Heat And Mass Transfer Effects On Chemical Reacting Fluid Flow Past An Exponentially Accelrated Vertical Plate

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Abstract. In this work finite element solutions of magnetohydrodynamic unsteady chemically reacting fluid flow past an exponentially vertical plate in nearness of heat and mass transfer impacts examined. The flow flow is coordinated by coupled non-linear governing partial differential equations with suitable limit conditions and are understood by finite element technique. A parametric report is completed for the velocity, temperature and concentration profiles inside the limit layer are examined.

Keywords: Heat transfer; Mass transfer; MHD; Chemical reaction; Finite element technique;

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1. INTRODUCTION:

In science, the finite element technique (FEM) is a numerical procedure for finding assessed answers for limit esteem issues for fractional differential conditions. It utilizes subdivision of an entire issue area into less difficult parts, called finite elements, and variational techniques from the analytics of varieties to take care of the issue by limiting a related mistake work. Practically equivalent to the possibility that associating numerous minor straight lines can inexact a bigger circle, FEM envelops approaches for interfacing numerous straightforward component conditions over numerous little sub-areas, named finite elements, to rough a more mind boggling condition over a bigger space. Jithender Reddy et al. [1] investgated the combined impacts of heat diffusion and diffusion thermo affects on compound responded MHD free convection from a rashly begun limitless vertical plate implanted in a permeable medium utilizing finite element approach. Finite element solutionss of MHD free convective Casson fluid (liquid/gas) flow past a vertically slanted plate submitted in magnetic field in nearness of heat and mass trnasfer considered by Srinivasa Raju et al. [2]. Srinivasa Raju [3] considered exchange consequences for a precarious MHD free convective stream past a vertical plate with substance response. impact of edge of tendency on temperamental MHD Casson fluid (liquid/gas) stream past a vertical surface filled by permeable medium in nearness of consistent heat mass transfer, mixture response and viscous dissipation examined by Srinivasa Raju et al. [4]. Murthy et al. [5] examined the impacts of heat and mass transfer magnetohydrodynamic free convective stream past a vast vertical permeable plate in nearness of thermal radiation and hall current utilizing finite element technique. The consequences of thermal radiation and heat source on a unsteady MHD free convective fluid flow over a boundless vertical plate in event of Soret and diffusion thermo were discussed about by Raju et al. [6]. Casson fluid flow on free convection stream past an endless vertical plate filled in magnetic field in nearness of edge of tendency and thermal radiation examined by Srinivasa Raju [7]. Shaky MHD Couette stream of water at $4^{o}C$ in a pivoting framework in nearness of heat exchange with sloped temperature through finite element technique considered by Jithender Reddy et al. [8]. Muthucumaraswamy and Valliammal [9] examined concoction response impact on MHD flow past an exponentially quickened vertical plate with variable temperature and mass diffusion. The point of the present examination is hence, to contemplate the impact of compound response on temperamental MHD flow past an exponentially quickened vertical plate in nearness of variable temperature numerically. Some of them are Srinivasa Raju and his co-authors ([10]-[14]). The coupled non-lineart coupled governing partial differential equations with appropriate limit conditions are unraveled by Finite element technique. The numerical outcomes are done and graphical outcomes for the velocity, temperature and concentration profiles inside the limit layer are discussed about.

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2. FORMULATION OF THE PROBLEM

