ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

IJETMR
International Journal of Engineering Technologies and Management Research
A Knowledge Repository

MATHEMATICAL ANALYSIS OF UNSTEADY MHD BLOOD FLOW THROUGH PARALLEL PLATE CHANNEL WITH HEAT SOURCE

Mr.M.V. Surseh [1], Dr.P.Sekar [2]
[1] Research Scholar-Mathematics, SPIHER, Avadi, Chennai – 600 054, India
[2] Dean, Faculty of Science and Humanities, SRM University, Ramapuram, Chennai, India

Abstract:
A mathematical model of flimsy blood move through parallel plate channel under the action of a connected steady transverse attractive field is proposed. The model is subjected to warm source. Expository articulations are gotten by picking the hub speed; temperature dispersion and the typical speed of the blood rely upon y and t just to change over the arrangement of fractional differential conditions into an arrangement of normal differential conditions under the conditions characterized in our model. The model has been breaking down to discover the impacts of different parameters, for example, Hart-mann number, warm source parameter and Prandtl number on the hub speed, temperature circulation, and the ordinary speed. The numerical arrangements of pivotal speed, temperature conveyances, and typical speed are demonstrated graphically for better comprehension of the issue. Subsequently, the present numerical model gives a straightforward type of pivotal speed, temperature circulation and typical speed of the bloodstream so it will help not just individuals working in the field of Physiological liquid elements yet in addition to the restorative professionals.

Keywords: *Blood Flow; Parallel Plate Channel; Boundary Layer; Heat Source; Magnetic Field.*

Cite This Article: Mr.M.V. Surseh, and Dr.P.Sekar. (2018). “MATHEMATICAL ANALYSIS OF UNSTEADY MHD BLOOD FLOW THROUGH PARALLEL PLATE CHANNEL WITH HEAT SOURCE.” *International Journal of Engineering Technologies and Management Research*, 5(1), 40-50. DOI: 10.5281/zenodo.1164063.

1. Introduction

The investigation of bloodstream has been completed by a few creators. Amid the most recent decades, broad research work has been done on the liquid flow of organic liquids within the sight of the attractive field. For various reasons, utilization of magneto hydrodynamics in physiological stream issues is of developing interest. Numerous analysts have revealed that the blood is an electrically leading liquid. The electromagnetic power (Lorentz compel) follows up on the blood and this power contradicts the movement of blood and along these lines stream of blood is blocked, so the outer attractive field can be utilized as a part of the treatment of a few sorts of maladies like cardiovascular ailments and in the infections with quickened blood flow, for example, hemorrhages and hypertension.

ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

All in all, natural frameworks are influenced by a utilization of outer attractive field on blood course through the human blood vessel framework. Numerous numerical models have just been examined by a few research specialists to investigate the idea of bloodstream affected by an outer attractive field. Considered a scientific model of biomagnetic fluid dynamics (BFD), reasonable for the depiction of the Newtonian bloodstream under the activity of the attractive field. This model is reliable with the standards of streamlined features and magneto hydrodynamics and considers both charge and electrical conductivity of blood. Contemplated magneto hydrodynamic impacts on blood course through a permeable channel. They considered the blood a Newtonian fluid and directing fluid.

A blood vessel MHD pulsatile stream of blood under intermittent body increasing speed has been contemplated. The bloodstream in exceptionally limit vessels under the impact of the transverse attractive field has been researched. It is accepted that there is a greasing up layer between red platelets and tube divider. A pulsatile stream of blood which is considered as a couple pressure liquid through a permeable medium affected by occasional body quickening within the sight of the attractive field gave a scientific arrangement of the two-dimensional model of bloodstream with variable consistency through an indented conduit because of low-thickness lipoprotein impact within the sight of the attractive field. The examination demonstrates that hypertensive patients are more sufficient to have heart circulatory issues. The impact of the uniform transverse attractive field on its pulsatile movement through an axisymmetric tube is broke. Considered Bloodstream downstream of a two-dimensional bifurcation with the unbalanced relentless stream.

