THERMOPHORESIS AND CHEMICAL REACTION EFFECTS ON MHD MIXED CONVECTIVE HEAT AND MASS TRANSFER PAST A POROUS WEDGE IN THE PRESENCE OF SUCTION

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Abstract — The effects of thermophoresis and MHD mixed convection flow with heat and mass transfer over a porous wedge are presented here, taking into account the homogeneous chemical reaction of first order. The governing fundamental equations are approximated by a system of nonlinear differential equations and are solved numerically by using the Runge Kutta Gill and shooting methods. The steady-state velocity, temperature and concentration profiles are shown graphically. It is observed that due to the presence of first-order chemical reaction, the concentration decreases with increasing values of the chemical reaction parameter. The results also showed that the particle deposition rates were strongly influenced by thermophoresis and the strength of the magnetic field in the presence of buoyancy force, particularly for opposing flow and hot surfaces. Numerical results for the skin-friction coefficient, wall heat and mass transfer are obtained and reported graphically for various parametric conditions to show interesting aspects of the solution.

Keywords — Chemical reaction, thermophoresis particle deposition and magnetic effect.

1. INTRODUCTION

Thermophoresis is a phenomenon, which causes small particles to be driven away from a hot surface and towards a cold one. It has also been shown that thermophoresis is the dominant mass transfer mechanism in the modified chemical vapor deposition process used in the fabrication of optical fiber perform and is also important in view of its relevance to postulated accidents by radioactive particle deposition in nuclear reactors. In the application of pigments, or chemical coating of metals, or removal of particles from a gas or liquid stream by filtration, there can be distinct advantages in exploiting deposition mechanisms to improve efficiency.

Goldsmith and May (1966) first studied the thermophoretic transport involved in a simple one-dimensional flow for the measurement of the thermophoretic velocity. Thermophoresis in laminar flow over a horizontal flat plate has been studied theoretically by Goren (1977). Thermophoresis in natural convection with variable properties for a laminar flow over a cold vertical flat plate has been studied by Jayaraj et al. (1999). Selim et al. (2001) studied the effect of surface mass flux on mixed convective flow past a heated vertical flat permeable plate with thermophoresis. The first analysis of thermophoretic deposition in geometry of engineering interest appears to be that of Hales et al. (1972). They have solved the laminar boundary layer equations for simultaneous aerosol and steam transport to an isothermal vertical surface situated adjacent to a large body of an otherwise quiescent air-steam-aerosol mixture. Recently, Chamkha and Pop (2004) studied the effect of thermophoresis particle deposition in free convection boundary layer from a vertical flat plate embedded in a porous medium.

Transport processes in porous media play a significant role in various applications such as in geothermal engineering, thermal insulation, energy conservation, petroleum industries solid matrix heat exchangers, chemical catalytic reactors, underground disposal of nuclear waste materials and many others. In many transport processes in nature and in industrial applications in which heat and mass transfer with thermophoresis particle deposition is a consequence of buoyancy effects caused by diffusion of heat and chemical species. The study of such processes is useful for improving a number of chemical technologies, such as polymer production and food processing.

A large amount of research work has been reported in this field. In particular, the study of heat and mass transfer with chemical reaction is of considerable importance in chemical and hydrometallurgical industries. Chemical reaction effects on heat and mass transfer laminar boundary layer flow have been discussed by many authors (Hakiem et al., 1999; Kuo, 2005; Cheng and Lin, 2002; Apelblat, 1982) in various situations.

On the other hand, when a conductive fluid moves through a magnetic field, an ionized gas is electrically conductive; the fluid may be influenced by the magnetic field. Magnetohydrodynamic(MHD) mixed convection heat transfer flow in porous and non-porous media is of considerable interest in the technical field due to its frequent occurrence in industrial technology and geothermal application, high temperature plasmas applicable to nuclear fusion energy conversion, liquid metal fluids, and (MHD) power generation systems.

At present, to the author’s best knowledge, two studies dealing with the thermophoresis effect in porous media were published: recently Chamkha and Pop (2004) looked to the effect of thermophoresis particle deposition in free convection boundary layer from a vertical flat plate embedded in a porous medium; the