Heat and mass transfer in a MHD Carreau fluid over a mixed porous plate

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Abstract

The paper present the numerical examination of the convection warmth and mass exchange in a MHD Carreau liquid past a vertical permeable plate in nearness of warm radiation and warm dissemination. The non – direct halfway differential conditions overseeing the stream are changed into standard differential conditions utilizing the typical similitude technique and the subsequent comparability conditions are illuminated numerically strategy. The outcomes are exhibited as speed, temperature and focus profiles for various estimations of parameters going into the issue.

Keywords: *Carreau fluid, , thermal radiation, thermal diffusion*

Introduction

As of late, specialists in designing and logical field have demonstrated incredible enthusiasm for the investigation of non – Newtonian liquids because of its significance in mechanical procedures. The advancement of the hypothesis of non – Newtonian liquid mechanics emerged from the insufficiency of the hypothesis of Newtonian liquids in anticipating the practices of numerous liquids particularly those of high sub-atomic weight.

Numerous creators have analyzed the stream, warmth and mass exchange in non – Newtonian of various sort, most particularly in power law and higher request liquids [1-18]. Be that as it may, little consideration has been paid to the four-parameter Carreau inelastic model as often as possible utilized in compound building. It fits sensibly well with the suspensions of polymers conduct in many stream circumstances. This model portrays the conduct of a simply gooey liquid whose consistency changes with expanding rate of twisting. Dissimilar to the power-law or Ostwald-De Waele model, it predicts a thickness that remaining parts limited as the shear rate methodologies zero. Hence, the Carreau constitutive condition suits well with the expectation of complimentary surface streams. Among the ongoing investigations in the hypothesis of Carreau liquid incorporate peristaltic stream and warmth move

Due to the non – direct reliance, the investigation of the conduct of the non – Newtonian Carreau liquids will in general be increasingly entangled and unpretentious in correlation with that of the non – Newtonian liquids. By and large, the conditions of movement for non – Newtonian liquids are of higher request than the Navier – Feeds conditions and along these lines one needs a few conditions notwithstanding the typical adherence limit condition. Subsequently, there is a requirement for a technique which gives a methods for acquiring different conditions important for the arrangement. One of such strategies is the Runge - kutta shooting technique. Moreover, to best of creator's learning the consolidated impacts of the suction, warm radiation and warm dissemination on the convection warmth and mass exchange stream in a Carreau liquid need to not been contemplated.

Along these lines, the target of this paper is to examine numerically the convection warmth and mass exchange in a hydromagnetic Carreau liquid past a vertical permeable plate in nearness of warm radiation and warm dissemination. The outcomes are displayed as speed, temperature and focus profiles for various estimations of parameters going into the issue. The impacts of suction, attractive field, warm radiation and warm dissemination on the skin contact, rate of warmth move and mass exchange are exhibited numerically in unthinkable structure.

Mathematical Formulation

Consider an unsteady convection flow of a generalized Newtonian Carreau fluid

$$\frac{\partial v}{\partial y} = 0 \qquad (1)$$

$$\frac{\partial u}{\partial t} + v\frac{\partial u}{\partial y} = \upsilon \frac{\partial^2 u}{\partial y^2}\left[1 + \lambda^2\left(\frac{\partial u}{\partial y}\right)^2\right]^{\frac{n-1}{2}} \qquad (2)$$

$$\frac{\partial T}{\partial t} + v\frac{\partial T}{\partial y} = \alpha \frac{\partial^2 T}{\partial y^2} + \frac{\alpha}{k}\frac{\partial q_r}{\partial y} \qquad (3)$$

$$\frac{\partial C}{\partial t} + v\frac{\partial C}{\partial y} = D_m \frac{\partial^2 C}{\partial y} + \frac{D_m K_T}{T_m}\frac{\partial^2 T}{\partial y^2} \qquad (4)$$

The appropriate boundary conditions are;

$$u = U, \quad T = T_w, \quad C = C_w \quad \text{at} \quad y = 0 \qquad (6)$$

$$u \to 0, \quad T \to T_\infty, \quad C \to C_\infty \quad \text{as} \quad y \to \infty, \ t > 0 \qquad (7)$$

Where U (at the time $t = 0$ the plate is impulsively set into motion with the velocity U) is the plate characteristics velocity.

