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Research Article

Similarity Analysis for Effects of Variable Diffusivity and Heat Generation/Absorption on Heat and Mass Transfer for a MHD Stagnation-Point Flow of a Convective Viscoelastic Fluid over a Stretching Sheet with a Slip Velocity

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A mathematical analysis has been carried out for stagnation-point heat and mass transfer of a viscoelastic fluid over a stretching sheet with surface slip velocity, concentration dependent diffusivity, thermal convective boundary conditions, and heat source/sink. The governing partial differential equations are reduced to a system of nonlinear ordinary differential equations using Lie group analysis. Numerical solutions of the resulting ordinary differential equations are obtained using shooting method. The influences of various parameters on velocity, temperature, and mass profiles have been studied. Also, the effects of various parameters on the local skin-friction coefficient, the local Nusselt number, and the local Sherwood number are given in graphics form and discussed.

1. Introduction

Practical applications have demand to find the solution of differential equations governing the motion of non-Newtonian fluids. Several types of non-Newtonian fluids exist, but one of the public ones is the viscoelastic fluid; they can exhibit a response that resembles that of an elastic solid under some circumstances or the response of a viscous liquid under other circumstances. In nature, fluids that exhibit this behavior are macromolecular such as polymeric fluids used to make plastic articles, food systems such as dough used to make bread and pasta, and biological fluids such as synovial fluids found in joints. Flow of a viscoelastic fluid and heat transfer phenomena over a stretching surface are encountered in a wide range of chemical and engineering applications, particularly in manufacturing process of artificial film, artificial fibers, polymer extrusion, drawing of plastic films and wires, glass fiber and paper production, manufacture of foods, and crystal growing. Rajagopal et al. [1] analyzed the flow of second-order fluid over a stretched surface. Dandapat and Gupta [2] extended this problem to present the exact analytical solutions of the nonlinear equations governing this problem. Vajravelu and Rollins [3] studied heat transfer characteristics in a viscoelastic fluid over a stretching sheet with frictional heating and internal heat generation/absorption.

Flow and mass transfer of a viscoelastic fluid over a stretching sheet were studied by many authors. Kelly et al. [4] investigated the analytical solution for the problem of heat and mass transfer of an MHD viscoelastic fluid over a porous stretching sheet. Sanjayanand and Khan [5] carried out the problem of heat and mass phenomena in a viscoelastic fluid flow over an exponentially stretching impermeable sheet. Cortell [6] presented the numerical analysis of flow and mass transfer for two MHD viscoelastic fluids, namely, second-grade and second-order non-Newtonian fluids, over a porous stretching sheet. Mahmoud [7] studied the effects of variable viscosity, surface slip velocity, and chemical reaction on the flow and mass transfer of a viscoelastic fluid immersed on porous medium over a stretching surface.