SORET AND DUFOUR EFFECTS IN A MIXED CONVECTION COUPLE STRESS FLUID WITH HEAT AND MASS FLUXES

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Abstract— **An analysis is presented to investigate the Soret and Dufour effects on the mixed convection heat and mass transfer along a semi-infinite vertical plate embedded in a couple stress fluid with flux distributions. The governing non-linear partial differential equations are transformed into a system of ordinary differential equations using similarity transformations and then solved numerically. Profiles of dimensionless velocity, temperature and concentration are shown graphically for various values of Dufour number, Soret number and Couple stress parameter.**

Keywords— **Mixed convection, Couple stress fluid, Soret and Dufour effect, Heat and mass transfer.**

I. INTRODUCTION

The analysis of mixed convection boundary layer flow along a vertical plate embedded in viscous fluid has received considerable theoretical and practical interest. The phenomenon of mixed convection occurs in many technical and industrial problems such as electronic devices cooled by fans, nuclear reactors cooled during an emergency shutdown, a heat exchanger placed in a low-velocity environment, solar collectors and so on. Several authors have studied the problem of mixed convection about different surface geometries. When heat and mass transfer occur simultaneously in a moving fluid, the relations between the fluxes and the driving potentials are of a more intricate nature. It has been observed that an energy flux can be generated not only by temperature gradients but also by concentration gradients. The energy flux caused by a concentration gradient is termed the diffusion-thermo (Dufour) effect. On the other hand, mass fluxes can also be created by temperature gradients and this embodies the thermal-diffusion (Soret) effect. In most of the studies related to heat and mass transfer process, Soret and Dufour effects are neglected on the basis that they are of a smaller order of magnitude than the effects described by Fourier and Fick's laws. But these effects are considered as second order phenomena and may become significant in areas such as hydrology, petrology, geosciences, etc. The Dufour effect was recently found to be of order of considerable magnitude such that it cannot be neglected (Eckeret and Drake, 1972). Dursunkaya and Worek (1992) studied diffusion-thermo and thermal-diffusion effects in transient and steady natural convection from a vertical surface, whereas Kafoussias and Williams (1995) presented the same effects on mixed convective and mass transfer transfer steady laminar boundary layer flow over a vertical flat plate with temperature dependent viscosity. Postelnicu (2004) studied numerically the influence of a magnetic field on heat and mass transfer by natural convection from vertical surfaces in porous media considering Soret and Dufour effects. Both free and forced convection boundary layer flows with Soret and Dufour have been addressed by Abreu *et.al.,* (2006). Alam and Rahman (2006) have investigated the Dufour and Soret effects on mixed convection flow past a vertical porous flat plate with variable suction. The effect of Soret and Dufour parameters on free convection heat and mass transfers from a vertical surface in a doubly stratified Darcian porous medium have been reported by Lakshmi Narayana and Murthy (2007). Recently, Lakshmi Narayana and Sibanda (2010) studied Soret and Dufour effects on free convection along a vertical wavy surface in a fluid saturated Darcy porous medium.

It is known that many of the industrially and technologically important fluids behave like a non-Newtonian fluid. The effects of heat and mass transfer in non-Newtonian fluid also have great importance in engineering applications like the thermal design of industrial equipment dealing with molten plastics, polymeric liquids, foodstuffs, or slurries. Several investigators have extended many of the available convection heat and mass transfer problems to include the non-Newtonian effects. Dufour and Soret effects on heat and mass transfer in a non-Newtonian micropolar fluid in a horizontal channel have been presented by Awad and Sibanda (2010). The couple stress fluid theory developed by Stokes (1966) represents the simplest generalization of the classical viscous fluid theory that sustains couple stresses and the body couples. The important feature of these fluids is that the stress tensor is not symmetric and their accurate flow behavior cannot be predicted by the classical Newtonian