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Unsteady Hall effects on magneto hydrodynamics flow through a permeable Channel

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Abstract - In this paper we talk about the corridor current impact on the pulsatile stream of a thick incompressible liquid through a permeable medium in an adaptable channel affected by cross over attractive field. The non-straight conditions administering the stream are tackled utilizing annoyance method. Accepting long frequency estimate, the speed segments and weights on the divider are determined up to arrange in and the conduct of the pivotal and cross over speeds just as the anxieties is examined for various variety in the administering boundaries. The shear weights on the divider are determined all through the pattern of swaying at various focuses inside a frequency and the stream partition is dissected.

Keywords: MHD flows, hall current effects, porous medium, unsteady.

I. INTRODUCTION

MHD is unstable with the common association of a directing liquid stream and attractive field. The liquids being examined are electrically directing and nonmagnetic, which restricts them to hot ionized gases (plasmas) and solid electrolytes. Because of the immense utilizations of attractive fields related to rotational impacts in current material handling, for example, driving pivoting MHD generators, adjustment of slender attractive fluid movies, and homogeneity control of leading liquids. Liquid streams affected by an applied attractive field happen in certain designing cycles, similar to glass fabricating, raw petroleum refinement, polymer innovation, geothermal vitality extraction and limit layer control in the field of streamlined features and blood stream. As of late, hydro magnetic stream and warmth move in it have gotten extensive consideration because of their different applications in science, building, and industry.

Impacts of radiation, compound response and soret on insecure mhd free convective stream over a vertical permeable plate concentrated by Dharmaiah et al. [1]. Temperamental mhd convective warmth and mass exchange stream past a slanted moving surface with heat assimilation have been analyzed by Ramprasad et al. [2]. Synthetic response and soret impacts on casson mhd liquid over a vertical plate proposed by Charan et al. [3].Chemical response, radiation and dufour impacts on casson magneto hydro elements liquid stream over a vertical plate with heat source/sink have detailed by Vedavathi et al. [4]. Engineered reaction and radiation impacts on flimsy mhd free convective stream over a vertical penetrable plate have been clarified by Babyrani et al. [5]. Mhd free convective stream past a semi-endless vertical penetrable moving plate with heat assimilation examined by Balamurugan et al. [6]. Impact of slip condition on radiative mhd stream of a thick liquid in equal permeable plate direct in presence of warmth assimilation and synthetic response examined by Venkateswarlu et al. [7]. A temperamental magneto hydro dynamic warmth move stream in a turning equal plate channel through a permeable medium with radiation impact communicated by Dharmaiah [8]. Magneto hydro elements convective stream past a vertical permeable surface in slip-stream system tested by Dharmaiah et al. [9]. Impact of substance response on mhd casson liquid stream past a slanted surface with radiation explored by Dharmaiah et al. [10]. MHD transient free convection adjusted attractive and artificially receptive stream past a permeable slanted plate with radiation and temperature slope subordinate warmth source in slip stream system explored by Babyrani et al. [11]. The impact of compound response on warmth and mass exchange mhd stream ag, tio2 and cu water nano liquids over a semi unending surface examined by Dharmaiah et al. [12]. Impact of radiation retention, thick and joules scattering on mhd free convection artificially receptive and radiative stream in a moving slanted permeable plate with temperature subordinate warmth source closed by Balamurugan et al. [13]. Impact of radiation on warmth and mass exchange in mhd liquid stream over an interminable vertical permeable surface with concoction response determined by Babyrani et al. [14]. Investigation of warmth and mass exchange on mhd stream of nanofluid over a semi endless moving surface with dissemination thermo have been concentrated by Dharmaiah et al. [15]. Warmth move on mhd nanofluid stream over a semi vast level plate implanted in a permeable medium with radiation retention, heat source and dispersion thermo impact created by Vedavathi et al. [16]. Examination of warmth and mass exchange on mhd stream with ag, al2o3 and cu water nanofluids over a semi limitless

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surface Vedavathi et al. [17]. Impacts of substance response and joule warming on mhd warmth and mass exchange free on convective radiative stream in a moving slanted permeable surface with corridor current and alinged attractive temperature subordinate warmth source introduced by Babyrani et al. [18]. Warmth and mass exchange on mhd liquid stream over a semi endless level plate with radiation retention, heat source and dispersion thermo impact utilized by Dharmaiah et al. [19]. Mhd limit layer stream and warmth move of a nanofluid past a radiative and incautious vertical plate scientifically concentrated by Dharmaiah et al. [20]. Scientific examinations of adjusted and lobby impacts on Unsteady free convection stream past a quickened slanted plate utilized by Vedavathi et al. [21]. Impacts of radiation and lobby current on flimsy mhd freeconvective stream over slanted permeable surface handled by Babyrani et al. [22]. Radiation impact on transient free convection mhd stream with exponentially rotting divider temperature recreated by Babyrani et al. [23]. An examination on mhd limit layer stream turning outline nanofluid with synthetic response considered by Vedavathi et al. [24]. A Study on Al2O3-H2O Nanofluid within the sight of Constant warmth source have been considered by Ramprasad et al. [25]. Uday kumar et al. [26] has been tended to by logical investigation of SiO2-water based nano liquid stream in a turning outline with thermo-phoresis.

