Magneto-hydrodynamic Effect on Mixed Convection in a Vertical Channel Presence of Internal Heat Generation/Absorption

[1]Mangala Kandagal and [2]Shreedevi Kalyan
[1]Research Scholar Dept of Mathematics, Sharnbasva University, Kalaburagi.
mkandagal@gmail.com
[2]Asso. Prof. Dept of Mathematics, Sharnbasva University, Kalaburagi.
kalyanshreedevi@gmail.com

ABSTRACT:
This article's purpose is to analyses the influence of magneto hydrodynamics on mixed convection in concentrated, vertical channel with heat production and absorption occurring internally. The governing coupled as well as nonlinear equations are analytically solved with a small-value-appropriate $\varepsilon = Brpc$ regular perturbation approach, and the solution obtained for concentration, temperature, and fluid velocity for heat production and absorption is described with the use of plotted graphs. Multiple temperatures are maintained throughout the length of the channels. The result of the velocity temperature with MHD and concentration are revealed.

KEYWORDS: Mixed convection, Magneto-Hydrodynamics, heat generation, heat absorption, regular perturbation method.

INTRODUCTION:

Under the action of a transverse magnetic field, electrically conducting fluids move and transfer heat in circular pipelines and channels through magneto hydro dynamics (MHD) generators, pumps, accelerators, and flow meters. Recent research has focused on the hydrodynamic and hydromagnatic characteristics of two-phase flow, using both experimental and theoretical efforts.M.S. Malashetty et. al. (2006) observed "Magneto convection of two-immiscible fluids in vertical enclosure"; T. Linga et. al. (2016) and "MHD Radioactive Boundary Layer Flow of Nano-fluid Plate with Internal Heat Generation/Absorption, Viscous and Ohmic Dissipation Effects" examined "MHD Heat Transfer In Two-Layed Flow Of Conducting Fluids Through Channel Bounded By A. K. Abdul Hakeem, N. Vishnu Ganesh, B. Ganga, S. Mohamed Yusuff Ansai (2015). Heat and mass transfer in MHD flow of a Nanofluid Over an Inclined Vertical Porous Plate With Radiation and Heat Generation/Absorption". (P. et al.2017). Engineers as well as scientists have taken a new interest in the magneto hydrodynamic (MHD) phenomena because of its importance in transformers, MHD accelerators, as well as metallic plates cooling in a cooling bath. Mixed convection or Natural flow of distinct fluids across various geometries was extensively explored in magneto hydrodynamics literature.

Heat and mass transfer study including heat absorption along with generation, however, is of great practical status to scientists and engineers for a variety of reasons, including the fact that these industries deal with a number of physical issues such as dissociating fluids as well as chemical reactions. The study of the flow of heat absorbing/generating fluid has attracted a lot of attention since the volumetric heat absorbing/generating term may have a major impact on the heat transfer, by extension, on the flow when the temperature differences are enlarged significantly.

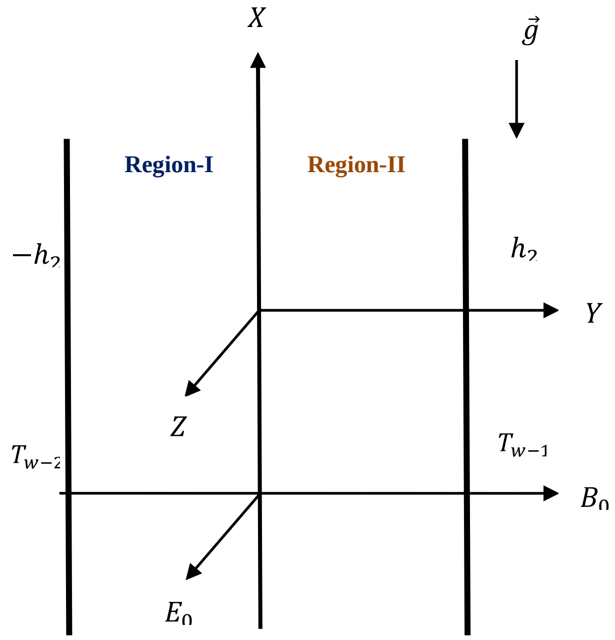
Mixed convection radiative flow as well as heat transfer in a vertical channel filled partially with Darcy-Forchheimer porous substrate I. Abioye and A. Adeniyan (2016). "Mixed Convection Flow of Viscous Reactive Fluids with Thermal

Diffusion and radial Magnetic Field in a Vertical Porous Annulus," M. Hamza, et al. (2018). "Flow and Heat Transfer of Composite Porous Medium Saturated with Nanofluid. Propulasion and Power Research" (2019).Basic issues with fluid flow in porous domains. Alkam MK, Al-Nimr MA, and J Porous Medi (2000). Mixed convection hydro magnetic flow with wall conductance effects in a rotating channel J.K. Singh, G.S. Seth (2016). Journal of Hydrodynamics article titled "Third-grade fluid through a vertical tube with internal heat generation" SO Adesanya and OD Makinde (2015). Zahir Saima Khan, Hamza Ayaz, Saeed Islam, and Shah (2018) analyze the Casson fluid flow between two rotating parallel plates, taking into account the hall current'simpact on heat and mass transfer. J. Umavati and Anwar Beg's study, "Convective Fluid Flow and Heat Transfer In a Vertical Rectangular Duct Containing a Horizontal Porous Medium and Fluid Layer" (2020).

