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A Study of Dufour and Soret Effect on MHD Mixed Convection Stagnation Point Flow towards a Vertical Plate in a Porous Medium

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Abstract

The goal of the present learning is to examine the study of dufour and soret effect on MHD mixed convection stagnation point flow near a vertical plate in a porous medium. The governing boundary layer equations are distorted into a set of ordinary differential equations using similarity transformations. The obtained numerical consequences are illustrated graphically. The skin fiction profile temperature and Concentration profiles overshoot adjacent the plate on growing the chemical reaction parameter, Richardson number and magnetic field parameter.

1. INTRODUCTION

Magneto hydrodynamics is one of the significant sub-fields of fluid dynamics which has pretty momentous applications in numerous divisions of science and equipment. When the fluid is electrically conducting. Roman had made a detailed review on MHD in his book especially in the field of electrically conducting fluid. Alam*et al*. (2006) evaluated the reading of the combined free-forced convection and mass transfer flow past a vertical porous plate in a porous medium with heat generation and thermal diffusion [1]. Anghel *et al* (2000) deliberate and experiential dufour and soret effects on free convection boundary layer over a vertical surface implanted in a porous medium [2]**.** Chiam (1994) studied two dimensional steady stagnation-point flow of an incompressible viscous fluid towards a stretching surface [3].El-Arabawy (2009) studied the soret and dufour effects in a vertical plate with variable surface temperature [4].Karthikeyan *et al* (2016) studied MHD mixed convection stagnation point flow towards a vertical plate embedded in a highly porous medium with heat and mass transfer in the presence of thermal radiation, internal heat generation soret and dufour effects [5].Mahapatra *et al* (2002) investigated the steady, two-dimensional stagnation-point flow of an incompressible viscous fluid towards a stretching surface [6].Niranjan Hari *et al* (2016) studied the two-dimensional steady stagnation-point flow, heat and mass transfer of an incompressible, electrically conducting fluid through a porous medium along a vertical isothermal plate in the presence magnetic field, volumetric heat generation/absorption and first order homogeneous chemical reaction [7]. Postelnicu (2010) analyzed the effect of soret and dufour on heat and mass transfer at a stagnation point [8].Sharma *et al* (2009) have investigated the effects of variable thermal conductivity, heat source/sink and variable free stream on flow of a viscous incompressible electrically conducting fluid and heat transfer on anon-conducting stretching sheet in the presence of transverse magnetic field near a stagnation point [9]. Sparrow *et al*. (1961) have discussed the temperature dependent heat sources or sinks in a stagnation point flow [10]. Tak *et al* (2010) investigated the MHD free convection- radiation in the presence of soret and dufour. Tak *et al* (2010) investigated the MHD free convection-radiation in the presence of soret and dufour [11].Vempati *et al* (2010) studied the soret and dufour on MHD with thermal radiation [12]. Yih (1998) explored in the present paper, we have considered the heat source/sink effect on MHD mixed convection in stagnation flows of incompressible, and electrically conducting fluids over a vertical permeable flat plate with linear wall temperature proportional to the distance in a porous medium [13].

2. MATHEMATICAL MODEL

Consider the two-dimensional steady stagnation-point flow, heat and mass transfer of an incompressible, electrically conducting fluid through a porous medium along a vertical isothermal plate in the presence magnetic field, volumetric heat generation/absorption and first order homogeneous chemical reaction, The magnetic field of constant strength is imposed along the y-axis. The velocity distribution of the potential region flow is assumed as $U_\infty = cx$, where c is a positive constant

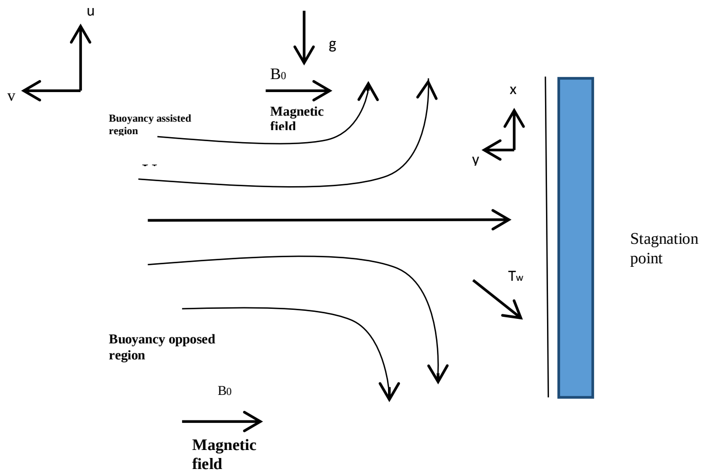

Figure 1: Schematic diagram of the problem

The governing equations of continuity of mass, momentum transfer, and Energy transfer and species concentration are given by,

