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Heat Generation/Absorption and Viscous Dissipation Effects on MHD Flow of a Micropolar Fluid Over a Moving Permeable Surface Embedded in a Non-Darcian Porous Medium

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The flow and heat transfer of an electrically conducting micropolar fluid on a continuously moving porous plate embedded in a non-Darcian porous medium in the presence of a transverse magnetic field and heat generation or absorption has been considered. Ohmic heating and a new model for viscous dissipation are taken into account. The transformed coupled non-linear ordinary differential equations are solved numerically by employing a fourth-order Rung-Kutta integration scheme coupled with the shooting technique. The effects of various physical parameters on the velocity, micro-rotation velocity and temperature are shown graphically. Moreover, the numerical values of the local skin-friction, the local wall couple stress and the local Nusselt number are displayed in a tabular form and are discussed.

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I. INTRODUCTION

The flow and heat transfer behavior of polymeric fluids, colloidal fluids, real fluids with suspensions, fluids containing certain additives, liquid crystals, animal blood, *etc.* cannot be explained by the classical Navier-Stokes theory. Eringen [1] proposed a theory of micropolar fluids and derived constitutive laws for fluids with micro-structure. The theory of thermo-micropolar fluids has been developed by Eringen [2]. The micropolar fluid theory has been applied extensively for studying many complicated fluid motions. Liquid crystal behavior was described by Lee and Eringen [3,4] by using the theory of micropolar fluids. In Refs. 5 and 6 the theory of micropolar fluid was applied in studying a low-concentration suspension flow. In studying blood rheology, many authors [7–10] have used the theory of micropolar fluid. The presence of dust or smoke, particulary in gas, may also be modelled using micropolar fluid dynamics [11]. Ishak *et al.* [12] studied the boundary layer flow of a micropolar fluid on a continuous moving or fixed surface. The effect of suction/injection on the boundary layer flow of a micropolar fluid on a continuously moving or fixed surface was investigated by Ishak *et al.* [13].

The study of boundary layer flow of an incompressible fluid over a moving surface has assumed significance in recent years because of its extensive use in many engineering applications. Examples may be found in continuous casting, glass fiber production, metal extrusion, hot rolling, paper production, drawing of plastic films, metal and polymer extrusion and polymer sheets or filaments continuously drawn from a die. Sakiadis [14, 15] first analyzed the boundary layer flow past a continuously moving surface whereas heat transfer aspects was studied by Tsou *et al.* [16]. Erickson *et al.* [17] studied the effects of suction or blowing on the flow and heat transfer in the boundary layer over a moving continuous surface. Chandran and Sacheti [18] investigated the effect of magnetic field on the flow and heat transfer past a continuously moving porous plate in a stationary fluid. Mahmoud [19] studied flow and heat transfer of an electrically conducting fluid over a continuously moving vertical surface. Soundalgekar and Takhar [20] studied flow of a micropolar fluid past a continuously moving plate. Takhar and Soundalgekar [21] analyzed flow and heat transfer of a micropolar fluid past a continuously moving porous plate. Hassanien and Gorla [22] studied heat transfer to a micropolar fluid from a non-isothermal stretching sheet with suction and blowing. Micropolar fluid flow past a continuously moving plate in the presence of magnetic field was studied by Mansour and Gorla [23].

Transport of momentum and thermal energy in fluid-saturated porous media with low porosities, such as rocks, soil, sand, *etc.*, is commonly described by using Darcy's model for conservation of momentum and by us-

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