the Eqs. (7-9) in operator form, we have the form

$$L_1 u = \left(\frac{1}{1+\frac{1}{\beta}}\right)(-L_y u + (M^2\sin^2\gamma + K_0)u - Gr\cos\alpha\,\theta) \quad (23)$$

$$L_2\theta = -\left(PrL_t\theta + PrEc\left(\frac{\partial u}{\partial y}\right)^2 + PrEcM^2u^2 + PrQ\theta + R\varphi\right) \quad (24)$$

$$L_3\varphi = \frac{-1}{Sc}(L_t\varphi - Kr\varphi) \quad (25)$$

Where

$$L_1(.) = L_2(.) = L_3(.) = \frac{\partial^2}{\partial y^2}(.), L_y = \frac{\partial u}{\partial y}, L_t = \frac{\partial}{\partial t}$$

Suppose the inverse of the operators, $L_1^{-1}(.),\ L_2^{-1}(.),\ L_3^{-1}(.)$ exists and defined in the form

$$L_1^{-1}(.) = L_2^{-1}(.) = L_3^{-1}(.) = \int_0^y \int_0^y (.)dydy \quad (26)$$

Operating the inverse operators, $L_1^{-1},\ L_2^{-1},\ L_3^{-1}$ on both sides of Eqs. (23-25), we have the form

$$u(y) = u(0) + yu'(0) + \left(\frac{\beta}{\beta+1}\right)\int_0^y \int_0^y [-L_y u + (M^2\sin^2\gamma + K_0)u - Gr\cos\alpha\,\theta]dydy \quad (27)$$

$$\theta(y) = \theta(0) + y\theta'(0) - \int_0^y \int_0^y \left(PrL_t\theta + PrEc\left(\frac{\partial u}{\partial y}\right)^2 + PrEcM^2u^2 + PrQ\theta + R\varphi\right)dydy \quad (28)$$

$$\varphi(y) = \varphi(0) + y\varphi'(0) - \frac{1}{Sc}\int_0^y \int_0^y (L_t\varphi - Kr\varphi)dydy \quad (29)$$

Inserting the boundary conditions in Eq. (10), we have the equivalent form

$$u(y) = \alpha_1 y + \left(\frac{\beta}{\beta+1}\right)\int_0^y \int_0^y [-L_y u + (M^2\sin^2\gamma + K_0)u - Gr\cos\alpha\,\theta]dydy \quad (30)$$

$$\theta(y,t) = 1 - \alpha_2 y + \int_0^y \int_0^y (PrL_t\theta + PrEcA_n + PrEcM^2B_n + PrQ\theta + R\varphi)dydy \quad (31)$$

$$\varphi(y,t) = 1 + \alpha_3 y - \frac{1}{Sc}\int_0^y \int_0^y (L_t\varphi - Kr\varphi)dydy \quad (32)$$

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Where $u'(0) = \alpha_1, \theta'(0) = \alpha_2, \varphi'(0) = \alpha_3$ are to be determined from the second boundary condition at $y \longrightarrow \infty$

Now by the standard Adomian procedure, we decompose the linear terms as an infinite series of the form

$$u(y) = \sum_{n=0}^{\infty} u_n(y), \theta(y,t) = \sum_{n=0}^{\infty} \theta_n(y,t), \varphi(y,t) = \sum_{n=0}^{\infty} \varphi_n(y,t) \quad (33)$$

Plugging Eq. (27) into Eqs. (29-31) gives the form

$$\sum_{n=0}^{\infty} u_n(y) = \alpha_1 y + \left(\frac{\beta}{\beta+1}\right) \int_0^y \int_0^y \left[-L_y \sum_{n=0}^{\infty} u_n(y) + (M^2 \sin^2\gamma + K_0) \sum_{n=0}^{\infty} u_n(y) - Gr\cos\alpha \sum_{n=0}^{\infty} \theta_n(y,t)\right] dydy \quad (34)$$

$$\sum_{n=0}^{\infty} \theta_n(y,t) = 1 - \alpha_2 y + \int_0^y \int_0^y (PrL_t \sum_{n=0}^{\infty} \theta_n(y,t) + PrEc \sum_{n=0}^{\infty} A_n + PrEcM^2 \sum_{n=0}^{\infty} B_n + PrQ \sum_{n=0}^{\infty} \theta_n(y,t) + R \sum_{n=0}^{\infty} \varphi_n(y,t)) dydy \quad (35)$$

$$\sum_{n=0}^{\infty} \varphi_n(y,t) = 1 + \alpha_3 y - \frac{1}{Sc} \int_0^y \int_0^y (L_t - Kr)(\sum_{n=0}^{\infty} \varphi_n(y,t)) dydy \quad (36)$$

