HEAT AND MASS TRANSFER ON AN UNSTEADY MHD FLOW THROUGH POROUS MEDIUM BETWEEN TWO POROUS VERTICAL PLATES

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Abstract

The mode of heat transfer will play an important role in the heat engineering applications. The present work is focused on analytical investigation of unsteady heat transfer rate through porous medium in the presence of uniform transverse magnetic field. In this an unsteady MHD Jeffery fluid flow over a vertical plate through a porous medium with the witness of uniform transverse magnetic field is considered for the investigating the effects of radiation/absorption, heat generation/ absorption and homogeneous chemical reaction. The methodology involves the converting the coupled nonlinear partial equations in the ordinary differential equations by super imposion.The Perturbation method is used to fulfil the insufficient boundary conditions while solving the ordinary differential equations. The effect of various parameters on the velocity and temperature of the flow is investigated .The results are tabulated and various graphs are plotted for the effect of different parameters on fluid flow.

Keywords: Thermal radiation, Grasoffs Number, Nusselt Number, Porous Medium, Skin friction.

1. Introduction:

Hayat et al. [1] have investigated oscillatory rotating flows of a fractional Jeffrey fluid filling a porous space. Hayat et al.[2] have studied the effect of thermal radiation on the unsteady mixed convection flow of a Jeffrey fluid past a porous vertical stretching surface using homotopy analysis method. Hayat et al. [3] have investigated radiative flow of Jeffery fluid in a porous medium with power law heat flux and heat source. Hussain et al. [4] have examined radiative hydro magnetic flow of Jeffrey nanofluid by an exponentially stretching sheet. Lakshiminarayana et al. [5] studied effect of slip and heat transfer on peristaltic transport of a Jeffrey fluid in a vertical asymmetric porous channel.

2. Formulation:

In the present investigation in the presence of radiation absorption and a transverse magnetic field is considered in an unsteady free convective flow of Jeffery fluid past an infinite vertical porous plate in a porous medium with time dependent oscillatory suction along with the permeability. Also considering the flow is of radiate, heat absorbing and chemically reactive.

Let a vertical plate is considered in a fluid flow direction such that assume the $–x^*$-axis is along the plate which is in the direction of flow and the-y^*- axis is normal to it.Let us consider the magnetic Reynolds number is much less than unity so that induced magnetic field is neglected in comparison with the applied transverse magnetic field. The basic flow in the medium is, therefore, entirely due to the buoyancy force caused by the temperature difference between the wall and the medium. It is assumed that initially, at $t^* < 0$, the plate as well as fluids are at the same temperature and also concentration as the species is very low so that the Soret and Dofour effects are neglected. When t^*, the temperature of the plate is

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OPTIMIZATION OF EDM PROCESS PARAMETERS BY USING HYBRID METHODS

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ABSTRACT

In present situation, Aluminium matrix boron carbide (AL- B4C) MMC plays an important role in aerospace, biomedical, nuclear power plants, automobile and automotive industries. In order to do machining on these materials, convectional machining methods are not suitable, because of high tool cost and high tool wear. Due to these reason Advanced machining methods are used for machining AL- B4C material i.e., EDM, ECM, LBM etc., out of these machining methods EDM is one the best unconventional machining process to machine such components. EDM processes which are worked by repetitive sparks between tool (electrode) and work piece based on material erosion. In order to produce the spark in between tool and work piece must be of a thermal conductivity nature. A slight pulse discharge between work piece material and instrument occurs a small distance by melting and vaporizing eliminates the material from the work piece. MRR, TWR & Ra play an important role in the machining process. The present research uses Hybrid methods are used to optimize the process parameters of EDM on AL- B4C metal matrix composite material. The main objective of this work is to decrease the wear rate of the tool and improve the material removal rate with the product having good surface quality.

Keywords: Metal Matrix Composites (MMC's), Electric Discharge Machining (EDM), MRR, R_a, TWR, GRA

Flexural and Impact Characterization of Polymer Laminated Composites Reinforced with Bi-Woven Glass Fibers

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ABSTRACT

The flexible, low weight and efficient materials are the latest requirement in the fabrication engineering. The aircraft, naval and aerospace applications are the highest demand for such materials in their fabrication. The laminated composites are the best one to fulfill the needs. The virtual characteristics of the composite are high strength to weight and stiffness. The present work is associated with the fabrication and characterization of polymer laminated composites reinforced with Bi-woven glass fibers. The epoxy material and Bi-woven glass fibers are used as matrix and reinforcement .The fabrication is achieved by using the hand layup technique. The mechanical properties such as flexural strength and impact strength are determined experimentally as per the ASTM standards. The response of the mechanical properties by varying the number of layers of Bi-woven glass fiber reinforcement content in the epoxy matrix material is investigated. It is observed that the flexural strength and impact strength are enhanced by increased the number of layers up to optimum number.

