Mathematical and Computer Modelling 54 (2011) 1228–1237

Contents lists available at ScienceDirect

Mathematical and Computer Modelling

journal homepage: www.elsevier.com/locate/mcm

Slip velocity effect on a non-Newtonian power-law fluid over a moving permeable surface with heat generation

Mostafa A.A. Mahmoud

Department of Mathematics, Faculty of Science, Benha University (13518), Egypt

ARTICLE INFO

Article history:
Received 1 January 2010
Received in revised form 30 March 2011
Accepted 30 March 2011

Keywords:
Non-Newtonian power-law fluids
Slip condition
Heat generation or absorption
Moving surface

ABSTRACT

The effects of surface slip and heat generation (absorption) on the flow and heat transfer of a non-Newtonian power-law fluid on a continuously moving surface have been examined. The governing nonlinear partial differential equations describing the problem are transformed to nonlinear ordinary differential equations using suitable transformations. The transformed ordinary differential equations are solved numerically using the fourth order Runge–Kutta method with the shooting technique. Graphical solutions for the dimensionless velocity and the dimensionless temperature are presented and discussed for various values of the slip parameter, the heat generation or absorption parameter and the Eckert number. The results show that the local skin-friction coefficient is decreased as the slip parameter increased. Also, it is found that the local Nusselt number is decreased as the slip parameter or the heat generation parameter increased and the heat absorption parameter has the effect of increasing the local Nusselt number.

1. Introduction

In recent years, the study of flow and heat transfer of non-Newtonian fluids has received considerable attention because of its wide use of these fluids in food engineering, petroleum production, power engineering and in many industries such as polymer melt and polymer solutions used in the plastic processing industries. Many of the non-Newtonian fluids encountered in chemical engineering processes are known to follow the empirical Ostwald–de Waele power-law model. The concept of boundary layer was applied to power-law fluids by Schowalter [1]. Acrivos et al. [2] studied the steady laminar flow of non-Newtonian fluids over a plate. Similarity solutions were obtained by Kapur and Srivastava [3], Lee and Ames [4], Berkovskii [5] and Hansen and Na [6]. Boundary layer flow generated by a continuous solid surface in an otherwise quiescent fluid has many applications in industry. Well-known examples are rolling sheet drawn from a die, drying of paper and manufacturing of polymeric sheets. The power-law fluid over a continuous moving flat plate with constant velocity and temperature has been considered by Fox et al. [7]. Howell et al. [8] studied the momentum and heat transfer occurring in the laminar boundary on a continuously moving surface in a non-Newtonian power-law fluid. The boundary layer problem of a non-Newtonian fluid with fluid injection on a semi-infinite flat plate whose surface moves with constant velocity in the opposite direction to that of the uniform mainstream investigated by Akçay and Yükselen [9]. Mahmoud and Mahmoud [10] analytically examined the boundary layer flow of a power-law non-Newtonian fluid over a continuously moving surface in the presence of a non-uniform transverse magnetic field. The flow and heat transfer in a power-law fluid over a nonisothermal stretching surface analyzed by Hassanien et al. [11]. Many authors [12–20] have studied the problem of non-Newtonian power-law fluids over a continuously stretching surface under different situations.

All of the above studies were done for the case that the flow obeys the conventional no-slip condition at the surface. However non-Newtonian fluids such as polymer melts often exhibit wall slip. Rao and Rajagopal [21] studied the effect

E-mail address: mostafabdelhameed@yahoo.com.

0895-7177/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.mcm.2011.03.034