Equating corresponding terms on both sides of Eqs. (34-35), we have the following approximates

$$u_0(y) = \alpha_1 y, \theta_0(y,t) = 1 - \alpha_2 y, \varphi_0(y,t) = 1 + \alpha_3 y \quad (37)$$

Similarly, the recursive scheme for the above become

$$u_{n+1}(y) = \left(\frac{\beta}{\beta+1}\right) \int_0^y \int_0^y \left[-L_y u_n + (M^2 \sin^2\gamma + K_0) u_n - Gr\cos\alpha\, \theta_n\right] dydy \quad (38)$$

$$\theta_{n+1}(y,t) = -\int_0^y \int_0^y (PrL_t\theta_n + PrEcA_n + PrEcM^2 B_n + PrQ\theta_n + R\varphi_n) dydy \quad (39)$$

$$\varphi_{n+1}(y,t) = -\frac{1}{Sc} \int_0^y \int_0^y (L_t\varphi_n - Kr\varphi_n) dydy, n \geq 0 \quad (40)$$

Using the relation for the partial sum, the approximate solution takes the form

$$u(y) \approx \sum_{n=0}^{\infty} u_n(y),\ \theta(y,t) \approx \sum_{n=0}^{\infty} \theta_n(y,t), \varphi(y,t) \approx \sum_{n=0}^{\infty} \varphi_n(y,t) \quad (41)$$

The accuracy of the solution procedure depends on the number of terms considered. Consequently, the higher the number of terms, the better the solution.

V. RESULTS

In this paper, the nonlinear system of equations in Eqs. (7-9) subject to the boundary condition (10) are solved using Adomian decomposition method for the velocity, temperature and concentration profiles on different flow parameters such as radiation absorption parameter, (R), chemical reaction, (Kr), Eckert number, (Ec), Prandtl number, (Pr), magnetic field parameter, (M), Grashoff number, (Gr), Casson parameter, (β), porosity parameter, (K_0), angle of inclination, (α), heat source, (Q). Tables (1-12) show the differences of the velocity, temperature, and concentration profiles.

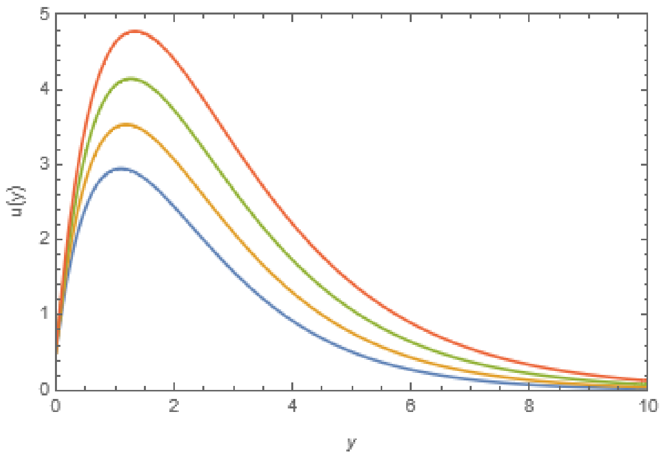

Figure 1: Effect of Casson parameter on velocity profile for parameter for constant values of $M = 1, Gr = 5.12, \alpha = 30, Ko = 1, \gamma = 25$

