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A NOTE ON VORTICITY OF UNSTEADY MHD FREE CONVECTION AND MASS TRANSFER FLOW OF RIVLIN-ERICKSEN FLUID THROUGH POROUS MEDIUM BETWEEN TWO VERTICAL PLATES

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1.1 ABSTRECT

The present paper deals with the study of vorticity of unsteady MHD free convection and mass transfer flow of Rivlin-Ericksen fluid through porous medium between two vertical plates. The effect of Hartmann number (M), porosity parameter (K), Prandtl number (P_r), Grashoff number (G_r), Modified Grashoff number (G_m) and Schmitty number (S_c) on the vorticity distribution are discussed tables and graphically.

1.2 Keywords: *Rivlin-Ericksen fluid, Hartmann number (M), Porosity parameter (K), Prandtl number (P_r), Grashoff number (G_r), Modified Grashoff number (G_m) Schmitty number (S_c).*

1.3 INTRODUCTION:

Revlin-Ericksen [6] has introduced constitutive equations for a class of visco-elastic fluid knows as Rivlin-Ericksen fluid several authors have studied flow of Rivlin-Ericksen fluid past an infinite parallel channel. Recently, Singh and *et. al*.[11] have discussed on free convection and mass transfer flow of Rivlin-Ericksen fluid in presence of constant heat flux and uniform magnetic field. Das, P. S. [1] has studied unsteady flow of visco-elastic Rivlin-Ericksen of first order due to periodic pressure gradient through a rectangular duct. Recently, Jadon, V. K., and *et. al*. [3] have discussed MHD free convection and mass transfer flow of visco-elastic fluid through porous medium between two vertical plates in presented taking heat and mass flux. Mittal, P. K., *et al.* [5] have discussed unsteady MHD flow of an incompressible conducting fluid through cylindrical ducts with parabolic suction. Recently, Das, P. S. [2] has studied unsteady flow of visco-elastic Rivlin-Ericksen of second order due to periodic pressure gradient through a rectangular duct.

In this paper, we study of verticity of unsteady MHD free convection flow of an incompressible, electrically conducting, Rivlin-Ericksen fluid through porous medium between two vertical parallel plates.

1.4 FORMULATION OF THE PROBLEM:

Consider a two dimensional unsteady free convection flow of an electrically conducting fluid through porous medium between two vertical plates in the presence of uniform transfer magnetic field. it is assumed that there is a uniform suction velocity of the fluid and the porous medium between two vertical plates. We take the origin at mid point of distance between two parallel plates and x'-axis in the direction of motion y'-axis perpendicular to it. Introduce magnetic field intensity B_0 in the y' direction. Now the components of velocity are [u(y, t), 0] in x' any y'- axis respectively, Jadon, V. K., Jha, R. and Yadav, S.S. [3] solved the problem under the boundary conditions,

$$\frac{du_0}{dy} = 1, \frac{dT_0}{dy} = -1, \quad at \quad y = 0$$
$$u_0 = 0, T_0 = 0, C_0 = 0, \quad at \quad y = 1$$

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And found the velocity distribution of Rivlin-Ericksen fluid down an inclined plate.

$$u(y,t) = [A_{14}e^{A_4 y} + A_{15}e^{-A_4 y} + G_r A_6 (A_3 e^{A_1 y} + A_2 e^{-A_1 y}) + G_m A_7 (B_3 e^{B_1 y} + B_2 e^{-B_1 y}].e^{-nt} \tag{1}$$

Where,

$$M = \frac{B_0^2 h^2}{\rho} \upsilon\sigma (Hartmann\ Number), P_r = \frac{\mu C_p}{k} \ (\Pr andtl\ Number)$$

$$G_r = \frac{g\beta(T_w^{`} - T_0^{`})}{\upsilon U} (Grashoff\ \ Number), G_m = g\beta \frac{(C_w^{`} - C_m^{`})}{\upsilon U}$$

$$S_c = \frac{\upsilon}{D} (Schmidt\ Number), \lambda = \frac{S^{`}}{h} (Visco - elastic\ Parameter$$

$$y = \frac{y^{`}}{h}, t = \frac{t^{`}\upsilon}{h^2}, u = \frac{u^{`}}{u}, T = \frac{T^{`} - T_0^{`}}{T_w^{`} - T_0^{`}}, C = \frac{C^{`} - C_0^{`}}{C_w^{`} - C_0^{`}}$$

