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

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 $U_x = cx$, where c is a positive constant.
The governing equations of continuity of mass, momentum transfer, and energy transfer and species concentration are given by,

\[ \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \]  \hspace{1cm} (1)

\[ u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \alpha \frac{\partial^2 T}{\partial y^2} + \frac{\partial q}{\partial y} + Q(T-T_\infty) + Dc \frac{\partial^2 C}{\partial y^2} \]  \hspace{1cm} (2)

\[ u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = D \frac{\partial^2 C}{\partial y^2} - \Gamma_0 (C-C_o) + S \frac{\partial^2 T}{\partial y^2} \]  \hspace{1cm} (3)

The boundary conditions are

\[ u=0, v=0, T=T_\infty, C=C_o \text{ as } y=0 \]  \hspace{1cm} (5)

\[ u \rightarrow U_e \text{ as } y \rightarrow \infty \]

Hence the radiation effect is taken in the medium due to Stefan Boltzmann slaw which states that the radiation is proportional to the 4\textsuperscript{th} power of temperature. Heat flux due to radiation is given by,
$q_r = \frac{4\sigma' T^4}{3K'} \frac{\partial T}{\partial y}$ \hspace{1cm} (6)

Where $\sigma'$ and $k'$ are the Stefan-Boltzmann constant and the mean absorption coefficient, 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 $T_\infty$, $T^4$ is approximately

$$T^4 = 4T_\infty^3 - 3T_\infty^4$$ \hspace{1cm} (7)

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

$$\eta = y \frac{c}{\sqrt{v}}, \Psi(x,y) = \sqrt{uv} \times f(\eta), C_r = \frac{\Gamma_0}{c}, \theta(\eta) = \frac{T - T_\infty}{T_\infty - T_\infty}, \phi(\eta) = \frac{C - C_\infty}{C_\infty - C_\infty}, Gr_r = \frac{g\beta(T_\infty - T_\infty)x^3}{\nu^2},$$

$$Gr_c = \frac{g\beta'(C_\infty - C_\infty)x^3}{\nu^2}, Ri_c = \frac{Gr_r}{Re_\infty^2}, Ri_\infty = \frac{Gr_r}{Re_\infty^2}, Re_\infty = \frac{U_\infty x}{\nu}, Rd = \frac{4\sigma' T_\infty^3}{kK'}, K = \frac{\nu}{cK}, Sc = \frac{\nu}{D},$$

$$M = \frac{\alpha c B_i^2}{c \rho}, S = \frac{Qu}{ac}, Pr = \frac{Q}{c}, D_f = \frac{Dr}{(C_\infty - C_\infty)}, S_f = \frac{S_f}{D} (T_\infty - T_\infty)$$ \hspace{1cm} (8)

Where $\psi$ 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

$$f'' + f'' - f'^2 + Ri_c \theta' + Ri_\infty \phi' - (K + M)(f' - 1) + 1 = 0$$ \hspace{1cm} (9)

$$(1 + \frac{4}{3} Rd) \theta'' + Pr f' \theta' + S \theta + D_r \phi(\eta) = 0$$ \hspace{1cm} (10)

$$\phi''(\eta) + Sc f' \phi' - Sc Cr \phi' + S \phi'' = 0$$ \hspace{1cm} (11)

The corresponding boundary conditions are

$$f = 0, f' = 0, \theta = 1, \phi = 1 \text{ as } \eta \rightarrow 0$$ \hspace{1cm} (12)

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

where $Cr$ is a chemical reaction parameter, $Gr_c$ is solutal Grashof number, $Gr_r$ 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:**

**Temperature profiles:**

**Concentration profiles**
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.

REFERENCES


