MHD flow of a dusty visco-elastic (Rivilin-Erickson type) past an inclined plane through permeable medium

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Abstract- The present issue is worried about the MHD laminar Flow of an unsteady visco-versatile (Rivlin-Ericksen Type) fluid with uniform conveyance of dust particles past a slanted plane through permeable medium affected by exponential weight slope. The fluid is limited by an equal upper surface a ways off h from the plane. Logical articulations for velocities of fluid and dust particles are acquired which is in rich structures. The velocity profiles of fluid and dust particles have additionally been plotted to picture the physical circumstance of the movement.

Keywords –

I. Introduction

The issue of laminar movement of dusty visco-adaptable liquid past an inclined plane has gotten noteworthy starting late particularly in the field of current and engineered working, for instance, latex particles emulsion paints and strengthening particles in polymer. The examination of these issues and rheological pieces of such stream have not gotten a ton of thought notwithstanding the way that this makes them bear on the issues of oil industry and substance building.

Stream of elastico-thick liquid in a penetrable medium is of uncommon and extending importance of the examination of pervasion through solids in hydrology, oil industry and in agrarian planning. Henry Darcy had watched while pondering stream of water through sand channels that the stream pace of water is comparative with the differentiation in head of water over the channel and the cross-sectional locale of bed. Thusly various preliminaries were coordinated to think about the movement of various fluids through different sorts of porous solids.

Chakraborty (2001) considered the laminar convection stream of an incompressible electrically driving second solicitation visco-flexible stratified fluid in penetrable medium down an equivalent plate channel inclined at point θ to the level surface inside the display of uniform transverse alluring field. **Singh et al. (2010)** mulled over a shaky two dimensional free convection stream of water at 4 degree centigrade past a tremendous vertical porous plate with predictable warmth change at the plate. The uniform appealing field is applied run of the mill to the stream region and the free stream speed influences with respect to a non-zero reliable mean and the mean stream is portrayed by speed and temperature. **Varshney et al. (2011)** discussed effects of rotator Rivlin-Ericksen fluid on

MHD free convective and mass trade course through penetrable medium with constants warmth and mass change across moving plate. **Sivaraj and Kumar (2013)** looked into falsely reacting dusty viscoelastic fluid stream in a capricious channel with convective point of confinement. **Raju et al. (2014)** pondered MHD convective course through penetrable medium in a level channel with secured and impermeable base divider inside seeing thick scattering and Joule warming. **Debnath (2015)** investigated a constant stratified visco-flexible fluid stream past a penetrable plate in a slip stream framework has been analyzed influenced by heat source/sink. The plate is presented to a consistent suction speed. They used summarized limit conditions for the slip stream framework at the plate. **Malleshwari (2018)** mulled over the united effects of transverse alluring field and twofold dispersion on temperamental farthest point layer stream of thick, incompressible, and electrically coordinating and two-dimensional warmth fascinating viscoelastic fluid stream past a semi-vast vertical permeable plate in closeness of free convection. The Rivlin-Ericksen model is used to emulate the rheological liquids experienced in cooling of electronic devices, polymer plans, hydrocarbons and invention planning methodology. **Srinivasa (2018**) inspected uncertain MHD limit layer stream of Casson fluid over an inclined surface introduced in a porous medium with warm radiation and compound reaction. Gooey dispersal influence on MHD free convection transmitting fluid stream past a vertical porous plate discussed by **Srinivasa et al. (2018)**. **Sankar and Reddy (2019)** considered the farthest point layer stream of warmth fascinating MHD Rivil-Ericksen fluid along a semi unbounded vertical vulnerable moving plate inside seeing warm buoyancy impact.

II. MATHEMATICAL FORMULATION AND SOLUTION

Consider the laminar progression of a unsteady visco-flexible (Rivlin Ericksen type) fluid through permeable medium with uniform dispersion of dust particles past a slanted plane θ of tendency to the horizontal.