Warmth move in natural frameworks is significant in numerous indicative and helpful applications that include changes in temperature. As we probably are aware, the cardiovascular framework is delicate to changes in nature, and stream attributes of blood are altered to fulfill changing requests of the climax. Notwithstanding transporting of oxygen, metabolites and other disintegrated substances to and from the tissues, bloodstream modifies warm exchange inside the body. Exhibited a correct arrangement of the issue of an oscillatory stream of a liquid and warmth exchange along a permeable wavering direct in the nearness of an outside attractive field. The impact of the blood stream in extensive vessels on the temperature dissemination of hyperthermia has been created. The bloodstream in a little tube was displayed by the two-liquid model. The stream is completely created, steady warmth transition convective warmth exchange.
A mathematical model for the insecure blood move through an exceptionally limit parallel-plate channel with warm source and outside transverse attractive field is introduced. This work is broad with warm exchange under the conditions characterized in our model. The primary point of this work is to get logical articulations for pivotal speed, temperature dissemination and typical speed utilizing new limit conditions and with changing over the framework of partial differential conditions into an arrangement of normal differential conditions. Additionally to think about the impact of attractive field (Hartmann number (Ha)), warm source parameter and Prandtl number (Pr) on the pivotal speed, temperature dispersion, and typing speed. Henceforth, the present scientific model gives a basic type of pivotal speed, temperature dissemination and ordinary speed of the bloodstream so it will help not just individuals working in the field of Physiological liquid flow yet added to the medicinal professionals. Actually, we contemplated the scientific model in with a couple of changes; additionally, we checked the expository arrangement and altered the outcomes.

ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

2. Detailing of the Problem

Consider stream between non-leading two parallel plates as appeared in Figure 1.

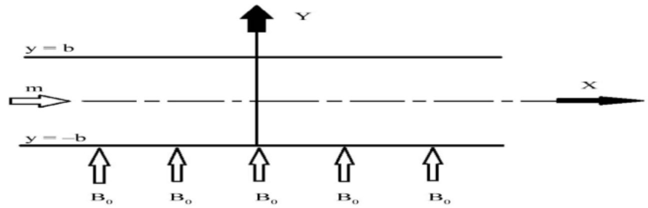

Figure 1: Geometry of the model

Here blood should be Newtonian, incompressible, homogenous and gooey fluid. Additionally, the consistency of blood is thought to be steady. The impact of the magnetic field is considered in this model which is connected towards a path opposite to the stream of blood.

Considering u and v as speed parts in the directions of x and y individually (hub and typical respectively) at time t in the stream field, we may compose the two-dimensional limit layer conditions in nearness of transverse attractive field as

$$\frac{\partial u}{\partial t}+\frac{1}{\rho}\frac{\partial p}{\partial x}=\frac{\mu}{\rho}\frac{\partial^2 u}{\partial y^2}-\frac{\sigma B_0^2 u}{\rho}+g\beta(T-T_0) \tag{1}$$

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{2}$$

$$\frac{\partial T}{\partial t}=\frac{K'}{\rho C_p}\frac{\partial^2 T}{\partial y^2}+\frac{Q}{\rho C_p}(T-T_0) \tag{3}$$

Introduce the following non-dimensional variables

$$x^*=\frac{x}{b},\quad y^*=\frac{y}{b},\quad u^*=\frac{u}{(m/2\rho b)},\quad v^*=\frac{v}{(m/2\rho b)},\quad t^*=\frac{t}{(\rho b^2/\mu)},\quad h^*(x,t)=\frac{dp/dx}{(\mu m/2\rho^2 b^3)},\quad \theta^*=\frac{\theta(2\rho^2 b^3)}{(\mu m)} \tag{4}$$

