10.48047/jocaaa.2024.33.05.87

# Numerical solution of Heat Generation Effect on MHD Flow nearStagnation Point towards a Stretching Sheet inPorous Medium

**[1]Penthala Rajitha, [2]S Karunakar Reddy**
[1]sar.telangana@gmail.com
[2]karunakarreddy.shadagonda@gmail.com
[1,2] Assistant Professor, Department of Mathematics,
St.Mary's Group of Institutions Hyderabad.

## Abstract

In this paper, the mai obejective of this workis to investagate the steady of two dimensional MHD flow near the stagnation point towards a streching sheet in a porous medium in an electrically conducting, viscous incompressible fluid with heat generation and transverse magnetic field.The governing nondimensional equation are transformed into set of coupled non linear ordinary differntial equations by using similarty transformations and then by using MATLAB in built solver bvc5c to obatin the approximate numreical results. With the help of nondimensional parameters the out comes of the velocity an temperature profiles have discussed through graphs and also the local skin-friction coefficient and the local Nusselt numberare presented via tables.

**Keywords:**stagnation point, MHD, bvc5c, Heat genertion, Magnetic field.

## Introduction

In recent years, the study of flow over a stretching surfacehas produced much interest many industrial applications in engineering,such as wire drawing, extrusionof polymer sheets, artificial fibers,rolling andmanufacturing plastic films.When the velocity of the fluid flow is zero, the stagnation point accurence on the surface of a body immersed in the fluid. It defining the fluid motion near thestagnation region, happens on all solid bodies moving in afluid. The stagnation region encounters the highest heat transfer, the highest pressure,and the highest rates ofmass testimony.Makinde et .al[1] was the main who thought about flow of an incompressible viscous fluid over a stretching sheet, an analytical soluition of the steady two-dimensional boundary layer fluid issues. Hassaniet,al[2],Bhattacharyya and Layek[3], Mahapatra, and Gupta[6], Anwar et.al[8],Bal Reddy et.al[9], talked about the influencesof heat transfer on a stretching surface taking into account various phases of the problem.B.ShankarGoud[4] presented the MHD flow past a vertical oscillating plate with radiation and chemical reaction in porous medium. Achi Reddy and Shankar [5] studied the magneto hydrodynamics stagnation point flow of a nano fluid over an exponentially stretching sheet with an effect of chemical reaction, heat source and suction/injunction. Attia[7],discussed on stagnation point flow towards a stretching surface through a porous medium with heat generation. Bhattacharyya et.al [10], Chaudhary [11],Pullet andWeidman[12] are investigated on slip effects on boundary layer stagnation-point flow and heat transfer towards a shrinking sheet in the porous medium.

In this paper focuses the heat generation effect on MHD flow near stagnation point towards a stretching sheet in porous medium. The governing equations are transformed to set of coupled non-linear equations. The effect of the governing parameter on the velocity and temperature are presented through graphs.

## Mathematical Formulations

10.48047/jocaaa.2024.33.05.87

Consider the steadystagnation pointflow along a stretching sheet which is place in an ellectrically conducting the plane $y = 0$, and flow is viscous incompressible. The flow is in th region,when $y > 0$space over the plane sheet is loaded up with the porous medium medium within the sight of an externally connected magnetic field of constant strength $B_0$ perpendicular to the sheet. Along the $x$-axis, two equal and opposing the forces are applied to the stretch sheet and origine is fixed is fixed. It has the linear velocity $u_w(x)$ and uniform temperature $T_w$ while the velocity of the fluid external to the boundary layer is $u_e(x)$ and temperature $T_\infty$.The velocity profile in the frictionless flow close to the stagnation point is given by $U(x) = ax$, and $V(x) = -ay$ ,where $U,V$ are the velocity components along the $x, y$ and $a > 0$ is a constant, which is comparative to the free strean velocity far away from sheet. The Governing equations are give by

Continuity equation: $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ …(1)

Momentum equation: $u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y} = \upsilon\frac{\partial^2 u}{\partial y^2} + U\frac{\partial U}{\partial x} + \frac{\upsilon}{K}\left[U(x) - u\right] - \frac{\sigma u B_0^2}{\rho}$ …(2)

Energy equation: $u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2} - Q\left[T - T_\infty\right]$…(3)

The proper boundary condition are given by

$$u = u_w(x) = cx \quad v = 0 \quad T = T_w \quad at\ y \to 0$$
$$u \to u_e(x) = ax, \quad T \to T_\infty, \quad as\ y \to \infty \qquad \ldots (4)$$

