EAST EUROPEAN JOURNAL OF PHYSICS. 3. 188-194 (2024)
DOI:10.26565/2312-4334-2024-3-18 ISSN 2312-4334

NUMERICAL STUDY OF CONVECTIVE FLOW OF CASSON FLUID THROUGH AN INFINITE VERTICAL PLATE WITH INDUCED MAGNETIC FIELD

Hiren Deka[a], Parismita Phukan[a,b]*
[a]*Department of Mathematics, Cotton University, Assam, India*
[b]*Department of Mathematics, Royal Global University, Assam, India*
Corresponding Author e-mail: parismita12007@gmail.com
Received April 17, 2024; revised June 3, 2024; accepted June 21, 2024

The present objective is to numerically analyze the induced magnetic field (IMF) effect of an unsteady MHD flow of Casson fluid through two infinite vertical plates. The effect of radiative heat has been scrutinized. Governing non-dimensional PDEs of the flow are discretized by the finite difference method to some algebraic system of equations, which is then numerically solved concerning the boundary conditions. The effects of the radiations, magnetic Prandtl number, Prandtl number, Hartmann number, and Casson parameter on temperature profile, velocity profile, and induced magnetic field have been depicted through graphs. The radiative effect and Prandtl number have considerable influence on the surface drag force and also on the rate of heat transfer.
Keywords: *MHD; Casson; induced magnetic field; FDM*
PACS: 44.05.+e, 44.40.+a,47.11.-j
MSC 2010: *76W05*

1 INTRODUCTION

Convective heat transfer takes place between a moving fluid and its surrounding surface when there is difference in temperature. Such convective flows have wide applications in different fields of engineering and industries. It also has its vast applications in many agricultural and industrial water distribution, geothermal mining and groundwater flows. Magnetohydrodynamic convective flows have drawn more attention in the past few decades owing to its applications in the study of chemical engineering, planetary magnetospheres and electronics.

For a free convective, the flow is induced by buoyancy forces. Free convection plays an important role to design performance of several system as it provides large resistance to heat

transfer. The convection of non-Newtonian fluid has recently been able to draw the attentions of many researchers as it has more explicable properties then the Newtonian fluid. A non- Newtonian fluid has the property that the deformation rate varies with viscosity. It has its wide applications in crude oil extraction. Casson fluid is a most popular non-Newtonian fluid that has its rheological effects on viscoelastic fluids. Casson fluid is a fluid with the properties of high viscosity shear thinning and yield stress below which flow is restricted. It has its significant applications in the field of chemistry and mechanics. Several mathematicians, engineers and scientists have analyzed the applications of Casson fluids. Many researchers have also contributed their work on convection of a Casson fluid. Rodi and Mopuri [1] have recently analyzed the convective flow a Casson fluid. They analytically deliberated the influence of magnetic field, chemical reaction along with Soret effect of flow through an inclined semi-infinite plate. Vijayaragavan and Karthikeyan [2] have examine the Hall current effect along with diffusion-thermo-effect, chemical reaction and radiative effect. In 2021, Vijayaragavan et al [3] have investigated transient convective flow pass an inclined vertical plate. Their work was concerned on transfer of mass and heat of a conducting Casson fluid. For a rotating system Pushpalatha [4] explored free convection of Casson fluid. Perturbation technique was applied in solving the equations. Throughout their study, they conclude that Casson parameter controls the fluid velocity profile and thermodiffusion effect enhance both concentrations and velocity profiles.

The study of fluid flow via various physical configurations and media has been able to capture the interest of many experts. Due to various significance of mass and heat transfer, magnetohydramic flow of fluid with the influence of reaction by chemical has drag a lot of interest in the intervening years. Additionally, the radiative transport of heat has several uses in the construction of nuclear power plants and different missile, satellite, and other technologies. Considering all of these important applications, Sarma et al., [5] examine the mass transfer for a flow through an infinite plate. Laplace transform method is applied in solving the governing equations. Their results show considerable changes due to influence of different parameters and along with it the porosity of the medium slows down the fluid velocity which is in agrees with physical reality. Through a flat plate and vertical cone Kumar et al., [6] have analyzed the non-Darcy convective flow. Muhammad Waqas et al [7] addresses the mixed convective flow of a viscous micropolar liquid with joule heating. The occurrence of fluid is towards non-linear stretched surface. The equations governing the problem are solved by homotopic procedure. A.K. Agrawal et al [8] have extended their work on transfer of mass of convective flow past a vibrating circular cylinder.