The Hall flows significantly affect the greatness and course of the current thickness and thusly on the attractive power. In practically the entirety of the previously mentioned examinations, steady liquid properties were accepted. Nonetheless, tests demonstrate this can hold just if the temperature doesn't change quickly or rashly. Thus, more exact expectation of stream and warmth move can be gotten distinctly by thinking about varieties of the liquid and electromagnetic properties, particularly the temperature varieties of the liquid thickness, warm conductivity, and the electrical conductivity. As a rule, most greases utilized in both building and mechanical cycles are receptive, e.g., hydrocarbon oils, engineered esters and so forth., and their effectiveness relies to a great extent upon the temperature variety. Accordingly, it is essential to decide the warmth move conditions and warm stacking properties of thick responsive liquids to gauge their viability as greases. Our paper is given to exploring the impacts of the Hall flows on a shaky hydromagnetic stream. The non-direct conditions overseeing the stream are illuminated utilizing irritation procedure.

II. FORMULATION AND SOLUTION OF THE PROBLEM

Consider the rickety fully developed pulsatile flow of fluid through a porous medium in a flexible channel of transverse field of magnetic strength H_O.

- Choosing the O(x, y), upper and lower walls of the channel are given by $y = \pm\, as\left(\frac{x}{\lambda}\right)$.
- The entire flow is subjected to strong uniform transverse magnetic field normal to the plate in its own plane.
- Equation of motion in both directions $\mu_e J_y H_o$ and $-\mu_e J_x H_o$.

The equations governing using Brinkman's model are

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \quad (1)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+\mu_e J_y H_0-\frac{\nu}{k}u \quad (2)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\nu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)-\mu_e J_x H_0-\frac{\nu}{k}v \quad (3)$$

$$J+\frac{\omega_e\tau_e}{H_0}J\times H=\sigma\,(E+\mu_e\, q\times H) \quad (4)$$

In equation (4), the electron pressure gradient, the ion-slip and thermo-electric effects are neglected. We also assume that the electric field $E=0$ under assumptions reduces to

$$J_x+m\,J_y=\sigma\mu_e H_0 v \quad (5)$$

$$J_y-m\,J_x=-\sigma\mu_e H_0 u \quad (6)$$

where $m=\omega_e\tau_e$ is the hall parameter.

On solving equations (5) and (6) we obtain

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$$J_x = \frac{\sigma\mu_e H_0}{1+m^2}(v+mu) \tag{7}$$

$$J_y = \frac{\sigma\mu_e H_0}{1+m^2}(mv-u) \tag{8}$$

Using the equations (7) and (8) the equations of the motion with reference to frame are given by

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+\frac{\sigma\mu_e{}^2 H_0{}^2}{\rho(1+m^2)}(mv-u)-\frac{\nu}{k}u \tag{9}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\nu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)-\frac{\sigma\mu_e{}^2 H_0{}^2}{\rho(1+m^2)}(v+mu)-\frac{\nu}{k}v \tag{10}$$

Eliminating p from equations (9) and (10), the governing the flow in terms of appropriate stream function ψ reduces to

$$(\nabla^2\psi)_t-\psi_y\nabla^2\psi_x+\psi_x\nabla^2\psi_y=-\left(\frac{\sigma\,\mu_e^2 H_0^2}{\rho(1+m^2)}+\frac{\nu}{k}\right)\nabla^2\psi+\nu\,\nabla^4\psi \tag{11}$$

Where ∇^2 is the laplacian operator

The relevant conditions on ψ are

$$u=-\frac{\partial\psi}{\partial y},\ v=\frac{\partial\psi}{\partial x} \tag{12}$$

The relevant boundary conditions are

$$\psi=0,\ \psi_{yy}=0 \qquad \text{on } y=0 \tag{13}$$

$$\psi_y=0,\ \psi=1+k_1e^{it} \qquad \text{on } y=s \tag{14}$$

We introduce the following non-dimensional variables.

$$x^*=\frac{\psi}{\lambda},\ y^*=\frac{y}{a},\ t^*=\omega t,\ \varepsilon=\frac{a}{\lambda},\ \psi^*=\frac{\psi}{q\,a},\ \psi^*{}_f=\frac{\psi_f}{q_a}$$

Substituting the above non-dimensional variables into the equation (11), the governing equation in terms of non-dimensional parameter ψ (on dropping the asterisks) reduces to

$$R\varepsilon\left(\varepsilon^2(\psi_x\psi_{yxx}-\psi_y\psi_{xxx})+\psi_x\psi_{yyy}-\psi_y\psi_{xyy}\right)+S\varepsilon^2\psi_{tyy}+S\psi^4\psi_{txx}=$$

$$\varepsilon^4\psi_{xxxx}+\psi_{yyyy}+\varepsilon^2\left[2\psi_{xxyy}-\left(\frac{M^2}{1+m^2}+D^{-1}\right)\psi_{xx}\right]-\left(\frac{M^2}{1+m^2}+D^{-1}\right)\psi_{yy} \tag{15}$$

Equation (15) is highly non-linear and is not amenable for exact solution. However assuming the slope of the flexible channel ε small (<<1). We take ψ may be given asymptotic expansion in the form

$$\psi=\left(\psi_0 k_1 e^{it}\,\bar{\psi}_0\right)+\varepsilon\left(\psi_1+k_1e^{it}\,\bar{\psi}_1\right)+------ \tag{16}$$

We are making use of transformation

$$\eta=\frac{y}{s(x)} \tag{17}$$

And the boundary conditions at $y = s(x)$, Now to be satisfied at $\eta=1$.

