Finite Element Solutions Of Jeffrey Fluid Flow Past A Vertically Inclined Plate In Presence Of Magnetic Field

R. Srinivasa Raju[1], G. Jithender Reddy[2] and Y. Sunitha Rani*

[1]*Department of Mathematics, GITAM, Hyderabad Campus, Rudraram, Medak (Dt), 502329,Telangana State, India.*

[2] *Department of Mathematics, VNR-VJIT, Hyderabad, Ranga Reddy (Dt), 500090, Telangana State, India.*

[*]*Department of Mathematics, Mallareddy Institute of Technology and Science, Maisammaguda, Dhulapally, Secunderabad, 500100, Telangana State, India.*

**Corresponding author:* ysunitarani@gmail.com

Abstract. A numerical analysis is conferred to investigate Jeffrey fluid behaviour on unsteady magneto fluid mechanics free convective flow over a past vertically inclined plate in with the presence of heat transfer study. The governing momentum and thermal physical phenomenon equations are reworked into a collection of partial differential equations and then solved numerically by the economical finite element technique. The behaviour of velocity and temperature has been discussed for variations within the governing parameters.

Keywords: MHD; Jeffrey fluid flow; Finite element technique;

1. INTRODUCTION

The study of non-Newtonian fluids has gained interest due to their in depth industrial and technological applications. However, the Navier Stokes equations are not any longer valid to exactly specific the physics behaviour of all non-Newtonian fluids. seeable of their variations with Newtonian fluids, many models of non-Newtonian fluids are projected. the foremost common and simplest model of non-Newtonian fluids is Jeffrey fluid that has time derivative rather than condemned derivative. The machine results of warmth supply associated thermal radiation on an unsteady generator fluid mechanics natural convective flow of fluid over a vertical plate that is infinite with the impact of concentration and gradient were studied by Raju et al. [1]. Ramya et al. [2]. mentioned the behaviour of nanofluid on physical phenomenon viscous flow over a nonlinearly equal stretching sheet within the presence of warmth generation/absorption, heat transfer and slip boundary conditions. Ramya et al. [3] found the rising machine solutions of generator fluid mechanics physical phenomenon nanofluid flow over a extended sheet with the presence of reaction and thermal radiation victimisation Keller-box technique. Keller-box solutions of generator fluid mechanics boundary layer partial slip flow of nanofluids over a nonlinear stretching sheet with suction/injection studied by Ramya et al. [4]. Raju et al. [5] studied the impact of angle of inclination on generator fluid mechanics flow of Casson fluid past over a vertical plate that is crammed with porous medium and also the presence of warmth flux, viscous dissipation and reaction by applying finite component technique. The study of magnetohydrodynamic free convection flow for non-Newtonian fluid past over a flat plate or surface has attracted the interest of the many researchers seeable of various non-Newtonian fluids like Stevens' power law [6], Jeffrey [7], Maxwell [8] models etc. there's associate another non-Newtonian fluid model, it's called Casson fluid, this model was introduced by Casson [9] for analyze the flow behavior of pigment oil and its suspensions of the printer's ink kind. Few authors ([10]-[13]) have studied on a vertical plate. Reddy [14] have studied associate unsteady MHD natural free convection fluid flow on associate periodic vertical plate embedded in a very porous media with the impact of some physical parameters. Double disseminating effects on MHD mixed convection casson fluid flow towards a vertically inclined plate crammed in porous medium in presence of biot range studied by Sailaja et al. [15] with the help of finite component technique. the present study is principally centered on unsteady MHD free convection flow of Jeffrey fluid flow past associate infinite vertically inclined plate saturated in a very porous medium. A numerical finite component technique is enforced to unravel the governing equations. Numerical results for rate and temperature profiles for varied pertinent parameters are planned diagrammatically and mentioned in details.

