ADV MATH SCI JOURNAL

Advances in Mathematics: Scientific Journal **9** (2020), no.7, 4449–4469 ISSN: 1857-8365 (printed); 1857-8438 (electronic) https://doi.org/10.37418/amsj.9.7.15 Spec. Issue on RDESTM-2020

NUMERICAL INVESTIGATION OF MAGNETO-HYDRODYNAMIC FLOW OF NON-NEWTONIAN FLUID WITH A SHARP POROUS WEDGE IN PRESENCE OF THERMAL BOUNDARY LAYER

SANTOSH KUMAR DIXIT¹, RAMESH YADAV, AND AVINASH SHARMA

ABSTRACT. Numerical investigation of the MHD flow of non-Newtonian fluids with a sharp porous wedge in the existence of the thermal or heated boundary surface has been studied. The solution of non-linear partial differential equation procedure is a totally numerical analysis process and Matlab software with help of ode45 solver has been used for obtaining non-linear partial differential equations. In this investigation, we have investigated the effect of Magnetic parameter, Porous wedge parameter, Prandtl number, Reynolds Number, Porous parameter σ , and power-law index number 'n' on the velocity and heat transfer of fluids. The effects of various parameters of fluid flow and heat flow have been discussed numerically and presented graphically.

1. INTRODUCTION

The boundary layer flow of Newtonian and non-Newtonian fluid passed over a sharp porous wedge with a transverse magnetic field has caused an appreciable interest for its countless industrial and engineering applications, which consists of a boundary surface together with the fluid film, chemical engineering processes, polymerization processing, and other fields. Many fluids such as multiphase mixture, glues, paints, cosmetics, toiletries, and biological fluids are called non-Newtonian fluids. The application of partition surface theory to power-law pseudoplastic fluid: a similar solution has been presented by W. R.

¹corresponding author

²⁰¹⁰ Mathematics Subject Classification. 76A05.

Key words and phrases. Boundary layer flow, Non-Newtonian fluid, Power-law fluid, Prandtl number, Reynold number, Porous media.

S. K. DIXIT, R. YADAV, AND A. SHARMA

Schowalter (1960). They have developed second and third dimensional boundary surface equations for pseudo-plastic and non-Newtonian fluid which are distinguished by a power-law index connection in the middle of velocity gradient and shear loads or shear stress. The free convection flow of non-Newtonian fluid in the presence of a vertical embedded in a porous medium has been analyzed by Chen and Chen (1988). Magyari and Keller (1999) have been analyzed heat and mass movements in the partition surface on rapid changes stretching regular surface. They have described the similarity solution of the steady plane (flow and thermal) boundary layers on stretching regular surfaces with and exponential distributions and presented numerically and analytically. The heat and mass transfer characteristics have been discussed and results compared to other earlier authors.

The consequences of the Rayleigh complication for the power-law index of non-Newtonian running fluid via class or category method have been studied Abd-el-Malek., et al. (2002). They have presented the mobility flow of MHD flow or voltaic running Newtonian and non-Newtonian fluid of limitless size in a horizontal outer magnetic field. A contingent symmetry, the classical Lie approach, and contact symmetries have leads superior trimmings and obtained results to the differential equations just but not for the beginning and dividing merit difficulties since the formed state restriction be minimized. The unsteady mixed-convective partition surface flow of fluids together with a uniform wedge with varying surface temperature has been presented by Hossain et al. (2006). They have transformed non-dimensional form of the governing boundary layer differential equations, and formed a non-linear system of partial differential equations is decreased into neighborhood dissimilarity boundary surface differential equations, which is presented by the analytical procedure. The main focus of their analysis is the effects of parameters such as Nusselt number, skin friction parameter, and other parameters on the fluid velocity and fluid temperature. The thermally emission effect on fully enlarged mixed deportation or convective flow of fluid in a perpendicular passage has been presented by Grosan and Pop (2007). They have solved the governing equation both analytically and numerically and obtained that is the lack in reversal flow of fluid with lead in the radiation parameters.