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Influence of performance and emission of diesel engine with alumina nano particle based catalyst biodiesel

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Abstract:

For last few decades, researches are investigating for control of emissions and improve the efficiency of an IC engines with any modifications. The researchers consider that the alternative fuels are the prominent solution for improve performance and at the same time reduce of emissions in diesel engines. An attempt has been made in this paper, production of the cottonseed biodiesel with transesterification process using ethonal and Cao-mg/Al_2O_3 as catalyst and its effects on diesel engine performance, combustion and emission characteristics based on experimental investigation. Four fuel blends prepared for testing of engine consists of CBDN10, CBDN20, CBDN30 and CBDN40 by volume respectively. For investigate the performance of cotton seed biodiesel blends on Kirloskar Engine TV1 diesel engine. Experimental results for CBDN blends show positive effects on engine performance, emissions and combustion. The Cao-mg/Al_2O_3 catalyst in cottonseed oil blends was found that the more effective reduction of emission NO_x, HC and CO. Also it reduces the fuel consumption and improves the brake thermal efficiency. Further the blends reduce the ignition delay and improve the combustion rate.

Key words: Cotton seed biodiesel, diesel engine, performance, emission

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Aligned magnetic field effect on unsteady natural MHD convection flow of a chemically reacting, radiative and dissipative fluid past a porous vertical plate in the presence of continuous heat and mass flux

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***Abstract*—ThiselecThe slip flow effects on unsteady hydromagnetic flow over a stretching surface with thermal radiation are studied in the presence of heat generation and porous media. The governing partial differential equations are reduced to a system of self-similar equations, using transformations of similarity.The resulting equations are then numerically solved using the fourth-order technique of Runge-Kutta and the shooting method. The effects on velocity and temperature of regulating physical parameters are measured and described in graphical and tabular ways, as well as the coefficient of skin friction and Nusselt number.**

Numerical computations have been carried out for different parameter values, such as the magnetic interaction parameter. (M^2), in order to evaluate the results Permeability of porous medium parameter *(K),* Heat generation parameter *(Q),* Unsteadiness parameter *(A),*Radiation parameter *(R),* Velocity slip parameter (h_1), Thermal jump parameter (h_2) and Prandtl number *(Pr).*With the help of figures and graphs, the results and numerical values are clarified. Also derived and discussed are the Skin Friction and Nusselt Number expressions.

***Keywords*—A chemically reacting, radiative and dissipative fluid heat and mass flux, aligned magnetic field, MHD normal convection flow**

I. INTRODUCTION

This induces magnetic fields by changing electrical charges and intrinsic magnetic moments of elementary particles related to their fundamental quantum property, their spin. In relativity, electric and magnetic fields are two interrelated aspects of a single entity, namely the electromagnetic tensor.Depending on the relative velocity of the charge and the observer, the division of the tensor into electric and magnetic fields. In quantum mechanics, the electromagnetic field is quantized and electromagnetic interactions arise from the exchange of photons. Raja Shekar and Karunakar Reddy [1] examined heat and mass transfer past a continuously moving porous boundary in the presence of a magnetic field.Sun et al.[2]studied heavy segregation and self-assembly induced by strong magnetic fields of micrometer-sized non-magnetic particles. Raja Shekar and Karunakar Reddy[3] explored heat and mass transfer past a continuously moving porous boundary in the presence of a magnetic field. The effects of radiation and variable viscosity on a free MHD convection flow past a semi-infinite flat plate with an aligned magneticfield were studied by Seddeek[4] in the case of unsteady flow. A chemical reaction is a procedure that results in one category of chemical substances being converted to another. Chemical reactions generally include changes that include only electron positions in the formation and breakdown of chemical bonds between atoms, without nucleus modification, and can usually be represented by a chemical equation. Chemical science can be a sub-discipline of chemistry involving the chemical reactions of elements in which electronic and nuclear modifications may take place that are unstable and radioactive.Krishna et al. [5] considered the effects of chemical reaction and radiation on MHD convective flow overa permeable stretching surface with suction and heat generation. In the presence of the heat source/sink for Soret and Dufour effects on free convective heat and mass transfer with thermophoresis and chemical reaction over a porous stretching surface, .Kandasamy et al.[6] acquired group theorytransformation. Ravikumar et al.[7] Joneidi et al.[8] investigated MHD double diffusive and chemically reactive flow through porous medium bounded by two verticalplates.[8] developed MHD free convective flow analytical treatment and mass transfer over a stretching board of chemical reactions.The effect of a chemical reaction on transient MHDfree convection flow over a vertical plate was acquired by Sahin[9] in slip-flow mode. Chamkha et al.[10] explored Unsteady MHD natural convection from a heated vertical porous plate in a micro-polar fluid with chemical reaction, heating effects of Joule, and radiation. Mohamed et al.[11] have recorded unstable MHD double-diffusive convection boundary-layer flow past a radiating hot vertical surface in porous media in the presence of chemical reaction and heat sink. The release or transmission of radiation across space or through a tissue medium in the form of waves or particles is radiation in physics.This includes electro-magnetic radiation such as radio waves, actinic rays, and x-rays, particle radiation such as alpha, β, and neutron radiation, and acoustic radiation such as vibration, ultrasound, and seismic waves. Radiation may also apply to the electricity, waves, or particles being radiated. Rajput and Kumar[12, 13] investigated radiation effects on MHD flow past a vertical plate with impulsively initiated variable heat and mass transfer. The influence of radiation on free-convection flow in a spinning fluid past an impulsively initiated vertical plate was discussed by Vijayalakshmi[14].Muthucumaraswamy and Janakiraman[15] studied MHD and radiation effects with variable mass diffusion on the moving isothermal vertical plate. Thermal radiation and magneto hydrodynamic effects on heat and mass transfer of chemically reactive fluid with periodic suction were obtained by Ahmedsahin and Tridip [16]. Pal and Talukdar[17] have studied perturbation study of unstable magneto hydrodynamic convective heat and mass transfer through a vertical permeable plate with thermal radiation and chemical reaction in a boundary layer slip flow.