The solution of the problem is given by

$$\psi=\left[C_1\sinh(\sigma_1\eta)+C_2\eta\right]+k_1e^{it}\left[C_8\sinh(\sigma_1\eta)+C_9\eta\right]+\varepsilon\{\ C_3\sinh(\sigma_1\eta)+c_4\eta+$$
$$C_5\eta^2\sinh(\sigma_1\eta)+C_6\eta\cosh(\sigma_1\eta)+C_7\sinh(2\sigma_1\eta)+k_1e^{it}(\ C_{10}\sinh(\sigma_1\eta)+$$
$$+C_{11}\eta+C_{12}\eta^2\sinh(\sigma_1\eta)+C_{13}\eta\cosh(\sigma_1\eta)+C_{14}\sinh(2\sigma_1\eta)\ )\ \} \tag{18}$$

The axial velocity and the transverse velocity are given by

$$u=\frac{-1}{s(x)}\{\ (C_1\sinh(\sigma_1\eta)+C_2\eta)_\eta+k_1e^{it}(C_8\sinh(\sigma_1\eta)+C_9\eta)_\eta+$$

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$$+\varepsilon\left(\left[(C_3\sinh(\sigma_1\eta)+C_4\eta+C_5\eta^2\sinh(\sigma_1\eta)+C_6\eta\cosh(\sigma_1\eta)+C_7\sinh(2\sigma_1\eta)\right]_\eta+\right.$$

$$\left.+k_1e^{it}\left[C_{10}\sinh(\sigma_1\eta)+C_{11}\eta+C_{12}\eta^2\sinh(\sigma_1\eta)+C_{13}\eta\cosh(\sigma_1\eta)+C_{14}\sinh(2\sigma_1\eta)\right]_\eta\right)\}$$

$$v=(C_1\sinh(\sigma_1\eta)+C_2\eta)_x+k_1e^{it}(C_8\sinh(\sigma_1\eta)+C_9\eta)_x+$$

$$+\varepsilon\{\left[(C_3\sinh(\sigma_1\eta)+C_4\eta+C_5\eta^2\sinh(\sigma_1\eta)+C_6\eta\cosh(\sigma_1\eta)+C_7\sinh(2\sigma_1\eta)\right]_x+$$

$$+k_1e^{it}\left[C_{10}\sinh(\sigma_1\eta)+C_{11}\eta+C_{12}\eta^2\sinh(\sigma_1\eta)+C_{13}\eta\cosh(\sigma_1\eta)+C_{14}\sinh(2\sigma_1\eta)\right]_x\}$$

Shear stress at the wall $y=s(x)$ is given by

$$\tau=\frac{\sigma_{xy}(1-s_{xx})+(\sigma_{yy}-\sigma_{xx})s_x}{1+(s_x)^2}$$

Where $\sigma_{xy}=-\mu(\psi_{yy}-\psi_{xx})$, $s(x)=1+\delta\sin x$, $\sigma_{yy}-\sigma_{xx}=1-4\mu\psi_{xy}$

III. RESULTS AND DISCUSSION

The stream administered by the non-dimensional boundaries R the Reynolds number, D^{-1} converse Darcy boundary, the abundance of the limit wave, k_1 the plentifulness of oscillatory transition, M the attractive boundary (Hartman number), S the oscillatory boundary and m lobby boundary. The pivotal, cross over speeds and the burdens are assessed computationally for various varieties in the administering boundaries R, D^{-1}, k_1, M, S and m. For computational reason we picked the limit wave s(x) = 1+ sinx in the non-dimensional structure. The figures (1-15) speak to the speed parts u and v for various varieties of the overseeing boundaries being different boundaries fixed. We see that for all varieties in the overseeing boundaries, the hub speed u accomplishes its most extreme on the mid plane of the channel. We notice that the greatness of the hub speed u improves and the cross over speed v lessens with expanding the Reynolds boundary R. The conduct of cross over speed v is oscillatory with its greatness diminishing on R increments through little qualities fewer than 30 and later decreases for additional expansion in R. The resultant speed likewise improves with expanding the Reynolds boundary R (Fig 1 and 2). From figures (3 and 4) we inferred that both the speed parts u and v diminishes with increment in the reverse Darcy boundary D^{-1}. Here we see that higher the porousness of the permeable medium bigger the hub speed along the channel and pace of increment is adequately high. Essentially, the resultant speed diminishes with expanding in the opposite Darcy boundary D^{-1}. It is obvious that the greatness of u, v and the resultant speed increment with expanding the boundaries k1, and m (5, 6, 9, 10, 13 and 14). The extent of the hub speed u upgrades and the cross over speed v diminishes with expanding in the abundance of the limit wave. The resultant speed additionally lessens with expanding the boundary (Fig 7 and 8). We notice that the greatness of the speed segments u and v lessens with expanding the power of the attractive field M. The resultant speed additionally diminishes with expanding the Hartmann number M (Fig 11 and 12). The size of the pivotal speed u upgrades and the cross over speed v decreases with expanding the oscillatory boundary S. The conduct of cross over speed v is oscillatory with its size diminishing on S increments through little qualities fewer than 3 and later decreases for additional expansion in S. The resultant speed likewise upgrades with expanding the oscillatory boundary S (Fig 15).