The consequences of emission or radiation and varying viscosity fluid on flow and motion of heat together with a uniform wedge have been analyzed by

Mukhopadhyay (2009). A second and third-order combined ordinary differential equation structure with respect to the energy and momentum equation is found. They obtained that fluid velocity leads with lead of temperaturedependent liquid viscosity variable and temperature of fluids lacks with leads of radiation parameter and Prandtl number. The numerical investigation of forced convection porous wedge pass of non-Newtonian liquid has been studied by Suratiand and Timol (2010). Ishak et al. (2011) have been investigated in motion wedge together with a uniform plate in a power-law index model of fluid or liquid. They solved the transformed boundary difficulty using the numerical solutions for some variables. The results of these variables on the skin rubbing parameter have been presented. He has also obtained that many numerous solutions exist when liquid or fluid move in opposite directions, near the side of detachment or separation. Prasad et al. (2013) have been analyzed heat flow and momentum of a non-Newtonian rheological method (or Eyring-Powell) liquid or fluid on top of Non-isothermal stretching plates of sheets. They have solved the non-linear differential equation using a second-order implicit finite difference method or finite difference scheme which is known as the Keller-box approximation. He has found the effects of the parameter of non-Newtonian fluid, variable thermal conductivity parameter, Hartmann number parameter, Prandtl number, and Eckert number on the flow of fluids. The flow of fluids and heat transfers of an incompressible fluid over a non-isothermal porous stretching sheet is studied numerical approximation.

The Quantitative analysis of non-Newtonian fluid flow which passed and accelerated in a perpendicular infinite plate in the appearance of free convection currents has been presented by Patel et al. (2013). They have obtained the effects of Grashof number and Prandtl number on the fluid velocity. The results are that the velocity of the liquid, leads to the class of similarity solution of the problem. The investigated the heated boundary partition surface of non-Newtonian fluid along a wedge has been presented by Manju Bisht and Anirudh Gupta (2014). They have studied the effects of some various parameters of the flow of fluid and heat flow characteristics discussed and analyzed graphically. The heat flows of a non-Newtonian and Newtonian fluid in mechanically agitated vessels have been presented by Ansar Ali et al. (2014). The heat transfer parameter has been calculated using Wilson graphical techniques with the improvement or modification which is suggested by Om Prakash et all. The heat

S. K. DIXIT, R. YADAV, AND A. SHARMA

transfer data for agitated water and 1, 2, and 4% aqueous CMS for impellor have been correlated by the equations with standard deviations The two variable Lie group study and Quantitative analysis of the unsteady free convective flow of non-Newtonian fluid have been presented by Uddin et al. (2016). They have solved the equation using a Runge-Kutta-Fehlberg fourth-fifth order quantitative method by shooting techniques. The velocity, temperature, and concentration of fluid have shown graphically. Umar Khan et al. (2017) have analyzed the non-linear propagation effects on the flow of nanofluid passed above the permeable wedge in the appearance of electrically conducting field. They have solved the non-linear differential equation with the help of the Runge-Kutta-Fehlberg method which is coupled by a shooting method. The effects of the various variables such as skin rubbing variable, local Nusselt number, and Sherwood number on fluid velocity, temperature, and concentration profiles using graphically.

Ramesh Yadav (2017) has been investigated the Analytical study of the magnetohydrodynamic flow of condensed adhesive fluid between equidistance plates in which one of a porous and other is rigid bounding wall. He has found the effects of Hartmann number M, wall Slip coefficient, Reynolds Number, and thickness of the medium or channel on the velocity component of fluids. Navneet Kumar Singh and Ramesh Yadav (2017) have been analyzed the investigation of heat Transfer of non-Newtonian liquids in appearance a porous barrier or porous wall. They have been presented the effect of permeable variable 'k', Prandtl number 'Pr', Reynold number 'Re', on the fluid velocity and heat flow. The Quantitative Study of MHD flow of non-Newtonian fluid along a sharp wedge in the existence of the hot boundary surface has been presented by Yadav et al (2018). They have obtained the non-linear partial differential equations with the assist of MATLAB software by ode 45 solver. They have got that the fluid velocity enhances with the enhancement of the magnetic variable M and reciprocal effects of heat flow with leads of magnetic variable M, and the various output has been found graphics. Dixit et al. (2018) have been studied Quantitative investigation of MHD flow with variable liquid viscosity and heat motion in the appearance of symmetrical porous Wedge. They have obtained the various parameters Hartmann number M, Prandtl Number Pr, Radiative Heating Parameter Q, porous wedge parameter, and Falkner Skan exponent m on the velocity of fluids and Heat Transfer of Fluid. They have found that radial and axial velocity of fluid