Substituting from Equation (4) into the Equations (1)- (3) we may compose these conditions in the wake of dropping the stars as

$$\frac{\partial u}{\partial t}+h=\frac{\partial^2 u}{\partial y^2}-Ha^2 u+g\beta\theta \tag{5}$$

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{6}$$

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

$$\frac{\partial\theta}{\partial t} = \frac{1}{\nu P_r}\frac{\partial^2\theta}{\partial y^2} + \frac{\mathrm{N}}{\nu P_r}\theta \qquad (7)$$

From Equation (7) we can watch that the gum based paint true appropriation θ has the first subsidiary regarding time t. From this perception and with the assistance of solution of incomplete differential condition by partition of variables system we can get the accompanying condition

$\left(\frac{d\theta_1}{dt}\right) \Big/ \theta_1 = -\lambda^2$, where $\theta_1 = \theta_1(t)$, $\theta_1 = e^{-\lambda^2 t}$

It is watched that the arrangement of this condition will be on the shape
Correspondingly, the pivotal speed u has a similar idea, and afterward the arrangement of the issue will take the shape specified in Section 3 and the limit conditions are taken as:

$$\left.\begin{array}{ll} \theta = e^{-\lambda^2 t},\ u = e^{-\lambda^2 t} & \text{at } y = -1 \\ \theta = 0,\ u = 0 & \text{at } y = -1 \end{array}\right\} \qquad (8)$$

3. Arrangement of the Problem

With the assistance of talk in the past area, let us pick the arrangements of the Equations (5) - (7) separately as

$$u = F(y)e^{-\lambda^2 t} \qquad (9)$$

$$v = G(y)e^{-\lambda^2 t} \qquad (10)$$

$$\theta = H(y)e^{-\lambda^2 t} \qquad (11)$$

Substituting from Equations (9) - (11) into Equations (5) - (8) we get the accompanying conditions individually

$$\frac{d^2F}{dy^2} + \xi^2 F = \eta - g\beta H \qquad (12)$$

Where $\xi = \sqrt{\lambda^2 - Ha^2}$ and $\eta = h \Big/ e^{-\lambda^2 t}$, G = C (a constant) (13)

$$\frac{d^2H}{dy^2} + \left(\mathrm{N} + \lambda^2 P_r \nu\right)H = 0 \qquad (14)$$

The limit conditions move toward becoming:

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

$$\left.\begin{aligned} H = 1,\ F = 1 \text{ at } y = -1 \\ H = 0,\ F = 0 \text{ at } y = 1 \end{aligned}\right\} \qquad (15)$$

Arrangement of condition (14) is as per the following

$$H(y) = C_1\cos(\Omega y) + C_2\sin(\Omega y) \qquad (16)$$

Where $\Omega = \sqrt{N + \lambda^2 P_r v}$.

Utilizing the limit conditions Equation (15) we acquire

$$C_1 = \frac{1}{2\cos\Omega} \text{ and } C_2 = \frac{-1}{2\sin\Omega}$$

At that point the last type of H(y) is

$$H(y) = \frac{1}{2\cos\Omega}\cos(\Omega y) - \frac{1}{2\sin\Omega}\sin(\Omega y) \qquad (17)$$

From Equation (11) and (17) at that point the temperature distribution is given by

$$\theta = \left(\frac{1}{2\cos\Omega}\cos(\Omega y) - \frac{1}{2\sin\Omega}\sin(\Omega y)\right)e^{-\lambda^2 t} \qquad (18)$$

Substituting from Equation (17) into Equation (12) we get

$$\frac{d^2F}{dy^2} + \xi^2 F = \eta - g\beta\left(\frac{1}{2\cos\Omega}\cos(\Omega y) - \frac{1}{2\sin\Omega}\sin(\Omega y)\right)$$