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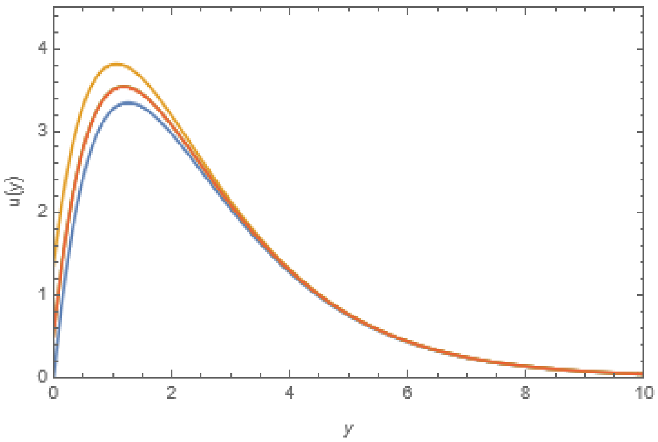

Figure 2: Influence of angle of inclination on velocity profile $M = 1, Gr = 5.12, \alpha = 30, Ko = 1, \gamma = 25, \beta = 1.82$

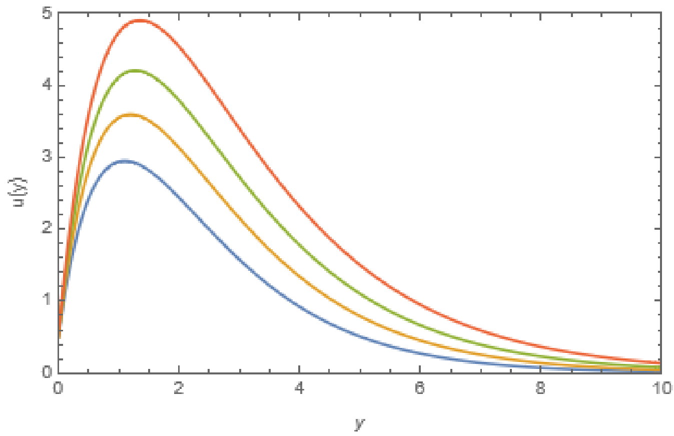

Figure 5: Influence of angle of magnetic field parameter on velocity profile $Gr = 5.12, \alpha = 30, Ko = 1, \gamma = 25, \beta = 1.82$

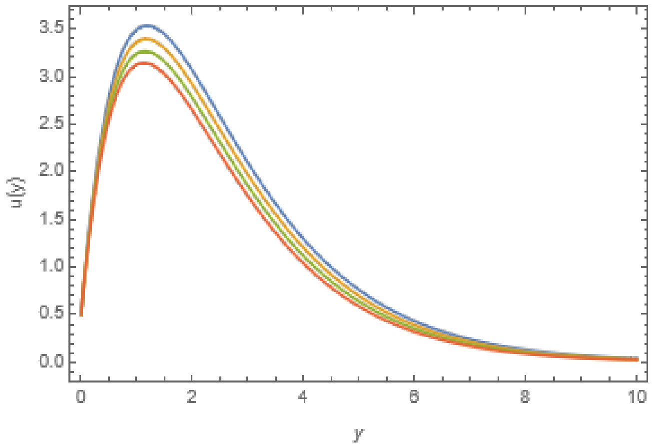

Figure 3: Influence of inclined angle parameter on velocity profile $M = 1, Gr = 5.12, \alpha = 30, Ko = 1, \beta = 1.82$

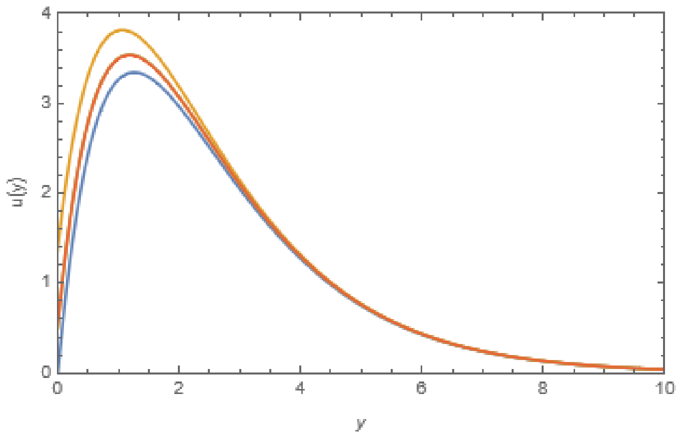

Figure 6: Influence of angle of porosity parameter on velocity profile $M = 1, \alpha = 30, Gr = 5.12, \gamma = 25, \beta = 1.82$