Method of solution

Introducing a dimensionless similarity variable,

$$\eta = \frac{Ay}{t^{\frac{1}{2}}} \qquad (8)$$

Where A is constant and t is the time, such that,

$$u = Uf(\eta) \tag{9}$$

Reduce the boundary valued problems to an initial valued problem. Let, $x_1 = \eta$, $x_2 = f$, $x_3 = f'$, $x_4 = \theta$, $x_5 = \theta'$, $x_6 = \phi$ and $x_7 = \phi'$. Then, the following system is obtained;

$$\begin{pmatrix} x_1' \\ x_2' \\ x_3' \\ x_4' \\ x_5' \\ x_6' \\ x_7' \end{pmatrix} = \begin{pmatrix} 1 \\ x_3 \\ \dfrac{Mx_2 - Gr\ x_4 - Gc\ x_6 - (\frac{x_1}{2} + c)x_3)}{\left[1 + \lambda_1\ (x_3)^2\right]^{\frac{n-1}{2}} + \left[2\lambda_1\left(\dfrac{n-1}{2}\right)(x_3)^2\right]\left[1 + \lambda_1 (x_3)^2\right]^{\frac{n-3}{2}}} \\ x_5 \\ \dfrac{-\Pr(\frac{x_1}{2} + c)x_5}{(1 - R_d)} \\ x_7 \\ \dfrac{x_5(\frac{x_1}{2} + c)Sc\ \Pr\ Sr - Sc(1 - R_d)x_7(\frac{x_1}{2} + c)}{(1 - R_d)} \end{pmatrix}$$

with the initial conditions;

$$\begin{pmatrix} x_1(0) \\ x_2(0) \\ x_3(0) \\ x_4(0) \\ x_5(0) \\ x_6(0) \\ x_7(0) \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ \gamma \\ 1 \\ \Omega \\ 1 \\ \Gamma \end{pmatrix}$$

Equation together with the initial condition is solved using Runge – Kutta shooting method. The values of γ, Ω and Γ are obtained such that the boundary conditions are satisfied. The numerical results are

presented in graphically in figures 1-

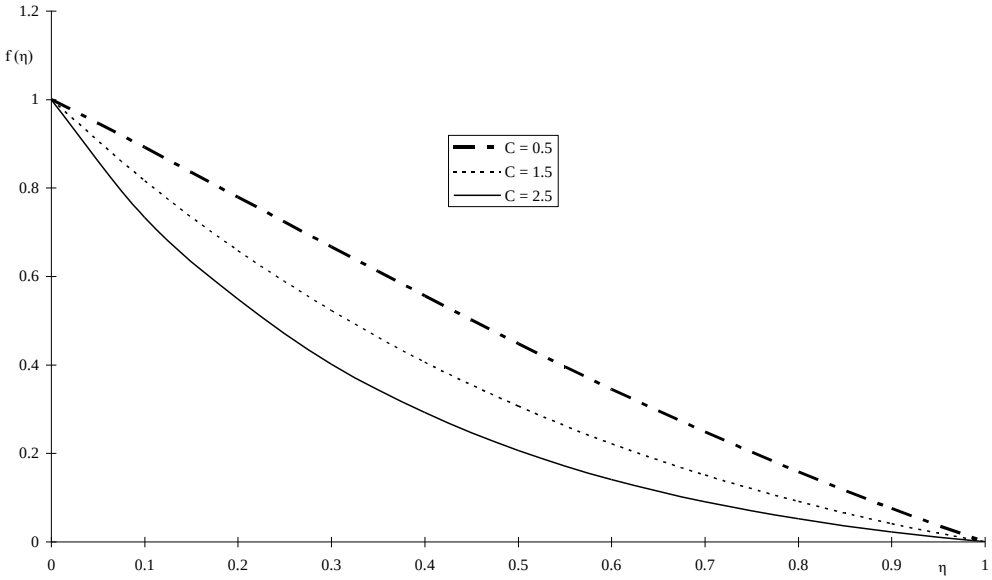

Figure 1: Velocity profile for various values of the Suction parameter, C

6.