leads sharply with a lead of Magnetic variable, porous wedge parameter, and reciprocal effect with leads of temperature-depending adhesive viscosity variable A, Falkner Skan Exponent parameter m. The heat transfer of fluid lacks sharply with leads of Falkner Skan exponent parameter, Magnetic Parameter M, porous wedge parameter, and Prandtl number Pr, whereas heat transfer leads with the lead of radiative heating parameter Q. The important application of this difficulty is associated in engineering fields and post accidental heat removal fields.

The MHD partition surface flow, which passes a wedge with heat flow and viscous Effects of Nanofluid inserted in permeable medium, has been analyzed by Ibrahim et al. (2019). Pandey et al (2020) have been presented the quantitative study of variable fluids, which passed through a uniform sharp wedge in the appearance of a perpendicular magnetic field. They have found the radial and axial velocity of fluid leads with a lead of magnetic variable M, whereas the reciprocal effect on the heat transfer of the fluid. Jabeen et al. (2020) have been studied the analysis of MHD fluids on all sides linearity be an elastic sheet in permeable medium with the thermophoresis propagation and chemical reaction. They analyzed thoroughly the behavior of velocity, temperature, and concentration. They have also obtained the heat and mass transfer surveys have been carried out theoretical as well as graphical and numerical approaches.

In this paper, we investigated the MHD flow of the non-Newtonian fluid with a sharp porous wedge in the appearance of the thermal partition surface problem. The results obtained numerically. After this resulting coupled ordinary non-linear differential equations are obtained using analytical techniques and solving by MATLAB application with the assist of an ode45 solver. The result was stated for velocity and temperature distribution of the various parameters by graphics.

For further reference see [1–9].

2. MATHEMATICAL FORMULATION

Let us assume that the stationary coordinated system. u and v be the velocity of the fluid in x and y direction respectively, in this, we have considered to a steady-state two-dimensional coordinate system of laminar flow for incompressible or concentrated non-Newtonian fluid, which obey the power-law index representation or model, and fluid is running above a sharp absorbent wedge with rigid or stable wall temperature Tw. The governing equations of partition surface flow are The progression equation

(2.1)
$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0.$$

The momentum and energy equation is given below

(2.2)
$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial x} = U\frac{\partial U}{\partial x} + \frac{1}{\rho}\frac{\partial \tau_{xy}}{\partial x} - \frac{\mu}{\rho k}u - \frac{\sigma_e B_0^2}{\rho}u,$$

(2.3)
$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha \frac{\partial^2 T}{\partial x^2},$$

with the boundary conditions

$$AT \quad y = 0; u = v = 0 \quad and \quad T = T_w$$
$$AT \quad y \to \infty; u \to U(x) = cx^m \quad and \quad T = T_\infty$$
$$AT \quad x = 0; u = U_\infty \quad and \quad T = T_\infty.$$

Where u and v is the corresponding velocity constituent in the x and y directions of the liquid flow, v stand as the kinematic fluid adhesiveness or viscosity and U stands as reference velocity of the fluid at the border of partition surface and it is a reason or function of x only, $m = \frac{\beta}{2\pi - \beta}$ is the sharp porous wedge parameter and β represent the wedge angle, ρ stand for the density of fluids and α represents the thermal spreading rate of fluid, T is the temperature is near the porous wedge.