The unsteady magnetohydrodynamic flow of thick incompressible fluid flow past an exponentially quickened interminable vertical plate with variable temperature and furthermore with variable mass diffusion within the sight of concoction response has been contemplated. At first, the plate and the liquid are at a similar temperature T'_∞ in the stationary condition with concentration level C'_∞ at all the focuses. At time $t' > 0$, the plate is exponentially quickened with a velocity $u = u_0 \exp(a't')$ in its very own plane and the temperature of the plate is raised straightly with time and species focus level close to the plate is likewise raised directly with time *t*. The temperature of the plate and the concentration level are also raised or lowered to $T'_\infty + (T'_w - T'_\infty)At'$ and $C'_\infty + (C'_w - C'_\infty)At'$ respectively. All the physical properties of the liquid are viewed as consistent aside from the impact of the body drive term. A transverse magnetic field of uniform quality is thought to be connected ordinary to the plate. The fluid should be a slight directing and thus the magnetic Reynolds number is lesser than induced magnetic filed and the initiated attractive field is little in examination with the transverse magnetic field. It is additionally assumed that there is no connected voltage, as the electric field is missing. Viscous dissipation and Joule heating in vitality condition are disregarded. Electric field is ignored. Under the above usual Boussinesq’s approximation, the unsteady flow is governed by the following set of equations:

Momentum Equation:

$$\left[\frac{\partial u'}{\partial t'}\right]=\nu\left[\frac{\partial^2 u'}{\partial y'^2}\right]-\left[\frac{\sigma B_o^2}{\rho}\right]u'+\left[g\beta(T'-T'_\infty)\right]+\left[g\beta^*(C'-C'_\infty)\right] \tag{1}$$

Energy Equation:

$$C_p\left[\frac{\partial T'}{\partial t'}\right]=\kappa\left[\frac{\partial^2 T'}{\partial y'^2}\right]+\left[Q_o(T'_\infty-T')\right] \tag{2}$$

Species Diffusion Equation:

$$\left[\frac{\partial C'}{\partial t'}\right]=D\left[\frac{\partial^2 C'}{\partial y'^2}\right]-D\left[K'_r(C'-C'_\infty)\right] \tag{3}$$

The corresponding initial and boundary conditions are

$$\left.\begin{array}{l} t'\le 0:\ \ u'=0,\ T'=T'_\infty,\ C'=C'_\infty\ \ for\,all\,y' \\ t'>0:\ \begin{cases} u'=u_0\exp(a't'),\ T'=T'_\infty+(T'_w-T'_\infty)\ At', \\ \ \ C'=C'_\infty+(C'_w-C'_\infty)\,At'\ \ \ at\ \ \ y'=0 \\ u'=0,\ T'\to T'_\infty,\ C'\to C'_\infty\ \ as\,y'\to\infty \end{cases} \end{array}\right\} \tag{4}$$

On introducing the following non-dimensional quantities into the Eqs. (1), (2) and (3)

$$\left.\begin{array}{l} u=\dfrac{u'}{u_0},\ t=\dfrac{t'{u_0}^2}{\nu},\ y=\dfrac{y'u_0}{\nu},\ \theta=\dfrac{T'-T'_\infty}{T'_w-T'_\infty},\ \phi=\dfrac{C'-C'_\infty}{C'_w-C'_\infty},\ M=\dfrac{\sigma {B_0}^2\nu}{\rho u_o^2},\ Gr=\dfrac{g\beta\nu(T'_w-T'_\infty)}{u_o^3}, \\ Gc=\dfrac{g\beta^*\nu(C'_w-C'_\infty)}{u_o^3},\ \Pr=\dfrac{\nu C_p}{\kappa},\ Sc=\dfrac{\nu}{D},\ \ a=\dfrac{a'\nu}{u_o^2},\ \lambda=\dfrac{\nu K'_r}{u_o^2},\ \mathrm{Re}_x=\dfrac{u_o x}{\nu},\ A=\dfrac{u_o^2}{\nu} \end{array}\right\} \tag{5}$$

then we get the following governing equations in dimensionless form.