2. FORMULATION OF THE PROBLEM

let axis is taken to be on the plate and also the $y'-$axis normal to the plate. Since the plate is taken into account infinite in $x'-$direction, thence all physical quantities are freelance of $x'-$direction. we have a tendency to chosen the rate parts on x' and y' axes be u' and v' and that are within the upward direction on the plate and perpendicular to the plate respectively. The constant temperature (T'_w) maintained close to the plate that is over the close temperature. a consistent field of magnitude B_o is applied traditional to the plate. The transversal applied field of force and magnetic Reynold's range are assumed to be terribly tiny, so the induced field of force is negligible. contemplate an unsteady generator fluid mechanics free convection flow of a viscous, incompressible, electrically conducting fluid past a semi-infinite leaning porous plate with an angle to the vertical and applying Boussinesq's approximation, the continuity, momentum and energy equations of the flow will be written as:

$$\frac{\partial v'}{\partial y'} = 0 \Rightarrow v' = -v_o \text{ (Constant)} \tag{1}$$

$$\frac{\partial u'}{\partial t'} + v'\frac{\partial u'}{\partial y'} = g\beta(T' - T'_\infty)(\cos\alpha) + \left(\frac{\nu}{1+\lambda}\right)\frac{\partial^2 u'}{\partial y'^2} - \frac{\sigma B_o^2}{\rho}u' \tag{2}$$

$$\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial y'} = \frac{\kappa}{\rho C_p}\frac{\partial^2 T'}{\partial y'^2} \tag{3}$$

The boundary conditions of the problem are:

$$\left.\begin{array}{l} u' = 0,\ v' = -v_o,\ T' = T'_w + \varepsilon\left(T'_w - T'_\infty\right)e^{i\omega' t'} \text{ at } y' = 0 \\ u' \to 0,\ T' \to T'_\infty \text{ as } y' \to \infty \end{array}\right\} \tag{4}$$

Consider the non-dimensional variables and parameters as,

$$y = \frac{y' v_o}{\nu},\ t = \frac{t' v_o^2}{4\nu},\ \omega = \frac{4\nu\omega'}{v_o^2},\ u = \frac{u'}{v_o},\ M = \left(\frac{\sigma B_o^2}{\rho}\right)\frac{\nu}{v_o^2},\ \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty},\ \Pr = \frac{\nu\rho C_p}{\kappa},\ Gr = \frac{\nu g\beta\left(T'_w - T'_\infty\right)}{v_o^3} \tag{5}$$

Substituting (5) in equations (2) and (3) under boundary conditions (4), we get:

$$\frac{1}{4}\frac{\partial u}{\partial t} - \frac{\partial u}{\partial y} = (Gr)(\cos\alpha)\theta + \left(\frac{1}{1+\lambda}\right)\frac{\partial^2 u}{\partial y^2} - Mu \tag{6}$$

$$\frac{1}{4}\frac{\partial \theta}{\partial t} - \frac{\partial \theta}{\partial y} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} \tag{7}$$

The corresponding boundary conditions are:

$$\left.\begin{array}{l} u = 0,\ \theta = 1 + \varepsilon e^{i\omega t} \quad \text{at } y = 0 \\ u \to 0,\ \theta \to 0 \quad \text{as } y \to \infty \end{array}\right\} \tag{8}$$