Ahmedsahin and Tridip [16] obtained thermal radiation and magneto hydrodynamic effects on heat and mass transfer of chemically reactive fluid with periodic suction. Pal and Talukdar[17] researched the perturbation analysis of unstable magneto hydrodynamic convective heat and mass transfer in a boundary layer slip flow through a vertical permeable plate with thermal radiation and chemical reaction. As the fluid is forced into a tube, the particles comprising the fluid generally travel faster near the tube's axis and more slowly near its walls:Thus, to resolve the friction between particle layers and keep the fluid flowing, some tension is needed. Umamaheswar et al.[18] investigated unsteady MHD Free Convective Visco-Elastic Fluid Flow Bounded by an Infinite Inclined Porous Layer in the presence of heat source, viscous dissipation and ohmic heating. Sandeep and Sugunamma[19] developed the effect of the inclined magnetic field on the unsteady free convective flow of dissipative fluid past a vertical plate. Seshaiah et al [20]

II. FORMULATION OF THE PROBLEM

First, the presence of the joule effect and heat source, Unsteady MHD free convective flow of an electrically conducting incompressible and viscous fluid in an optically thin setting past an infinite vertical plate put in a porous medium is considered. The x^* - axis is taken parallel to the infinite vertical plate and the y^* - axis is perpendicular to the plate. In the presence of thermal radiation, a distributed magnetic field is applied. Therefore, following the equilibrium model of Cogley et al. (1968), the expression of the radiative heat flux is taken as given below.

$$\frac{\partial q_r}{\partial y} = 4\left(T^* - T_\infty\right)\int_0^\infty K_{\lambda\omega}\left(\frac{\partial e_{b\lambda}}{\partial T}\right)_W d\lambda = 4I^*\left(T^* - T_\infty\right) \tag{1}$$

Where the radiation absorption coefficient is on the wall and where the feature of the plank is. As the plate is infinite in scope, all the flow variables are independent of x* and so their derivatives disappear with regard to x*. Only the non-zero velocity part is in the x*- direction. The portion and temperature of non-zero velocity are functions of y* and t* only. In the x*- direction, in contrast to the y*- direction, the radiative heat flux is considered negligible. Hence, the continuity equation is solved immediately. The following equations govern the unstable flow and temperature fields within the context of the above assumptions.

.

$$\rho\frac{\partial u^*}{\partial t^*} = \mu\frac{\partial^2 u^*}{\partial y^{*2}} + g\rho\beta\left(T^* - T_\infty\right) + g\rho\beta^*\left(C^* - C\right. \tag{2}$$

$$\rho C_p\frac{\partial T^*}{\partial t^*} = k\frac{\partial^2 T^*}{\partial y^{*2}} + \mu\left(\frac{\partial u^*}{\partial y^*}\right)^2 + Q^*\left(T^* - T_\infty\right) - 4I\left(T^* - T_\infty\right) + \sigma B_0^2 u^{*2} \tag{3}$$

$$\frac{\partial C^*}{\partial t^*} = D_m\frac{\partial^2 C^*}{\partial y^{*2}} - Kr^*\left(C^* - C_\infty\right) \tag{4}$$

Where ¤ is the density, t* is the time, u* is the velocity variable in the x* direction, μ is the viscosity, g is the gravity acceleration, β is the coefficient of thermal expansion, T* is the fluid temperature in the boundary layer, T ⁇ is the fluid temperature far from the plate, σ is the electrical conductivity, B0 is the strength of the magnetic field, σ is the kinematic viscosity,

.