Now by defining the stream functions $u = \frac{\partial \psi}{\partial y},\ v = -\frac{\partial \psi}{\partial x}$ are satisfies the equation (1). Next, introduce the similarity transformations

$\psi = \sqrt{c\upsilon}xf(\eta)$ , $T = T_\infty + (T_w - T_\infty)\theta(\eta)$ where $\eta = y\sqrt{\left(c/\upsilon\right)}y$. Using the dimensionless and similarity variables, eqns.(2) and (7) reduce to the following form:

$$f''' + ff'' - (f')^2 - (\lambda + M)f' + C(\lambda + C) = 0 \qquad \ldots (8)$$

$$\theta'' + \Pr\left(f\theta' + B\theta\right) = 0 \qquad \ldots (9)$$

The boundary conditions becomes in the following form:

$$f = 0, f' = 1, \theta = 1, \quad at\ \eta \to 0$$
$$f' \to C, \theta \to 0, \quad as\ \ \eta \to \infty \qquad \ldots (10)$$

Where prime denotes diff. with resp. to η. Where $\Pr = \frac{\mu C_p}{k}$ (Prandtl number),

$\lambda = \frac{\upsilon}{cK}$ (Porosity parameter), $M = \frac{B_0^2\sigma}{\rho c}$ (Magnetic parameter), $C = \frac{a}{c}$ (Stretching parameter) ,

$B = \frac{Q}{C_p \rho c}$ (Heat generation or absorption coefficient).

10.48047/jocaaa.2024.33.05.87

**Solution of the problem**

The set of nonlinear ordinary differential Eqs. (8-9) along withboundary conditions (10) are incorporated with the help of MATLAB tool bvp5c. To obtain this,the coupled ordinary differential equationsare first reformed to firstorderordinary differential equations. Utilizing the succeeding substitutions.The margin was stable to $10^{-6}$.In this strategy, the choice of $\eta_\infty = 6$, ensures that each numerical solution approach asymptotic qualities precisely.The interesting physical quantities are the local skin-friction coefficient $C_f$ and the local Nusselt number $Nu$, which are defined as: $C_f = \frac{\tau_w}{\rho u_w^2/2} = \frac{\mu\left(\frac{\partial u}{\partial y}\right)_{\eta=0}}{\rho u_w^2/2}$ and $Nu = \frac{x\left(\frac{\partial T}{\partial y}\right)_{\eta=0}}{T_w - T_\infty}$. In the present study case which can be expressed as $C_f = \frac{2}{\sqrt{\mathrm{Re}_x}} f''(0)$, $Nu = -\sqrt{\mathrm{Re}_x}\,\theta'(0)$. Where $\tau_w = \mu\left(\frac{\partial u}{\partial y}\right)_{\eta=0}$ the surface shear stress and local Reynolds number isis $\mathrm{Re}_x = \frac{u_w x}{\upsilon}$. For various values of the physical parameters of the numerical values of $f''(0)$ and $\theta'(0)$ are presented in the table 1-2.

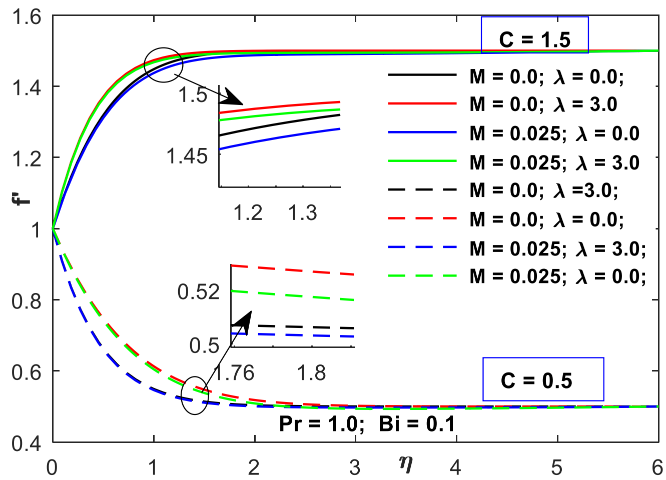


Figure 2. Velocity profile for different values of $M$, $C$and $Pr$ .