Understanding the last condition to get F utilizing the Equation (15) as takes after
The Homogenous arrangement:

$$F_h = C_3\cos(\zeta y) + C_4\sin(\zeta y)$$

Substitute from Equation (15) to figure the constants C_3 and C_4

$$C_3 = \frac{1 - 2\left(\frac{\eta}{\xi^2}\right) + \left(\frac{g\beta}{(\xi^2 - \Omega^2)}\right)}{2\cos(\xi)} \qquad C_4 = -\frac{1 + \left(\frac{g\beta}{(\xi^2 - \Omega^2)}\right)}{2\sin(\xi)}$$

The specific arrangement is:

$$F_p = \frac{\eta}{\xi^2} - \frac{g\beta}{2\cos(\Omega)(\xi^2 - \Omega^2)}\cos(\Omega y) + \frac{g\beta}{2\sin(\Omega)(\xi^2 - \Omega^2)}\sin(\Omega y)$$

The general arrangement of F is

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

F(y) =

$$\frac{\eta}{\xi^2}-\frac{g\beta}{2\cos(\Omega)(\xi^2-\Omega^2)}\cos(\Omega y)+\frac{g\beta}{2\sin(\Omega)(\xi^2-\Omega^2)}\sin(\Omega y)+\frac{1-2\left(\frac{\eta}{\xi^2}\right)+\left(\frac{g\beta}{(\xi^2-\Omega^2)}\right)}{2\cos(\xi)}\cos(\xi y)-\frac{1+\left(\frac{g\beta}{(\xi^2-\Omega^2)}\right)}{2\sin(\xi)}\sin(\xi y) \quad (19)$$

From Equation (9) and Equation (19) the pivotal speed of blood is given by
u(y,t)=

$$\left[\frac{\eta}{\xi^2}-\left(\frac{g\beta}{(\xi^2-\Omega^2)}\right)\frac{\cos(\Omega y)}{2\cos(\Omega)}+\left(\frac{g\beta}{(\xi^2-\Omega^2)}\right)\frac{\sin(\Omega y)}{2\sin(\Omega)}+\left(1-2\left(\frac{\eta}{\xi^2}\right)+\left(\frac{g\beta}{(\xi^2-\Omega^2)}\right)\right)\frac{\cos(\xi y)}{2\cos(\xi)}-\left(1+\left(\frac{g\beta}{(\xi^2-\Omega^2)}\right)\right)\frac{\sin(\xi y)}{2\sin(\xi)}\right]e^{-\lambda^2 t} \quad (20)$$

Additionally, from Equations (10) and (13) the ordinary speed is given by

$$v = Ce^{-\lambda^2 t} \quad (21)$$

Where C is a discretionary steady (C = 1).
Conditions (18), (20) and (21) demonstrate the temperature circulation, the pivotal speed, and typical speed individually.

4. Mathematical Results and Discussion

The stream examination has been completed by considering the impact of individual variables like warmth source and attractive field. The principal target of the examination is to discover the part of warmth source parameter, attractive field (Hartmann number), Prandtl number and rot parameter on them perature dissemination, pivotal speed, and ordinary speed. To watch these impacts, numerical codes are produced for the numerical assessments of the logical outcomes ob prepared. In Figure 2 we think about the variety of temperature dissemination versus y at t = 1.0, $\lambda =$ 0.5, v 0.5 and Pr = 1.0, with various estimations of the warmth source parameter $(\mathrm{N} = 1.00,\ 1.25,\ 1.50,\ 1.75,\ 2.00)$. We watch that for the same estimation of y the temperature field increments with expanding the estimation of warmth source parameter N. Likewise, the temperature field increments to achieve its greatest esteem at

y = 0 at that point diminishes. Figure 3 gives the temperature field appropriation for various estimations of Prandtl number (Pr = 0.50, 1.00, 3.00, 5.00, 7.00) at t = 1.00, $\lambda =$ 0.50,