Cite as: H. Deka, P. Phukan, East Eur. J. Phys. 3, 188 (2024), https://doi.org/10.26565/2312-4334-2024-3-18

The research mentioned above have often been limited to relatively low magnetic Reynolds numbers, allowing for the disregard of magnetic induction effects. If magnetic Reynolds number is relatively high, such effects is considered. Due to its employment in numerous technological and scientific phenomena, such as MHD power generation, geophysics, crude oil purification, glass making, etc., the IMF has many essential applications in the theoretical and experimental studies. The study of mixed convective constant flow of a Newtonian fluid through a vertical infinite plate in porous material was examined by Ahmed and Chamkh [9]. In presence of IMF the main objective was to study the rate of transfer of heat and mass with the effects of chemical reaction, thermal radiation. Sarveshanand and Singh [10] analyzed the free convective steady flow between two vertical infinite porous plate in addition of suction velocity. Fadzilah Md. Ali et al., [11] numerically illustrated the transfer of heat of a steady convective flow through a stretching sheet. Hazarika et al [12] numerical analyzed the convective flow with fuzzified boundary conditions and with the effect of IMF. The impact of an IMF on a free convective unsteady flow of conducting fluid across a vertical semi-infinite plate has been analyzed by Kumar and Singh [13]. The implicit finite difference approach of Crank-Nicolson type was applied in solving the PDEs. Ahmed [14] precisely solved a continuous Poiseuille flow with mass and heat transfer under the influence of a transverse magnetic field with effect of thermal diffusion and IMF.

The present study of MHD convective flow of Casson fluid through infinite vertical plates with induced magnetic field is presumed to be used in various technological phenomena and will have significant role in many scientific experimental processes. The effect of radiation can be seen in various space technology and in design of nuclear power plants. The suction velocity plays an important role in artificially controlling the behavior of the boundary layer and hence it has wide application in industries and aeronautical engineering. Hence, from the above properties of different parameters and its wide applications in various fields has motivated to do the present analysis. The novelty of the present study is to analyze MHD convective flow of fluid in addition with significant impact of magnetic Reynold's number so that the effect of induced magnetic field is considered along with the radiative effect.

2. PROBLEM FORMULATION

A free convective flow of a Casson fluid passing through two infinite vertical plates is assumed. Let d be the distance between the two plates. The x' −axis is chosen vertically along the plate and the y' −axis is chosen perpendicular to the plate. B_0 is a uniform magnetic field applied along the y' −direction as shown in Figure 1. Initially, the fluid and the plate are at a same temperature T_0. With time $t > 0$ the temperature of the first plate increases to T_1 while temperature of the second plate is kept at temperature T_0. The magnetic Reynold's number is not assumed to be small and so the induced magnetic field is not insignificant.

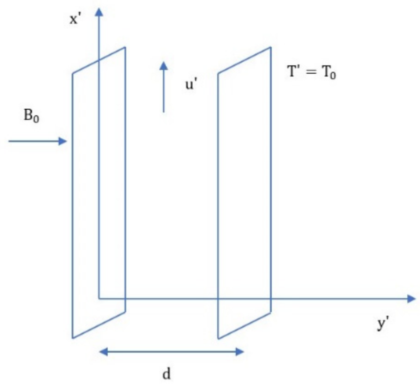

Figure 1. Configuration of the flow problem

Equations governing the flow problem are:

$$\frac{\partial u'}{\partial t'} + v'\frac{\partial u'}{\partial y'} = v_\infty\left(1+\frac{1}{\alpha}\right)\frac{\partial^2 u'}{\partial y'^2} + g\beta(T' - T_0') + \frac{\mu_e B_0}{\rho}\frac{\partial H'}{\partial y'} \tag{1}$$

$$\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial y'} = \frac{k}{\rho C_p}\frac{\partial^2 T'}{\partial y'^2} - \frac{1}{\rho C_p}\frac{\partial {q_r}'}{\partial y'} \tag{2}$$

$$\frac{\partial H'}{\partial t'} + v'\frac{\partial H'}{\partial y'} = \frac{1}{\sigma\mu_e}\frac{\partial^2 H'}{\partial y'^2} + B_0\frac{\partial u'}{\partial y'} \tag{3}$$