MATHEMATICAL FORMULATION:

Physical configuration is seen in figure 1; it resembles an indefinitely long vertical conduit with walls that are heated or cooled in various temperature T_{w1} and T_{w2} $(T_{w1} > T_{w2})$. An electric field with the same strength everywhere as magnetic field when applied in x-direction. There is an incompressible, electrically conducting, viscous fluid present in the area $0 \le y \le h_1$. A separate viscous, incompressible fluid that is electrically nonconductive occupies the space $-h_2 \le y \le 0$. We suppose that both fluids are Newtonian, capable of producing and absorbing heat, and possess constant characteristics. A completely developed, laminar, and steady flow is expected.

Governing equations for energy and motion are created, according to the aforementioned assumptions.



REGION-I

$$\rho_1 g\beta T_1(T_1 - T_{w2}) - \frac{\partial p}{\partial x} + \mu_1 \frac{\partial^2 u_1}{\partial y^2} + \rho g\beta c_1(c - \bar{c}_1) - \sigma_0(E_0 + B_0 U_1)B_0 = 0 \quad (2.1)$$

$$k_1 \frac{d^2 T_1}{dy^2} + \mu_1 (\frac{du_1}{dy})^2 \pm Q(T - T_{w2}) + \sigma_0 (E_0 + B_0 U_1)^2 = 0 \quad (2.2)$$

$$\frac{d^2c_1}{dy^2}=0 \quad (2.3)$$

REGION-II

$$\mu_2\frac{d^2u_2}{dy^2}+\rho_2 g\beta_{T2}(T_2-T_{w2})+\rho_2 g\beta_{c2}(c_1-\bar{c}_2)-\frac{\partial p}{\partial x}=0 \quad (2.4)$$

$$k_2\frac{d^2T_2}{dy^2}+\mu_2(\frac{du_2}{dy})^2\pm Q_2(T_2-T_{w2})=0 \quad (2.5)$$

$$\frac{d^2c_2}{dy^2}=0 \quad (2.6)$$

It has been recognized that the fluids have a common pressure gradient in equations (2.1) and (2.4). The heat creation of both fluids is represented by the positive sign for Q_1 as well as Q_2 is when applicable for the conditions, and the heat absorption by both fluids is represented by the negative sign for Q_1 as well as Q_2.

Velocities are:

“ $u_1(h_1)=0,$ (2.7a)

$u_1(0)=u_2(0),$ (2.7b)

$u_2(-h_2)=0,$ (2.7c)

$\mu_1\left(\frac{du_1}{dy_1}\right)=\mu_2\left(\frac{du_2}{dy_2}\right)$ at $y=0$” (2.7d)

Temperatures are:

“ $T_1(h_1)=w_1T,$ (2.8a)

$T_1(0)=T_2(0),$ (2.8b)

$(-h_2)T_2=w_2T,$ (2.8c)”

$k_1\frac{dT_1}{dy_1}=k_2\frac{dT_2}{dy_2}$ at $y=0$ (2.8d)

Concentrations are:

$c_1(h_1)=\bar{c}_1,$ (2.9a)

$c_1(0)=c_2(0),$ (2.9b)

$$c_2(-h_2) = \bar{c}_2, \quad (2.9c)$$

$$D_1 \frac{dc_1}{dy_1} = D_2 \frac{dc_2}{dy_2} \quad \text{at} \quad y = 0 \quad (2.9d)$$

Following are the non-dimension transformation, assuming $T_0 = T_{w2}$ and employing:

$$u_i^* = \frac{u_i}{\bar{u}_i},\; y_i^* = \frac{y_i}{h_i},\; \theta_1 = \frac{(T_1 - T_0)}{(T_{w_1} - T_{w2})},\; p = \frac{h_1^2}{\mu_1 \bar{u}_1}\frac{\partial p}{\partial x},\; \varphi = \frac{(c_i - \bar{c}_2)}{(\bar{c}_1 - \bar{c}_2)}\; i = (1,2). \quad (2.10)$$

Simplifying and substitute eq. (2.10) in eq. (2.1) to (2.5) which results the dimensionless equations as follow.

REGION-I

$$\frac{d^2u_1}{dy^2} + \frac{Gr}{\mathrm{Re}}\theta_1 + \frac{Gc}{\mathrm{Re}}\phi_1 - p - M^2(E + u_1) = 0 \quad (2.11)$$

$$\frac{d^2\theta_1}{dy^2} + Br[(\frac{du_1}{dy})^2 + M^2(u_1 + E)^2] \pm \phi_1\theta_1 = 0 \quad (2.12)$$

$$\frac{d^2\phi_1}{dy^2} = 0 \quad (2.13)$$

REGION-II

$$\frac{d^2u_2}{dy^2} = a_1\theta_2 + a_1\phi_2 + mh^2 p \quad (2.14)$$

$$\frac{d^2\theta_2}{dy^2} + \frac{k}{m} Br(\frac{du_2}{dy})^2 \pm \phi_2\theta_2 = 0 \quad (2.15)$$

$$\frac{d^2\phi_2}{dy^2} = 0 \quad (2.16)$$

Interface conditions for dimensionless form of the velocity, temperature, and concentration boundary “are

$$u_1(1) = 0, \quad (2.17a)$$

$$u_1(0) = u_2(0), \quad (2.17b)$$

$$u_2(-1) = 0, \quad (2.17c)$$

$$\frac{du_1}{dy} = \frac{1}{mh}\frac{du_2}{dy} \quad \text{at} \quad y = 0 \quad (2.17)$$

$$\theta_1(1) = 1, \quad (2.18a)$$

$$\theta_1(0) = \theta_2(0), \quad (2.18b)$$

$$\theta_2(-1) = 0, \quad (2.18c)$$

$$\frac{d\theta_1}{dy} = \frac{1}{kh}\frac{d\theta_2}{dy} \quad \text{at} \quad y = 0 \tag{2.18d}$$

$$\varphi_1(1) = 1, \tag{2.19a}$$

$$\varphi_1(0) = \varphi_2(0), \tag{2.19b}$$

$$\varphi_2(-1) = 0, \tag{2.19c}$$

$$\left(\frac{d\varphi_1}{dy}\right) = \frac{d}{h}\left(\frac{d\varphi_2}{dy}\right) \quad \text{at} \quad y = 0 \tag{2.19d}$$