Momentum Equation:

$$\frac{\partial u}{\partial t}=Gr\theta+Gc\phi+\frac{\partial^2 u}{\partial y^2}-Mu \tag{6}$$

Energy Equation:

$$\frac{\partial \theta}{\partial t}=\frac{1}{\Pr}\frac{\partial^2\theta}{\partial y^2} \tag{7}$$

Concentration Equation:

$$\frac{\partial \phi}{\partial t}=\frac{1}{Sc}\frac{\partial^2\phi}{\partial y^2}-\frac{\lambda}{Sc}\phi \tag{8}$$

The initial and boundary conditions in dimensionless form are as follows:

$$t\le 0:\ u=0,\ \theta=0,\ \phi=0\quad for\ \ all\quad y\ \&\,t>0:\ \begin{cases} u=\exp(at),\ \ \theta=t,\ \ \phi=t\ \ \ at\ \ \ y=0 \\ u=0,\ \theta\to 0,\ \ \phi\to 0\ \ \ as\ \ \ y\to\infty \end{cases} \tag{9}$$

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3. RESULTS AND DISCUSSIONS

Numerical assessment of the numerical outcomes utilizing finite element technique ([15] and [16]) are accounted for in the past area was performed and a specific agent set of results is accounted for graphically in Figs. 1-6. These outcomes are gotten to outline the impact of Magnetic field parameter (Hartmann number), Grashof number for heat and mass transfer, Prandtl number, Chemical reaction parameter and time on velocity, temperature, concentration profiles. For all calculations, the estimations of the Prandtl number are picked with the end goal that they speak to Mercury (Pr = 0.025), Air (Pr = 0.71), Water (Pr = 7.0), Water at $4^{o}C$ (Pr = 11.62) and the estimations of the Schmidt number are spoken to the nearness of species by Hydrogen (Sc = 0.22), Water-vapor (Sc = 0.60), Oxygen (Sc = 0.66) and Ammonia (Sc = 0.78). Every one of the profiles show the asymptotic conduct in the stream because of exponential movement of the plate. This is because of the initiated stream produced by the exponentially quickened plate. In the present examination, the limit condition for $y \rightarrow \infty$ is supplanted by y_{max} which is an adequately expansive estimation of y where the speed profile approaches the pertinent free stream speed and a range savvy step separation of 0.01 is utilized with y_{max} = 20.

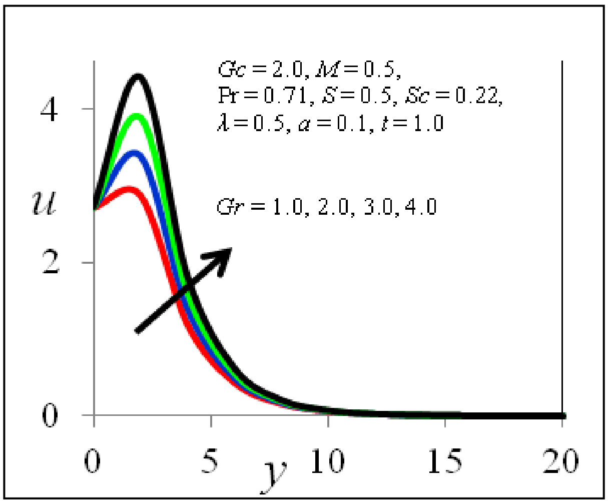

Fig. 1. Velocity profiles for different values of *Gr*.

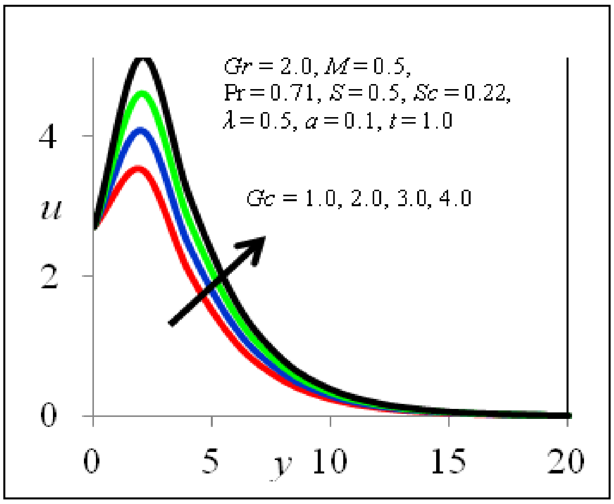

Fig. 2. Velocity profiles for different values of *Gc*.