Boundary conditions are:

$$u' = 0, T' = T_1, H' = 0 \text{ at } y' = 0 \tag{4}$$

$$u' = 0, T' = T_0, H' = 0 \text{ at } y' = d. \tag{5}$$

Where velocity along x' −axis is u' ,the suction velocity is v' , t' ,T' ,H' are the dimensional time, temperature and induced magnetic field respectively. The kinematic viscosity is v_∞, g is the acceleration due to gravity, α is the casson parameter,

β is the thermal expansion coefficient, μ_e is the magnetic permeability, σ is the electrical conductivity and ρ is the fluid density.

The radiative term $\frac{\partial q_r}{\partial y}$ present in the energy Eq. (2.2) can be simplified by using Rosseland approximation as given below:

$$q_r' = -\frac{4\sigma_1}{3k_1}\frac{\partial T'^4}{\partial y'}, \tag{6}$$

where Stefan-Boltzmann constant is σ_1 and the mean absorption coefficient is k_1.
With the application of Taylor's series, we expand linear function T'_4 about the free stream temperature. Hence neglecting the high order terms the result of the approximation transforms into the form:

$$T'^4 \cong 4T_0^3T' - 3T_0^4. \tag{7}$$

Using Eq. (2.6) and Eq. (2.7), we have

$$\frac{dq_r'}{dy} = -\frac{16\sigma_1 T_0^3}{3k_1}\frac{\partial^2 T'}{\partial y'^2}. \tag{8}$$

Then Eq. (2.2) takes the form:

$$\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial y'} = \frac{k}{\rho C_p}\frac{\partial^2 T'}{\partial y'^2} + \frac{16\sigma_1 T_0^3}{3k_1\rho C_p}\frac{\partial^2 T'}{\partial y'^2}. \tag{9}$$

Using the following non-dimensional quantities:

$$y = \frac{y'}{d}, t = \frac{t'v_\infty}{d^2}, v = \frac{v'd}{v_\infty}, H = \frac{H'v_\infty\sqrt{\frac{\mu_e}{\rho}}}{d^2 g\beta(T_1 - T_0)}, u = \frac{u'v_\infty}{d^2 g\beta(T_1 - T_0)}, \theta = \frac{T' - T_0}{T_1 - T_0},$$

$$M = \frac{dB_0}{v_\infty}\sqrt{\frac{\mu_e}{\rho}}, Pr = \frac{\mu_e C_p}{k}, N = \frac{kk_1}{4\sigma_1 T_\infty^3}, \lambda = \frac{3N+4}{3N}, P_m = \sigma\mu_e v_\infty.$$

he corresponding non-dimensional governing equations takes the form:

$$\frac{\partial u}{\partial t} + v\frac{\partial u}{\partial y} = \left(1 + \frac{1}{\alpha}\right)\frac{\partial^2 u}{\partial y^2} + \theta + M\frac{\partial H}{\partial y}. \tag{10}$$

$$\frac{\partial \theta}{\partial t} + v\frac{\partial \theta}{\partial y} = \frac{\lambda}{Pr}\frac{\partial^2 \theta}{\partial y^2}. \tag{11}$$

$$\frac{\partial H}{\partial t} + v\frac{\partial H}{\partial y} = \frac{1}{Pm}\frac{\partial^2 H}{\partial y^2} + M\frac{\partial u}{\partial y}. \tag{12}$$

and the boundary conditions are:

$$u = 0, \theta = 1, H = 0 \text{ at } y = 0, \tag{13}$$

$$u = 0, \theta = 0, H = 0 \text{ at } y = 1. \tag{14}$$

The non-dimensional skin friction (τ) and Nusselt number (Nu) is given by:

$$\tau = -\left(\frac{\partial u}{\partial y}\right)_{y=0}, \quad Nu = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0}$$

