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Utilizing the Perturbation Approach, Effects of Chemical Reaction, Heat and Mass Transfer and Viscous Dissipation over an MHD Flow in a Vertical Porous Wall

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Abstract

In the presence of a homogeneous chemical reaction of first order, an analytical solution of a magneto hydrodynamic steady mixed convective flow of an incompressible, viscous, Newtonian, electrically conducting and chemically reacting fluid over an infinite vertical porous plate is described. Considering the induced magnetic field with viscous and magnetic energy dissipations, a uniform magnetic field is considered to be applied transversely to the direction of the flow. Both a uniform mixed stream velocity and a constant suction velocity are applied to the porous plate. The perturbations technique is used to solve the governing equations. For the various values of the parameters involved in the problem, the expressions for the velocity field, induced magnetic field, current density and the rate of heat transfer at the plate are produced and graphically illustrated. The velocity field, temperature field, induced magnetic field, current density and rate of heat transfer from the plate to the fluid are examined in relation to the Hartmann number, chemical reaction parameter, magnetic Prandtl number and other factors.

Keywords: Homogeneous; Incompressible; Viscous; Transversely; Parameters

Introduction

Numerous subfields of the process, metallurgical and chemical engineering sectors are finding growing use for the research of mixed convection magneto hydrodynamic transport phenomena with chemical reaction and induction effects. The magnetic flux in such flows Reynolds number is high and induced magnetic fields interact and have a considerable impact on the diffusion fields of temperature, velocity and species. Chemically reactive synthesis of ultra fine particles in a thermal plasma reactor, non-contact measurement of the specific heat capacity, enthalpy of fusion and thermal transport properties of electromagnetically levitated liquid metallic alloys, reactive plasmas in an inductively coupled RF discharge system and bioelectro chemical electromagnetic induction of protection against oxidative stress extrusion of conducting polymer are important technologies that take advantage of these phenomena. Many of these events could have buoyancy forces that are either thermal, species driven or both. In nature and in numerous industrial settings, such as in geophysics, oceanography, the drying process, the formation and dispersion of fog, the role of factories waste gas diffusion in a differentially heated circulated air, the extrusion of plastics in the production of rayon and nylon, the purification of crude oil, etc. combined heat and mass transfer is also observed. Relevant research include those by Chen and Ahmed, Muthucumaraswamy and Ganesan and numerous academics have investigated the issues of steady and erratic combined heat and mass transmission by free convection along an infinite and semi-infinite vertical plate with and without chemical reaction in great detail.

Description

Ahmed and Liu studied the effects of mixed convection and mass transfer of three dimensional oscillatory flow of a viscous incompressible fluid past an infinite vertical porous plate in presence of transverse sinusoidal suction velocity oscillating with time and a constant free stream velocity in light of this. The effects of heat generation, absorption and thermophoresis on hydromagnetic flow with heat and mass transfer over a flat surface were examined by Chamkha and Camille. Chamkha looked at the impact of chemical reactions on laminar boundary layer flow, heat transfer and mass transfer in the presence of heat generation and absorption. The problem of flow past an abruptly began finite vertical plate in the presence of heat flux and

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variable mass diffusion was addressed analytically by Muthucumaraswamy and Kulaivel, who also took into account the homogeneous chemical reaction of first order. The effects of heat generation, absorption and thermophoresis on hydromagnetic flow with heat and mass transfer over a flat surface were examined by Chamkha and Camille. Chamkha looked at the impact of chemical reactions on laminar boundary layer flow, heat transfer and mass transfer in the presence of heat generation and absorption. The problem of flow past an abruptly began finite vertical plate in the presence of heat flux and variable mass diffusion was addressed analytically by Muthucumaraswamy and Kulaivel, who also took into account the homogeneous chemical reaction of first order. The impact of changing viscosity, chemical reaction, heat and mass transfer on laminar flow down a semi-infinite horizontal plate was examined by Ghaly and Seddeek. The effect of varying surface temperature and concentration on natural convection flow from a vertical plate was investigated by Hossain, et al. When the free stream velocity oscillates around a non-zero constant mean, Ahmed looked at the impact of periodic heat transfer on an unsteady MHD mixed convection flow *via* a vertical porous flat plate with constant suction and heat sink. In order to investigate the effects of thermophoresis on magnetohydrodynamic heat and mass transfer in boundary layer flow along a flat plate with viscous heating, Joule heating, and wall suction, Zueco, et al. used the network simulation approach.

The research mentioned above has often been limited to relatively low magnetic Reynolds numbers, allowing for the disregard of magnetic induction effects. When the magnetic Reynolds number is greater, these effects must be taken into account. For hydromagnetic flat plate boundary layers along a magnetized plate with a homogeneous magnetic field in the stream direction at the plate, Glauert provided a seminal study. He was able to get series expansion solutions for the magnetic and velocity fields for both large and small values of the electrical conductivity parameter, showing that boundary layer separation occurs at a crucial amount of applied magnetic field. Over a wide range of magnetic Prandtl numbers and Hartmann numbers, Beg, et al. recently established local non-similarity numerical solutions for the velocity, temperature and induced magnetic field distributions in forced convection hydromagnetic boundary layers. Alom and colleagues looked into the steady MHD heat and mass transfer by mixed convection flow from a moving vertical porous plate with induced magnetic, thermal diffusion, constant heat and mass fluxes. All of these experiments showed that transverse magnetic fields had a significant impact on a variety of flow regimes. The majority of research, with the exception of, have entirely disregarded the study of magnetic Prandtl number by ignoring the solution of the magnetic induction equations in combined magneto hydrodynamic heat and mass transfer fluxes. Therefore, taking into account the induced magnetic field, viscous/magnetic dissipation and first order chemical reaction, we consider the impact of the transverse magnetic field on steady free convective heat and mass transfer from an infinite vertical isothermal porous plate with constant suction in the current study. Under the right boundary conditions, the conservation equations are non-dimensionalized and analytically solved. Due to applications in the processing of magnetic materials, such an attempt has been undertaken in the current work.

Conclusion

The theoretical solution of a steady convective magneto hydrodynamic flow of an incompressible viscous electrically conducting fluid past an infinite vertical porous plate in presence of chemical reaction of first order and with combined heat and mass transfer, taking into account the induced magnetic field with viscous and magnetic dissipations of energy is obtained in this work. The dimensionless governing equations are solved by the usual perturbation technique.