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Combined effects of Joule heating and chemical reaction on unsteady magnetohydrodynamic mixed convection of a viscous dissipating fluid over a vertical plate in porous media with thermal radiation

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ABSTRACT

This paper deals with the interaction of convection and thermal radiation on an unsteady hydromagnetic heat and mass transfer for a viscous fluid past a semi-infinite vertical moving plate embedded in a porous media in the presence of heat absorption and first-order chemical reaction of the species. The fluid is considered to be a gray, absorbing–emitting but non-scattering medium, and the Cogley–Vincent–Gilles formulation is adopted to simulate the radiation component of heat transfer (Cogley et al. (1968) [25]). The plate moves with a constant velocity in the direction of fluid flow while the free stream velocity is assumed to increase exponentially. A uniform transverse magnetic field is applied to the porous surface which absorbs the fluid with suction velocity varying with time. Analytical perturbation solutions are obtained for the velocity, temperature and concentration fields as well as for the skin friction coefficient, Nusselt number and Sherwood number. Results are presented graphically and in tabulated forms to study the effects of various physical parameters. The computed results are in good agreement with the earlier published results.

1. Introduction

The problem of boundary layer flow over a continuously moving solid surface is an important type of flow occurring in many industrial processes, such as heat-treated materials traveling between a feed roll and a wind-up roll or materials manufactured by extrusion, glass fiber and paper production. In these cases, the final product of desired characteristics depends greatly on the rate of cooling of the stretched materials. Convection of a heated or cooled vertical plate is one of the fundamental problems in heat and mass transfer studies in recent times. If the existing free convection is accompanied by an external flow, the combined mode of free and forced convection exists, which is commonly known as mixed convection. At the same time the study of magnetohydrodynamics (MHD) is important in many engineering applications such as, in MHD power generators, cooling of nuclear reactors, the boundary layer control in aerodynamics and crystal growth. Transport processes in porous media play a significant role in various applications, such as thermal insulation, energy conservation, petroleum industries, solid matrix heat exchangers, geothermal engineering, chemical catalytic reactors, and underground disposal of nuclear waste materials. In many transport processes in nature and in industrial applications, the heat and mass transfer with variable viscosity is a consequence of buoyancy effects caused by the 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. In nature, the presence of pure air or water is impossible. Some foreign mass may be presented either naturally

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