3. RESULTS AND DISCUSSIONS

The governing dimensionless partial differential equations are solved by finite element methodology (Reddy [15]). The results of dimensionless terms like rate field u and temperature θ are nonheritable for variety of values of governing physical parameters, throughout the entire manipulation, we have a tendency to thought-about the value of Prandtl number Pr = 0.71, t = 1.0, $\omega t = \pi/2$, ε = 0.001, k = 0.01 and also the mesh size h = 0.1, wherever the domain of similarity variable lies between $0 < y < 9$. during this study, the influence of relatable parameter like magnetic field parameter M, Jeffrey fluid parameter λ, Grashof number for heat transfer Gr, Angle of inclination parameter α and Prandtl number Pr on flow field and thermal field are analyzed. The profiles of velocity and temperature of the fluid are shown within the Figs. 1, 2, 3, 4 and 5 severally. For numerous values of Grashof number for heat transfer on the rate of the fluid profiles are planned in Fig. 1. It's determined that a rise in Gr ends up in an increase within the values of velocity because of improvement in buoyancy force. Here, the positive values of Gr correspond to cooling of the plate. Additionally, it's determined that the velocity will increase sharply close to the wall of the plate as Gr will increase so decays to the free stream worth. Fig. 2. exhibits the result of magnetic field parameter on the velocity profiles with different parameters are fastened. It's determined that the velocity of the fluid decreases with the rise of the magnetic field parameter values. The decrease within the rate because the magnetic field parameter will increase is as a result of the presence of a magnetic field in an electrically conducting fluid introduces a force known as the Lorentz force, that acts against the flow if the magnetic flux is applied within the normal direction, as within the present study. This resistive force slows down the fluid rate component as shown in Fig. 2. Distributions are in the midst of coincidental reductions within the momentum physical phenomenon. The result of angle of inclination of the plate (α) on the rate field has been illustrated in Fig. 3. it's seen that, the fluid rate decreases because the angle of inclination of the plate will increase. The impact of Jeffrey fluid parameter on fluid rate is as shown within the Fig. 4. From this figure, we have a tendency to determined that Jeffrey fluid parameter will increase the rate profiles of flow field in any respect points.

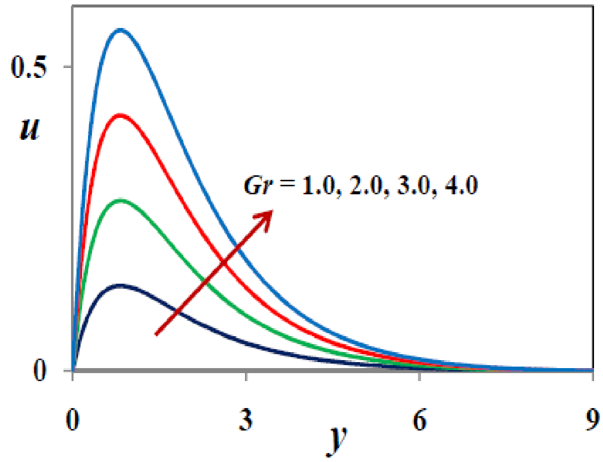

Fig. 1. Influence of *Gr* on velocity profiles

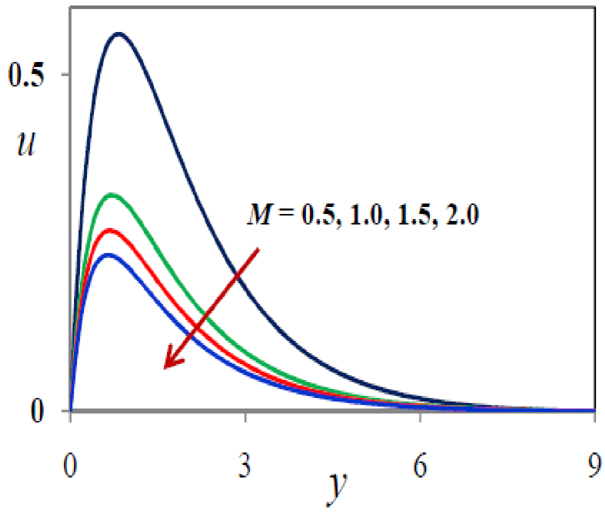

Fig. 2. Influence of *M* on velocity profiles

Fig 5. Shows the behaviour of temperature for various values of Prandtl number. It's determined that a rise within the Prandtl number results a decrease of the thermal physical phenomenon thickness and generally lower average temperature at intervals the physical phenomenon. the explanation is that smaller values of Pr are appreciate increase within the thermal physical phenomenon of the fluid and thus, heat is in a position to diffuse removed from the heated surface more rapidly for higher values of Pr. Hence, within the case of smaller Prandtl number because the thermal physical phenomenon is thicker and therefore the rate of heat transfer is reduced.