The impact of Grashof number for heat transfer (Gr) on velocity profiles is exhibited in Fig. 1. The Grashof number for heat transfer demonstrates the general impact of the thermal buoyancy force to the viscous hydrodynamic force in the boundary layer. Obviously, it is seen that there is an expansion in the velocity because of the upgrade of thermal buoyancy force. Likewise, as Gr raises, the pinnacle estimations of the velocity increments rapidly close to the permeable plate and after that disintegrates easily to the free stream velocity. For various estimations of Grashof number for mass transfer (Gc) on velocity profiles is displayed in Fig. 2. The Grashof number for mass transfer describes the proportion of the lightness power to the thick hydrodynamic power. Obviously, the liquid speed increments and the pinnacle esteem is more particular because of improve in the species lightness constrain. The velocity transportation achieves an unmistakable most noteworthy incentive in the territory of the plate and afterward diminishes legitimately to move towards the free stream esteem. It is seen that the velocity amplifies with expanding estimations of Grashof number for mass transfer.

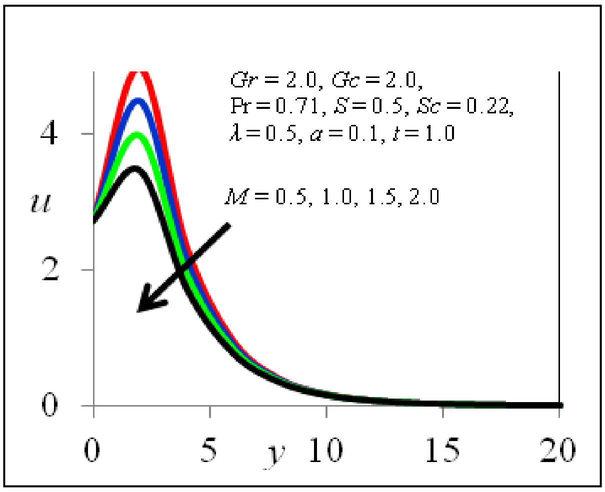

Fig. 3. Velocity profiles for different values of *M*.

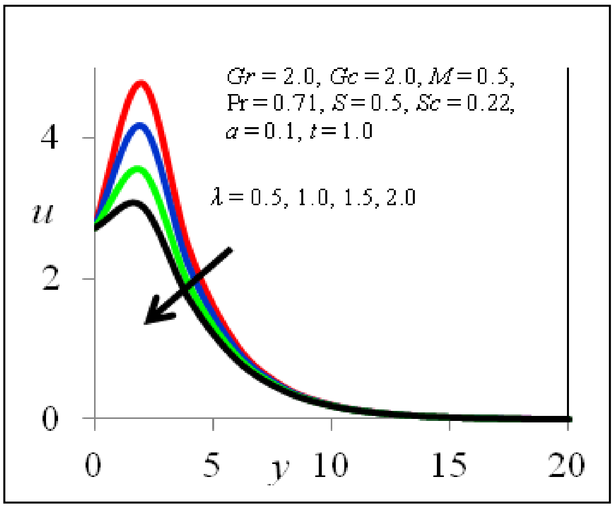

Fig. 4. Velocity profiles for different values of λ.

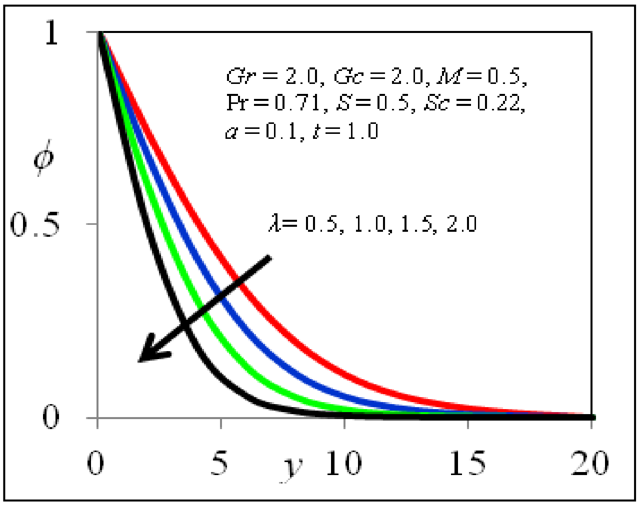

Fig. 5. Concentration profiles for different values of λ.