Where

$$Gr = \frac{g\beta_1\rho_1 h_1^3 (T_{w1} - T_{w2})}{\mu_1^2},\ Ec = \frac{\bar{u}_1^2}{c_p(T_{w1} - T_{w2})},\ \mathrm{Re} = \frac{\bar{u}_1 h_1 \rho_1}{\mu_1},\ \mathrm{Pr} = \frac{\mu_1 c_p}{k_1},\ \phi_1 = \frac{Q_1 h_1^2}{k_1},\ \phi_2 = \frac{Q_2 h_2^2}{k_2},\ m = \frac{\mu_1}{\mu_2},$$

$$h = \frac{h_2}{h_1},\ n = \frac{\rho_2}{\rho_1},\ \beta = \frac{\beta_2}{\beta_1},\ k = \frac{k_1}{k_2}.$$

3. SOLUTION.

By using the suitable boundary and interface conditions indicated above, the governing equations (2.11) to (2.15) are analytically solved; 2.17(a) to 2.19(d) are the governing equations for velocity, concentrations, along with temperature, respectively. Due to the energy equation's inclusion of the dissipation factors, these equations are linked and nonlinear. The Eckert number is often of order 10^{-5} and is quite modest in practical problems. Due to the extremely small product $\mathrm{Pr}.Ec(=\varepsilon)$, This equation may be used in conjunction with the conventional perturbation method, where the parameter represents the change in the original value. The solution is probably there in front of us.

$$(u_1, \theta_1) = (u_{10}, \theta_{10}) + \varepsilon(u_{11}, \theta_{11}) + \ldots\ldots\ldots \tag{3.1}$$

$$(u_2, \theta_2) = (u_{20}, \theta_{20}) + \varepsilon(u_{21}, \theta_{21}) + \ldots\ldots\ldots \tag{3.2}$$

By setting equal ε powers to zero along with one, here we may gain zeroth as well as first order equations, respectively, as shown below.

REGION-I

ZEROTH-ORDER EQUATIONS

$$\left(\frac{d^2 u_{10}}{dy^2}\right) + \lambda_1(\theta_{10}) + \lambda_2(\phi_1) - p - M^2(E + u_{10}) = 0 \tag{3.3}$$

$$\left(\frac{d^2\theta_{10}}{dy^2}\right) \pm \phi_1\theta_{10} = 0 \tag{3.4}$$

FIRST-ORDER EQUATIONS

$$\frac{d^2u_{11}}{dy^2}+\lambda_1\theta_1-M^2u_{11}=0 \tag{3.5}$$

$$\frac{d^2\theta_{11}}{dy^2}+[(\frac{du_{10}}{dy})^2+M^2(u_{10}+E)^2]\pm\phi_1\theta_{11}=0 \tag{3.6}$$

REGION-II

ZEROTH-ORDER EQUATIONS

$$\frac{d^2u_{20}}{dy^2}=a_1\theta_{20}+a_2\phi_2+mh^2p \tag{3.7}$$

$$\frac{d^2\theta_{20}}{dy^2}\pm\phi_2\theta_{20}=0 \tag{3.8}$$

FIRST-ORDER EQUATIONS

$$\frac{d^2u_{21}}{dy^2}+a_1\theta_{21}=0 \tag{3.9}$$

$$\frac{d^2\theta_{21}}{dy^2}+a_3(\frac{du_{20}}{dy})^2\pm\phi_2\theta_{21}=0 \tag{3.10}$$

Interface conditions and Corresponding boundaryare:

ZEROTH-ORDER CONDITIONS

$u_{10}(1)=0,$ “(3.11a)

$u_{10}(0)=u_{20}(0),$ (3.11b)

$u_{20}(-1)=0,$ (3.11c)”

$\frac{du_{10}}{dy}=\frac{1}{mh}\frac{du_{20}}{dy}$ at $y=0$ (3.11d)

$\theta_{10}(1)=1,$ (3.12a)

$\theta_{10}(0)=\theta_{20}(0),$ (3.12b)

$\theta_{20}(-1)=0,$ (3.12c)

$\frac{d\theta_{10}}{dy}=\frac{1}{kh}\frac{d\theta_{20}}{dy}$ at $y=0$ (3.12d)

FIRST-ORDER CONDITIONS

$u_{11}(1)=0,$ “(3.13a)

$u_{11}(0)=u_{21}(0),$ (3.13b)

$u_{21}(-1)=0,$ (3.13c)"

$\frac{du_{11}}{dy}=\frac{1}{mh}\frac{du_{21}}{dy}$ at $y=0$ (3.13d)

$\theta_{11}(1)=0,$ (3.14a)

$\theta_{11}(0)=\theta_{21}(0),$ (3.14b)

$\theta_{21}(-1)=0,$ (3.14c)

$\frac{d\theta_{11}}{dy}=\frac{1}{kh}\frac{d\theta_{21}}{dy}$ at $y=0$ (3.14d)

The following equations (3.3) through (3.10) are obtained analytically based on boundary as well as interface conditions (3.11a) through (3.14d). The solutions for θ_1 and θ_2 are distinct depends on the ϕ_1 and ϕ_2 whether positive or negative. As a consequence, two distinct solutions of and are found for the instances of heat-generating fluids $(\phi_2 > +\theta_1 > 0)$ and heat-absorbing fluids $(\phi_2 > +\theta_1 > 0)$, respectively, where, in both cases, one of the fluids is heat-absorbing and the other is heat-generating.