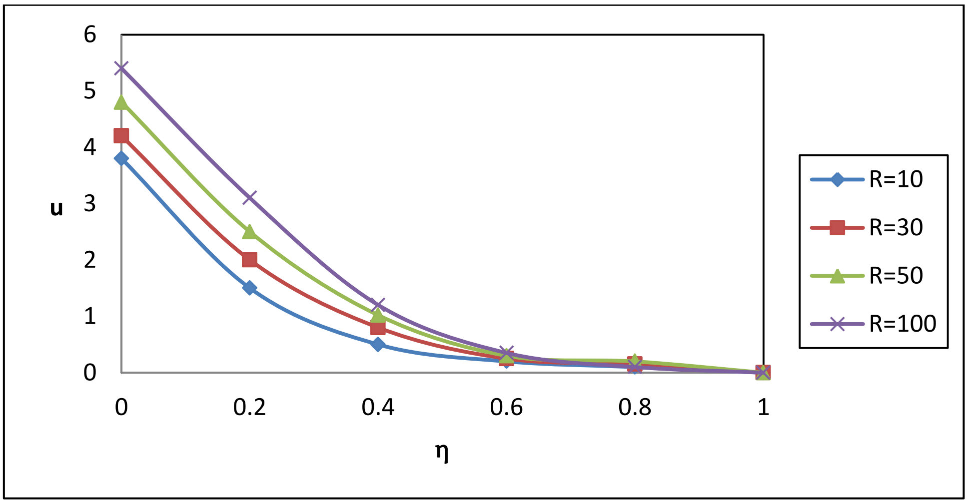

Fig 1: The velocity profile for *u* against *R*

k_1=1, S=1, D^{-1} =1000, M=2, m=1, $x=t=\frac{\pi}{4}$, $\delta=0.01$

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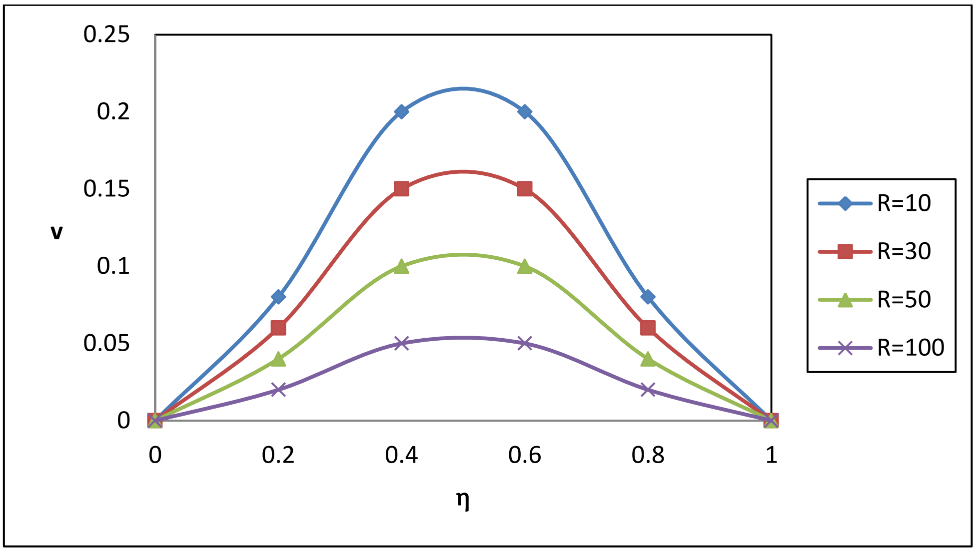

Fig 2: The velocity profile for *v* against *R*

k_1=1, *S*=1, D^{-1} =1000, *M*=2, *m*=1, $x = t = \dfrac{\pi}{4}$, $\delta = 0.01$