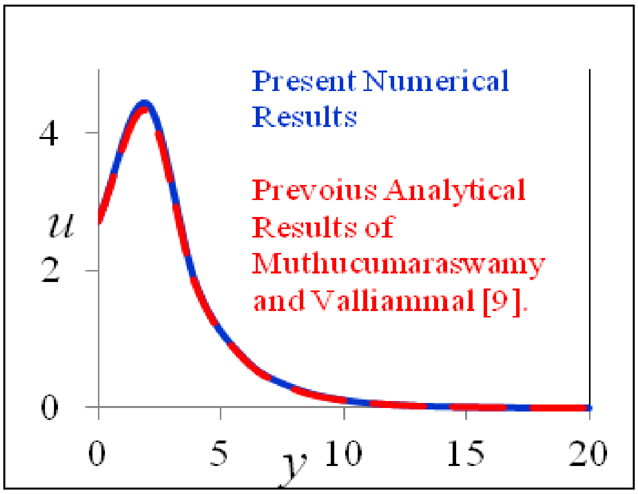

Fig. 6. Comparison of present numerical results with analytical results of Muthucumaraswamy and Valliammal [9].

In Fig. 3 the impact of expanding the magnetic field quality on the momentum boundary layer thickness is illustrated. It is currently an entrenched reality that the magnetic field shows a damping impact on the velocity field by making drag constrain that restricts the smooth movement, making the velocity diminish. Be that as it may, for this situation an expansion in the *M* just somewhat backs off the movement of the fluid far from the moving vertical plate surface towards the free stream velocity, while the fluid velocity close to the moving vertical plate surface declines. This wonder has an astounding concurrence with the physical reality that the Lorentz force created in the present stream display because of association of the transverse magnetic field and the liquid velocity goes about as a resistive power to the liquid stream which serves to decelerate the stream. Of course, the nearness of the chemical reaction altogether influences the fixation profiles and in addition the velocity profiles from Figs. 4 and 5. It ought to be referenced that the contemplated case is both for damaging and generative chemical reaction. Actually, as expands, the impressive decrease in the velocity profiles is anticipated, and the nearness of the peak shows that the most extreme estimation of the velocity happens in the body of the liquid near the surface yet not at the surface. Additionally, with an expansion in the chemical reaction parameter, the fixation diminishes. It is apparent that the expansion in the chemical reaction essentially modifies the fixation boundary layer thickness yet does not modify the momentum boundary layers. Fig. 6 shows the assessment of the velocity profiles in examination with the consequences of Muthucumaraswamy and Valliammal [9]. This Fig. 6 demonstrates a decent understanding between the outcomes and this loans support to the present numerical code.

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6. CONCLUSIONS

In this present examination, we considered the impact of chemical reaction on incompressible, viscous fluid stream past an exponentially quickened vertical plate with variable temperature in nearness of magnetic field. Finite element technique is utilized to incorporate the conditions administering the stream. From the present numerical examination, It was discovered that when the Grashof number for heat and mass transfer expanded, the fluid velocity expanded. The velocity, and concentration profiles inside the boundary layer diminishes with the expansion in estimations of the Chemical reaction parameter. As of now the creators are augmenting this work to ponder a few non-Newtonian liquids of enthusiasm for glass rheological warm preparing including viscoelastic models. The consequences of these examinations will be conveyed quickly.

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