For the power-law index fluids, the shearing is represented as

$$\tau_{xy} = K(\frac{\partial u}{\partial y})^n \,.$$

Thus the equation (2.2) becomes

(2.4)
$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = U\frac{dU}{dx} + \frac{k}{\rho}\frac{\partial}{\partial y}\left(\frac{\partial u}{\partial y}\right)^l - \frac{\mu}{\rho K}u - \frac{\sigma_e B_0^2}{\rho}u, \ l = 1, 2, \dots$$

In this study, we employ the following conversion; utilized to ease of the solution of the governed equation is given by

(2.5)
$$\psi = \left(\frac{Kx}{\rho}\right)^{\frac{1}{(n+1)}} [U(x)]^{\left(\frac{(2n-1)}{(n+1)}\right)} f(\lambda)$$

(2.6)
$$\lambda = \left[\frac{\left(\rho U(x)^{(2-n)}\right)}{Kx}\right]^{\binom{(n+1)}{2}} y$$

(2.7)
$$\theta = \frac{T - T_{\infty}}{T_w - T_{\infty}}.$$

Stream functions are

(2.8)
$$u = \frac{\partial \varphi}{\partial y} \quad and \quad v = \frac{-\partial \varphi}{\partial x}$$

Where λ stands for the similarity parameter and $f(\lambda)$ and $\theta(\lambda)$ is similarity depending variables for fluid flow and heat flow.

Now equation (2.1) is satisfied automatically. Substituting Equations (2.5), (2.6), (2.7), (2.8) into momentum equation (2.4) and energy equation (2.3) changes or lead to given differential equations:

$$f'''(\lambda) + \frac{2mn - m + 1}{n(n+1)} f(\lambda) [f''(\lambda)]^{(2-n)} + \frac{m}{n} [1 - f'(\lambda)^2] [f''(\lambda)]^{(1-n)}$$
$$\frac{-\mu cx}{KnU^2} [f''(\lambda)]^{(1-n)} f'(\lambda) - \frac{\sigma_e B_0^2}{\rho Cn} x^{1-m} [f''(\lambda)]^{(1-n)} f'(\lambda) = 0$$

or

(2.9)
$$f''' + \eta f(f'')^{(2-n)} + \frac{m}{n} [1 - (f')^2] (f'')^{((1-n))} - \sigma^2 (f'')^{(1-n)} f' - M^2 [f'']^{(1-n)} f' = 0$$

(2.10)
$$\theta'' + \eta f P r R e \theta = 0,$$

where $\eta = \frac{2mn-m+1}{n(n+1)}$, $\sigma^2 = \frac{\mu cx}{KnU^2}$, $Re = \frac{R}{R_{(n,x)}^{\frac{2}{n+1}}}$, the generalized Reynold number for non-Newtonian fluids is represented as $R_{(n,x)} = \frac{x^n U^{(2-n)}}{u}$ and $R = \frac{xU}{u}$ and $Pr = \frac{(\rho \mu C_p)}{K}$ which stands the Reynolds number and Prandtl number correspondingly.

The above differential equations partition condition is associated as:

(2.11)
$$f' = 0, f = 0, \theta = 1, \text{ for } \lambda = 0;$$

(2.12) and $f' = 1, \theta = 0, \text{ for } \lambda = \infty;$

here prime notation represented as the differentiation with respect to nondimensional parameter λ . For the Newtonian fluid the power law index number for fluid is one or n=1 and m=0. Equation (2.9) and (2.10) may reduced to (2.13)

$$f^{'''} + \frac{1}{2}(m+1)f(f^{''})^{(2-n)} + \left[1 - (f^{'})^2\right](f^{''})^{(1-n)} - \sigma^2(f^{''})^{(1-n)}f' - M^2(f^{''})^{(1-n)}f' = 0,$$
 or

(2.14)
$$f''' + \frac{1}{2}(m+1)ff'' + [1-(f')^2] - \sigma^2 f' - M^2 f' = 0,$$

(2.15)
$$\theta'' + \frac{1}{2}Pr(m+1)Ref\theta' = 0,$$

where $\sigma^2 = \frac{\mu cx}{KU^2}$, is permeability of porous wedge. Here the importance of physical quantity of attentiveness is the Nusselt number Nu which is represented as

(2.16)
$$Nu_x = \frac{q_w x}{(T_0 - T_\infty)K} = -\theta'(0)Re_{(n,x)}^{\frac{2}{(n+1)}}$$

On solving above ordinary differential equation (2.15), involving the above boundary surface condition (2.11) and (2.12), we obtained the results given below.