3. METHOD OF SOLUTION

The above transformed equation Eq. (2.10) - Eq. (2.12) are coupled non-linear partial differential equations. As the analytical or exact solutions seems to be not feasible so we use Finite Difference Method (FDM) in order to solve the differential equations. This method is comparatively precise, effective and has better stability characteristics. Here we discretized the governing PDE about the point (i, j) and reduce it to a system of algebraic equations. The following equations are the reduced form of finite difference approximation by truncating the higher order terms:

$$\frac{\partial u}{\partial t}\Big|_{i,j} = \frac{u_{i+1,j} - u_{i,j}}{\Delta t}$$

$$\frac{\partial u}{\partial y}\Big|_{i,j} = \frac{u_{i,j+1} - u_{i,j}}{\Delta y}$$

$$\frac{\partial^2 u}{\partial y^2}\Big|_{i,j} = \frac{u_{i,j+1} - 2u_{i,j} + u_{i,j-1}}{(\Delta y)^2}$$

The above equations discretize the dimensionless PDEs to a system of algebraic equations. The equivalent finite difference scheme for equation Eq. (2.10)-Eq. (2.12) is as follows:

$$\frac{u_{i+1,j}-u_{i,j}}{\Delta t} - v_0\frac{u_{i,j+1}-u_{i,j}}{\Delta y} = \frac{\left(1+\frac{1}{\alpha}\right)u_{i,j+1}-2u_{i,j}+u_{i,j-1}}{(\Delta y)^2} + \theta_{i,j} + M\frac{H_{i,j+1}-H_{i,j}}{\Delta y}, \tag{15}$$

$$\frac{\theta_{i+1,j}-\theta_{i,j}}{\Delta t} - v_0\frac{\theta_{i,j+1}-\theta_{i,j}}{\Delta y} = \left(\frac{\lambda}{Pr}\right)\frac{\theta_{i,j+1}-2\theta_{i,j}+\theta_{i,j-1}}{(\Delta y)^2}, \tag{16}$$

$$\frac{H_{i+1,j}-H_{i,j}}{\Delta t} - v_0\frac{H_{i,j+1}-H_{i,j}}{\Delta y} = \frac{1}{Pm}\frac{H_{i,j+1}-2H_{i,j}+H_{i,j-1}}{(\Delta y)^2} + M\frac{u_{i,j+1}-u_{i,j}}{\Delta y}, \tag{17}$$

Where Δt and Δy are the dimensionless time-step and finite difference grid size in the y −direction respectively. Here i is the grid point in the time variable t and j designates the grid points along the y −directions. The mesh size is considered as $\Delta y = 0.1$ with time step $\Delta t = 0.14$. The order of accuracy of this method is $o[(\Delta y), (\Delta y)^2]$. The scheme is unconditionally stable and so this method is compatible.

4. RESULT AND DISCUSSION

An unsteady MHD convective flow of a Casson fluid through vertical infinite plate with IMF has been examined. The governing non-dimensional equations has been discretized to algebraic system of equations. Along with the boundary conditions the system of equations are numerically solved by Gauss-Seidel iterative method. The numerical results along with the influence of the parameters have been depicted through tables and figures. Throughout our discussion we have chosen arbitrarily some of the values for the parameters such as radiation parameter (N = 5), suction parameter (v = 1), Casson parameter (α = 0.5), magnetic parameter (M = 5) and magnetic Prandtl number (Pm = 1). We have considered the Prandtl number Pr to be 0.7 that corresponds to air in a range where the dynamic and the thermal boundary layer are approximately equal. Figure 2 - Figure 5 displays the influence of Prandtl number, Hartmann number, radiation effect and Casson parameter on velocity profile respectively.