The velocity of the flow (1) may be calculated as;

$$\zeta = [A_4 (A_{14}e^{A_4 y} - A_{15}e^{-A_4 y} + G_r A_1 A_6 (A_3 e^{A_1 y} - A_2 e^{-A_1 y}) + G_m B_1 A_7 (B_3 e^{B_1 y} - B_2 e^{-B_1 y})].e^{-nt} \tag{2}$$

Where,

$$A_1 = \sqrt{\frac{P_r n}{\lambda n - 1}} \qquad A_2 = \frac{e^{A_1}}{2A_1 Cosh A_1}$$

$$A_{12} = \frac{A_8 e^{-A_4} + A_3 e^{A_1} + A_2 e^{-A_1}}{e^{A_4} + e^{-A_4}}$$

$$A_{13} = \frac{A_9 e^{-A_4} + B_3 e^{B_1} + B_2 e^{-B_1}}{e^{A_4} + e^{-A_4}}$$

$$A_{14} = A_{11} - G_r A_6 A_{12} - G_m A_7 A_{13}$$

$$A_{15} = (A_{14} - A_{11}) + G_r A_6 A_8 + G_m A_7 A_9$$

$$A_3 = \frac{A_2 A_1 - 1}{A_1} \qquad A_5 = \frac{1}{\lambda n - 1}$$

$$B_1 = \sqrt{\frac{S_c n}{\lambda n - 1}} \qquad B_2 = \frac{e^{B_1}}{2B_1 Cosh B_1} \qquad B_3 = \frac{B_2 B_1 - 1}{B_1}$$

$$A_6 = \frac{A_5}{A_1^2 - A_4^2}$$

$$A_4 = \sqrt{\frac{n - q}{\lambda n - 1}} \qquad A_7 = \frac{A_5}{B_1^2 - A_4^2}$$

NUMERICAL CALCULATIONS AND DISCUSSION:

Table-1: Vorticity distribution against Y different values of Hartmann number (M), K= 2,

$G_r = 2, S_c = 2$

$\rightarrow y$ $\downarrow$ ζ	0	1	2	3	4	5
M=0.2, K=2	-0.069×10^0	3.473×10^0	1.774×10^5	1.154×10^5	1.418×10^7	5.25×10^{19}
M=0.4,K=2	-0.055×10^0	1.242×10^0	1.655×10^4	9.009×10^4	3.401×10^6	1.158×10^8
M=0.6,K=2	-0.046×10^0	0.040×10^0	0.106×10^0	0.066×10^0	0.226×10^0	8.490×10^6

Table-2: Vorticity distribution against Y different values of Hartmann number (M), K= 2,

$G_r = 2, S_c = 2$

$\rightarrow y$ $\downarrow$ ζ	0	1	2	3	4	5
M=0.8, K=2	-0.033×10^0	0.361×10^0	1.00×10^2	4.691×10^2	1.975×10^4	7.060×10^5
M= 1.0,K=2	-0.022×10^0	2.695×10^0	6.455×10^0	3.605×10^2	1.605×10^3	6.005×10^3
M=1.2,K=2	-0.011×10^0	0.169×10^0	4.345×10^0	1.645×10^2	1.065×10^3	5.050×10^4