The initial and boundary conditions are:

For $t^* \le 0$, $u^* = 0$, $T^* = T_\infty$, $C^* = C_\infty$ for all y^*

For $t^* > 0$, at

$$y^* = 0; u^* = U\left(1 + \varepsilon e^{i\omega^* t^*}\right), \frac{\partial T^*}{\partial y^*} = -\frac{q}{\kappa}, \frac{\partial C^*}{\partial y^*} = -\frac{q_w}{\kappa}; \tag{5}$$

at

$$y^* \to \infty : u^* = 0, T^* = T_\infty, C^* = C_\infty$$

Where U is the mean velocity of plate and $\varepsilon << 1$.

III. METHOD OF SOLUTION

Introducing the following non-dimensional quantities

$$y = \frac{Uy^*}{\nu}, f = \frac{u^*}{U}, t = \frac{U^2 t^*}{\nu}, \omega = \frac{\nu\omega^*}{U^2}, \theta = \frac{\kappa U\left(T^* - T_\infty\right)}{q\nu}, Gr = \frac{g\beta\nu^2 q}{\kappa U^4}, K = \frac{K^* U^2}{\nu^2}, Ha = \frac{\sigma B_0^2 \nu}{\rho U^2},$$

$$Gc = \frac{g\beta^* q_\omega \upsilon^2}{\kappa U^4}, \Pr = \frac{\mu C_p}{\kappa}, R = \frac{4I^*\nu}{\rho C_p U^2}, Ec = \frac{\kappa U^3}{C_p \nu q}, Q = \frac{Q^*\nu}{\rho C_p U^2}, \phi = \frac{\kappa U\left(C^* - C_\infty\right)}{q_w \nu},$$

$$Sc = \frac{\nu}{D_m}, Kr = \frac{Kr^*\nu}{U^2}. \tag{6}$$

Into the equations (2), (3) and (4), we get

$$\frac{\partial f}{\partial t} = \frac{\partial^2 f}{\partial y^2} + Gr.\theta + Gc.\phi - \left(H_a \sin^2\psi + \frac{1}{K}\right)f \ , \tag{7}$$

$$\frac{\partial \theta}{\partial t} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} - \left(R - Q\right)\theta + Ec\left(\frac{\partial f}{\partial y}\right)^2 + EcH_a f^2 \tag{8}$$

$$\frac{\partial \phi}{\partial t} = \frac{1}{Sc}\frac{\partial^2 \phi}{\partial y^2} - Kr.\phi \tag{9}$$

Where u is the non-dimensional velocity along the x-axis, ⁇ is the non-dimensional temperature, t is the time, Gr is the number of Grashof heat transfer, Gc is the number of Grashof changed, Ha is the number of Hartmann, K is the permeability parameter, Ec is the number of Eckert, Pr is the number of Prandtl, R is the radiation parameter, Q is the heat source parameter, Sc is the number of Schmidt. The corresponding boundary conditions are reduced to For $f = 0, \theta = 0, \phi = 0$ for all y

For $t > 0,$ at $y = 0: f = 1 + \varepsilon e^{i\omega t}, \frac{\partial \theta}{\partial y} = -1, \frac{\partial \phi}{\partial y} = -1$

At $y \to \infty: f = 0, \theta = 0, \phi = 0.$

In view of boundary conditions, the velocity and temperature distributions are separated into steady and unsteady parts as given below

$$\left.\begin{aligned} f(y,t) &= f_0(y) + \varepsilon e^{i\omega t} f_1(y) \\ \theta(y,t) &= \theta_0(y) + \varepsilon e^{i\omega t}\theta_1(y) \\ \phi(y,t) &= \phi_0(y) + \varepsilon e^{i\omega t}\phi_1(y) \end{aligned}\right\} \tag{12}$$

The equations (7), (8) and (9) are replaced by (11) and the harmonic and non-harmonic terms are equated.

Equations of the zeroth order

$$f_0'' - \left(H_a \sin^2 \psi + \frac{1}{K} \right) f_0 = -Gr\theta_0 - Gc\phi_0$$

(13)

$$\theta_0'' - \Pr\left(R - Q\right)\theta_0 = -\Pr Ecf_0'^2 - \Pr EcH_a f_0^2$$

(14)

$$\phi_0'' - Kr.Sc.\phi_0 = 0$$

(15)

First order equations

$$f_1'' - \left(H_a \sin^2 \psi + \frac{1}{K} + i\omega \right) f_1 = -Gr\theta_1 - Gc\phi_1$$

(16)

$$\theta_1'' - \Pr\left(R - Q + i\omega\right)\theta_1 = -2\Pr Ecf_0' f_1' - 2\Pr EcH_a f_0 f_1$$

(16)

$\phi_1'' - \left(Kr + i\omega\right) Sc.\phi_1 = 0$ (17)

Here, prime denotes the differentiation with respect to y.

