Similarity Analysis of MHD Unsteady Free Convection Flow over moving porous plate with surface heat flux

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Abstract: The current analysis presents the effect on unsteady free convection flow past a moving vertical porous plate with influence of the magnetic strength and constant heat flux. The governing equations (pde’s) of flow situation model is remoulded into non-linear ordinary differential equations via similarity technique.

Introduction:

In the recent years, most of the authors have gained their attention over porous media fluid flow because of its applications in most of the branches of science, technology and materials process engineering. e.g natural gas movement, water from oil receivers, clay coating, physiological properties, filtration and purification processes, etc. A detailed study on heat transfer flow of convection over porous medium has been discussed by Nield and Bejan [8]. Gholizadeh [5] reported the MHD oscillatory flow considering porous medium over vertical plate in the influence of the thermal radiation. Ramana Kumari and Bhaskar Reddy [10] presented systematic simulation of 2D unsteady convective flow with magnetic field over vertical porous plate considering suction. Kandasamy et al [7] analysed effects of MHD convective flows over porous wedge considering radiation. The flow of unsteady mixed convection past vertical porous plate derived by Sharma and Chaudhary [13]. Uddin et al [16] discussed unsteady MHD flow of convective heat and mass transfer past vertical surface. Mixed convection flow of unsteady hydromagnetic heat and mass transfer in the region of stagnation with complex wall condition were studied by Chamka et al. [2]. Elbashbeshy and Aldawody [4] explained the magnetic and thermal radiation effects over unsteady flow and heat transfer over porous surface considering heat generation/absorption. Several authors [1,12,14,15,16,17,18,19] has been studied the situation of MHD flow considering porous media.

Radiation effects in heat transfer are very important which incorporates the applications in the areas like astrophysics, manufacturing industries and high temperature processes. Das [3] obtained the exact solution of flow of free convection with mass transfer in MHD over vertical plate with radiation. Effects of radiation over free convection over porous medium are studied by Raptis [11]. Israel et al. [6] presented the dissipation of viscous and influence of radiation on unsteady flow of MHD free convection subject to vertical plate over porous media. Pal [9] considered Buoyancy influence with chemical reaction over unsteady flow of MHD convection heat and mass transfer considering radiation over porous media.

The aim of this study is to extend the results obtained by El-Aziz et al [18] to the case of similarity solutions by appropriate similarity method.

Problem Formulation:

Consider the one-dimensional unsteady flow of an incompressible, viscous and electrically conducting fluid over moving porous plate with heat flux  The axis is considered along the plate with up direction and  axis is considered normal to the plate. The uniform magnetic field acts in the transverse direction of the flow. In comparison with applied magnetic field, induced magnetic field is neglected because of the smaller Reynolds number. As the length of the plate is infinite, hence the rest field quantities becomes the function of the  In the starting phase, the plate and the fluid are at same temperature and concentration and other hand plate started to move in its own region and accelerates with gravitational filed acceleration along direction. Also, heat is transferred from plate surface to fluid which keeps the flow of fluid throughout uniform rate and concentration. The governing equations of flow are as follows:

 (1)

 (2)

 (3)

And the boundary conditions

 (4)

Where the perpendicular distances along the plate are, is the velocity of fluid, is the dimensionless time, are the temperature and the concentration of the fluid, are the free stream temperature and concentration, is the coefficient of heat absorption, is the thermal conductivity, is the heat flux constant, D is the diffusivity of the mass, the kinematic viscosity, is the electrical conductivity, is the fluid density, is the porous medium permeability, is the ratio of thermal diffusion, is the constant of chemical reaction.

We introduce similarity variables and the dimensionless quantities in above equations (1)-(4), we get



 (5)

 (6)

 (7)

And the transformed boundary conditions are

 (8)

Conclusion:

The flow of unsteady free convection of heat and mass transfer over moving porous plate considering magnetic influence and heat flux has been investigated. The appropriate similarity transformation has been employed to transform the given set of nonlinear partial differential equations to nonlinear ordinary differential equations with appropriate boundary conditions.

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