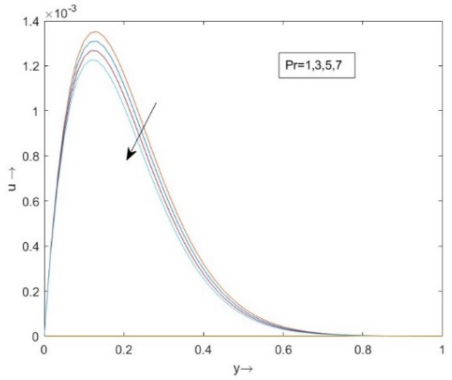

Figure 2. Variation of Prandtl number(Pr) on velocity

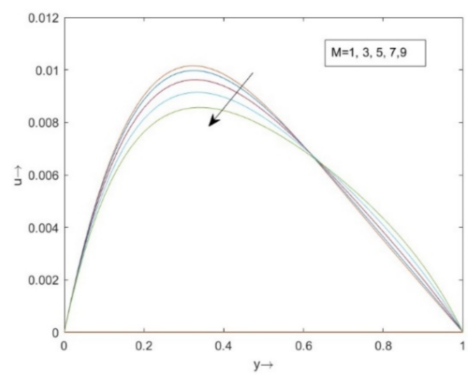

Figure 3. Variation of Hartmann number(M) on velocity

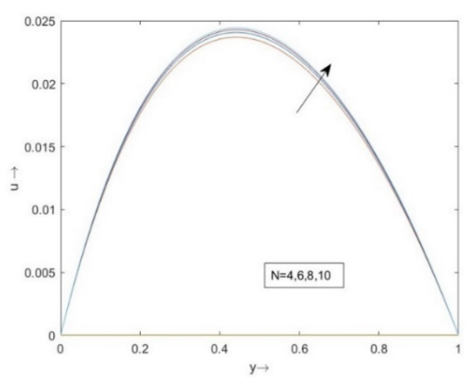

Figure 4. Variation of radiation parameter(N) on velocity

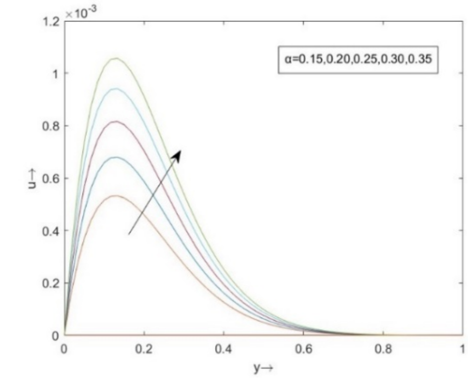

Figure 5. Variation of Casson parameter(α) on velocity

The Prandtl number is a quantity that shows how the molecular diffusivity of heat and momentum are related. It calculates the relative amount of heat and momentum in the velocity and thermal boundary layer. Figure 2 clearly depicts the rise in Prandtl number, lowers the velocity boundary layer thickness. Figure 3 examines that with the rise in Hartmann number the flow velocity lowers and reverse is the case as y increases. The velocity profile in Figure 4 shows a parabolic shape with the addition of radiation parameter with maximum value somewhere in the middle region. It also examines that due to high effect of radiation, the velocity increases. Casson fluid exhibits high viscosity shear thinning characteristics as well as yield stress. The impact of the Casson parameter on the fluid velocity is anticipated. Figure 5 demonstrates that as α rise, the rate of motion considerably increases. Figure 6 and Figure 7 depict how temperature changes with the addition of N and Pr. In both the figures temperature tends to zero at maximum value of y. The thermal boundary layer thickness rise with the rise in radiation effect whereas it lowers with the rise in Pr. Figure 8 and Figure 9 demonstrate how the induced magnetic field is influenced by the M and Pm.