v = 0.50 and N = 1.00. It is watched that the temperature field increments with expanding the estimation of Prandtl number Pr. The impact of Prandtl number is the same as warmth source parameter. The impact of rot parameter on the temperature field dispersion t = 1.00, $\lambda =$ 0.50, v = 0.50 and P_r = 1.00 is appeared in Figure 4. It is demonstrated that the temperature field diminishes with expanding the rot parameter. The most extreme impact of the rot parameter on the temperature a field is at y = – 1 and there is no impact roughly on the rot parameter on the temperature appropriation at y = 1. Figure 5 gives the hub speed dissemination for various estimations of warmth source parameter (N = 0.50, 0.75, 1.00, 1.25, 1.50) at t = 1.0, $\lambda =$ 0.5, v 0.5, β = 0.50, g = 9.81, h = 0.50, Ha = 1.00 and P_r = 1.00.. It is watched that the pivotal speed increments with expanding the warmth source parameter N. The impact of attractive field on the pivotal speed for diverse estimations of Hartmann number (Ha = 1.00, 2.00, 3.00, 4.00, 6.00) is appeared in Figure 6 at t = 1.00, $\lambda =$ 0.50, v 0.50, β = 0.50,

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

g = 9.81, h = 0.50, N = 1.50 and P_r = 1.00. It is demonstrated that the attractive field diminishes the pivotal speed. We can watch that the hub speed at Ha = 1.00 increments from y = – 1

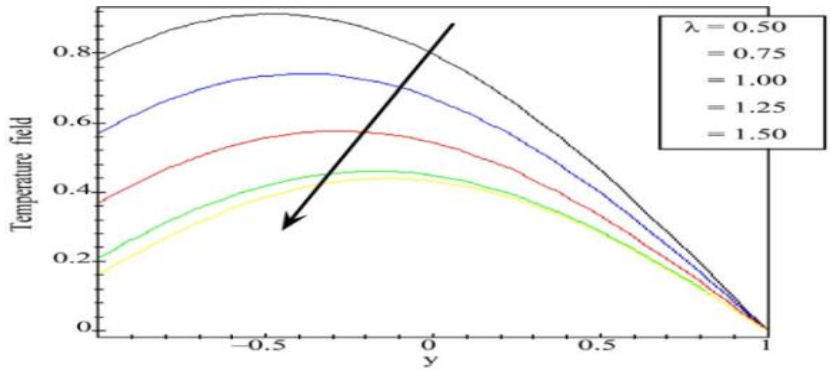

Figure 2: Temperature conveyance for various of warm source at t = 1.00, λ = 0.50, υ = 0.50 and Pr = 1.00

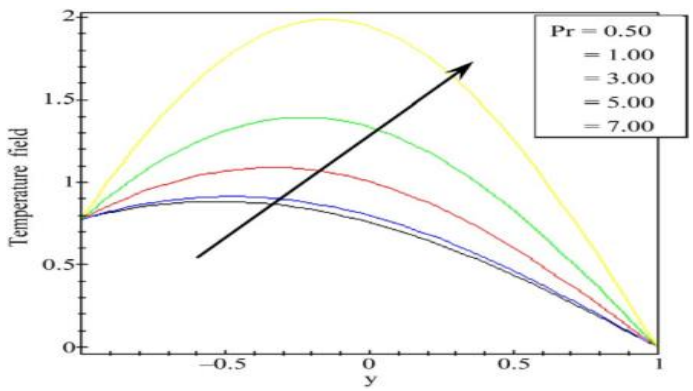

Figure 3: Temperature conveyance for estimations various estimations of Prandtl number at t = 1.00, λ = 0.50, υ = 0.50 and N = 1.00.

