# MIXED CONVECTION FLOW OF A MICROPOLAR FLUID PAST A VERTICAL STRETCHING SURFACE IN A THERMALLY STRATIFIED POROUS MEDIUM WITH THERMAL RADIATION

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**ABSTRACT**

This paper is concerned with the effect of thermally stratification on the steady, two-dimensional mixed convection flow of a micropolar fluid past a vertical stretching permeable surface saturated in porous medium taking into account the effect of thermal radiation. The governing system of partial differential equations describing the problem are converted into a system of non-linear ordinary differential equations using similarity transformation. The resulting system of coupled nonlinear ordinary differential equations is solved numerically using the Chebyshev spectral method. The numerical results for the velocity, the micro-rotation and the temperature are displayed graphically showing the effects of various parameters like the buoyancy parameter, the radiation parameter, the stratification parameter, the permeability parameter and the suction/injection parameter. Moreover, the numerical values of the local skin-friction coefficient, the wall couple stress and the local Nusselt number for these parameters are also tabulated and discussed.

**Keywords:** Micropolar fluid, Mixed convection, Stretching plate, Thermally stratified porous medium, Thermal radiation.

## 1. INTRODUCTION

The study of non-Newtonian fluid flows have gained much attention by the researchers because of its applications in biology, physiology, technology and industry. In addition, the effects of heat transfer in non-Newtonian fluid saturated porous media also have great importance in engineering applications like the thermal design of industrial equipment dealing with molten plastics, polymeric liquids, or slurries. Several investigators have extended many of the available convective heat transfer in fluid saturated porous media problems to include the non-Newtonian effects. More discussion and applications of convective transport in porous media can be found in the book by Nield and Bejan [1], Ingham and Pop [2,3], Vafai [4,5], Pop and Ingham [6], Ingham *et al.* [7] and Bejan *et al.* [8]. There are several models for non-Newtonian fluids depending on the constitutive relationships between stress and rate of strain one of them is a micropolar fluid. The early studies of Eringen [9,10] have reported results on the theory of a micropolar fluids. Extensive reviews of this theory and its applications can be found in the articles by Ariman *et al.* [11,12] and the recent books by Lukaszewicz [13] and Eringen [14]. Mixed convection of a micropolar fluid over a moving surface have been studied by many authors [15-19] under different situations. Recently, Gupta and Sharma [20] studied the thermal instability of a micropolar fluid through a porous medium that has a constant thickness. Raptis [21] studied the steady boundary layer flow of a micropolar fluid through a porous medium by using the generalized Darcys law.

In spite of the extensive research over the past few decades, there are still some fundamental problems that need to be understood. One of them is the convective transport in thermally stratified porous medium because of the broad range of engineering applications. They include heat rejection into the environment such as lakes, rivers and seas, thermal energy storage systems such as solar ponds, and heat transfer from thermal sources such as the condensers of power plants. Although this thermal stratification effect on heat transfer in porous medium is important, only limited number of references are available in the literature, only for certain special cases. An early study of natural convection heat transfer from a semi-infinite vertical plate immersed in a thermally stratified medium was first conducted by Cheesewright [22]. Chen and Eichhorn [23] used boundary-layer approach to study free convective heat transfer for a thermally-stratified regime. Vekatachala [24] also studied free convection in thermally-stratified fluids. Kulkarni *et al.* [25] studied the problem of natural convection flow

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