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

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\nu\frac{\partial^2 u}{\partial y^2}+g\beta(\mathrm{T}-\mathrm{T}_\infty)+\mathrm{g}\,\beta^*(\mathrm{C}-C_\infty)-(\frac{\sigma_\varepsilon B_0^2}{\rho}+\frac{\nu}{\tilde{\mathrm{K}}})(\mathrm{u}-\mathrm{U}_\infty)+\mathrm{U}_\infty\frac{dU_\infty}{dx} \qquad (2)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\frac{\partial^2 T}{\partial y^2}-\frac{\alpha}{k}\frac{\partial q_r}{\partial y}+Q(\mathrm{T}-\mathrm{T}_\infty)+\mathrm{D}_r\frac{\partial^2 C}{\partial y^2} \qquad (3)$$

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D\frac{\partial^2 C}{\partial y^2}-\Gamma_0(\mathrm{C}-C_\infty)+S_r\frac{\partial^2 T}{\partial y^2} \qquad (4)$$

The boundary conditions are

$$u=0, v=0, T=T_w, \mathrm{C}=C_\omega \text{ as } y=o \qquad (5)$$
$$u\to U_\infty=cx, T\to T_\infty, C\to C_\infty \text{ as } y\to\infty$$

Hence the radiation effect is taken in the medium due to Stefan Boltzmann slaw which states that the radiation is proportional to the 4$^{\text{th}}$power of temperature. Heat flux due to radiation is given by,

$$q_r = -\frac{4\sigma^*}{3K'}\frac{\partial T^4}{\partial y} \tag{6}$$

Where σ^* and k′ are the Stefan-Boltzmann constant and the mean absorptioncoefficient, respectively. Using the Rosseland approximation, it is assumed that the differences in temperature within the flow are too small, so that, using Taylor series T^4 may be shown as a linear function of temperature T about the free stream temperature T_∞, T^4 is approximately

$$T^4 = 4T_\infty^3 T - 3T_\infty{}^4 \tag{7}$$

Equation (7) is substituted in (3) for temperature. We introducing the following dimensionless variable and parameters

$$\eta = y\sqrt{\frac{c}{\upsilon}}, \Psi(\mathrm{x,y}) = \sqrt{\upsilon c}xf(\eta), \mathrm{C}_r = \frac{\Gamma_0}{c}, \theta(\eta) = \frac{T-T_\infty}{T_\omega - T_\infty}, \phi(\eta) = \frac{C-C_\infty}{C_\omega - C_\infty}, Gr_T = \frac{g\beta(\mathrm{T}_\omega - \mathrm{T}_\infty)\mathrm{x}^3}{\upsilon^2},$$
$$Gr_c = \frac{g\beta^*(\mathrm{C}_\omega - C_\infty)\mathrm{x}^3}{\upsilon^2}, Ri_T = \frac{Gr_T}{\mathrm{Re}_x^2}, Ri_c = \frac{Gr_c}{\mathrm{Re}_x^2}, \mathrm{Re}_x = \frac{U_\infty x}{\upsilon}, Rd = \frac{4\sigma^* T_\infty^3}{kK'}, K = \frac{\upsilon}{c\tilde{K}}, Sc = \frac{\upsilon}{D},$$
$$M = \frac{\sigma_\varepsilon B_0^2}{c\rho}, S = \frac{Q\upsilon}{\alpha c} = \mathrm{Pr}\frac{Q}{c}, D_f = \frac{Dr}{\alpha}\frac{(C_\omega - C_\infty)}{(\mathrm{T}_\omega - \mathrm{T}_\infty)}, St = \frac{Sr}{D}\frac{(\mathrm{T}_\omega - \mathrm{T}_\infty)}{(C_\omega - C_\infty)} \tag{8}$$