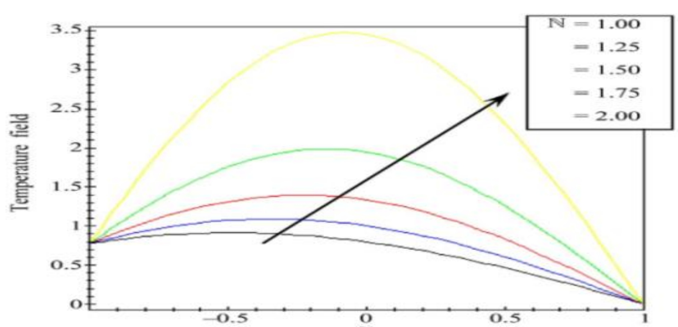

Figure 4: Temperature dissemination for various estimations of rot parameter at t = 1.00, Pr = 1.00, υ = 0.50 and N =1.00

Accomplishes the most extreme at y = 0 at that point diminishes until y = 1. While at Ha = 6.00 we watch that the hub speed diminishes along y.

Figure 7 demonstrates the impact of Prandtl number on the appropriation of the pivotal speed at t = 1.00, λ = 0.50, v 0.50, β = 0.50, g = 9.81, h = 0.50, N = 1.00 and Ha = 1.00. It is

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

demonstrated that the hub speed increments with expanding the Prandtl number. The impact of rot the parameter is shown in Figure 8 at t = 1.00, P_r = 1.00, ν 0.50, β = 0.50, g = 9.81, h = 0.50, N = 1.00 and Ha = 3.00. The hub speed diminishes with expanding the rot parameter. The most extreme impact of the rot parameter on the hub speed is at y = – 1 and the hub speed roughly not influenced by the rot parameter at y = 1.

Figure 9 demonstrates the impact of rot parameter on the typical speed circulation. It is demonstrated that the ordinary speed diminishes with expanding the rot parameter. The ordinary speed is diminished gradually at low estimations of the rot parameter (λ = 0.50) while it diminishes extremely quick and tends to zero at high estimations of rot parameter
(λ = 2.50).

5. Conclusions

A mathematical model for the temperamental blood course through an exceptionally limit parallel-plate channel with a warmth source and outer transverse attractive a field is introduced. This work is a broad investigation of with warm exchange under the conditions characterized in our model. The impact of attractive field, warm a source is by all accounts critical. The fundamental finishes of the present paper might be abridged as takes after:

- The mathematical model gives a basic frame of pivotal speed, temperature circulation and ordinary a speed of the bloodstream. Expository articulations are

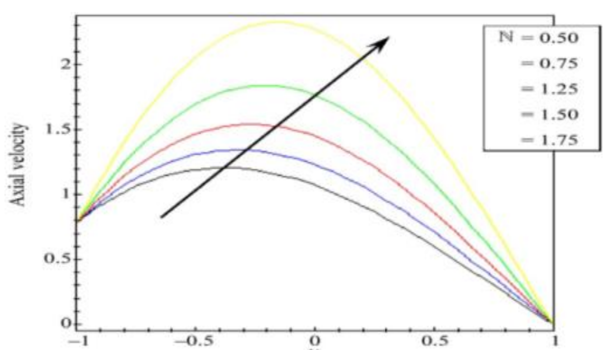

Figure 5: Pivotal speed conveyance for various estimations of warm source at t = 1.00, Pr = 1.00, υ = 0.50, λ = 0.50, h = 0.50, β = 0.50, g = 9.81 and Ha = 1.00

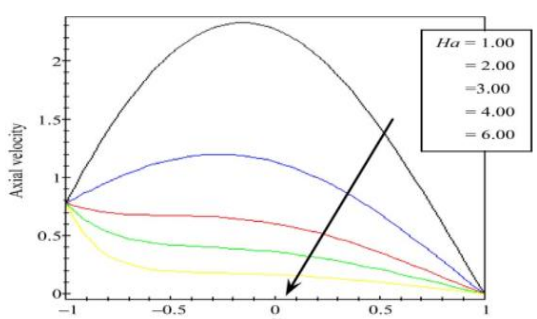

Figure 6: Hub speed dissemination for various estimations of Hartmann number at t = 1.00, Pr = 1.00, υ = 0.50, λ = 0.50, h = 0.50, β = 0.50, g = 9.81 and = 1.50