(2.17)
$$\theta = e^{-\frac{1}{2}Pr(m+1)Ref(\lambda))}.$$

3. METHOD OF SOLUTION

In this analysis, we study and obtain the solution of the non-linear differential equation (2.13), (2.14) and (2.17) quantitatively numerically with the assist of MATLAB operating system to ode45 solver. We have solved a set of differential equations with the sketched partition condition which is stated in differential equations (2.11) and (2.12). In this analysis the proposed of the time-space or interval (0, 10) with to begin state vector (0, 0, 1) has been lay hold of for merging basis or meeting basis options has been taken ('Rel Tol', 1e-4,' Abs Tol', [1e-4 1e-5]). The non-identical sets of parameters have been taken and presented the obtained analysis. Enlarge or stretch of non-dimensional parameter λ ($0 \ge \lambda \le 10$), the permeable parameter σ has been chosen (1, 2, 3, 4, 5), Permeable wedge variable m has been taken 1, 2, 3, 4). The field of

non-dimensional parameter λ ($0 \ge \lambda \le 10$), the utility of Reynolds number Re has been chosen 1, 2, 3, 4, 5), Prandtl number Pr has been chosen (1, 2, 3, 4, 5), power-law index n have been chosen 1, 2, 3, 4). Different graphs, which has been sketched or reported sets of variables and talked about the obtained analysis.

4. RESULTS AND DISCUSSIONS

Here in the above non-linear ordinary differential equations (2.13), (2.14), (2.15) has integrated under the subject (2.11), (2.12) by numerical analysis or quantitative procedure, with the assist of ode45 solver, and obtain the numerical outcome with the help of graphs. The numerical outcomes are found to analyze the outcome of different values of the Reynolds number Re, permeable wedge parameter m, Porous law index parameter n, Prandtl number Pr, and Magnetic parameter M on dimensionless radial and axial velocity components of non-Newtonian fluids and non-dimensional temperature descriptions. Figure 1 represents the graph in the middle of axial velocity components of non-Newtonian fluids $f(\lambda)$ against dimensionless parameter λ at constant variables $(n = 2, m = 2/9, \sigma = 0)$; it is obtained that the axial velocity component of fluids leads with a lead of Magnetic variable M (1, 2, 3, 4, 5). Figure 2 represents graph in the middle of axial velocity components of non-Newtonian fluids $f(\lambda)$ against dimensionless parameter λ at constant variables (n = 2, m = 2/9, $\sigma = 3$; it fallows that velocity component of fluids leads sharply with a lead of Magnetic parameter M (1, 2, 3, 4, 5) as compared to figure 1 ($\sigma = 0$).

Figure 3 represents sketch in the middle of axial velocity components of non-Newtonian fluids $f(\lambda)$ against non-dimensional variable λ at constant variables (n = 3, m = 2/9, σ = 3); it fallow that axial velocity leads slowly with the lead of Magnetic variable M (1, 2, 3, 4, and 5). Figure 4 represents graph between radial velocity components of non-Newtonian fluids f '(λ) against nondimensional variable λ at constant variables (n = 2, m = 2/9, σ = 3); it is obtained that radial velocity leads sharply with the lead of Hartmann Numer or Magnetic variable M (1, 2, 3, 4, and 5). Figure 5 represents graph in the middle of axial velocity components of non-Newtonian fluids f (λ) against nondimensional parameter λ at constant variables (n = 3, m = 2/9, M = 4); it is obtained that axial velocity leads sharply with the lead of porous wedge variable

S. K. DIXIT, R. YADAV, AND A. SHARMA

 σ (1, 2, 3, 4, and 5). Figure 6 represents graph between the velocity of fluids f (λ) against non-dimensional parameter λ at constant variables (n = 3, m = 2/9, M = 4); it obtained that velocity of non-Newtonian fluids enhances with the enhance of porous wedge variable σ (1, 2, 3, 4, and 5).