Where ψ is the stream functions which is defined as the form as $u = \frac{\partial\psi}{\partial y}$, $v = \frac{\partial\psi}{\partial x}$ So that the continuity equation (1) is automatically satisfied, substituting the expression in (7) together the variable in (8) into (1)-(5), we obtain the following nonlinear ordinary differential equations

$$f''' + ff'' - f'^2 + Ri_T\theta + Ri_c\phi - (\mathrm{K}+\mathrm{M})(f'-1) + 1 = 0 \tag{9}$$

$$(1+\frac{4}{3}\mathrm{Rd})\theta'' + \mathrm{Pr}\, f\theta' + S\theta + D_f\phi''(\eta) = 0 \tag{10}$$

$$\phi''(\eta) + \mathrm{Sc}\, f\phi' - ScCr\phi + S_t\theta'' = 0 \tag{11}$$

The corresponding boundary conditions are

$$f = 0, f' = 0, \theta = 1, \phi = 1 \text{ as } \eta = 0 \tag{12}$$
$$f' = 1, \theta = 0, \phi = 0, \text{ as } \eta \to \infty$$

where Cr is a chemical reaction parameter, Gr_c is solutal Grashof number, Gr_T is thermal Grashof number, K is a porous medium permeability parameter, M is magnetic field parameter, Pr is Prandtl number, Rd is a thermal radiation parameter, Ri_c is the solutal Richardson number, Ri_T is the thermal Richardson number,

3. NUMERICAL ANALYSIS

In this study is to analyze dufour and soret effect on MHD mixed convection stagnation point flow towards a vertical plate in a porous medium. The governing boundary layer equations are transformed into a set of ordinary differential equations using similarity transformation. Then they are solved by shooting technique with runge kutta fourth order iteration. The obtained numerical results are illustrated graphically for different values done by using Mathematica computer language. From the process of numerical computation the fluid velocity, the temperature, the concentration, the Skin friction coefficient has analyzed.

4. RESULTS AND DISCUSSION

The results are displayed graphically for different parameters (K, M, Ri_T, Ri_c ,S, Rd, Cr), The skin friction increases with increasing porous medium permeability parameter, magnetic field perimeter and it decreases with increasing the chemical reaction parameter. The local Nusselt number increases with an increasing permeability parameter, magnetic field parameter, thermal radiation parameter and decreases with increasing Richardson number, heat generation parameter. The local Sherwood number increases with an increasing permeability parameter, magnetic field parameter, Richardson number, internal heat generation, chemical reaction parameter.

From figure 2 and 3 it has been noted that Ri_T and Ri_c be a solutal and thermal Richardson number, It can be seen from these figures that coefficient increase in the Richardson number. Figure 4 Noted that M is a magnetic field parameter, with the increase in M, decreases considerably owing to the a increase in skin friction. The rate of heat transfer decreases owing to increasing the magnetic field parameter. It is observed from Figure 5 that the temperature increases with increasing the thermal radiation parameter. Figures 6 illustrate the temperature profiles for different values of S. We can observe that thermal boundary layer thickness is more than the momentum boundary layer thickness. Figure 7 illustrate the temperature decreases with increase in dufour number. Figure.8 illustrates the concentration profiles for different Cr values with constant Ri_T, Ri_c, K, M, S, Rd values. We observe that the concentration gradually decreases exponentially in the boundary layer on increasing Cr values. Figure 9 illustrate there is an increase in concentration with an increase in permeability of the porous medium. Figure.10 concentration increases with increase in soret number. This is because either increase in concentration difference or decrease in temperature difference leads to an increase in the value of D_f resulting trends similar to the above observation.

Skin friction profiles:

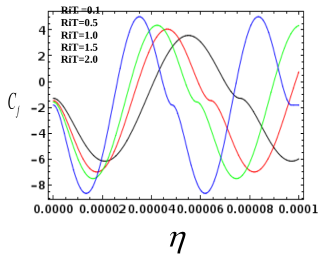

Figure 2. Skin friction profiles for different Ri_T Values with Ri_T = 1, Ri_c = 0.5, K = 0.5, Rd = 0.2, S = 0.2, Cr = 0.2.