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

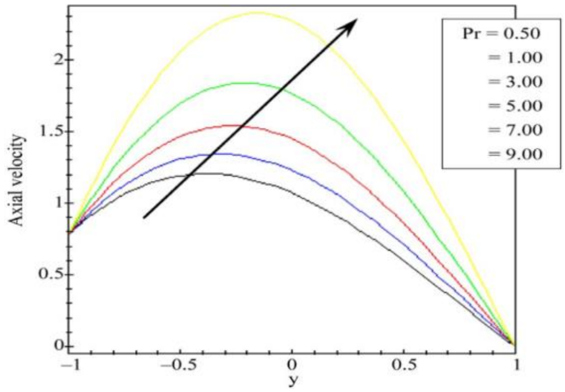

Figure 7: Pivotal speed conveyance for various estimations of Prandtl number at t = 1.00, Ha = 1.00, υ = 0.50, λ = 0.50, h = 0.50, β = 0.50, g = 9.81 and N = 1.50

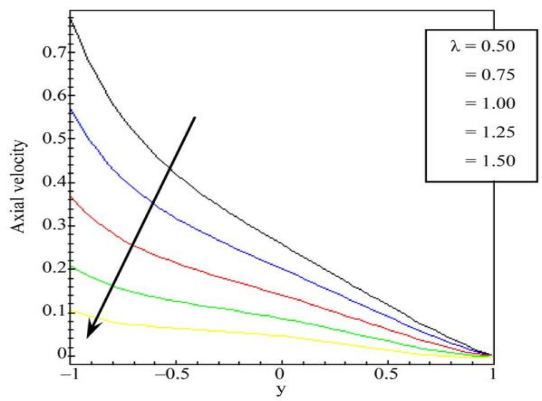

Figure 8: Pivotal speed dissemination for various estimations of rot parameter at t = 1.00, Ha = 3.00, υ = 0.50, Pr = 1.00, h = 0.50, β = 0.50, g = 9.81 and N = 1.00

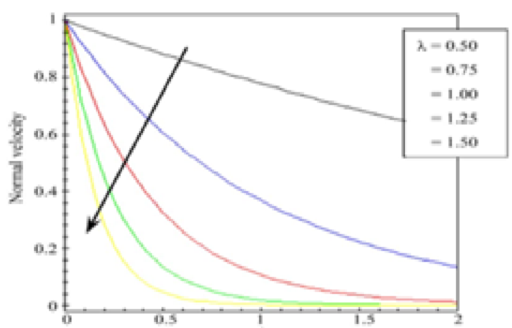

Figure 9: Ordinary speed dispersion for various esteems of rot parameter

Acquired by picking the hub speed; temperature dispersion and the typical speed of blood depend on y and t just alongside the comparing limit conditions to change the arrangement of incomplete differential conditions into the arrangement of conventional differential conditions.

- The temperature field increments with expanding the warm source parameter and Prandtl number while diminishes with expanding the rot parameter.
- The pivotal speed increments with expanding heat source parameter and Prandtl number while diminishes with expanding the Hartmann number and rot parameter.

 ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

- The ordinary speed diminishes with expanding the rot parameter and tending to zero quick for higher estimations of the rot parameter. Subsequently, the present scientific model gives a basic a type of hub speed, temperature circulation and typical a speed of the bloodstream with the goal that it will help not just individuals working in the field of Physiological liquid flow yet added to the medicinal specialists.

Acknowledgements

The creator might want to express profoundly appreciative to ref for giving profitable proposals to enhance the nature of the original copy.

References

[1] M. Jain, G. C. Sharma and A. Singh, "Mathematical Ana-lysis of MHD Flow of Blood in Very Narrow Capillar-ies," *International Journal of Engineering Transactions B*: *Applications*, Vol. 22, No. 3, 2009, pp. 307-315.