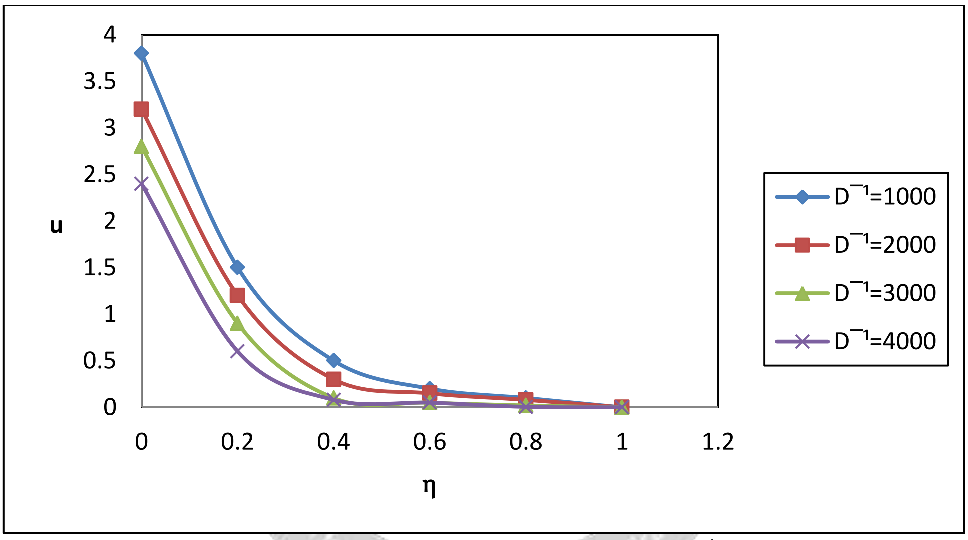

Fig 3: The velocity profile for *u* against D^{-1}

R=10, *S*=1, k_1=1, *M*=2, *m*=1 $x = t = \dfrac{\pi}{4}$, $\delta = 0.01$

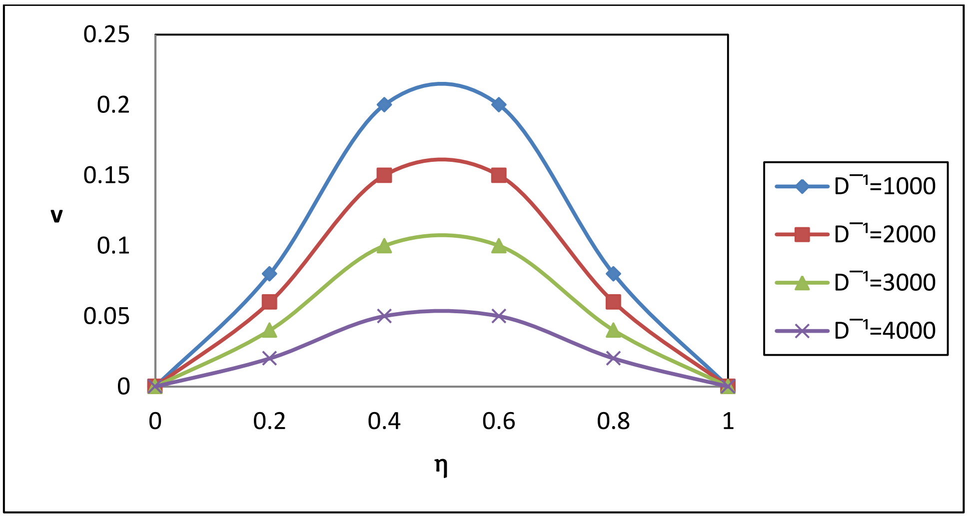

Fig 4: The velocity profile for *v* against D^{-1}

R=10, *S*=1, k_1=1, *M*=2, *m*=1 $x = t = \dfrac{\pi}{4}$, $\delta = 0.01$

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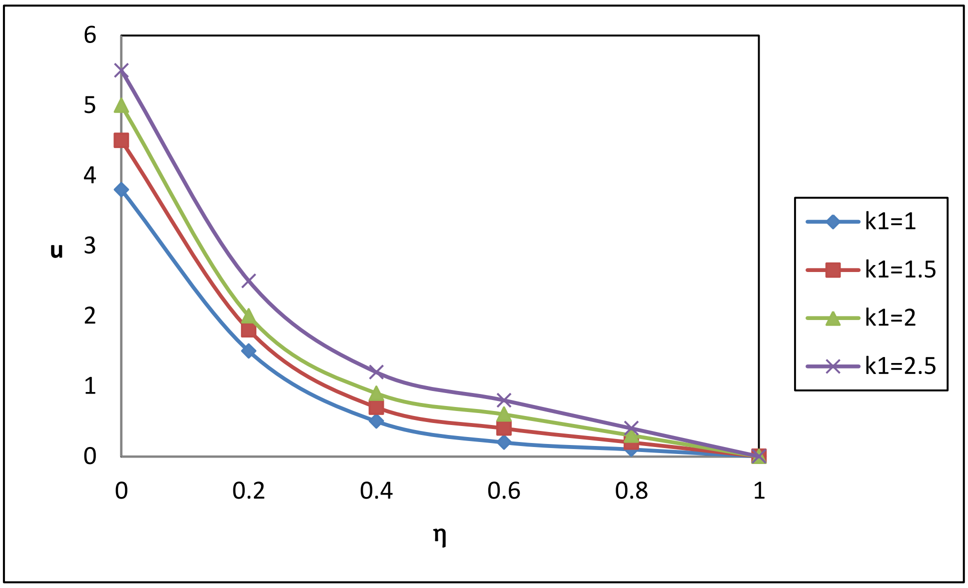