We pick the inception of the co-ordinate framework at the base of the slanted plane the $x-axis$ is taken inverse to the bearing of the stream and along the best incline of the plane and $y-axis$ is taken opposite to the plane. The magnetic field of uniform strength is applied along to $y-axis$. Since both the dust and fluid particles move along the highest slant of the plane and the stream is laminar through the permeable medium, the velocity of the both fluid and dust particles can be characterized by the

$$\left.\begin{aligned} u_1 = u_1(y,t), \quad u_2 = 0, \quad u_3 = 0 \\ v_1 = v_1(y,t), \quad v_2 = 0, \quad v_3 = 0 \end{aligned}\right\} \tag{1}$$

Where u_1, u_2, u_3 and v_1, v_2, v_3 are the velocity components of liquid and dust particles respectively.

The equation of motion for the progression of dusty visco-flexible fluid (Rivlin Ericksen type) through permeable medium are given by

$$\frac{\partial u_1}{\partial t} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \left(\upsilon + \alpha\frac{\partial}{\partial t}\right)\frac{\partial^2 u_1}{\partial y^2} + \frac{K_0 N_0}{\rho}(v_1 - u_1) - \frac{\upsilon}{K}u_1 - \frac{\sigma B_0^2}{\rho}u_1 - g\sin\theta \quad (2)$$

$$\frac{1}{\rho}\frac{\partial p}{\partial y} + g\cos\theta = 0 \quad (3)$$

$$-\frac{1}{\rho}\frac{\partial p}{\partial z} = 0 \quad (4)$$

$$\frac{\partial v_1}{\partial t} = \frac{K_0}{m}(u_1 - v_1) \quad (5)$$

Where p is the pressure, υ is the kinematic co-efficient of viscosity of the gas, α is the co-efficient of visco-elasticity of the gas, K_0 is the Stoke's resistance co-efficient, N_0 is the number density of the particles, which is taken to be constant, ρ is the density of the liquid, m is the mass of a dust particle and K is the co-efficient of medium permeability.

The initial boundary conditions are

$$\left.\begin{array}{lll} t \le 0; & u_1 = 0 = v_1; & at\ y = 0 \\ t > 0; & u_1 = 0 = v_1; & at\ y = 0 \\ & u_1 = U; & at\ y = h \end{array}\right\}$$

We express the pressure p as

$$p = -pg(x\sin\theta + y\cos\theta) - x\rho\phi(t) \quad (6)$$

With the held of equation (6), equation (2) and (5) become

$$\frac{\partial u_1}{\partial t} = \phi(t) + \left(\upsilon + \alpha\frac{\partial}{\partial t}\right)\frac{\partial^2 u_1}{\partial y^2} + \frac{K_0 N_0}{\rho}(v_1 - u_1) - \frac{\upsilon}{K}u_1 - \frac{\sigma B_0^2}{\rho}u_1 \quad (7)$$

$$\frac{\partial v_1}{\partial t} = \frac{k_0}{m}(u_1 - v_1) \tag{8}$$

Let us choose u_1, v_1 and $\phi(t)$ as

$$\left.\begin{aligned} u_1(y,t) &= u(y)e^{-\lambda^2 t} \\ v_1(y,t) &= v(y)e^{-\lambda^2 t} \\ \phi(t) &= ce^{-\lambda^2 t} \end{aligned}\right\} \tag{9}$$

Substituting the values of u_1, v_1 and $\phi(t)$ in equation (7) and (8)

we get

$$(\upsilon - \alpha\lambda^2)\frac{d^2u}{dy^2} + (\lambda^2 - M_0^2 - \frac{\upsilon}{K})u + M(v-u) = -c \tag{10}$$

$$v = \frac{K_0}{K_0 - m\lambda^2}u \tag{11}$$

where

$$M_0^2 = \frac{\sigma B_0^2}{\rho},$$
$$M = \frac{K_0 N_0}{\rho}$$

The boundary conditions are

$$\left.\begin{aligned} y = 0; \quad u = 0, \\ y = h; \quad u = U, \end{aligned}\right\} \tag{12}$$