Figure 7 and Figure 8 represents graph between axial velocity component $f(\lambda)$ and radial velocity component f' (λ) of non-Newtonian fluids in opposition to dimensionless variable λ at constant variables ($\sigma = 4$, m = 2/9, M = 4); it is found the axial velocity component and radial velocity component of non-Newtonian fluid lacks sharply with leads of power-law index parameter n (1, 2, 3, 4). Figure 9 represents graph between heat transfer of fluids $\theta(\lambda)$ against dimensionless variable λ at sustained parameter ($\sigma = 4$, m = 2/9, Re = 0.5, Pr = 2, n = 3; it is found that flow of heat of non-Newtonian fluids decreases sharply with leads of magnetic variable M (1, 2, 3, 4, and 5). Whereas from figure 10 represents graph between the heat transfer rate of non-Newtonian fluids $\theta'(\lambda)$ against dimensionless variable λ at constant parameter or variables ($\sigma =$ 4, m = 2/9, Re = 0.5, Pr = 2, n = 3; it follows that the heat transfer rate of non-Newtonian fluids slowly increases with an enhance of Hartmann number variable M (1, 2, 3, 4, 5). Figure 11 represents graph between heat transfer rate of non-Newtonian fluid θ (λ) against dimensionless variable λ at constant variables (M = 4, m = 2/9, Re = 0.5, Pr = 2, n = 3); it is found that heat transfer of non-Newtonian fluids lacks sharply with the increase of porous wedge parameter σ (1, 2, 3, 4, and 5). Whereas figure 12 represents graph between the heat transfer rate of non-Newtonian fluid θ '(λ) against dimensionless variable λ at constant variables (M = 4, m = 2/9, Re = 0.5, Pr = 2, n = 3); it is seen that heat transfer rate of the non-Newtonian fluid increases slowly with the increase of porous or permeable wedge parameter σ (1, 2, 3, 4, and 5).

Figure 13 represents graph between heat transfer of fluids $\theta(\lambda)$ against dimensionless variable λ at constant variables (M = 4, m = 2/9, Re = 0.5, σ = 4, n = 3); it has obtained that heat flow rate of non-Newtonian fluids decreases with the enhance of Prandtl number Pr (1, 2, 3, 4, and 5). Whereas figure 14 represents graph between heat transfer rate of non-Newtonian fluids $\theta'(\lambda)$ against dimensionless variable λ at constant variables (M = 4, m = 2/9, Re = 0.5, σ = 4, n = 3); it is put out that heat transfer rate of non-Newtonian fluid leads slowly with the lead of Prandtl number Pr(1, 2, 3, 4, and 5). Figure 15 represents graph between heat transfer rate of fluid $\theta(\lambda)$ against dimensionless



FIGURE 1. Graph in the middle of Velocity of fluid $f(\lambda)$ against non-dimensional parameter λ with variation of Magnetic variable M (Hartmann Number) with constant parameter n = 2, m = 2/9 and σ =0.

variable λ at constant variables (M = 4, m = 2/9, Pr = 2, σ = 4, n = 3); it is found that heat transfer rate of fluid lacks sharply with the lead of Reynolds number Re (1, 2, 3, 4, and 5). Whereas figure 16 represents graph between the heat transfer rate of non-Newtonian fluids θ '(λ) against dimensionless variable λ at constant variables (M = 4, m = 2/9, Pr = 2, σ = 4, n = 3); it is followed that heat transfer rate of non-Newtonian fluids enhances slowly with enhancing of parameter Re (1, 2, 3, 4, and 5).

Figure 17 represents graph between the heat flow rate of non-Newtonian fluids $\theta(\lambda)$ against dimensionless variable λ at constant variables (M = 4, m = 2/9, Pr = 2, σ = 4, Re = 0.5); it is found that heat flow of non-Newtonian fluids reduces sharply with the lead of power-law index variable n (1, 2, 3, 4) which means the increase of non-Newtonian coefficients. Figure 18 represents graph between heat transfer rate of non-Newtonian fluids $\theta(\lambda)$ against dimensionless variable λ at constant or sustained parameter (M = 4, n = 2, Pr = 2, σ = 4, Re = 0.5); it is obtained that heat flow of non-Newtonian fluids enhances sharply with leads of porous wedge variable m (1/9, 3/9, 5/9, 7/9, 9/9).