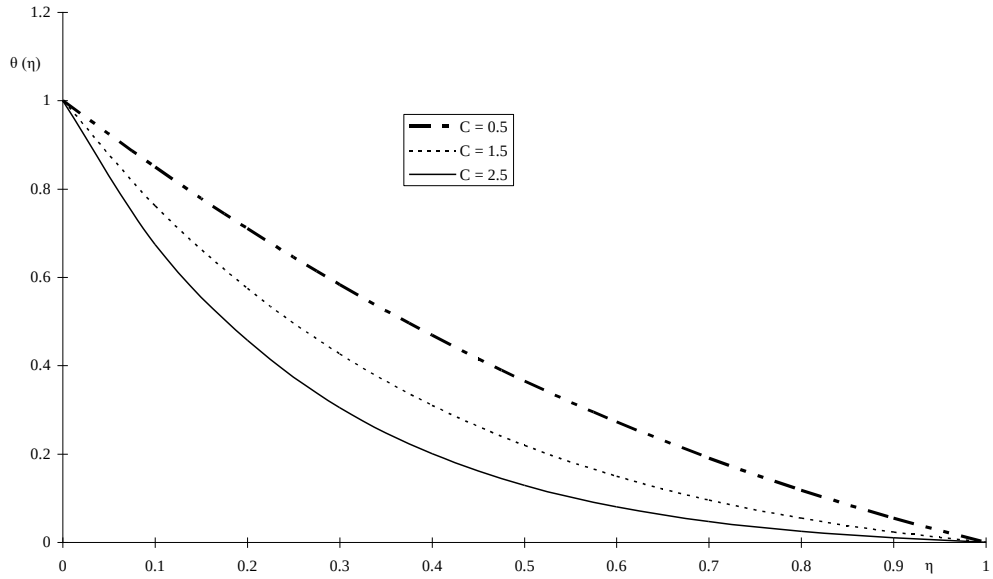

Figure 2: Temperature profile for different values of the suction parameter, C

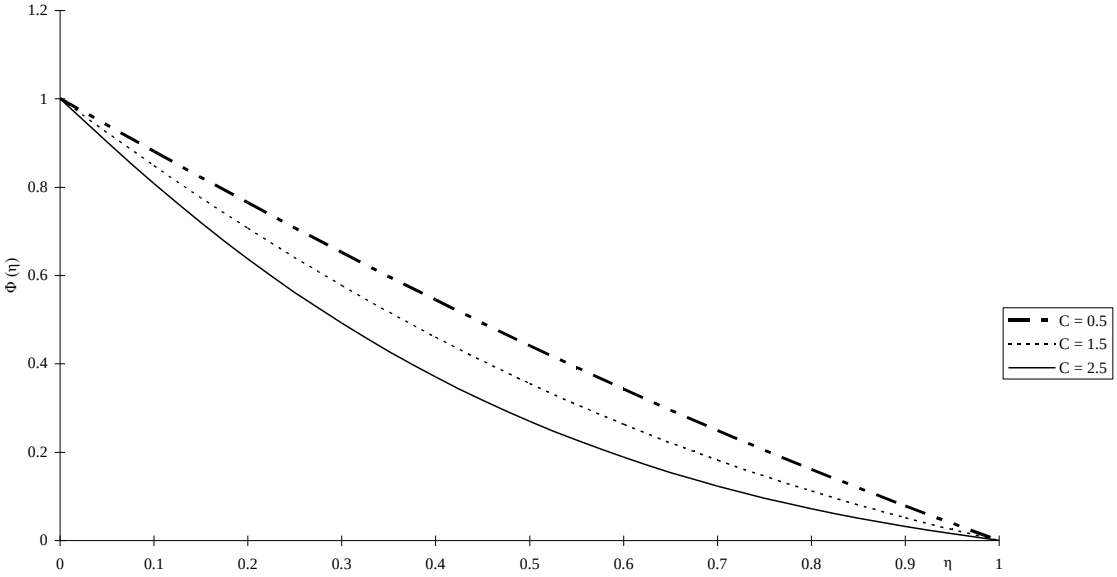

Figure 3: Concentration profile different values of the suction parameter, C