[2] V. P. Rathod and S. Tanveer, "Pulsatile Flow of Couple Stress Fluid through a Porous Medium with Periodic Body Acceleration and Magnetic Field," *Bulletin of the Malaysian Mathematical Sciences Society*, Vol. 32, No. 2, 2009, pp. 245-259.

[3] J. Singh and R. Rathee, "Analytical Solution of Two- Dimensional Model of Blood Flow with Variable Viscos-ity through an Indented Artery Due to LDL Effect in the Presence of Magnetic Field," *International Journal of Physical Sciences*, Vol. 5, No. 12, 2010, pp. 1857-1868.

[4] C. S. Dulal and B. Ananda, "Pulsatile Motion of Blood through an Axi-Symmetric Artery in Presence of Mag-netic Field," *Journal of Science and Technology of Assam University*, Vol. 5, No. 2, 2010, pp. 12-20.

[5] M. Zamir and M. R. Roach, "Blood Flow Downstream of a Two-Dimensional Bifurcation," *Journal of Theoretical Biology*, Vol. 42, No. 1, 1973, pp. 33-42. doi:10.1016/0022-5193(73)90146-X

[6] S. D. Adhikary and J. C. Misra, "Unsteady Two-Dimen-sional Hydromagnetic Flow and Heat Transfer of a Fluid," *International Journal of Applied Mathematics and Me-chanics*, Vol. 7, No. 4, 2011, pp. 1-20.

[7] J. J. W. Lagendijk, "The Influence of Blood Flow in Large Vessels on the Temperature Distribution in Hyperther-mia," *Physics in Medicine and Biology*, Vol. 27, No. 1, 1982, p. 17. doi:10.1088/0031-9155/27/1/002.

[8] C. Y. Wang, "Heat Transfer to Blood Flow in a Small Tube," *Journal of Biomechanical Engineering*, Vol. 130, No. 2, 2008, p. 024501. doi:10.1115/1.2898722

[9] J. Singh and R. Rathee, "Analytical Solution of Two- Dimensional Model of Blood Flow with Variable Viscos-ity through an Indented Artery Due to LDL Effect in the Presence of Magnetic Field," *International Journal of Physical Sciences*, Vol. 5, No. 12, 2010, pp. 1857-1868.

[10] O. Prakash, S. P. Singh, D. Kumar and Y. K. Dwivedi, "A Study of Effects of Heat Source on MHD Blood Flow through Bifurcated Arteries," *AIP Advances*, Vol. 1, No. 4, 2011, pp. 1-7. doi:10.1063/1.3658616.

[11] N. Verma and R. S. Parihar, "Effects of Magneto-Hydro-dynamic and Hematocrit on Blood Flow in an Artery with Multiple Mild Stenosis," *International Journal of Applied Mathematics and Computer Science*, Vol. 1, No. 1, 2009, pp. 30-46.

[12] D. C. Sanyal, K. Das and S. Debnath, "Effect of Magnetic Field on Pulsatile Blood Flow through an Inclined Circu-lar Tube with Periodic Body Acceleration," *Journal of Physical Science*, Vol. 11, 2007, pp. 43-56.

ISSN: 2454-1907
DOI: 10.5281/zenodo.1164063

[13] E. E. Tzirtzilakis, "A Mathematical Model for Blood Flow in Magnetic Field," *Physics of Fluids*, Vol. 17, No. 7, 2005, p. 077103. doi:10.1063/1.1978807
[14] G. Ramamurthy and B. Shanker, "Magnetohydrodynamic Effects on Blood Flow through Porous Channel," *Medi-cal and Biological Engineering and Computing*, Vol. 32, No. 6, 1994, pp. 655-659. doi:10.1007/BF02524242
[15] K. Das and G. C. Saha, "Arterial MHD Pulsatile Flow of Blood under Periodic Body Acceleration," *Bulletin of So-ciety of Mathematicians Banja Luka*, Vol. 16, 2009, pp. 21-42.

*Corresponding author.
E-mail address: m.v.sureshpari@ gmail.com, cicesekar@ yahoo.co.in