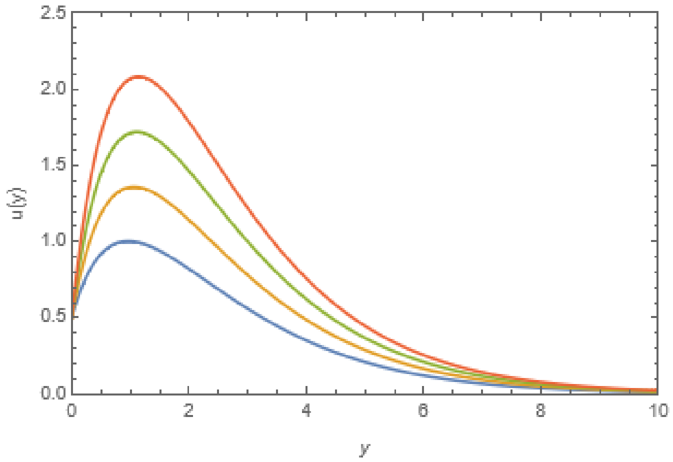

Figure 4: Influence of Grashof number on velocity profile when $M = 1, \alpha = 30, Ko = 1, \gamma = 25, \beta = 1.82$

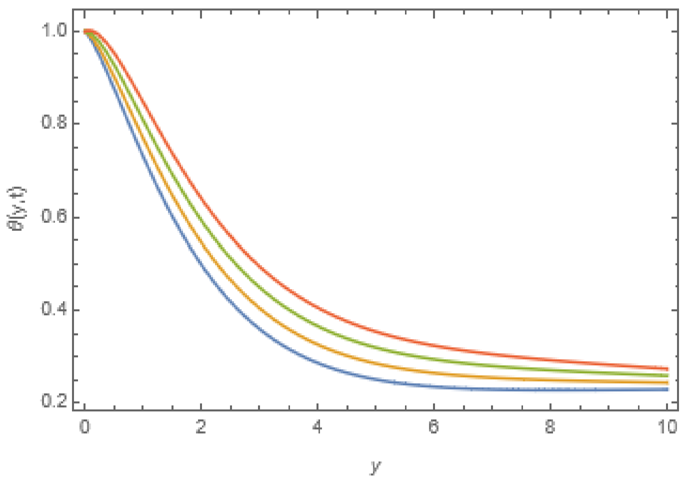

Figure 7: Temperature profile for variation in heat source parameter and constant values of $R = 0.45, M = 1$ $Pr = 0.71, \alpha = 30, Ec = 0.001$

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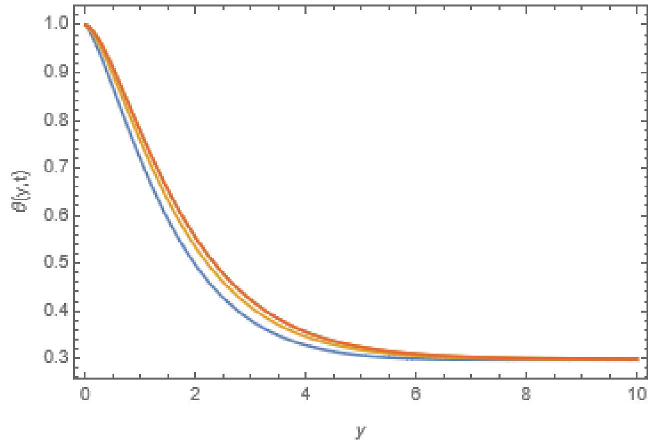

Figure 8: Temperature profile for variation in Prandtl number parameter and constant values of $R = 0.45, M = 1$, $Pr = 0.71, \alpha = 30, Ec = 0.001, Q = 5$