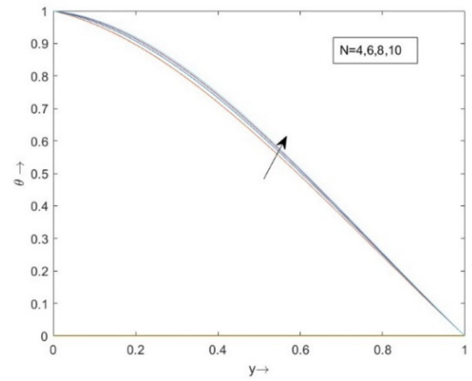

Figure 6. Variation of radiation parameter (N) on temperature

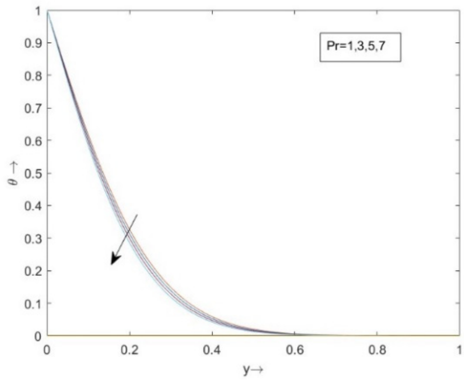

Figure 7. Variation of Prandtl number (Pr) on temperature

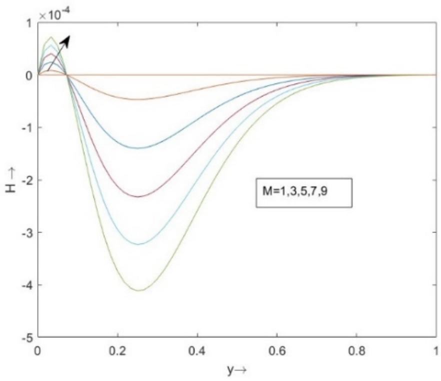

Figure 8. Variation of Hartmann number (M) on induced magnetic field

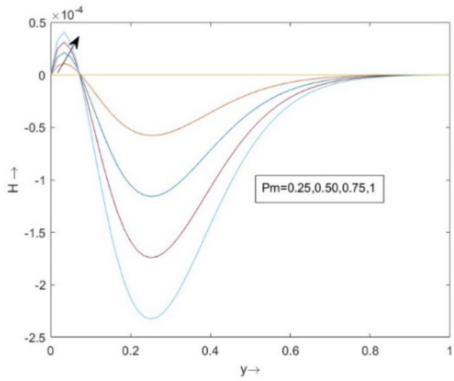

Figure 9. Variation of magnetic Prandtl number (Pm) on induced magnetic field

It is clear that the variation of Hartmann number initially increases the induced magnetic field, which falls down after a certain value of y. The same observation is seen in case of variation of magnetic Prandtl number on IMF. Nusselt number is a non-dimensional heat transfer coefficient. It is a coefficient that is used to determine the conduction or convection of heat transfer. Table 1 and Table 2 shows how the N and Pr affect the heat transfer rate. It follows that when the radiation rise, the heat transfer rate lowers. Similarly, the rate of heat transmission is slowed down as the Pr increases. Table 3 -Table 7 exhibit the variation of Skin friction with influence of Casson parameter, Hartmann number, radiation parameter, Prandtl number and magnetic Prandtl number. The viscous drag force is enhanced with rise in Casson parameter. Table 4 illustrates that rise in M results in a steady decrease in the magnitude of skin friction. That is the frictional force lowers due to addition of magnetic field. Table 5, Table 6 and Table 7 shows that the direction of drag force is reversed as radiation parameter, Prandtl number and magnetic Prandtl number increases.

Table 1. Nusselt Number with change in radiation parameter.

N	Pr	Nusselt number
1.0	0.7	-4.04438
3.0	0.7	-4.06635
5.0	0.7	-4.07465
7.0	0.7	-4.07901

Table 2. Nusselt Number with change in Prandtl number.

N	Pr	Nusselt number
1.0	**1.0**	-4.0596
1.0	**3.0**	-4.1710
1.0	**5.0**	-4.3003
1.0	**7.0**	-4.4480

Table 3. Skin friction with change in Casson parameter

α	M	N	Pr	Pm	Skin friction
0.15	5.0	1.0	0.7	1.0	0.00920
0.20	5.0	1.0	0.7	1.0	0.01177
0.25	5.0	1.0	0.7	1.0	0.01413
0.30	5.0	1.0	0.7	1.0	0.01632
0.35	5.0	1.0	0.7	1.0	0.01834

Table 4. Skin friction with change in Hartmann number

α	M	N	Pr	Pm	Skin friction
0.5	**1**	1.0	0.7	1.0	0.02374
0.5	**3**	1.0	0.7	1.0	0.02370
0.5	**5**	1.0	0.7	1.0	0.02362
0.5	**7**	1.0	0.7	1.0	0.02350
0.5	**9**	1.0	0.7	1.0	0.02334