Now, the corresponding boundary conditions are reduced to

$$y = 0: \; f_0 = 1,\, f_1 = 1, \theta_0' = -1, \theta_1' = 0, \phi_0' = -1, \phi_1' = 0$$

$$y \to \infty:$$

$$f_0 \to 0,\, f_1 \to 0, \theta_0 \to 0, \theta_1 \to 0, \phi_0 \to 0, \phi_1 \to 0$$

(18)

Equations (12) to (17) are also coupled with ordinary differential equations of the second order. Therefore, since the Eckert number Ec is very small for incompressible fluid flows and can be extended in the Ec powers as shown below.

$$F\left(y\right) = F_0\left(y\right) + EcF_1\left(y\right) + 0\left(Ec^2\right) + ...$$

(19)

Where *F* stands for any $f_0, f_1, \theta_0, \theta_1, \phi_0$ and ϕ_1. Substituting (19) into the equations (12) to (17), equating the coefficients of like powers of *E*c and neglecting terms of O (*E*c^2), we get

Zeroth order equations

$$f_{00}'' - K_1 f_{00} = -Gr\theta_{00} - Gc\phi_{00}$$

(20)

$$f_{10}'' - K_2 f_{10} = -Gr\theta_{10} - Gc\phi_{10}$$

(21)

$$\theta_{00}'' - \alpha_1\theta_{00} = 0$$

(22)

$$\theta_{10}'' - \alpha_2\theta_{10} = 0$$

(23)

$$\phi_{00}'' - K_3\phi_{00} = 0$$

(24)

$$\phi_{10}'' - K_4\phi_{10} = 0$$

(25)

First order equations

$$f_{01}'' - K_1 f_{01} = -Gr\theta_{01} - Gc\phi_{01}$$

(26)

$$f_{11}'' - K_2 f_{11} = -Gr\theta_{11} - Gc\phi_{11}$$

(27)

$$\theta_{01}'' - \alpha_1\theta_{01} = -\Pr\left(f_{00}'\right)^2 - \Pr H_a\left(f_{00}\right)^2$$

(28)

$$\theta_{11}'' - \alpha_2\theta_{11} = -2\Pr f_{00}' f_{10}' - 2\Pr H_a f_{00} f_{10}$$

(29)

$$\phi_{01}'' - K_3\phi_{01} = 0 \qquad (30)$$

$$\phi_{11}'' - K_4\phi_{11} = 0$$

(31)

Where K$_1$, K$_2$, K$_3$, K$_4$, α_1 and α_2 are constants presented in Appendix - A

Now, the corresponding boundary conditions are reduced to

$$y = 0:$$

$$f_{00} = 1,\, f_{01} = 0,\, f_{10} = 1,\, f_{11} = 0, \theta_{00}' = -1, \theta_{01}' = 0, \theta_{10}' = 0, \theta_{11}' = 0,$$

$$\phi_{00}' = -1, \phi_{01}' = 0, \phi_{10}' = 0, \phi_{11}' = 0$$

(32)

$$y \to \infty:$$

$$f_{00} \to 0,\, f_{01} \to 0,\, f_{10} \to 0,\, f_{11} \to 0, \theta_{00} \to 0, \theta_{01} \to 0, \theta_{10} \to 0, \theta_{11} \to 0,$$

$$\phi_{00} \to 0, \phi_{01} \to 0, \phi_{10} \to 0, \phi_{11} \to 0$$

Equations (20) to (31) are now common differential equations that are coupled in the second order and resolved under boundary conditions (32). Thus, by straight forward calculations, the expressions for velocity, temperature and concentration distribution are known and given.

$$f\left(y,t\right) = A_{16}e^{-y\sqrt{K_1}} + A_3e^{-y\sqrt{\alpha_1}} + A_4e^{-y\sqrt{K_3}} + Ec(A_{37}e^{-y\sqrt{K_1}} + A_{30}e^{-y\sqrt{\alpha_1}} + A_{31}e^{-2y\sqrt{K_1}} + A_{32}e^{-2y\sqrt{\alpha_1}} + A_{33}e^{-2y\sqrt{K_3}} +$$
$$A_{34}e^{-y\alpha_6} + A_{35}e^{-y\alpha_7} + A_{36}e^{-y\alpha_8}) + \varepsilon e^{i\omega t}[e^{-y\sqrt{K_2}} + Ec(A_{42}e^{-y\sqrt{K_2}} + A_{38}e^{-y\sqrt{\alpha_2}} + A_{39}e^{-y\alpha_3} + A_{40}e^{-y\alpha_4} + A_{41}e^{-y\alpha_5})]$$

(5.33)

$$\theta\left(y,t\right) = A_2e^{-y\sqrt{\alpha_1}} + Ec\left(A_{29}e^{-y\sqrt{\alpha_1}} + A_{23}e^{-2y\sqrt{K_1}} + A_{24}e^{-2y\sqrt{\alpha_1}} + A_{25}e^{-2y\sqrt{K_3}} + A_{26}e^{-y\alpha_6} + A_{27}e^{-y\alpha_7} + A_{28}e^{-y\alpha_8}\right)$$
$$+\varepsilon e^{i\omega t}\left[Ec\left(A_{15}e^{-y\sqrt{\alpha_2}} + A_{12}e^{-y\alpha_3} + A_{13}e^{-y\alpha_4} + A_{14}e^{-y\alpha_5}\right)\right]$$

(34)

$$\phi\left(y,t\right) = A_1e^{-y\sqrt{K_3}}.$$

(35)

whereA_1 to A_{42} ; K$_1$, to K$_4$; α_1 to α_8 are constants presented in Appendix – A

A. NUSSELT NUMBER, SHERWOOD NUMBER AND SKIN FRICTION

B. Nusselt number (Nu) $= -\left(\frac{\partial\theta}{\partial y}\right)_{y=0} = -1$

Sherwood number (Sh) $= \left(\frac{\partial\phi}{\partial y}\right)_{y=0} = -1$

C.