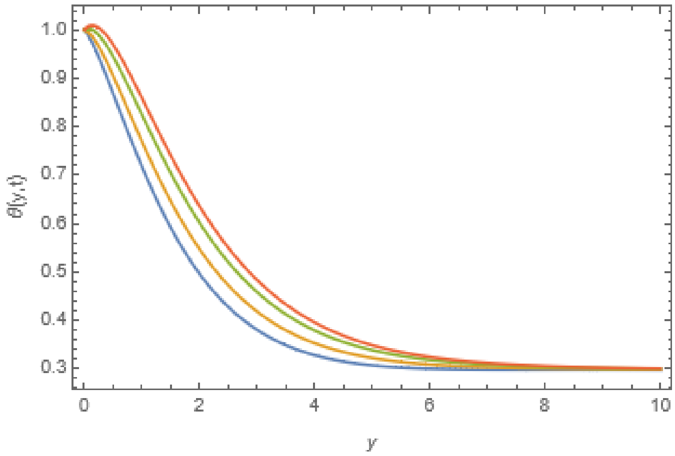

Figure 9: Temperature profile for variation in radiation absorption parameter and constant values of $M = 1$ $Pr = 0.71, Ec = 0.001, \alpha = 30, Q = 5, Kr = 2.5$

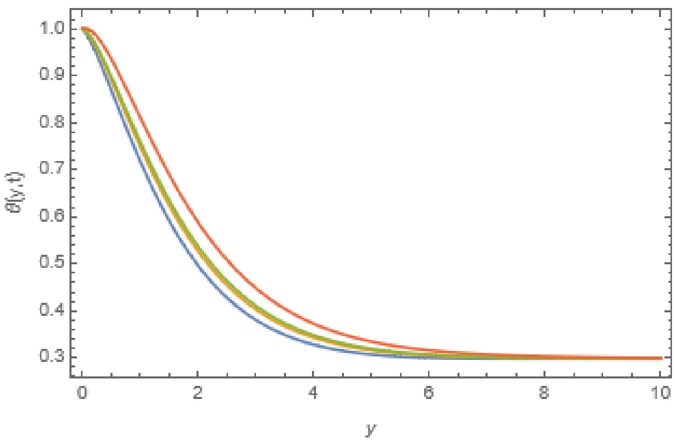

Figure 10: Temperature profile for variation in thermal radiation parameter and constant values of $M = 1, Pr = 0.71$, $Ec = 0.001, \alpha = 30, Q = 5, R = 5.5$

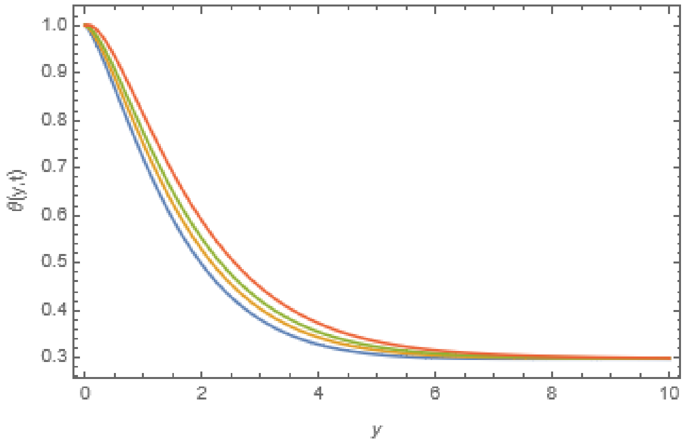

Figure 11: Temperature profile for variation in magnetic field Parameter for constant values of $R = 0.45, Q = 5, Kr = 0.17$, $Pr = 0.71, \alpha = 30, Ec = 0.01$

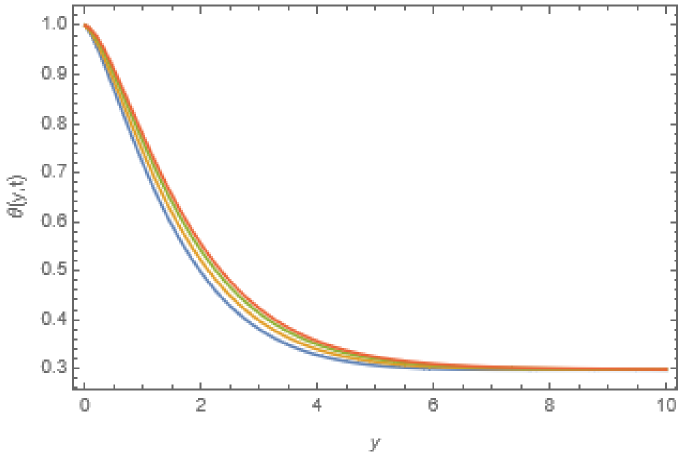

Figure 12: Temperature profile for variation in Eckert number for constant values of $R = 0.45, Q = 5, Kr = 0.17$, $Pr = 0.71, \alpha = 30, M = 1$