Table 5. Skin friction with change in radiation parameter

α	M	N	Pr	Pm	Skin friction
0.5	5.0	**1.0**	0.7	1.0	0.02362
0.5	5.0	**3.0**	0.7	1.0	0.02354
0.5	5.0	**5.0**	0.7	1.0	0.02352
0.5	5.0	**7.0**	0.7	1.0	0.02350
0.5	5.0	**9.0**	0.7	1.0	0.02349

Table 6. Skin friction with change in Prandtl number

α	M	N	Pr	Pm	Skin friction
0.5	5.0	1.0	**0.25**	1.0	0.02369
0.5	5.0	1.0	**0.50**	1.0	0.02365
0.5	5.0	1.0	**0.75**	1.0	0.02361
0.5	5.0	1.0	**1.00**	1.0	0.02357
0.5	5.0	1.0	**1.25**	1.0	0.02348

Table 7. Skin friction with change in Magnetic Prandtl number

α	M	N	Pr	Pm	Skin friction
0.5	5.0	1.0	0.7	**0.25**	0.02371
0.5	5.0	1.0	0.7	**0.50**	0.02368
0.5	5.0	1.0	0.7	**0.75**	0.02365
0.5	5.0	1.0	0.7	**1.00**	0.02362
0.5	5.0	1.0	0.7	**1.25**	0.02358

5. CONCLUSION

We examined the free convection of an unsteady flow of a Casson fluid through vertical plates of infinite length with the effect of IMF. Here, an electrically conducting and viscous fluid is considered. The equations which govern are non-dimensionalized to a system of PDE's and then solve numerically. The graphical representations of the fluid properties under the influence of embedded parameters shows considerable changes. The tabular illustration of rate of heat transfer and the surface drag force shows significant influence of the parameters. The present study of fluid through infinite vertical plates is frequently used in many technological phenomena.

The results of the present study can be concluded as below:

- The rise in Prandtl number leads to the fall in velocity profile and the rise in Hartmann number initially lowers the velocity profile which is then reverse later on.
- The velocity profile falls with the rise in Casson parameter and radiation parameter.
- The fluid temperature falls with the application of Prandtl number and rise with the rise in radiation parameter.
- Induced magnetic field initially rise with the rise in magnetic Prandtl number and Hartmann number which decreases later on.
- The heat transfer rate for the fluid problem is decreased with the radiation parameter and Prandtl number.
- With the application of Casson parameter the viscous drag force increases. The viscous drag force falls as the radiation effect, magnetic Prandtl number and Prandtl number rises.

ORCID

Hiren Deka, https://orcid.org/0009-0002-1512-5984

REFERENCES

[1] R. Kodi, and O. Mopuri, "Unsteady MHD oscillatory Casson fluid flow past an inclined vertical porous plate in the presence of chemical reaction with heat absorption and Soret effects," Heat Transfer, **623**, 1-20 (2021). https://doi.org/10.1002/htj.22327

[2] R. Vijayaragavan, and S. Karthikeyan, "Hall Current Effect on Chemically Reacting MHD Casson Fluid Flow with Dufour Effect and Thermal Radiation," Asian Journal of Applied Science and Technology, 228–245 (2018). https://ajast.net/data/uploads/4032.pdf

[3] R. Vijayaragavan, M. Ramesh, and S. Karthikeyan, "Heat and Mass Transfer Investigation on MHD Casson Fluid Flow past an Inclined Porous Plate in the Effects of Dufour and Chemical Reaction," Journal of Xi'an University of Architecture and Technology, **13**, 860–873 (2021).