Substituting the value of v from equation (11) in (10), we get

$$\frac{d^2u}{dy^2}+s^2u=-c_1 \tag{13}$$

where

$$s^2=\left(\lambda^2-M_0^2-\frac{\upsilon}{K}+\frac{Mm\lambda^2}{K_0-m\lambda^2}\right)/(\upsilon-\alpha\lambda^2)$$

$$c_1=c/(\upsilon-\alpha\lambda^2)$$

Solution of equation (13) under boundary condition (12) is given by

$$u(y)=A_1\cos(sy)+A_2\sin(sy)-\frac{c_1}{s^2} \tag{14}$$

where

$$A_1=\frac{c_1}{s^2},$$

$$A_2=\frac{U+\frac{c_1}{s^2}\{1-\cos(sh)\}}{\sin(sh)}$$

The velocity of the liquid and dust particles are expressed as

$$u_1=\left\{A_1\cos(sy)+A_2\sin(sy)-\frac{c_1}{s^2}\right\}\mathrm{e}^{-\lambda^2t} \tag{15}$$

$$v_1=\frac{K_0}{K_0-m\lambda^2}\left\{A_1\cos(sy)+A_2\sin(sy)-\frac{c_1}{s^2}\right\}e^{-\lambda^2t} \tag{16}$$

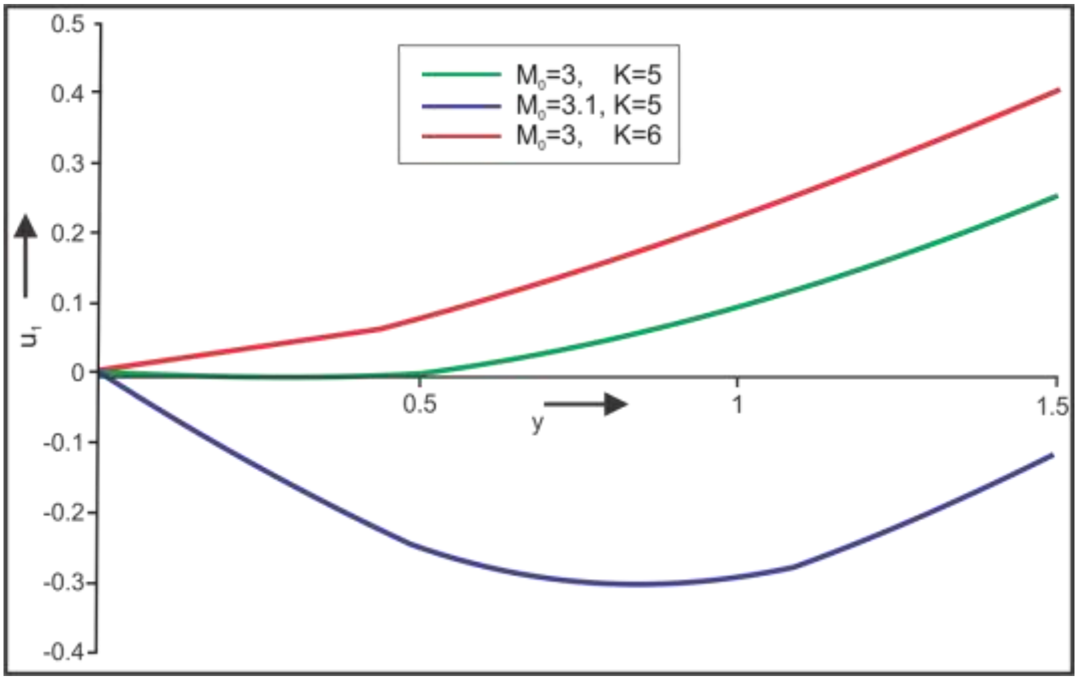
III. NUMERICAL RESULTS

y	u_1	u_1	u_1
	$M_0 = 3, K = 5$	$M_0 = 3.1, K = 5$	$M_0 = 3, K = 6$
0	0.00000	0.00000	0.00000
0.5	0.00033	-0.24712	0.07780
1	0.09900	-0.28937	0.23197
1.5	0.26717	-0.10835	0.41863