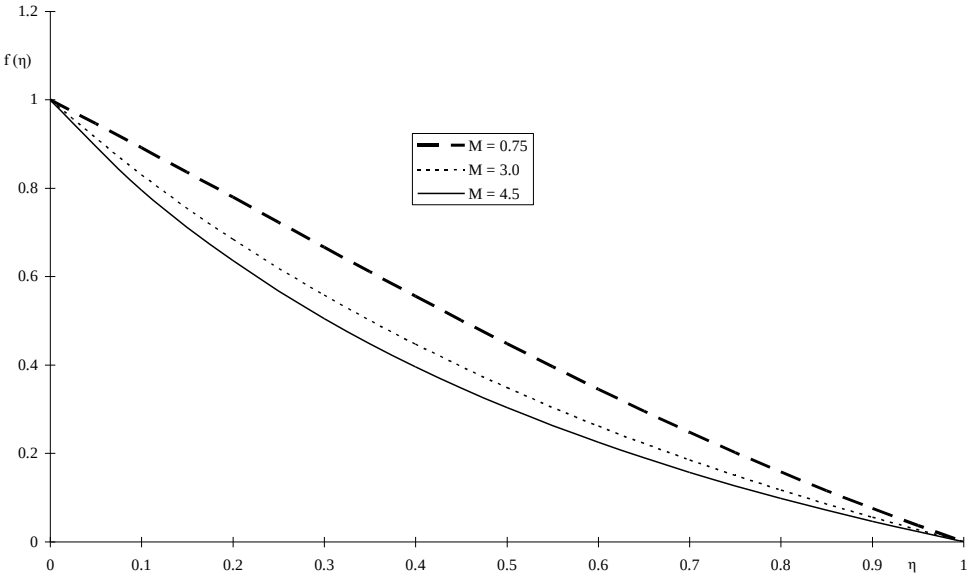

Figure 4: Velocity profile for various values of the Magnetic field parameter, M

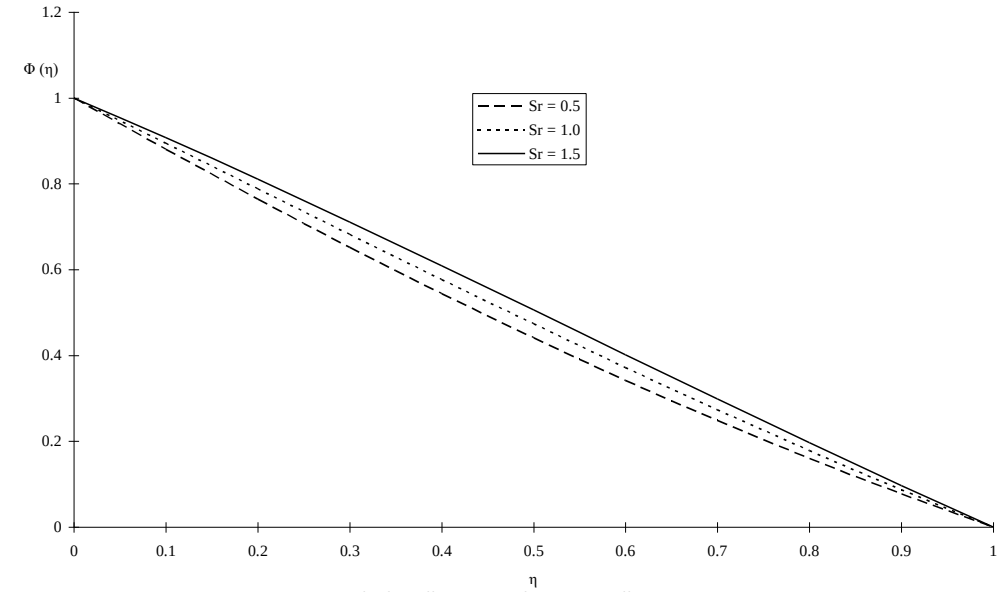

Figure 5: Concentration profile flor different values of the thermal diffusion parameter (Soret number), Sr