SOLUTION FOR CONCENTRATION:

$\varphi_1 = c_1 y + c_2,$

$\varphi_2 = c_3 y + c_4.$

HEAT GENERATION CASE $(+\phi_1 > 0 + \phi_2 > 0)$

The following are the solutions to the zeroth-order equations (3.3), (3.4), (3.7), and (3.8) derived using the regular perturbation technique with the boundary conditions (3.11 a-d) and (3.12 a-d).

$\theta_{10} = c_5 \,\mathrm{Cos}\sqrt{\phi_1}\, y + c_6 \,\mathrm{Sin}\sqrt{\phi_1}\, y,$

$\theta_{20} = c_7 \,\mathrm{Cos}\sqrt{\phi_2}\, y + c_8 \,\mathrm{Sin}\sqrt{\phi_2}\, y,$

$u_{10} = A_1 CosMy + A_2 SinMy + r_1 + r_2 y + r_3 Cos\sqrt{\phi_1}\, y + r4Sin\sqrt{\phi_1}\, y$

$u_{20} = A_4 + A_3 y + r_5 y_2 + r_6 y_3 + r_7 Cos\sqrt{\phi_2}\, y + r8Sin\sqrt{\phi_2}\, y$

Using the boundary conditions (3.13 a-d) and (3.14 a-d), the solutions to the first-order equations (3.5), (3.6), (3.9), and (3.10) are.

$$\theta_{11} = c_9 Cos\sqrt{\phi_1}\, y + c_{10} Sin\sqrt{\phi_1}\, y + s_1 + s_2 y + s_3 y^2 + s_4 yCos\sqrt{\phi_1}\, y + s_5 ySin\sqrt{\phi_1}\, y + s_6 Cos2\sqrt{\phi_1}\, y + s_7 Sin2\sqrt{\phi_1}\, y + s_8 Cos2My + s_9 Sin2My + s_{10} CosMy + s_{11} SinMy + s_{12} yCosMy + s_{13} ySinMy + s_{14} y2Sin\sqrt{\phi_1}\, y + s_{15} y2Cos\sqrt{\phi_1}\, y + s_{16} Cos(\sqrt{\phi_1} + M)y + s_{15} Cos(\sqrt{\phi_1} - M)y + s_{18} Sin(\sqrt{\phi_1} + M)y + s_{19} Sin(\sqrt{\phi_1} - M)y$$

$$\theta_{21} = c_{11}Cos\sqrt{\phi_2}\,y + c_{12}Sin\sqrt{\phi_2}\,y + s_{20} + s_{21}y + s_{22}y^2 + s_{23}y^3 + s_{24}y^4 + s_{25}yCos\sqrt{\phi_2}\,y + s_{26}ySin\sqrt{\phi_2}\,y + s_{27}y^2Cos\sqrt{\phi_2}\,y + s_{28}y^2\sin\sqrt{\phi_2}\,y + s_{29}y^3Cos\sqrt{\phi_2}\,y + s_{30}y^3Sin\sqrt{\phi_2}\,y + s_{31}Cos2\sqrt{\phi_2}\,y$$

$$u_{11} = a_5CosMy + A_6SinMy + B_1 + B_2y + B_3y^2 + B_4Cos\sqrt{\phi_1}\,y + B_5Sin\sqrt{\phi_1}\,y + B_6yCos\sqrt{\phi_1}\,y + B_7ySin\sqrt{\phi_1}\,y + B_8Cos2\sqrt{\phi_1}\,y + B_9Siny + B_{10}Cos2My + B_{11}Sin2My + B_{12}yCosMy + B_{13}ySinMy + B_{14}y^2SinMy + B_{15}y^2CosMy + B_{16}y^2Sin\sqrt{\phi_1}\,y + B_{17}y^2Cos\sqrt{\phi_1}\,y + B_{18}Cos(\sqrt{\phi_1}+M)y + B_{19}Cos(\sqrt{\phi_1}-M)y + B_{20}Sin(\sqrt{\phi_1}+M)y + B_{21}Sin(\sqrt{\phi_1}-M)y$$

$$u_{21} = A_8 + A_7y + B_{45}y^2 + B_{46}y^3 + B_{47}y^4 + B_{48}y^5 + B_{49}y^6 + B_{36}Cos\sqrt{\phi_2}\,y + B_{37}Sin\sqrt{\phi_2}\,y + B_{38}yCos\sqrt{\phi_2}\,y + B_{39}ySin\sqrt{\phi_2}\,y + B_{40}y^2Cos\sqrt{\phi_2}\,y + B_{41}y^2Sin\sqrt{\phi_2}\,y + B_{42}y^3Cos + B_{43}y^3 + B_{44}Cos2\sqrt{\phi_2}\,y$$