[4] K. Pushpalatha, V. Sugunamma, J. V. Ramana Reddy, and N. Sandeep, "Heat and Mass Transfer in Unsteady MHD Casson Fluid Flow with Convective Boundary Conditions," International Journal of Advanced Science and Technology, **91**, 19–38 (2016). http://dx.doi.org/10.14257/ijast.2016.91.03

[5] D. Sarma, N. Ahmed, and H. Deka, "MHD free convection and mass transfer flow past an accelerated vertical plate with chemical reaction in presence of radiation," Latin American Applied Research, **44**, 1–8 (2014). https://doi.org/10.52292/j.laar.2014.412

[6] B.R. Kumar, and R. Sivaraj, "MHD viscoelastic fluid non-Darcy flow over a vertical cone and a flat plate," International Communications in Heat and Mass Transfer, **40**, 1–6 (2013). https://doi.org/10.1016/j.icheatmasstransfer.2012.10.025

[7] M. Waqas, M. Farooq, M.I. Khan, A. Alsaedi, T. Hayat, and T. Yasmeen, "Magnetohydrodynamic (MHD) mixed convection flow of micropolar liquid due to Nonlinear stretched sheet with convective condition," International Journal of Heat and Mass Transfer, **102**, 766–772 (2016). https://doi.org/10.1016/j.ijheatmasstransfer.2016.05.142

[8] A.K. Agrawal, B. Kishor, and A. Raptis, "Effects of MHD free convection and mass transfer on the flow past a vibrating infinite vertical circular cylinder," Waerme- und Stoffuebertragung, **24**, 243–250 (1989). https://doi.org/10.1007/BF01625500

[9] S. Ahmed, and A.J. Chamkha, "Effects of Chemical Reaction, Heat and Mass Transfer and Radiation on MHD Flow along a Vertical Porous Wall in the Present of Induced Magnetic Field," Int. J. Industrial Mathematics, **2**, 245–261 (2010). https://sid.ir/paper/584929/en

[10] Sarveshanand, and A.K. Singh, "Magnetohydrodynamic free convection between vertical parallel porous plates in the presence of induced magnetic field," SpringerPlus, **4**, 333 (2015). https://doi.org/10.1186/s40064-015-1097-1

[11] F.M. Ali, R. Nazar, N.M. Arifin, and I. Pop, "MHD boundary layer flow and heat transfer over a stretching sheet with induced magnetic field," Heat and Mass Transfer, **47**, 155-162 (2011). https://doi.org/10.1007/s00231-010-0693-4

[12] G.C. Hazarika, P. Dutta, and J. Borah, "Numerical analysis of an MHD flow in fuzzy environment in presence of induced magnetic field," Heat Transfer, 1–11 (2021). https://doi.org/10.1002/htj.22163

[13] A. Kumar, and A.K. Singh, "Unsteady MHD free convective flow past a semi-infinite vertical wall with induced magnetic field," Applied mathematics and computation, **222**, 462–471 (2013). https://doi.org/10.1016/j.amc.2013.07.044

[14] N. Ahmed, "Heat and Mass Transfer in MHD Poiseuille Flow with Porous Walls," J. Eng. Phys. Thermophy. **92**, 122-131 (2019). https://doi.org/10.1007/s10891-019-01914-w

ЧИСЕЛЬНЕ ДОСЛІДЖЕННЯ КОНВЕКТИВНОГО ПОТОКУ КАССОНОВОЇ РІДИНИ ПОВЗ НЕСКІНЧЕННУ ВЕРТИКАЛЬНУ ПЛАСТИНУ З ІНДУКОВАНИМ МАГНІТНИМ ПОЛЕМ

Хірен Дека[a], Парісміта Пхукан[a,b]

[a]*Факультет математики, Університет Коттон, Ассам, Індія*

[b]*Департамент математики, Королівський глобальний університет, Ассам, Індія*

Поточна мета полягає в чисельному аналізі ефекту індукованого магнітного поля (ІМП) нестаціонарного МГД потоку рідини Кассона через дві нескінченні вертикальні пластини. Вплив радіаційного тепла було ретельно вивчено. Керівні безрозмірні часткові часткові деталі потоку дискретизуються методом скінченних різниць до деякої алгебраїчної системи рівнянь, яка потім чисельно розв'язується щодо граничних умов. Вплив випромінювань, магнітного числа Прандтля, числа Прандтля, числа Гартмана та параметра Кассона на профіль температури, профіль швидкості та індуковане магнітне поле було зображено на графіках. Радіаційний ефект і число Прандтля мають значний вплив на силу поверхневого опору, а також на швидкість теплопередачі.

Ключові слова: *МГД; рідина Кассона; індуковане магнітне поле; FDM*