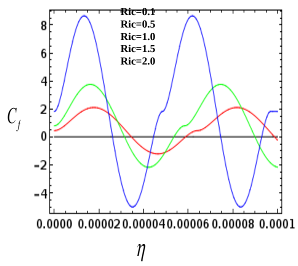

Figure 3. Skin friction profiles for different RicValues with Ri_c = 1, K = 0.5, M = 0.5,Rd = 0.2, S = 0.2, Cr = 0.2.

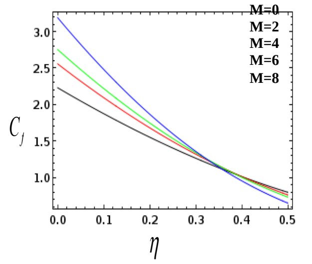

Figure 4.Skin friction profiles for different M Values with Ri_T = 1, Ri_c = 0.5, K = 0.5, Rd = 0.2, S = 0.2, Cr = 0.2.

Temperature profiles:

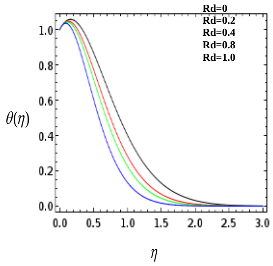

Figure 5.Temperature profiles for differentRd values with Ri_T = 1, Ri_c = 0.5, K = 0.5, M = 0.5, S = 0.2, Cr = 0.2

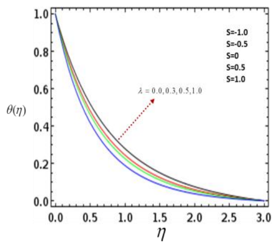

Figure 6.Temperature profiles for different SValueswith Ri_T = 1, Ri_c = 0.5, K = 0.5, M = 0.5, Rd = 0.2, Cr = 0.2.

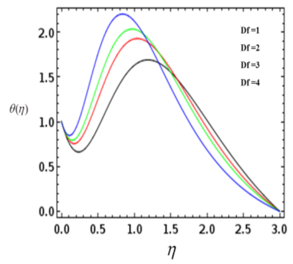

Figure 7.Temperature profiles for differentDf valueswith Ri_T = 1, Ri_c = 0.5, K = 0.5, M = 0.5, S = 0.2, Cr = 0.2.

Concentration profiles

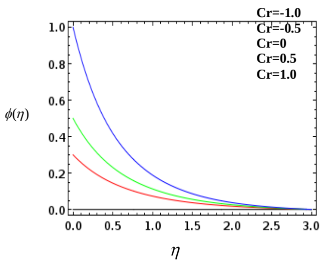

Figure 8. Concentration profiles for different Cr values with Ri_T = 1, Ri_c = 0.5, K = 0.5, M = 0.5, Rd = 0.2, S = 0.2.

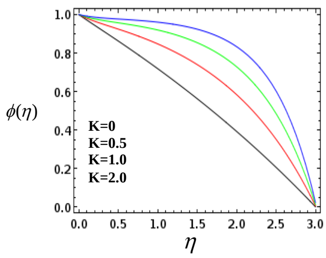

Figure 9. Concentration profiles for different K values with Ri_T = 1, Ri_c = 0.5, K = 0.5, M = 0.5, Rd = 0.2, S = 0.2.

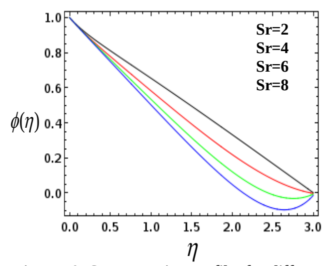

Figure 10. Concentration profiles for differentSr Values with Ri_T = 1, Ri_c = 0.5, K = 0.5, M = 0.5, Rd = 0.2, S = 0.2.

CONCLUSION

In this paper, we studied the learning on mass transfer effects of chemical reaction on MHD mixed convection stagnation point flow near a vertical plate in a porous medium. The main findings are shortened as follows: The skin friction profiles overshoot neighboring the plate surface on growing the magnetic field, Richardson number and internal heat generation parameter. The skin friction reductions on growing the porous medium permeability parameter. The temperature raises with an increase in the heat generation and thermal radiation parameters. The concentration declines on swelling the chemical reaction parameter.

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