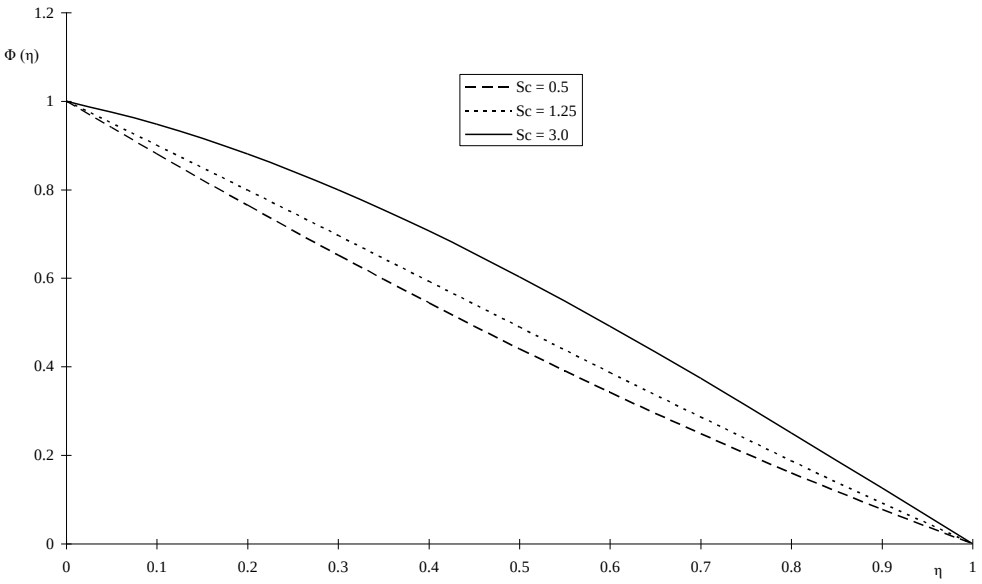

Figure 6: Concentration profile for different values of the Schmidt number, Sc

Discussion of result

The joined impact of the suction, warm radiation, warm dissemination and the attractive field parameter on the convection warmth and mass exchange in a Carreau liquid is considered for a shear diminishing case. The numerical calculation was gotten for estimations of the power law types, suction, attractive field parameter, warm dispersion (Soret number), warm dissemination parameters, the material parmeter and Schimdt number; These qualities are then shifted to watch their impacts on the warmth and mass exchange issue. The numerical outcome is introduced as the temperature profiles 1 – 6.

Figures 1, 2 and 3 demonstrate the impact of the suction parameter on the speed, temperature and fixation profiles. It is plainly demonstrated that the speed of the liquid stream diminishes with increment in the suction

parameter, the temperature and centralization of the liquid increment with increment in the suction parameter. Figures 5 demonstrates that the centralization of the liquid declines with increment in warm dissemination parameter. Figure 6 demonstrates that the convergence of the liquid increments with increment in the Schmidt number.

Conclusion

A numerical study the convection heat and mass transfer in a hydromagnetic Carreau fluid past a vertical porous plate in presence of thermal radiation and thermal diffusion has been carried out.

References

[1] M. Subhas Abel , Mahantesh M. Nandeppanavar , Sharanagouda B. Malipatil, Heat transfer in a second grade fluid through a porous medium from a permeable stretching sheet with non-uniform heat source/sink, International Journal of Heat and Mass Transfer 53 (2010) 1788–1795.

[2] I. Ahmad, M. Sajid, T. Hayat, Heat transfer in unsteady axisymmetric second grade fluid, Applied Mathematics and Computation 215 (2009) 1685–1695.