Heat Absorption case $(+\phi_1 < 0 + \phi_2 < 0)$

In the same way as in the case of $+\phi_2 > 0$ and $+\phi_1 > 0$, solutions obtained by regular perturbation method for zeroth-order equations (3.3),(3.4),(3.7),along with(3.8) using boundary conditions (3.11a-3.11d) along with (3.12a-3.12d) are as:

$$\theta_{10} = c_5\,\mathrm{Cos}\,h\sqrt{\phi_1}\,y + c_6\,\mathrm{Sin}\,h\sqrt{\phi_1}\,y,$$

$$\theta_{20} = c_7\,\mathrm{Cos}\,h\sqrt{\phi_2}\,y + c_8\,\mathrm{Sin}\,h\sqrt{\phi_2}\,y,$$

$$u_{10} = A_1CoshMy + A_2SinhMy + r_1 + r_2y + r_3Cosh\sqrt{\phi_1}\,y + r4Sinh\sqrt{\phi_1}\,y$$

$$u_{20} = A_4 + A_3y + r_5y_2 + r_6y_3 + r_7Cosh\sqrt{\phi_2}\,y + r8Sinh\sqrt{\phi_2}\,y$$

The solutions of first-order equations (3.5), (3.6),(3.9) and (3.10) using boundary conditions (3.13 a to d) and (3.14 a to d) are:

$$\theta_{11} = c_9Cosh\sqrt{\phi_1}\,y + c_{10}Sinh\sqrt{\phi_1}\,y + s_1 + s_2y + s_3y^2 + s_4yCosh\sqrt{\phi_1}\,y + s_5ySinh\sqrt{\phi_1}\,y + s_6Cosh2\sqrt{\phi_1}\,y + s_7Sinh2\sqrt{\phi_1}\,y + s_8Cosh2My + s_9Sinh2My + s_{10}CoshMy + s_{11}SinhMy + s_{12}yCoshMy + s_{13}ySinhMy + s_{14}y2Sinh\sqrt{\phi_1}\,y + s_{15}y2Cosh\sqrt{\phi_1}\,y + s_{16}Cosh(\sqrt{\phi_1}+M)y + s_{15}Cosh(\sqrt{\phi_1}-M)y + s_{18}Sinh(\sqrt{\phi_1}+M)y + s_{19}Sinh(\sqrt{\phi_1}-M)y$$

$$\theta_{21} = c_{11}Cos\sqrt{\phi_2}\,y + c_{12}Sinh\sqrt{\phi_2}\,y + s_{20} + s_{21}y + s_{22}y^2 + s_{23}y^3 + s_{24}y^4 + s_{25}yCosh\sqrt{\phi_2}\,y + s_{26}ySinh\sqrt{\phi_2}\,y + s_{27}y^2Cosh\sqrt{\phi_2}\,y + s_{28}y^2\sinh\sqrt{\phi_2}\,y + s_{29}y^3Cosh\sqrt{\phi_2}\,y + s_{30}y^3Sinh\sqrt{\phi_2}\,y + s_{31}Cosh2\sqrt{\phi_2}\,y$$

$$u_{11} = a_5CoshMy + A_6SinhMy + B_1 + B_2y + B_3y^2 + B_4Cosh\sqrt{\phi_1}\,y + B_5Sinh\sqrt{\phi_1}\,y + B_6yCosh\sqrt{\phi_1}\,y + B_7ySinh\sqrt{\phi_1}\,y + B_8Cosh2\sqrt{\phi_1}\,y + B_9Sinhy + B_{10}Cosh2My + B_{11}Sinh2My + B_{12}yCoshMy + B_{13}ySinhMy + B_{14}y^2SinhMy + B_{15}y^2CoshMy + B_{16}y^2Sinh\sqrt{\phi_1}\,y + B_{17}y^2Cosh\sqrt{\phi_1}\,y + B_{18}Cosh(\sqrt{\phi_1}+M)y + B_{19}Cosh(\sqrt{\phi_1}-M)y + B_{20}Sinh(\sqrt{\phi_1}+M)y + B_{21}Sinh(\sqrt{\phi_1}-M)y$$

$$u_{21} = A_8 + A_7y + B_{45}y^2 + B_{46}y^3 + B_{47}y^4 + B_{48}y^5 + B_{49}y^6 + B_{36}Cosh\sqrt{\phi_2}\,y + B_{37}Sinh\sqrt{\phi_2}\,y + B_{38}yCosh\sqrt{\phi_2}\,y + B_{39}ySinh\sqrt{\phi_2}\,y + B_{40}y^2Cosh\sqrt{\phi_2}\,y + B_{41}y^2Sinh\sqrt{\phi_2}\,y + B_{42}y^3Cosh + B_{43}y^3 + B_{44}Cosh2\sqrt{\phi_2}\,y$$

Because we are limited on space, we will not be presenting the constants that are used in the answers.Analytical and graphical representations of the solutions to Equations (3.3) through (3.10) are represented in Figure 2 through 13 by fixing certain physical parameters, such as, $p = -5,\ \mathrm{Re} = 5,\ n = 0.5,\ bt = 0.5,\ bc = 0.5,\ \varepsilon = 0.1$ and conciseness for all computations is analyzed, as is the non-dimensional parameters'effect on heat as well asflow transfer in every figure except varying one. When calculating heat transfer rate between fluid and plates, this is significant to know how the temperature and velocity distributions change as they move apart along the channel.

RESULTS AND DISCUSSION:

This research looks at two fluid heat transfer and MHD flow in a vertical channel having 2 areas, one of which is electrically conductive along with other of which is not. Analytical answers are gotten by utilizing the regular perturbation technique with Eckert number along withPrandtle number product as perturbation parameter. According to thermal features of issue, for exampleheat absorption as well as heat generation, two examples are taken into consideration. As a result, we give our explanation in a graphical format.