Fig 5: The velocity profile for u against k_1

m=1, S=1, D^{-1} =1000, M=2, $x = t = \dfrac{\pi}{4}$, R=10, $\delta = 0.01$

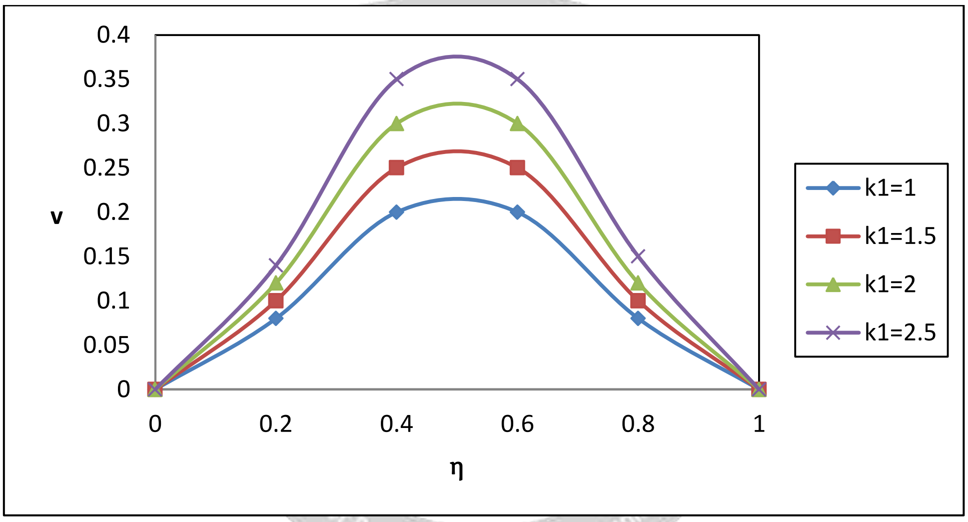

Fig 6: The velocity profile for v against k_1

m=1, S=1, D^{-1} =1000, M=2, $x = t = \dfrac{\pi}{4}$, R=10, $\delta = 0.01$

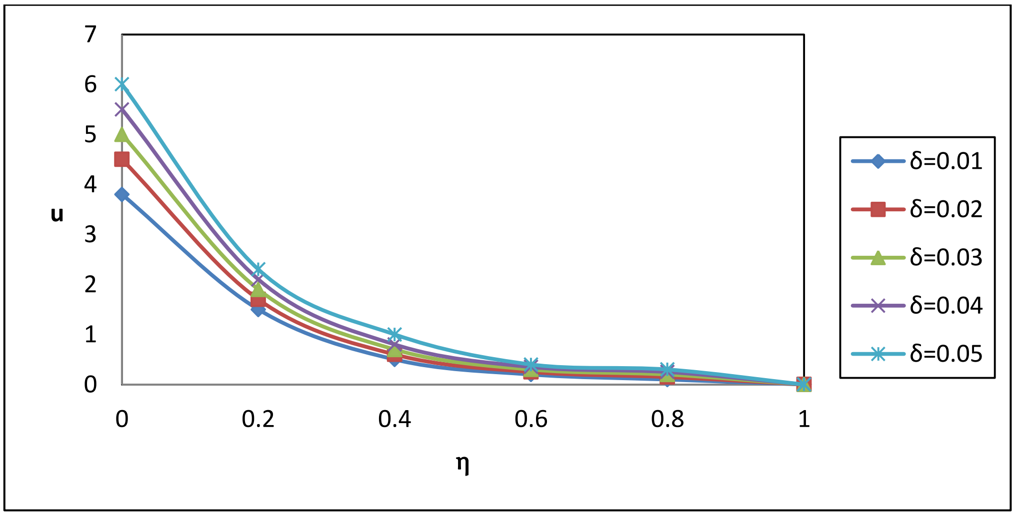

Fig 7: The velocity profile for u against δ

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k_1=1, S=1, D^{-1} =1000, R=10, M=2, $x = t = \frac{\pi}{4}$, m=1