D. The coefficient of skin-friction at the plate is given by

III. RESULTS AND DISCUSSIONS

The effects of the various physical parameters on the fluid velocity, fluid temperature and fluid concentration are shown through graphs when ϵ = 0.01, t=1 and ω=2. From figures 1 to 11, noted that fluid velocity increases by increasing the Grashof number (Gr) for heat transfer, Modified Grashof number (Gc), the

Eckert number (Ec), the heat source parameter (Q) or the permeability parameter (K) while it decreases by increasing the radiation parameter (R), theHartmann number (H_a), the angle of inclination of magnetic field (ψ), Chemical reaction parameter (Kr), Schmidt number (Sc) or the Prandtl number (Pr). The effects of the Eckert number (Ec), the heat source parameter (Q) and the Hartmann number (H_a) on temperature field are shown through figure 12 to 14 Shown that with the growth of these physical parameters, fluid temperature increases. In addition, the results of the radiation parameter (R), the Prandtl number (Pr), the Schmidt number (Sc) and the parameter for the chemical reaction are shown in Figures 15 to 18. (Kr). It is observed that the fluid temperature decreases with the increase of these physical parameters. Figures 19 and 20 show the outcomes of the chemical reaction parameter (Kr) of the Schmidt number (Sc). It is observed that the concentration of fluid decreases as these physical parameters increase.

For engineers, the physical amount of interest is the coefficient of skin friction. This is the stress intensity of non-dimensional shear. For the various physical parameter values, the numerical results of the plate skin friction coefficient are calculated and shown in Table 1. Table 1 shows that the skin friction coefficient increases as a result of an increase in the number of Grashof (Gr) for heat transfer, the permeability parameter (K), the number of Modified Grashof (Gc), the number of Eckert (Ec), the heat source parameter (Q); while it decreases as a result of an increase in the number of Hartmann (⁇), the number of Prandtl (Pr), the radiation parameter (R), the angle of the heat source (Q)

