Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER Applied Mathematics and Computation 169 (2005) 806–818
APPLIED MATHEMATICS AND COMPUTATION
www.elsevier.com/locate/amc

MHD free-convection flow of a non-Newtonian power-law fluid at a stretching surface with a uniform free-stream

Emad M. Abo-Eldahab, Ahmed M. Salem *

Faculty of Science, Department of Mathematics, Helwan University, Ain Helwan, Cairo 11795, Egypt

Abstract

The momentum and heat transfer in laminar boundary layer of a non-Newtonian power-law fluid flowing past a stretching surface with uniform surface heat flux and uniform free-stream, are analyzed. The sheet is linearly stretched in the presence of a uniform transverse magnetic. The effect of internal heat generation or absorption is also considered. The governing similar equations are solved numerically for several values of the power-law viscosity index and the non-Newtonian Prandtl number of the fluid. A discussion is provided for the effect of the magnetic field and heat source/sink parameters on the velocity and temperature fields. Friction coefficients and Nusselt number are calculated for the mentioned parameters.
© 2004 Published by Elsevier Inc.

1. Introduction

Fluids for which the relationship between the shear stress and rate of strain is not linear through the origin at given temperature and pressure are said to be

* Corresponding author.
E-mail address: ah_marei@hotmail.com (A.M. Salem).

0096-3003/$ - see front matter © 2004 Published by Elsevier Inc.
doi:10.1016/j.amc.2004.09.089

non-Newtonian. The subject of the boundary-layer flow on a continuously moving surface travelling through a quiet ambient fluid is currently one of important in view of its relevance to a number of engineering processes. Flows due to a continuously moving surface is encountered in several processes for thermal and moisture treatment of materials, particularly in processes involving continuous pulling of a sheet through a reaction zone, as in metallurgy in textile and paper industries, in the manufacture of polymeric sheets, sheet glass and crystalline materials. As examples on stretched sheets, many metallurgical processes involve the cooling of continuous stripe or filaments by drawing them through a quiescent fluid and that in the process of drawing, when these strips are stretched.

Since the pioneering work of Sakiadis [1] with regards to the boundary layer on a cylinder that is moving with a uniform velocity in a Newtonian fluid. Erickson et al. [2] extended Sakiadis problem to include blowing or suction at the moving surface and investigated its effects on the heat and mass transfer in the boundary layer. Many investigations have concentrated on the problems of a stretched sheet with a linear velocity and different thermal boundary conditions (see for instance [3–11]). Recently, Abo-Eldahab [12] studied the Hall effects on magnetohydrodynamic free-convection flow at a stretching surface with uniform free-stream. Most of the fluids in the mentioned applications are not strictly Newtonian. Therefore, an analysis considering the non-Newtonian behavior of these fluids in such flows seems appropriate. In view of these applications, viscoelastic boundary-layer flow along a stretching sheet has been the subject of a large number of publications [13–20].

Its worth mentioning here that many of the inelastic non-Newtonian fluids encountered in chemical engineering processes, are known to follow the empirical Ostwaald–de Waele model or the so-called "power-law model" in which the shear stress varies according to a power function of the strain rate. Hassanien et al. [21] studied the flow and heat transfer in a power-law fluid over a non-isothermal stretching sheet.

The present paper is devoted to study the MHD free-convection flow of a non-Newtonian power-law fluid near a stretching surface with a uniform free-stream of constant velocity and temperature. The flow is subjected to external magnetic field. The effect of internal heat generation or absorption is also considered. The governing non-linear partial differential equation under the assumption of small magnetic Reynolds number transformed into a system of ordinary differential equations, which are solved numerically using a shooting method with fourth order Runge–Kutta method. Numerical calculations are performed for various values of the power-law viscosity index, the non-Newtonian Prandtl number, the magnetic field and heat source/sink parameter. Results are given for the velocity field distribution and thermal field distribution. Friction coefficients and Nusselt number have been calculated and presented in tables.

Download English Version:

https://daneshyari.com/en/article/9506401

Download Persian Version:

https://daneshyari.com/article/9506401

Daneshyari.com