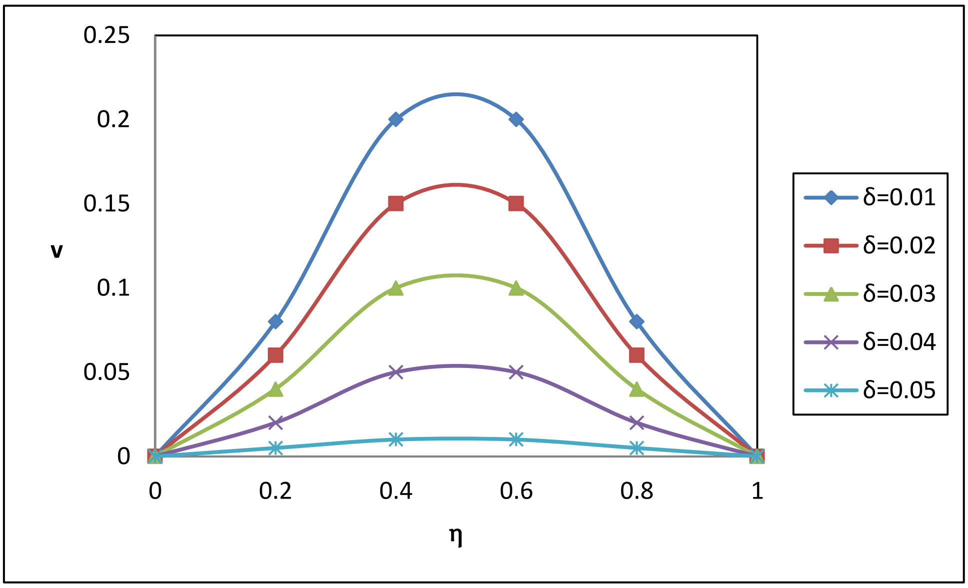

Fig 8: The velocity profile for v against δ

k_1=1, S=1, D^{-1} =1000, R=10, M=2, $x = t = \frac{\pi}{4}$, m=1

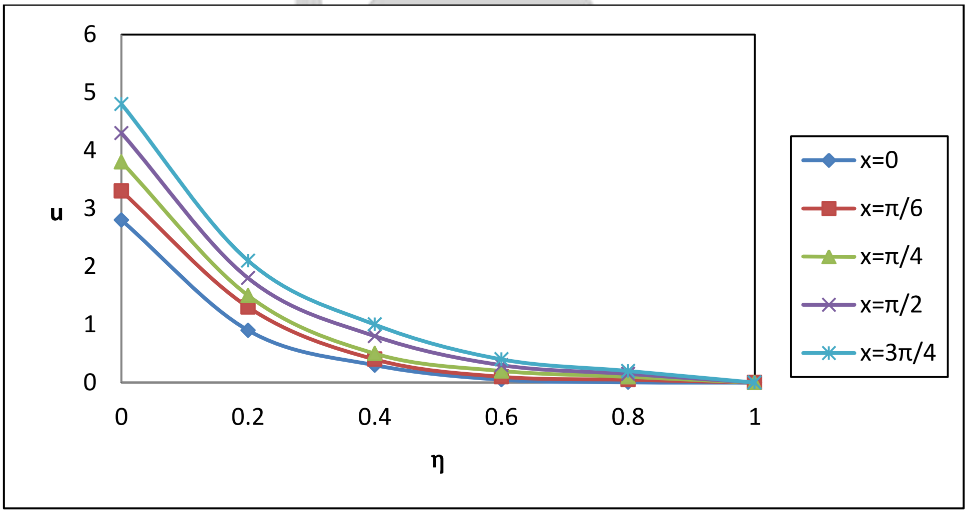

Fig 9: The velocity profile for u against x

R=10, S=1, D^{-1} =1000, k_1=1, M=2, m=1, $t = \frac{\pi}{4}$, $\delta = 0.01$

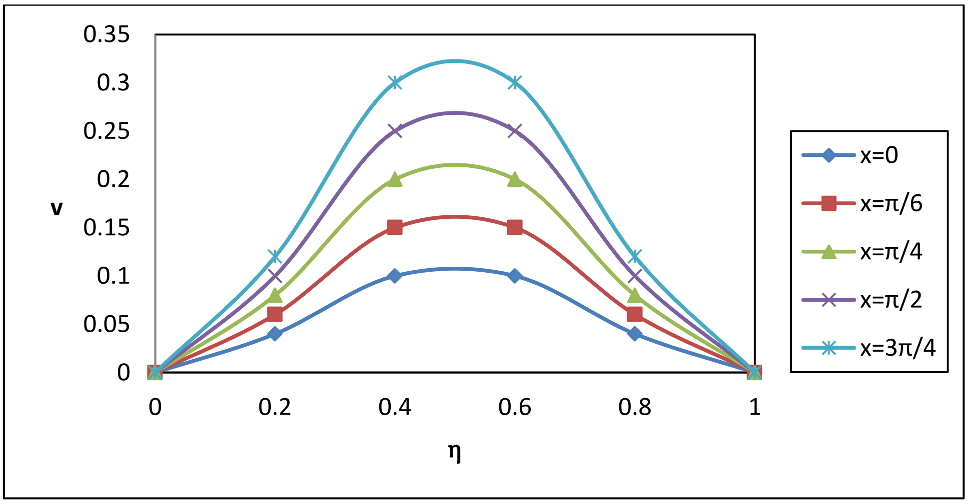

Fig 10: The velocity profile for v against x

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R=10, S=1, D^{-1} =1000, k_1=1, M=2, m=1, $t=\frac{\pi}{4}$, $\delta=0.01$