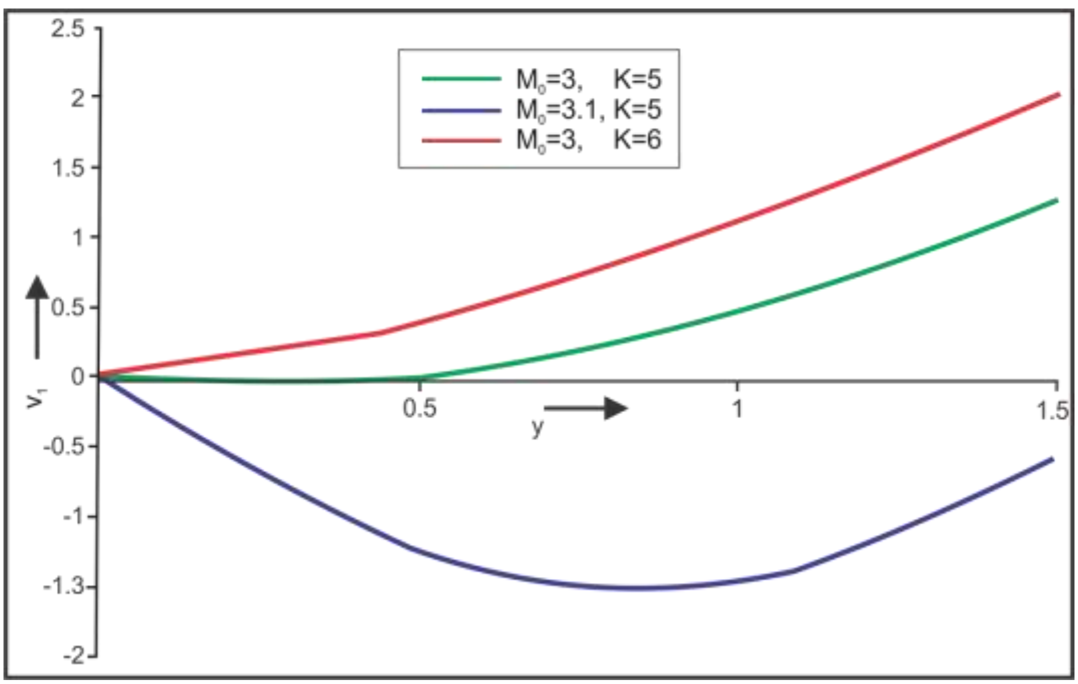
Table 1: Calculated values of u_1 with different values of M_0 and K

y	v_1	v_1	v_1
	$M_0 = 3, K = 5$	$M_0 = 3.1, K = 5$	$M_0 = 3, K = 6$
0	0.00000	0.00000	0.00000
0.5	0.00163	-1.23559	0.38900
1	0.49502	-1.44685	1.15987
1.5	1.33584	-0.54174	2.09317

Table 2: Calculated values of v_1 with different values of M_0 and K



Graph 1- Velocity Profile of Liquid with different values of M_0 and K



Graph 2- Velocity Profile of dust particle with different values of M_0 and K

For numerical calculation we have considered following values:

$$\upsilon = 1, U = 1,\ t = 0.4,\ \lambda = 2,\ h = 30,\ M = 1,\ \frac{m}{K_0} = 0.2,\ c = 2$$

The Profile for visco-elastic liquid and dust particles are tabulated in tables (4.1) and (4.2) and plotted in Graphs (4.1) and (4.2) respectively.

It is noticed that velocity of visco-elastic liquid and dust particles decreases when M_0 increases at constant K. It is also seen that velocity of visco-elastic liquid and dust particles increases when increases K at constant M_0.

IV. CLOSING COMMENTS

In this investigation of MHD flow of a dusty visco-flexible (Rivlin-Ericksen type) fluid past a slanted plane through permeable medium considering distinctive numerical estimations of and M_0 and K, we finish up our outcomes as: (i)The velocity of visco-flexible fluid and dust particles diminishes when M_0 increments at consistent K. (ii)The velocity of visco-flexible fluid and dust particles increments when increments K at steady M_0.

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