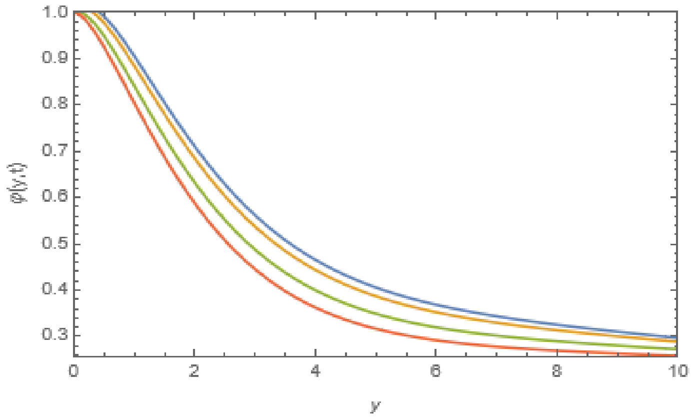

Figure 13: Concentration profile for variation in Schmidt number for constant values of $R = 0.45, Q = 5, Kr = 0.17$, $Pr = 0.71, \alpha = 30, M = 1$

ISSN (online): 2581-3048
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https://doi.org/10.47001/IRJIET/2023.704007

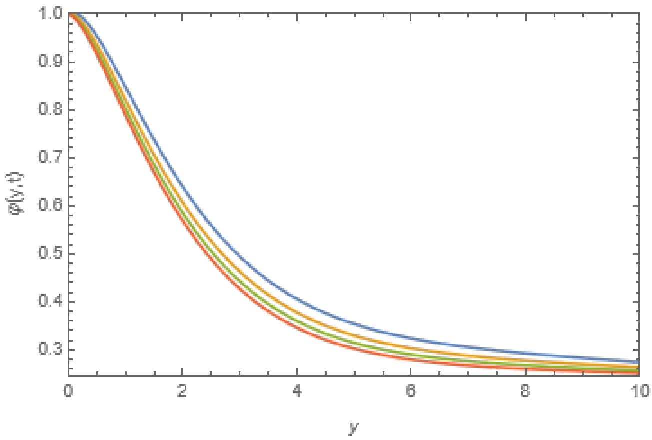

Figure 14: Concentration profile for variation in thermal radiation Parameter for constant values of $R = 0.45$, $Q = 5, Sc = 0.12, Pr = 0.71, \alpha = 30, M = 1$

VI. CONCLUSION

In this research article, we have implemented the Adomian decomposition technique to solve the problem of magnetohydrodynamic fluid flowing through a vertical porous plate in the presence of chemical reaction, radiation absorption and inclined magnetic field. Applying this method, to the dimensionless nonlinear ordinary differential equations, we obtained the approximate analytical solution of the velocity, temperature, and concentration profiles in the form of convergent series solutions. Influence of pertinent parameters is investigated graphically and coded using Wolfram Mathematica 12.3. The result obtained from the different profiles agrees with literature which shows the involved parameters have profound influence on the fluid flow geometry. The following conclusions can be drawn from our study:

- The velocity profile increases in the presence of Casson parameter, angle of inclination, Grashof number and Magnetic field parameters
- Radiation absorption and inclined magnetic field parameter cause a decrease in the velocity profile of the fluid
- Positive increment in the heat source parameter, Prandtl number, Eckert number and thermal radiation parameter lead to an increased temperature distribution of the fluid
- Increase in the Radiation and magnetic field parameters cause a decrease in the temperature profile
- The presence of Schmidt and thermal radiation parameters decrease the concentration gradient of the fluid.

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Citation of this Article:

Liberty Ebiwareme, Kubugha Wilcox Bunonyo, Nicholas Nkasiovu Tasie, “Analytical Investigation of MHD Casson Fluid Flow Past an Inclined Semi-Infinite Porous Plate with Radiation Absorption and Magnetic Field Effects” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 4, pp 45-55, April 2023. Article DOI https://doi.org/10.47001/IRJIET/2023.704007

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