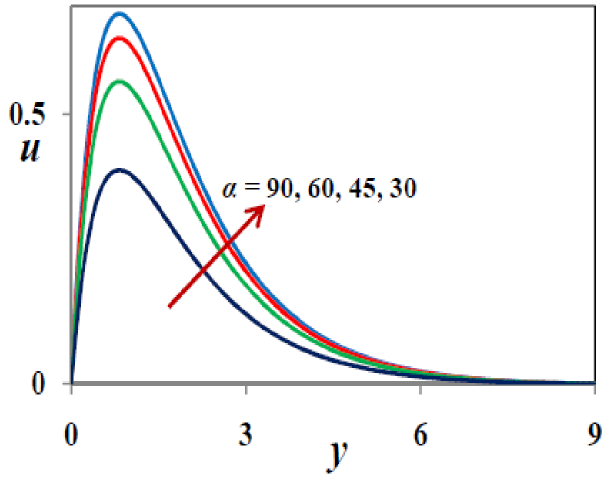

Fig. 3. Influence of α on velocity profiles

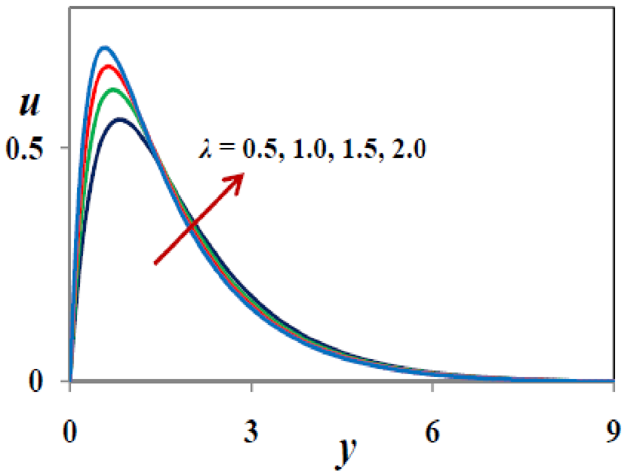

Fig. 4. Influence of λ on velocity profiles

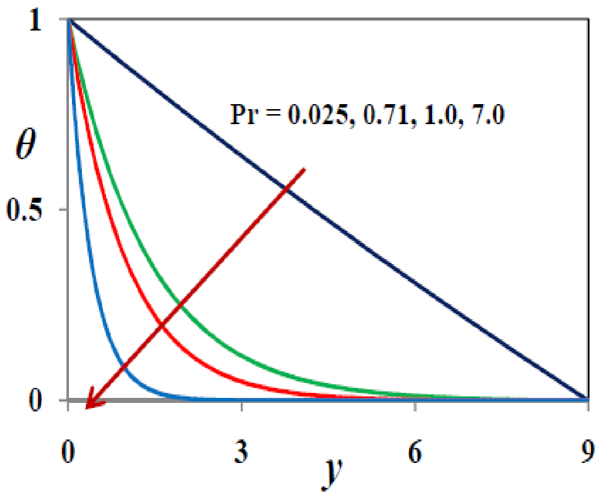

Fig. 5. Influence of Pr on temperature profiles

6. CONCLUSIONS

In this work, the combined influence of heat transfer and angle of inclination on unsteady magnetoelectric machine fluid mechanics flow of on a vertical plate presence of Jeffrey fluid are analyzed. From this investigation,the fluid rate will increase as increasing of Jeffery fluid parameter. The influence of applied magnetic flux reduces the velocity profiles whereas opposite behaviour is found for Grashof range for heat transfer. Angle of inclination parameter tends to retard the fluid rate throughout the physical phenomenon.

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