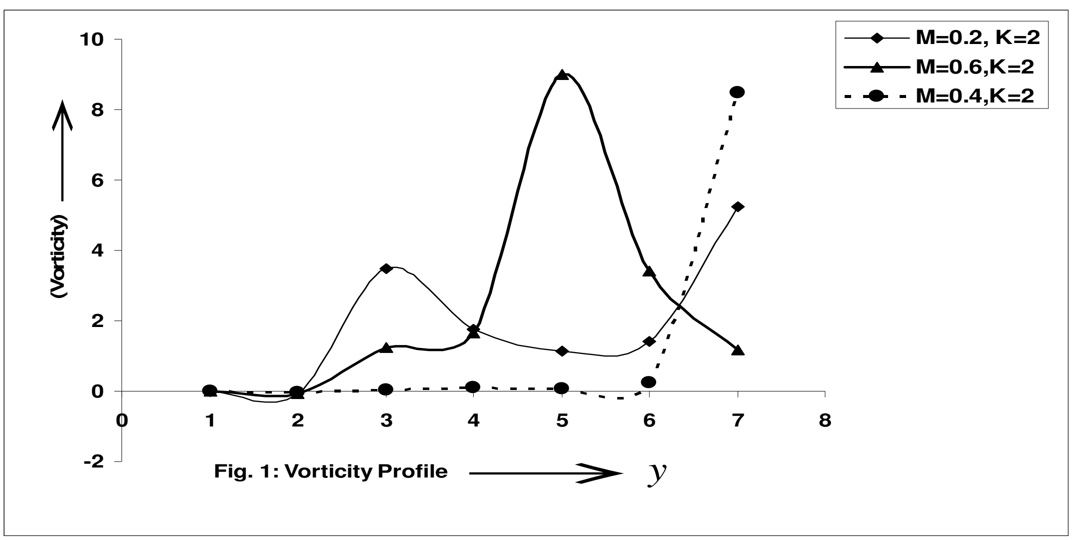

Fig. 1: Vorticity Profile

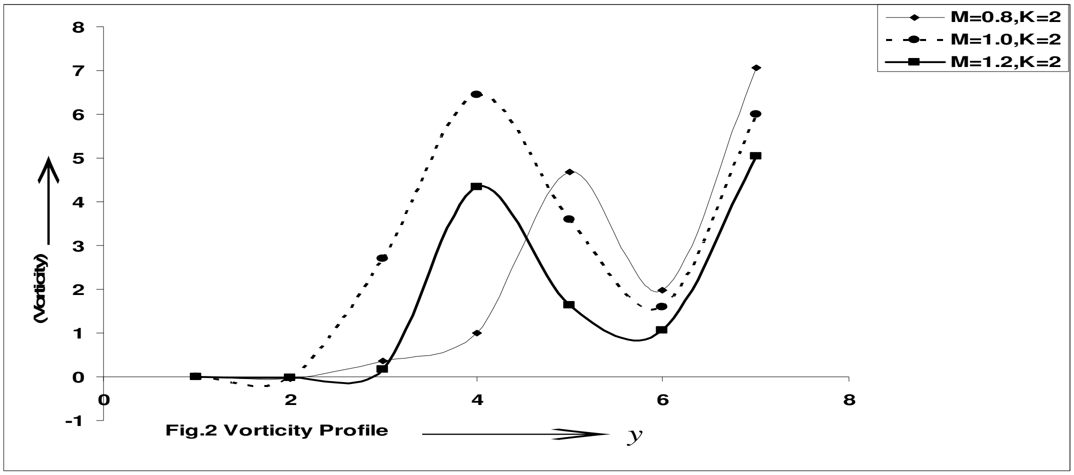

Fig.2 Vorticity Profile

It is clear from the above figures and Tables that;

The vorticity distribution of boundary layer flow plotted against y for Prandtl number ($P_r = 2$), Grashoff number ($G_r = 2$), Modified Grashoff number ($G_m = 2$), Schmidt number ($S_c = 0.6$), Porosity parameter (K= 2) and different values of Hartmann number M. separately it is found that vorticity increases continuously with increases in y. It is observed that the fluid vorticity decreases due to increasing Hartman number M. At y= 0 the value of vorticity is negative. It is obvious that the flow will also be irrotational at y = 0.

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