FIGURE 2. Graph in the middle of Velocity of fluid $f(\lambda)$ against non-dimensional parameter λ with variation of Magnetic variable M (Hartmann Number) with constant parameter n = 2, m = 2/9 and $\sigma = 3$.



FIGURE 3. Graph in the middle of Velocity of fluid $f(\lambda)$ against non-dimensional parameter λ with variation of Magnetic variable M (Hartmann Number) with constant parameter n = 3, m = 2/9 and σ =0.



FIGURE 4. Graph in the middle of Velocity of fluid $f'(\lambda)$ against non-dimensional parameter λ with variation of Magnetic variable M (Hartmann Number) with constant parameter n = 2, m = 2/9 and $\sigma = 3$.



FIGURE 5. Graph in the middle of Velocity of fluid $f(\lambda)$ against non-dimensional parameter λ with variation of porous variable σ (1,2,3,4,5) at constant parameter n = 3, m = 2/9 and M=4.



FIGURE 6. Graph in the middle of Radial velocity of fluid f '(λ) against non-dimensional variable λ with variation of porous variable σ (1,2,3,4,5) at constant parameter n = 3, m = 2/9 andM=4.



FIGURE 7. Graph in the middle of Axial velocity of fluid $f(\lambda)$ against non-dimensional variable λ with variation of power law index variable n(1,2,3,4) at constant parameter m = 2/9,M=4, σ =4.

NUMERICAL INVESTIGATION OF MAGNETO-HYDRODYNAMIC FLOW ...



FIGURE 8. Graph in the middle of Axial velocity of fluid f '(λ) against non-dimensional variable λ with variation of power law index variable n(1,2,3,4) at constant parameter m = 2/9, M=4, σ =4.



FIGURE 9. Graph in the middle of Heat transfer of fluids $\theta(\lambda)$ against non-dimensional variable λ with variation of magnetic variable M (1, 2, 3, 4, 5) at constant parameter n = 3, m = 2/9, Pr=2, σ =4, Re = 0.5.



FIGURE 10. Graph in the middle of temperature profile of fluids $\theta'(\lambda)$ against non-dimensional variable λ with variation of magnetic variable M (1, 2, 3, 4, 5) at constant parameter n = 3, m = 2/9, Pr=2, σ =4, Re = 0.5.



FIGURE 11. Graph in the middle of temperature profile of fluids $\theta(\lambda)$ against non-dimensional variable λ with variation of porous variable σ (1, 2, 3, 4, 5) at constant parameter n = 3, m = 2/9, Pr=2, Re = 0.5, M = 4.



FIGURE 12. Graph in the middle of temperature profile of fluids $\theta'(\lambda)$ against non-dimensional variable λ with variation of porous variable σ (1, 2, 3, 4, 5) at constant parameter n = 3, m = 2/9, Pr=2,Re=0.5,M=4.



FIGURE 13. Graph in the middle of temperature profile of fluids $\theta(\lambda)$ against non-dimensional variable λ with variation of Prandtl number Pr (1, 2, 3, 4, 5) at constant variables n = 3, m = 2/9, M = 4, σ =4, Re = 0.5.



FIGURE 14. Graph in the middle of temperature profile of fluids $\theta'(\lambda)$ against non-dimensional variable λ with variation of Prandtl number Pr (1, 2, 3, 4, 5) at constant variables n = 3, m = 2/9,M=4, σ =4, Re = 0.5.



FIGURE 15. Graph in the middle of temperature profile of fluids $\theta(\lambda)$ against non-dimensional variable λ with variation of variable Re (1, 2, 3, 4, 5) at constant parameter n = 3, m = 2/9, Pr=2, σ =4, M = 4.



FIGURE 16. Graph in the middle of temperature profile of fluids $\theta'(\lambda)$ against non-dimensional variable λ with variation of variable Re (1, 2, 3, 4, 5) at constant parameter n = 3, m = 2/9, Pr=2, σ =4, M = 4.



