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Effects of internal heat generation and Soret/Dufour on natural convection of non-Newtonian fluids over a vertical permeable cone in a porous medium

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ABSTRACT

This investigation examines numerically the combined heat and mass transfer of a uniform blowing/suction, non-Newtonian power-law fluid, and the effects of internal heat generation on natural convection adjacent to a vertical cone in a porous medium in the presence of Soret/Dufour effects. The surface of the vertical cone has a uniform wall temperature and a uniform wall concentration (UWT/UWC). A non-similarity analysis is carried out, and the transformed governing equations are solved using the Keller box method. The effects of the Dufour parameter, the Soret parameter, the Lewis number, the buoyancy ratio, the power-law index of the non-Newtonian fluid, the blowing/suction parameter and the internal heat generation coefficient on the heat and mass transfer characteristics were elucidated. In general, for the case of blowing, both the local Nusselt number and the local Sherwood number decrease. This trend reversed for suction of fluid. The local Nusselt (Sherwood) number decreases (increases) as the internal heat generation coefficient A^* is increased. Increasing the non-Newtonian fluid n reduces both the local Nusselt number and the local Sherwood number. The physical aspects of the problem are discussed in detail.

Keywords: non-Newtonian fluid, Soret/Dufour effects, internal heat generation, natural convection, vertical permeable cone, porous medium

1. Introduction

Convective heat transfer in porous media has various applications such as geothermal reservoirs, geophysical engineering, nuclear waste disposal, chemical reactor engineering and the storage of heat-generating materials grain and coal. Nield and Bejan (2006) recently provided a comprehensive account of available information in this field.

With respect to pure heat transfer with a lateral mass flux, Yih (1998) presented the effect of a uniform lateral mass flux on the natural convection of non-Newtonian fluids over a cone in a porous medium. Chamkha and Quadri (2002) studied the combined heat and mass transfer by hydromagnetic natural convection over a cone embedded in a non-Darcian porous medium with heat generation/absorption effects. Kechil and Hashim (2008) presented the series of solutions for boundary-layer flows in porous media with a lateral mass flux. Turkyilmazoglu and Pop (2012) examined the Soret and heat source effects on the unsteady radiative MHD free convection flow from an impulsively started infinite vertical plate. Chamkha et al. (2014) investigated the effect of suction/injection on free convection along a vertical plate in a nanofluid-saturated non-Darcy