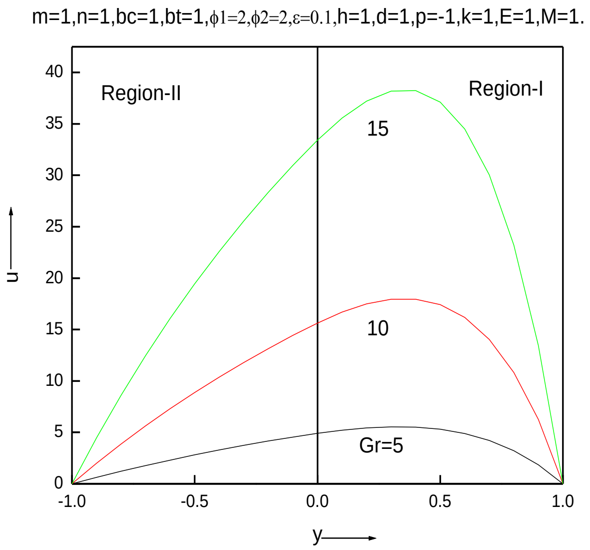


Fig.2(a) Velocity profiles for different values of Grashof number Gr.

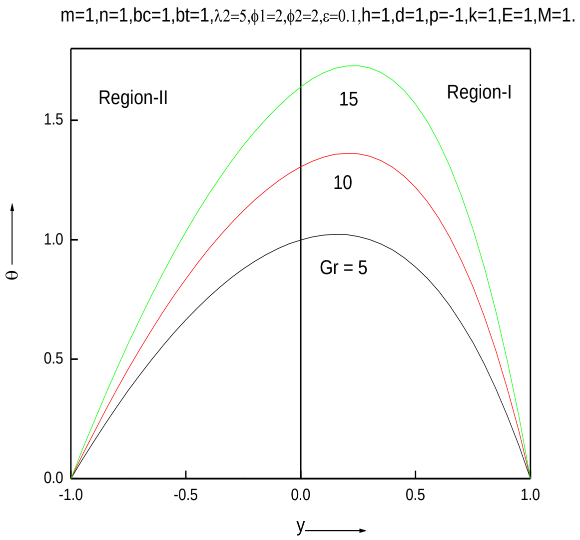


Fig.2(b) Temperature profile for different value of Grashof number Gr.

Both the temperature and velocity fields are affected by the Grashof number Gr, as seen in Figures 2(a) and 2(b). When the Grashof number is raised, the temperature and velocity fields increase, as predicted. A higher Grashof number increases the buoyant force that sustains the flow.

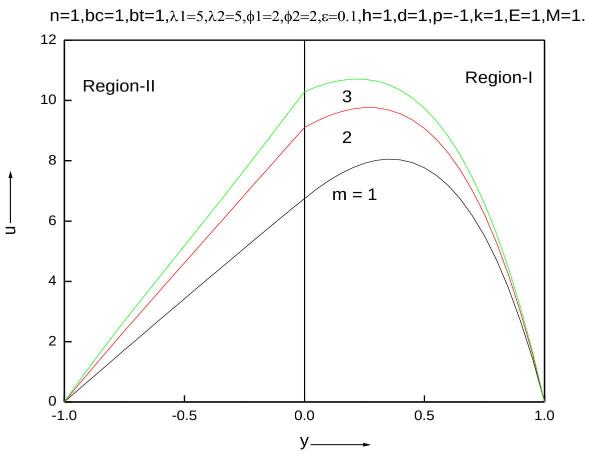


Fig.3(a) Velocity profile for different values of the viscosity m.

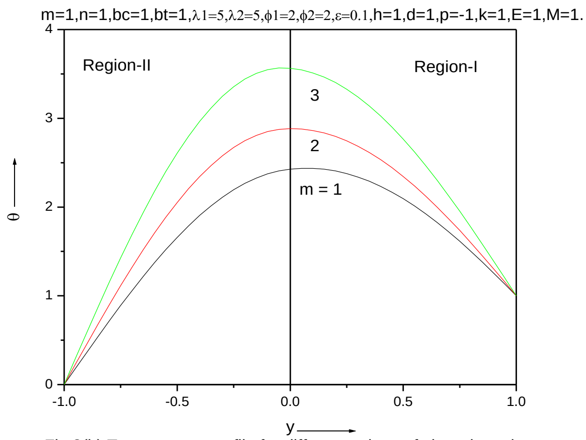


Fig.3(b) Temperature profile for different values of viscosity ratio m.

Figure 3(a) and 3(b), given a range of values of the electric parameter E, the temperature along with velocity fields both increase as the viscosity ratio m increases.

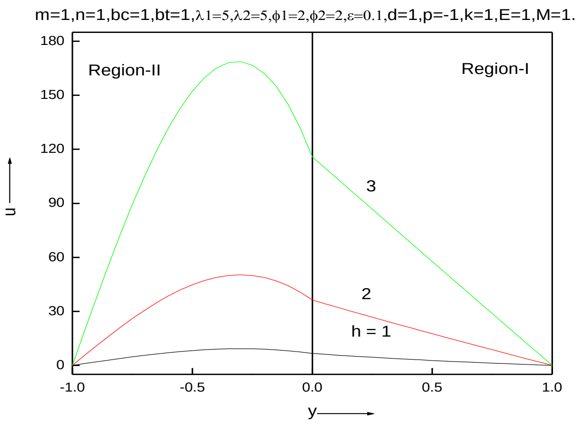


Fig.4(a) Velocity profile for different vslues of the ratio of width h.