## Results and Discussion

Numerical calculations have been carried out for different values of the non-dimensional parameters the porosity parameter $\lambda$ , the magnetic parameter $M$and the stretching parameter $C$,Prandtl number $Pr$ and heat generation $B$ on the velocity and temperature distribution.

The velocity profiles for different values of $\lambda$, $M$ and $C$ presented in figures 2. It is found that velocity go down as increases the porosity parameter for the stretching parameter $(C = 0.5)$, while an increasing the porosity parameter velocity increases. For the the greater values of stretching$(c > 1)$, it is observed that veloctity decreases with an increasing he magnetic parameter, whereas it increases with an increase of stretching parameterC.It is evident from figure3, an increasing of magnetic parameter $M$the temperature distribution increases and reverse phenomena occurs for the stretching parameter $C$. It is further found that the temperature distribution falls with the increasing value of the Prandtl number Pr.In Figure 4 gives the changes in the temperature distribution, with increases porosity parameter temperature increases, for the stretching parameter $(c<1)$ whereas it temperature decreases with the increasing the porosity parameter, for the stretching parameter $(c>1)$. Table 1 and 2 gives the numerical values of skin-friction and local Nusselt number for different values of non-dimensional parameters.

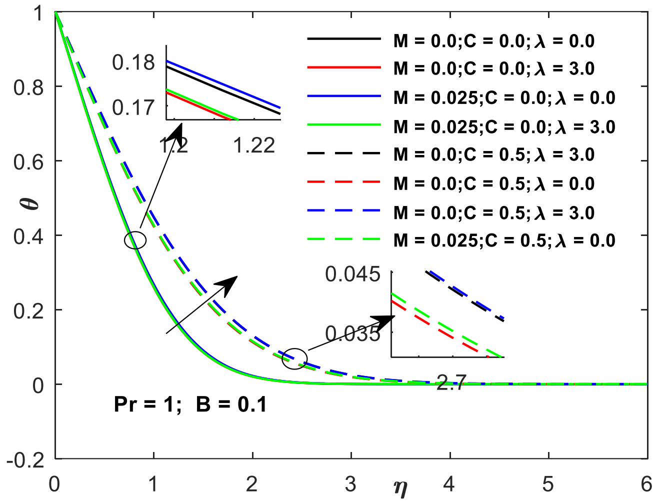


Figure 3. Temperature profile for different values of $M, C$ and $Pr$

From table 1, it is notice that an increasing the values of the porosity parameter $\lambda$, skin-friction coefficient and the local Nusselt number decreases, for the stretching parameter $(C<1)$,whereas it increases for the stretching parameter $(c>1)$.from table 2 with an increasing the Prandtl number the local Nusselt number increases.

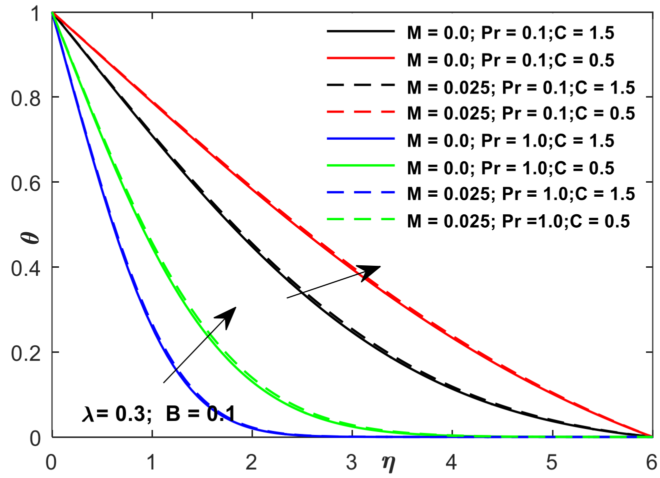


Figure 4. Temperature profile for different values of $\lambda, M$ and $C$

Table1. Values of $f''(0)$ for different values of $\lambda, M$ and $C$

| | $C=0.5$ | $C=1.5$ |
|---|---|---|

10.48047/jocaaa.2024.33.05.87

| λ | $M = 0.0$ | $M = 0.25$ | $M = 0.0$ | $M = 0.25$ |
|---|---|---|---|---|
| **0** | -0.667264 | -0.8256 | 0.90953 | 0.70137 |
| **3** | -1.091021 | -1.1802 | 1.25330 | 1.11518 |