[3] Ahmed A. Afify, Some new exact solutions for MHD aligned creeping flow and heat transfer in second grade fluids by using Lie group analysis, Nonlinear Analysis 70 (2009) 3298–3306.

[4] Bikash Sahoo, Hiemenz flow and heat transfer of a third grade fluid, Communications in Nonlinear Science and Numerical Simulation 14 (2009) 811–826.

[5] I-Chung Liu, Flowand heat transfer of an electrically conducting fluid of second grade in a porous medium over a stretching sheet subject to a transverse magnetic field, International Journal of Non-Linear Mechanics 40 (2005) 465 – 474.

[6] T. Hayat, M. Sajid, Analytic solution for axisymmetric flow and heat transfer of a second grade fluid past a stretching sheet, International Journal of Heat and Mass Transfer 50 (2007) 75–84.

[7] T. Hayat, Z. Abbas, M. Sajid, Heat and mass transfer analysis on the flow of a second grade fluid in the presence of chemical reaction, Physics Letters A, 372 (2008) 2400–2408.

[8] T. Hayat, S. Saif, Z. Abbas, The influence of heat transfer in an MHD second grade fluid film over an unsteady stretching sheet, Physics Letters A 372 (2008) 5037–5045.

[11] T. Hayat, S. Noreen, M. Sajid, Heat transfer analysis of the steady flow of a fourth grade fluid, International Journal of Thermal Sciences 47 (2008) 591–599.

[9] T. Hayat, Z. Abbas, S. Asghar, Effects of Hall current and heat transfer on rotating flow of a second grade fluid through a porous medium, Communications in Nonlinear Science and Numerical Simulation 13 (2008) 2177–2192.

[10] T. Hayat, T. Javed, Z. Abbas, Slip flow and heat transfer of a second grade fluid past a stretching sheet through a porous space, International Journal of Heat and Mass Transfer 51 (2008) 4528–4534.

[11] T. Hayat, Z. Abbas, I. Pop, S. Asghar, Effects of radiation and magnetic field on the mixed convection stagnation-point flow over a vertical stretching sheet in a porous medium, International Journal of Heat and Mass Transfer 53 (2010) 466–474.

[12] Kai-Long Hsiao, Conjugate heat transfer of magnetic mixed convection with radiative and viscous dissipation effects for second-grade viscoelastic fluid past a stretching sheet, Applied Thermal Engineering 27 (2007) 1895–1903.

[13] F. Khani, A. Farmany, M. Ahmadzadeh Raji, Abdul Aziz, F. Samadi, Analytic solution for heat transfer of a third grade viscoelastic fluid in non-Darcy porous media with thermophysical effects, Commun Nonlinear Sci Numer Simulat 14 (2009) 3867–3878.

[14] B.I Olajuwon, Convection heat and Mass Transfer in an electrically conducting power law flow over a heated vertical porous plate, *International Journal of Computational Methods in Engineering Science and Mechanics, Vol.* 11: 2, 100 — 108 (2010)

[15] B. I Olajuwon**,** Flow and Natural Convection Heat Transfer in a power law fluid past a vertical plate with Heat generation, *International Journal of nonlinear Sciences, Vol.7,No.1,pp 50 – 56,* (2009)

[16] B. I Olajuwon, Convection Heat and Mass Transfer in a power law fluid with Heat generation and Thermal diffusion past a vertical Plate, *Journal of Energy, Heat and Mass Transfer, Vol. 30 (1), pp 1 – 19,* (2008)

[17] B. I Olajuwon, Convection heat and mass transfer in power law fluid with thermal radiation past a moving porous plate, *Progress in Computational fluid Dynamics: An International Journal Vol. 8, no. 6, pp 372 – 378,* (2008)

[18] B. I Olajuwon B.I (2007)**,** Thermal Radiation interaction with convection in a power law flow past a vertical plate with variable suction, *International Journal of Heat and Technology,vol.25(2), pp 57 – 65,* (2007).