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The Rmosolutal Chemically Reacting Mhd Natural Convective Flow Past a Low -Heat -Resistance Sheet With Soret Effect

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Abstract: The present work is focused on the study of thermo-solutal chemically reacting MHD natural convective flow past as low-heat-resistance sheet under soret effect. The physical boundary layer flow is presented in term of mathematical model form i.e set of nonlinear PDE namely momentum, energy and concentration equations. The coupled set of PDE is transformed into system of ODE using the similarity transformation. The transformed system of equation solved numerically using Finite difference method. The study of different physical parameters is presented graphically. The obtained results are also verified with some existing result under special case. The work is motivated from [7] and further extended by inclusion of chemical reaction and soret effect.

1. Introduction

Heat and mass transfer play an important role in manufacturing industries for the design of fins, steel rolling, nuclear power plants, gas turbines and various propulsion devices for aircraft, combustion and furnace design, materials processing, energy utilization, temperature measurements. A number of studies have been reported in the literature focusing on the problem of mixed convection about different surface geometries in porous media Extensive reviews on this subject can be found in the books Nield and Bejan [1]. The Numerical study of heat transfer with chemically reacting fluid was also recently studied by Rawat .et.al [2-5]. The study was focused on vertical moveing surface under magnetic effect followed by a linear streaching sheet of micropolar fluid. Combined effect of heat and mass transfer is also documented in [5]. The study of low-heat-resistance sheet was undertaken by Kumar.et.al [7] numerically. Keeping in view of the above an attempt has been taken.

2. Proposed Model

Consider the problem of cooling of a low-heat-resistancesheet that moves downwards in a viscous fluid when the velocity of the fluid far away from the plate is equal to zero. The variation of surface temperature are linear. The flow configuration and coordinate system is shown in [7]. All the fluid properties are assumed to be constant except for the density variations in the buoyancy force term of linear momentum. The magnetic Reynolds number is assumed to be small, so that the induced magnetic field is neglected. Electric field is assumed to exists and both viscous and magnetic dissipation are neglected. The Hall Effect, viscous dissipation and the joule heating term are neglected. Under these assumption along with the Bousineque approximation, the system will be:

2.1. Governing Equations

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}=0$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=v\left(\frac{\partial^2 u}{\partial y^2}\right)+g\beta(T-T_\infty)+g\beta(S-S_\infty)-\sigma\mu_e^2H_0^2u$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\kappa\frac{\partial^2 T}{\partial y^2}+\frac{\sigma k_T}{c_s c_p}\frac{\partial^2 S}{\partial y^2}$$

$$u\frac{\partial S}{\partial x}+v\frac{\partial S}{\partial y}=\sigma\frac{\partial^2 S}{\partial y^2}+\Gamma S$$

Subject to the boundary conditions

$$u=0,\quad v=0,\ T=T_0\,,S=\ S_0 \text{ at } y=0 \; and \; u\to 0,\quad T\to\infty\ \ ,S\to\infty \text{ as } y\to\infty,$$

2.2. Non-Dimensional Parameters

$$\psi=[g\beta(T-T_\infty)v^2x_0^3]^{\frac{1}{4}}f(\eta),$$

$$T=T_\infty+(T-T_\infty)\left[\frac{x_0}{x_0-x}\right]^3\theta(\eta),S=S_\infty+(S-S_\infty)\left[\frac{x_0}{x_0-x}\right]^3\emptyset(\zeta)$$

$$\eta=\left[\frac{g\beta(T-T_\infty)x_0^3}{v^2}\right]\frac{y}{(x_0-x)},\zeta=\left[\frac{g\beta(S-S_\infty)x_0^3}{v^2}\right]\frac{y}{(x_0-x)}$$

2.3. Non-Dimensional Equations

$$f'''-(f'+M)f'+Gr\theta+Gc\emptyset=0,$$

$$\frac{1}{\mathrm{Pr}}\theta''-3f'\theta+3Du\emptyset''=0.$$

$$\frac{1}{\mathrm{Sc}}\emptyset''-3f'\emptyset+3Sr\theta''-Kr\emptyset=0$$

The boundary conditions becomes:

$$f(0)=0,\ \ f'(0)=0,\ \ f'(\infty)\to 0,$$

$$\theta(0)=1,\theta'(0)=0\ \ \theta(\infty)\to 0,\ \emptyset(0)=1,\emptyset'(0)=0\ \ \emptyset(\infty)\to 0$$

2.4. Numerical Computation

In order to solve the system of equations presented in section 2.3. The finite difference method is adopted to find the numerical solution of the nonlinear coupled differential equations which is well documented in [6]. The discretize / linearize set of equation is solved using the Gauss Jacobi method with the accuracy of order 0.0005

2.5. Result Predictions

The prandtl number was taken to be Pr=0.72 which corresponds to air, the value of Schmidt number (Sc) were chosen to be Sc=0.24,0.62, 0.78,2.62, representing diffusing chemical species of most common interest in air like H_2 , H_2O, NH_3 and Propyl Benzene respectively. Attention is focused on positive value of the buoyancy parameters that is, Grashof number Gr>0(which corresponds to the cooling problem) and solutal Grashof number Gc>0(which indicates that the chemical species concentration in the free stream region is less then the concentration at the boundary surface. The effect of distinguished parameter studied by fixing some parameters.

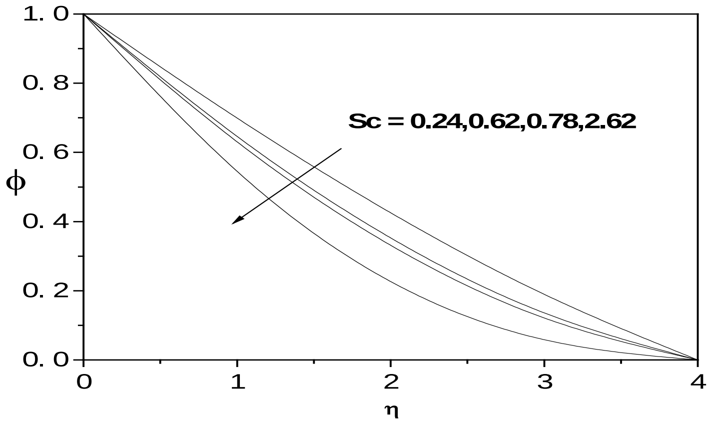

Figure 1 : Variation of the concentration with Sc for Pr=0.72 , Kr=0.5 ,Gr=Gc=M=0.1, Du=0.2 ,Sr=1.

3. Conclusions

From the above study we conclude the following

1) The Finite difference method works effectively

2) Every profile (Velocity or temperature and concentration) has shows an asymptomatic behavior and converges for the large value ofη. The soret effected the velocity, temperature and concentration profile significantly

3) The species concentration is highest at the plate surface and decrease to zero far away from the plate satisfying the boundary condition

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