FIGURE 17. Graph in the middle of temperature profile of fluids $\theta(\lambda)$ against non-dimensional variable λ with variation of power law index n (1, 2, 3, 4, 5) at constant parameter M = 4, m = 2/9, Pr= $2,\sigma=4$, Re = 0.5.



FIGURE 18. Graph in the middle of temperature profile of fluids $\theta(\lambda)$ against non- dimensional variable λ with variation of porous wedge variable m (1/9, 3/9, 5/9, 7/9, 9/9) at constant parameter n = 2, M = 4,Pr=2, σ =4, Re = 0.5.

5. CONCLUSION

In this paper, we have done a numerical investigation of non-Newtonian fluid flow with a sharp permeable porous wedge in the appearance of the thermal partition surface. In this study the main aim to investigate the consequences of variables such as M, n, m, Pr, Re on the fluid velocity of the non-Newtonian liquid and heat flow; it has been obtained that radial and axial velocity of non-Newtonian fluids leads sharply with the lead of Magnetic variable 'M', porous wedge parameter ' σ ' whereas the reciprocal effects on velocity component of fluids with the lead of power-law index variable n. The heat transfer of non-Newtonian fluid lacks sharply with the leads of Reynolds number 'Re', Prandtl Number 'Pr', magnetic variable 'M', power-law index variable 'n' and reciprocal change in the heat transfer of non-Newtonian fluid with the lead of permeable wedge parameter or porous wedge parameter 'm'.

REFERENCES

[1] A. ISHAK, R. NAZAR, I. POP: *Moving wedge and flat plate in a power-law fluid*, International Journal of Non-linear Mechanics, **46** (2011), 1017–1021.

- [2] S. K. ANSAR ALI, L. P. SINGH, S. N. GUPTA: Heat transfer to Newtonian and non-Newtonian fluids in mechanically agitated vessel, International Journal of Scientific Engineering and Technology Research (IJSETR), 3(14) (2014), 3031–3035.
- [3] E. MAGYARI, B. KELLER: Heat and mass transfer in the boundary layer on an exponentially stretching continuous surface, Journal of Physics D: Applied Physics, **32** (1999), 577–585.
- [4] H. C. SURATIAND, M. G. TIMOL: Numerical study of forced convection wedge flow of some non-Newtonian fluids, International Journal of Applied Mathematics and Mechanics, 6(18) (2011), 50–65.
- [5] H. T. CHEN, C. K. CHEN: Free convection of non-Newtonian fluids along a vertical plate embedded in a porous medium Transactions of ASME, Journal of Heat Transfer, 110 (1988), 257–260.
- [6] K. JABEEN, M. MUSHTAQ, R. M. AKRAM MUNTAZIR: Analysis of magneto hydrodynamic fluids around a linearly stretching sheet in porous media with thermophoresis, radiation and chemical reaction, Hindawi publication, Mathematical Problems in Engineering, 2020 Article ID 9685482, 1–14.
- [7] M. BISHT, A. GUPTA: Investigation of thermal boundary layer of non-Newtonian fluid past over a wedge, International Journal for Research in Applied Science and Engineering Technology (IJRASET), 2(4) (2014), 76–82.
- [8] K. V. PRASAD, P. S. DUTTI, B. T. RAJU: Momentum and heat transfer of a non-Newtonian Eyring-Powell fluid over a Non-isothermal stretching sheet, International Journal of Mathematics Archive, 4(1) (2013), 230–241.
- [9] M. B. ABD-EL-MALEK, N. A. BADRAN, H. S. HASSAN: Solution of the Rayleigh problem for a power law non-Newtonian conducting fluid via group method, Int. Jour Eng. Sci., 40 (2002), 1599–1609.

AMITY SCHOOL OF ENGINEERING AND TECHNOLOGY AMITY UNIVERSITY PATNA, BIHAR, INDIA Email address: skdixit4444@gmail.com

DEPARTMENT OF MATHEMATICS BABU BANARASI DAS NATIONAL INSTITUTE OF TECHNOLOGY AND MANAGEMENT LUCKNOW, U. P. INDIA

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING MAHARISHI MARKANDESHWAR UNIVERSITY (DEEMED UNIVERSITY) Ambala, Haryana, India