Journal of Applied Mechanics and Technical Physics, Vol. 54, No. 1, pp. 90–99, 2013.

THERMAL RADIATION EFFECT ON MIXED CONVECTION HEAT AND MASS TRANSFER OF A NON-NEWTONIAN FLUID OVER A VERTICAL SURFACE EMBEDDED IN A POROUS MEDIUM IN THE PRESENCE OF THERMAL DIFFUSION AND DIFFUSION-THERMO EFFECTS

M. A. A. Mahmoud and A. M. Megahed

UDC 536.24, 539.217.1

Abstract: Thermal radiation, thermal diffusion, and diffusion-thermo effects on heat and mass transfer by mixed convection of non-Newtonian power-law fluids over a vertical permeable surface embedded in a saturated porous medium are investigated. The governing equations describing the problem are non-dimensionalized and transformed into a non-similar form. The transformed equations are solved by using the local non-similarity method combined with the shooting technique. The effects of the physical parameters of the problem on the fluid temperature and concentration are illustrated graphically and analyzed. Also, the effects of the pertinent parameters on the local Nusselt number and the local Sherwood number are presented.

Keywords: non-Newtonian fluid, mixed convection, porous medium, thermal radiation, thermal diffusion and diffusion-thermo effects.

DOI: 10.1134/S0021894413010112

INTRODUCTION

Recently, the study of free-forced convection in a non-Newtonian boundary layer flow along a vertical surface embedded in a fluid-saturated porous medium has received considerable interest. This interest was motivated by numerous engineering applications in several areas (chemical engineering, soil science, mechanical engineering, powder metallurgy, geothermal engineering, thermal insulation systems, petroleum recovery, filtration processes, packed bed reactors, ceramic processing, and ground water pollution).

Similarity solutions for free convective heat transfer from a vertical plate in a fluid-saturated porous medium were obtained by Cheng and Minkowycz [1]. Hooper et al. [2] discussed the effects of surface injection or suction on mixed convection from a vertical plate in porous media. Sparrow et al. [3] introduced a new solution method for non-similarity boundary layers, applicable locally and independently of information from other streamwise positions. Sparrow and Yu [4] investigated the solutions for a class of thermal boundary-layer problems that do not admit similarity solutions. The problem of boundary layer flow and heat transfer of a non-Newtonian fluid through a porous medium was studied by many authors [5–13] under various physical situations. Radiative transport in porous media has important engineering applications (combustion, heat exchangers for high-temperature applications, including solar collectors, insulation systems, packed and circulating bed combustors and reactors, and manufacturing and material processes. Several investigators [14–17] studied the thermal radiation effect on the flow and heat transfer of non-Newtonian fluids through porous media in different situations.

Benha University, Benha, 13518 Egypt; mostafabdelhameed@yahoo.com. Translated from Prikladnaya Mekhanika i Tekhnicheskaya Fizika, Vol. 54, No. 1, pp. 105–115, January–February, 2013. Original article submitted August 7, 2011.