A. GRAPHS

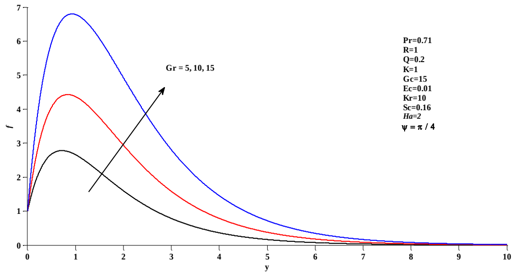

Fig.1Distribution of velocity for various Gr values

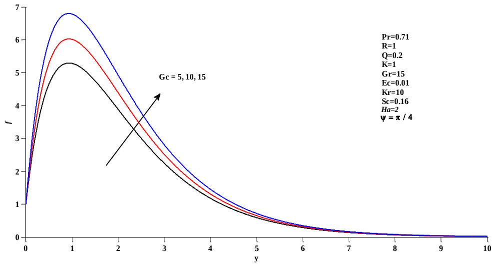

Fig 2Distribution of velocity for various Gc values

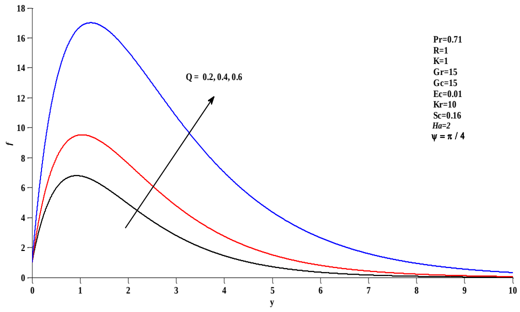

Fig.3.Distribution of velocity for various Q values

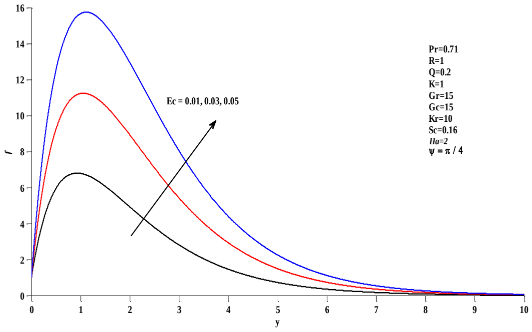

Fig.4.Velocity distribution for different values of Ec

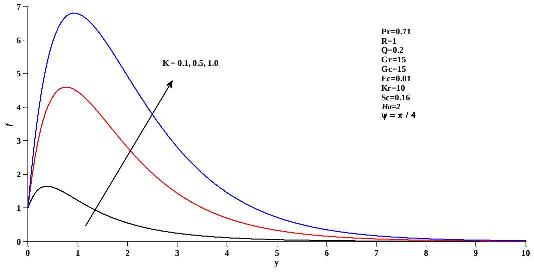

Fig.5.Distribution of velocity for various K values

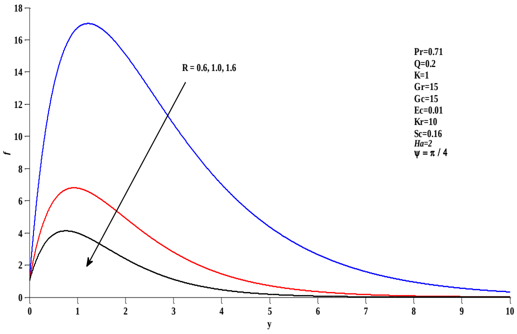

Fig.6.Distribution of velocity for various R values

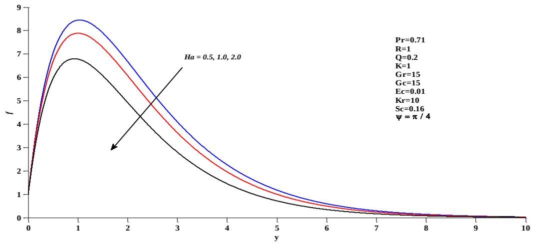

Fig.7.Distribution of velocity for various values H_a

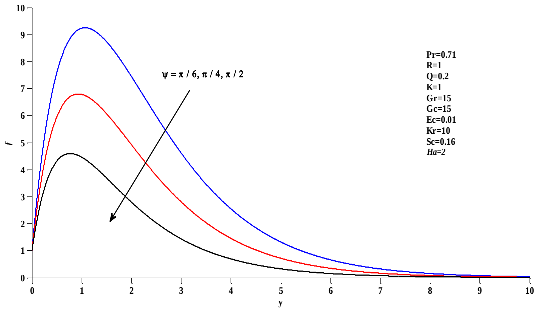

Fig.8.Distribution of velocity for various values ψ

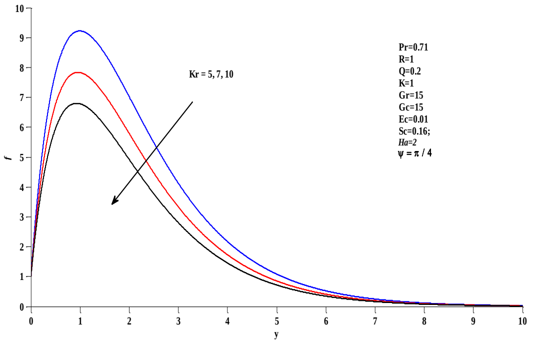

Fig.9Distribution of velocity for various Kr values

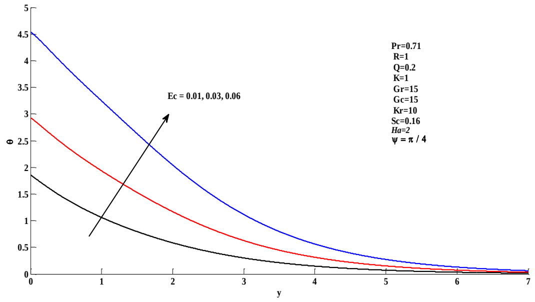

Fig.10.Distribution of velocity for various Sc values

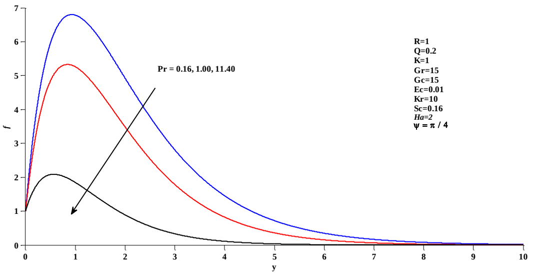

Fig.11.Distribution of velocity for various values Pr

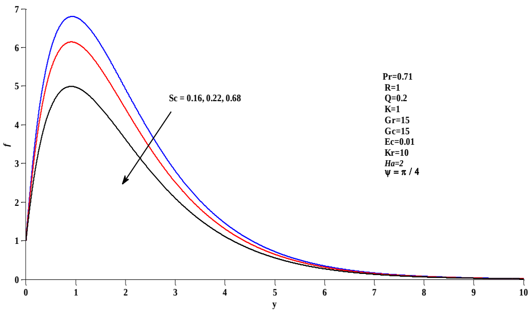

Fig.12.Temperature distribution for different values of Ec

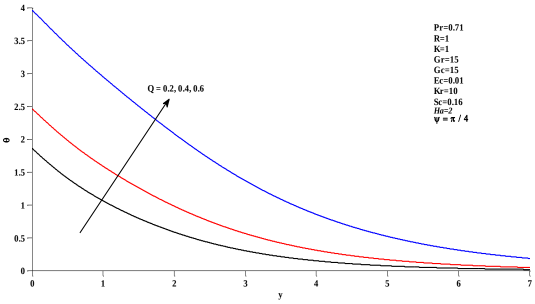

Fig.13.Distribution of temperature for similar Q value values

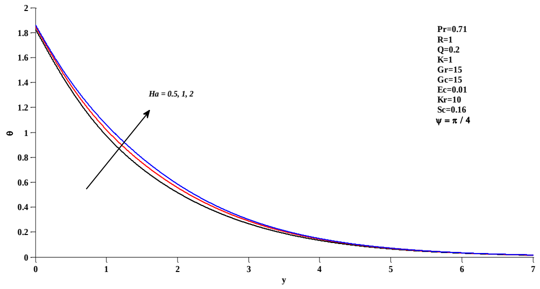

Fig.14.Distribution of temperature for similar value values H_a

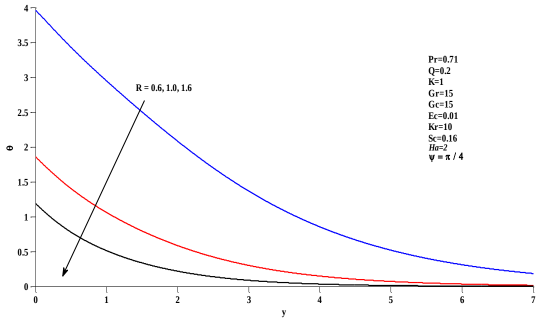

Fig.15.Distribution of temperature for similar R value values

A. TABLES

Table 1: Numerical values of skin friction coefficient at the plate for various values of physical parameters when t=1 and ω=2.

	Pr	**R**	**Ec**	**Gr**	**Gc**	**Q**	**Ha**	**K**	**ψ**	**Kr**	**Sc**	**C_f**
0.00	0.71	1	0.01	5	5	0.2	2	1	π/2	10	0.16	2.3577
0.01	0.71	1	0.01	5	5	0.2	2	1	π/2	10	0.16	2.3704
0.01	1.00	1	0.01	5	5	0.2	2	1	π/2	10	0.16	1.8086
0.01	0.71	2	0.01	5	5	0.2	2	1	π/2	10	0.16	1.1728
0.01	0.71	1	0.02	5	5	0.2	2	1	π/2	10	0.16	2.4723
0.01	0.71	1	0.01	10	5	0.2	2	1	π/2	10	0.16	5.4881
0.01	0.71	1	0.01	5	10	0.2	2	1	π/2	10	0.16	3.7489
0.01	0.71	1	0.01	5	5	0.4	2	1	π/2	10	0.16	2.9824