Table1. Values of $\theta'(0)$ for different values of λ, , $M$,$C$and $Pr$ with $B = 0.1$

| | | $C = 0.5$ | | $C = 1.5$ | |
|---|---|---|---|---|---|
| $\lambda$ | $Pr$ | $M = 0.0$ | $M = 0.25$ | $M = 0.0$ | $M = 0.25$ |
| **0** | 0.1 | -0.2148 | -0.2076 | -0.2898 | -0.2820 |
| | 1.0 | -0.6221 | -0.5899 | -0.8437 | -0.8222 |
| **3** | 0.1 | -0.2103 | -0.2076 | -0.2921 | -0.2876 |
| | 1.0 | -0.5888 | -0.5756 | -0.8566 | -0.8446 |

## Conclusions

The steady two-dimensional stagnation point flowover a stretching sheet anelectrically conducting, viscous incompressible fluid in porous medium with heat generation in the presence of a magnetic field is investigated in this work. The numerical results attained agreed very well with before reported cases existing in the literature and found the following:

- With an increasing the porosity parameter, the velocity, skin-friction and local Nusselt number decreases and thermal boundary layer thickness increases for ($C < 1$), whereas reverse phenomenonoccurs for($c > 1$).
- With an increasing the Magnetci parameter, the velocity, skin-friction and local Nusselt number decreases and increases Temperature reverse phenomena occurs while increasing the stretching parameter.
- With and increasing the Prandtl number temperature decreases and Nusselt number increases,

## References


1. O.D. Makinde, W.A. Khan, Z.H. Khan Buoyancy effects on MHD stagnation point flow and heat transfer of a nanofluid past a convectively heated stretching/shrinking sheet”,*Int. J. Heat Mass Transf.,* 62, pp. 526-533,2013.
2. M. Hassani, M. Mohammad Tabar, H. Nemati, G. Domairry, F. Noori “An analytical solution for boundary layer flow of a nanofluid past a stretching sheet”, *Int J ThermSci,* 50, pp. 2256-2263,2011.
3. K. Bhattacharyya and G. C. Layek “Chemically Reactive Solute Distribution in MHD Boundary Layer Flow over a Permeable Stretching Sheet with Suction or Blowing”, *Chem. Eng. Comm.,*197, pp.1527–1540, 2010.
4. B.ShankarGoud“MHD flow past a vertical oscillating plate with radiation and chemical reaction in porous medium- finite difference method”, *International Journal of Emerging Technologies in Engineering Research*,5(11), pp.32-35, 2017.

10.48047/jocaaa.2024.33.05.87


5. Ch. Achi Reddy, B. Shankar "Magneto hydrodynamics stagnation point flow of a nano fluid over an exponentially stretching sheet with an effect of chemical reaction, heatsource and suction/injunction",*World J. of Mechanics*, 5(11), pp.211-221,2015.
6. T.R. Mahapatra, and A.S. Gupta, "Heat Transfer in Stagnation-Point Flow towards a Stretching Sheet" Heat and Mass Transfer, 38, pp.517-521,2012.
7. H. A. Attia, "Stagnation point flow towards a stretching surface through a porous medium with heat generation", Turkish J. Eng. Env. Sci., 30(5),pp. 299-306,2006.
8. Anwar, I., Shafie, S. and Salleh, M.Z. "Radiation Effect on MHD Stagnation Point Flow of a Nanofluid over an Exponentially Stretching Sheet",*Walailak Journal of Science and Technology*, 11(7), pp.569-591, 2014.
9. G. Bal Reddy., B. Shankar Goud., and MN. Raja Shekar., "Implicit finite difference solution of radiation effects on MHD fluid flow of a nanofluid past an exponential stretching sheet embedded in a porous medium", *Jour of Adv Research in Dynamical & Control Systems*, 10(06), pp.746-760, 2018.
10. Bhattacharyya. K., Mukhopadhyay. S., and Layek G.C., "slip effects on boundary layer stagnation-point flow and heat transfer towards a shrinking sheet", *Int. J. Heat Mass Transfer*, **54**, pp. 308-313, 2011.
11. SantoshChaudhary.,Sawai Singh.,SusheelaChaudhary"MHD Flow and Heat Generation Near Stagnation Point towards a Stretching Sheet in Porous Medium",*Applied Mathematical Sciences,* 9(8), pp. 369 – 378,2015.
12. J. Paullet .,P. Weidman, "Analysis of stagnation point flow toward a stretching sheet", *Int. J. Non-Linear Mech*., 42(9) pp.1084-1091, 2007.