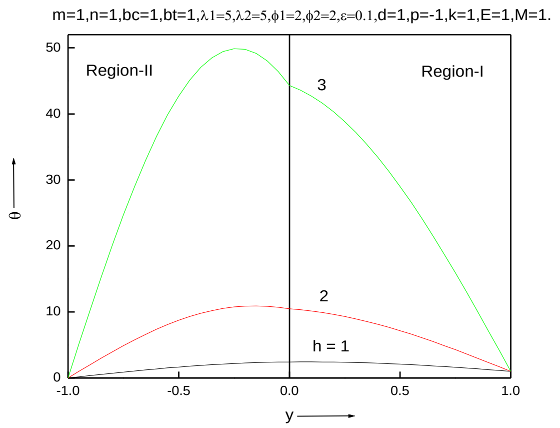


Fig.4(b) Shows the different value of temperature profile of width ratio h.

Both the temperature and velocity fields are affected by the width ratio of the two sections, as given in Figure 4(a) and (b). we noticed that impact is comparable to the viscosity ratio m in terms of overall quality.

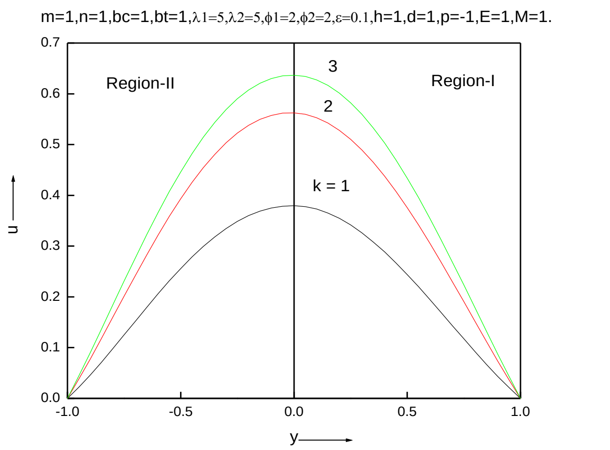


Fig.5(a) Velocity profile for different values of the ratio of thermal conductivity k.

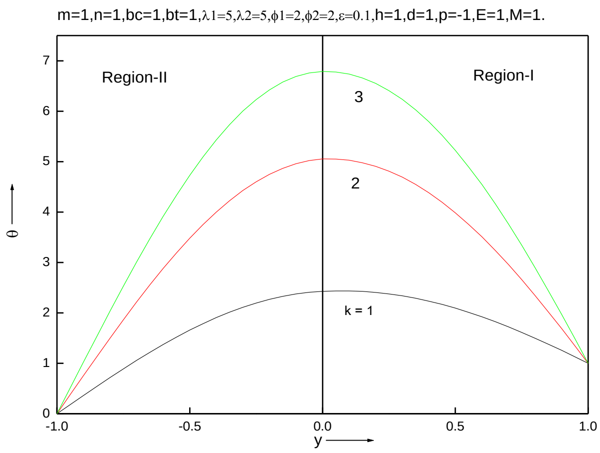


Fig.5(b) Temperature profile for different value of thermal conductivity ratio k.

Figure 5(a) and (b) shows how thermal conductivity k ratio affects the velocity along with temperature fields. As can be seen in the above diagram, a rise in the ratio of thermal conductivity causes an increase in both fluid flow rate and temperature.

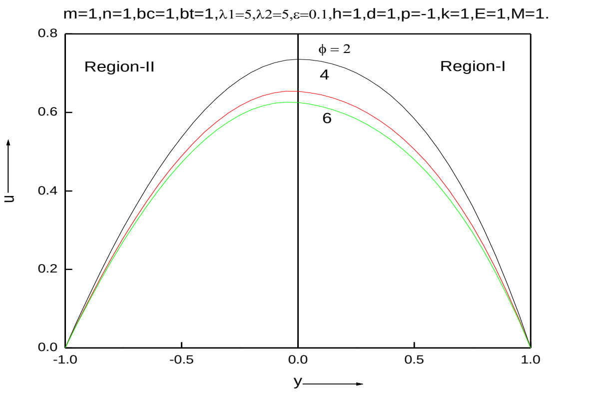


Fig.6(a) Velocity profile for different value of heat absorption coefficient ϕ.

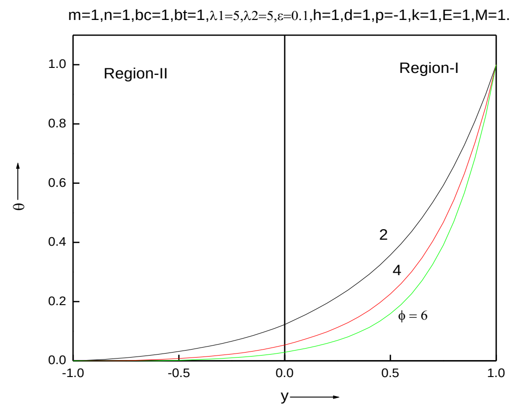


Fig.6(b) Temperature profile for different value of the heat absorption coefficient ϕ.

Both the temperature and velocity fields are affected by the heat absorption parameter ϕ , as given in Figure 6(a) and (b). Heat absorption parameter's impact on temperature as well as velocity field for both fluids demonstrates that the two quantities rise in tandem with their value.