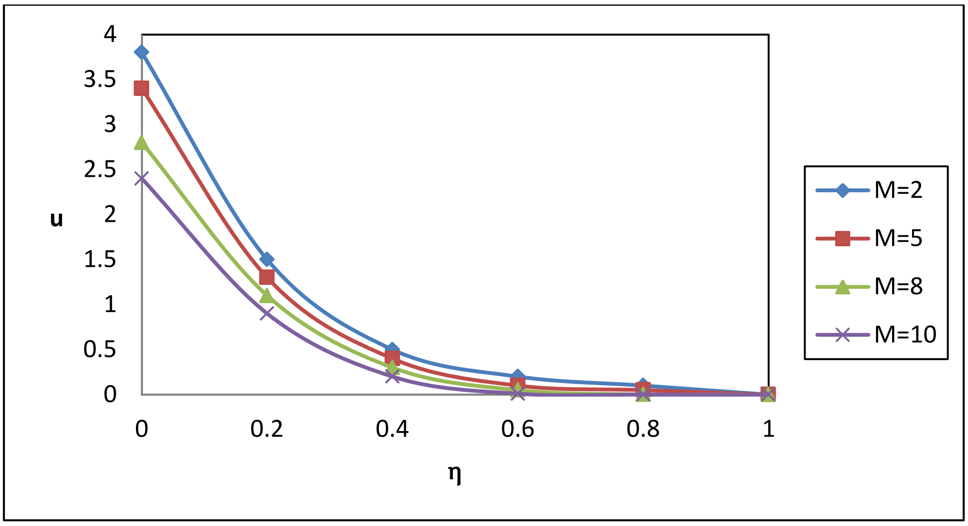

Fig 11: The velocity profile for *u* against M

k_1=1, S=1, D^{-1} =1000, m=1, $x=t=\frac{\pi}{4}$, R=10, $\delta=0.01$

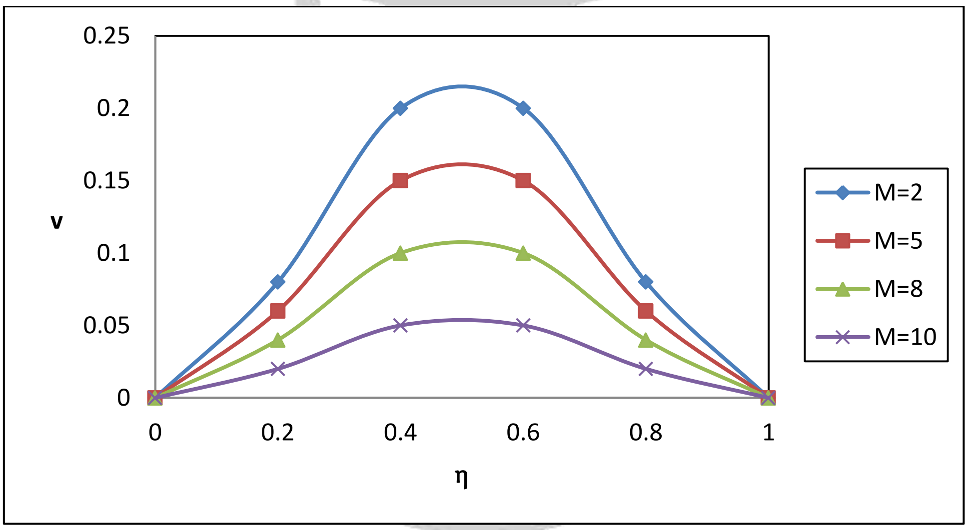

Fig 12: The velocity profile for *v* against M

k_1=1, S=1, D^{-1} =1000, m=1, $x=t=\frac{\pi}{4}$, R=10, $\delta=0.01$

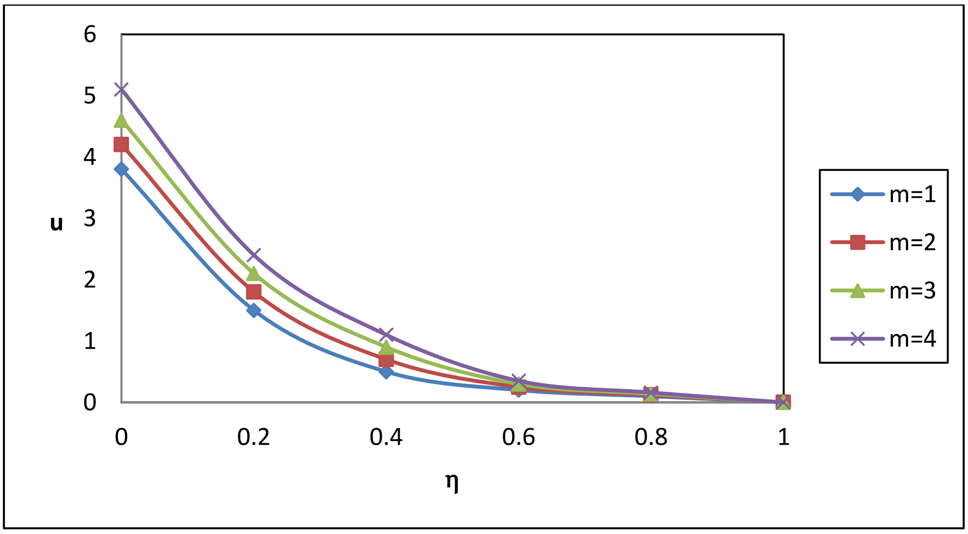

Fig 13: The velocity profile for *u* against *m*

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k_1=1, S=1, D^{-1} =1000, M=2, $x = t = \dfrac{\pi}{4}$, R=10, $\delta = 0.01$

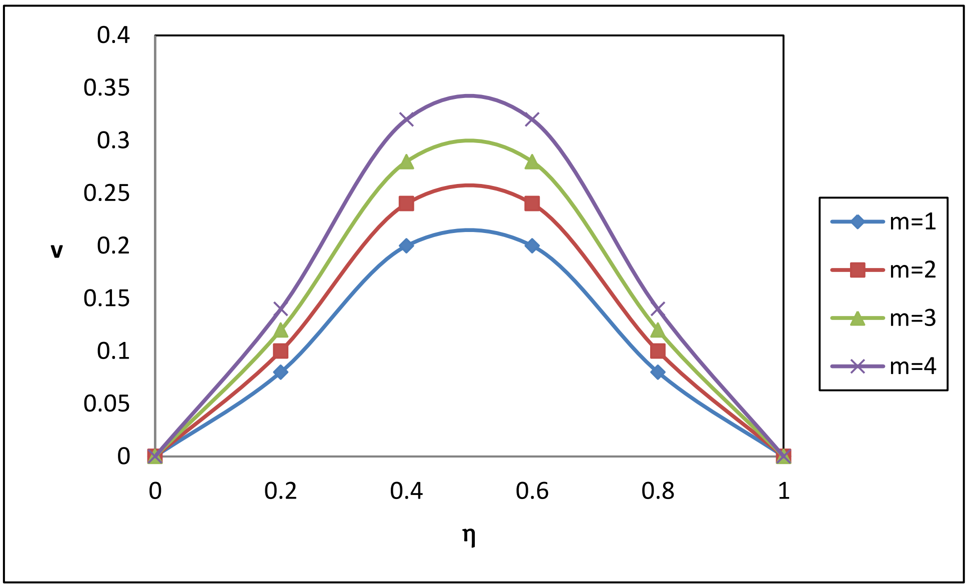

Fig 14: The velocity profile for *v* against *m*

k_1=1, S=1, D^{-1} =1000, M=2, $x = t = \dfrac{\pi}{4}$, R=10, $\delta = 0.01$

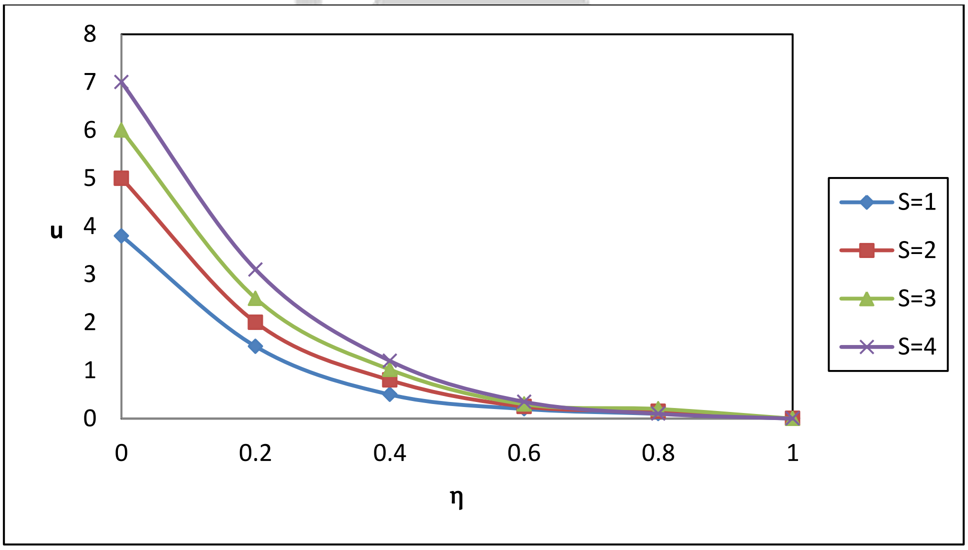

Fig 15: The velocity profile for *u* against *S*

k_1=1, D^{-1} =1000, M=2, m=1, $x = t = \dfrac{\pi}{4}$, R=10, $\delta = 0.01$

IV. Conclusions

The resultant speed likewise improves with expanding the Reynolds boundary R. Higher the penetrability of the permeable medium bigger the pivotal speed along the channel and pace of increment is adequately high. The resultant speed decreases with expanding in the opposite Darcy boundary D-1. The resultant speed increment with expanding the boundaries k_1 and m. The resultant speed additionally lessens with expanding the boundary .The resultant speed likewise diminishes with expanding the Hartmann number M. The size of the hub speed u upgrades and the cross over speed v lessens with expanding the oscillatory boundary S. The resultant speed additionally upgrades with expanding the oscillatory boundary S.

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