0.01	0.71	1	0.01	5	5	0.2	4	1	π/2	10	0.16	1.2055
0.01	0.71	1	0.01	5	5	0.2	2	0.4	π/2	10	0.16	1.4176
0.01	0.71	1	0.01	5	5	0.2	2	1	π/6	10	0.16	4.0438
0.01	0.71	1	0.01	5	5	0.2	2	1	π/2	15	0.16	2.0197
0.01	0.71	1	0.01	5	5	0.2	2	1	π/2	10	0.22	2.0873

IV. CONCLUSIONS

The radiation effect on an unstable megnetohydrodynamic free convective heat and mass transfer flow past a moving vertical porous plate embedded in a porous medium is investigated in the presence of a chemical reaction. The governing partial differential equations are reduced to a system of self-similarequations, using transformations of similarity. The resulting equations are then solved numerically using the fourth order Runge-Kutta method, along with the shooting technique.The effects of the governing physical parameters on velocity, temperature and concentration as well as the skin-friction coefficient, Nusselt number and Sherwood number are measured and presented in graphical and tabular forms. Comparisons are made with previously published work and are found to be in excellent agreement with the conclusions. The following conclusions are also given.

i. The sum of mass diffusion and thermal diffusion appears to increase the concentration of fluid for both ramped and isothermal plates. As time passes, for both ramped and isothermal plates, there is a rise in fluid concentration.

ii. i. In the case of the ramp temperature plate, the fluid velocity is slower than in the case of the isothermal plate. In the case of the ramp temperature plate, the fluid temperature is lower than in the case of the isothermal plate. In the case of a ramped temperature plate, fluid concentration is lower than in the case of an isothermal plate.On both ramped temperature and isothermal plates, the magnetic field appears to increase skin friction while the thermal buoyancy force has a reverse effect on it.

iii. It. iii. For the ramped temperature plate and isothermal plate, radiation helps to minimize skin friction.

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