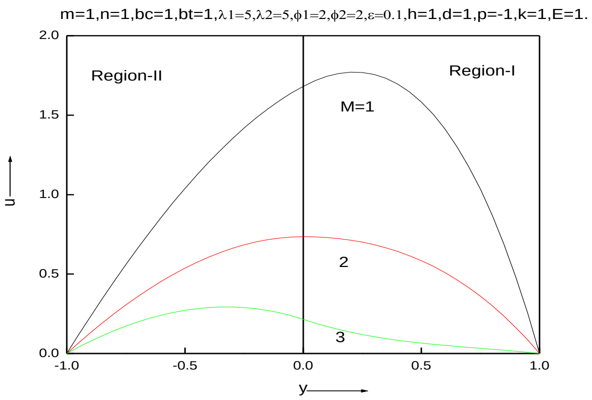


Fig.7(a) Velocity profile for different values of the Hartmann number M.

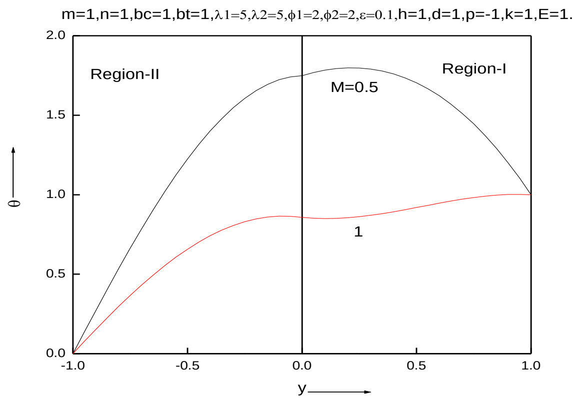


Fig.7(b) Temperature profile for different value of the Hartmann number M.

Figure 7(a) and 7(b) demonstrate the Hartmann number M effect on temperature as well asvelocity fields. We find that when M, the Hartmann number, increases, temperature and velocity decrease.

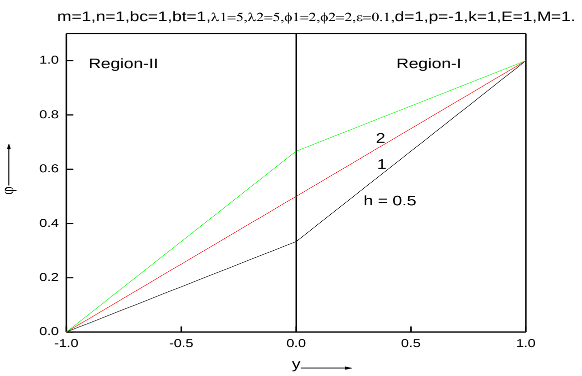


Fig.8(a) Concentration profile for different value of width ratio h.

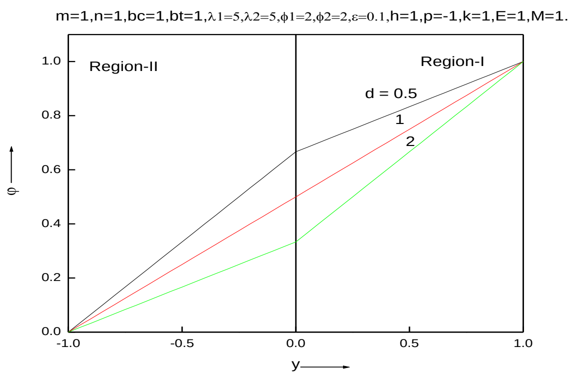


Fig.8(b) Concentration profile for different value of diffusion coefficient d.

Figure 8(a) and 8(b) demonstrate the concentration profile for varying width ratios. The ratio of width to height has been shown to have a significant impact on fluid flow**.**

Scientists and engineers have recently been interested in the magneto hydrodynamic (MHD) phenomenon because of its usefulness in a variety of real-world applications, including electric transformers, MHD accelerators, along with cooling of a metallic plate in a cooling bath. MHD mixed convection or natural flow of various fluids across distinct geometries was the subject of much investigation in the literature.

CONCLUSION:

Themagnetic field effects on vertical concentric annular electrically conductive flow, incompressible, viscous, heat- absorbing/generating fluid are studied. The energy equations and governing dimensionless momentum are analytically solved when the system is partitioned into stable and periodic regions. It was discovered that the existence of buoyant force and heat generation enhances the channel's flow rate, and that heat absorption has the reverse effect. Increases in the Hartmann number, thermal conductivity ratio, width ratio, viscosity ratio, and diffusion coefficient ratio improved the flows in both zones. Finally, we draw the conclusion that heat and momentum transfer are controlled by viscosity, channel width, source, and sink. The magnetic field'seffects on the steady mixed convection flow of a viscous, non-Newtonian fluid are studied.

Nomenclature:

b coefficient of thermal expansion ratio.

c_p Specific heat constant pressure

E_c Eckart number.

g acceleration due to gravity

h ratio of the two regions widths of

h_i Channel width

G_r Grashof number

K ratio of the thermal conductivity

m viscosities ratio

n densities ratio

p non-dimensionals pressure gradient

p_r Prandtl numbers

Br Brinkman Number

M Hartmann number

Greek Symbols

β_1 Thermal expansion coefficient

ϕ dimensionless heat generation or absorption coefficient

ρ_1 Density of the fluid

ν kinematic viscosity

μ_1 viscosity

σ Porous Parameter

ε product of Prandtl number and Eckert number (Pr x Ec)

θ non dimensional temperature

Suffix: i = 1, 2 refers to the quantities for region 1 and 2 respectively

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