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Influence of MHD and Heat Transfer on Blood Flow in a Stenosed Porous Artery: DTM

Approach

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ABSTRACT

This paper investigates the motion of blood in a stenosed porous artery subjected to heat transfer and magnetohydrodynamic impact. Atherosclerosis having attributed as one of the arterial circulation diseases risk factor, caused by the build-up of plaques resulting to stenosis and hardening in the arteries, hence the need for investigation of stenosed artery become imperative. The governing equations were modeled with assumption that the stenosis is in form of cosine-shaped. Differential Transformation Method (DTM) was implemented on the obtained momentum and energy equations, from which expressions for axial velocity and temperature were deduced. The volumetric flow rate and wall shear stress expressions were also obtained. These expressions were used to simulate the effects of heat transfer parameter, magnetic field among other flow parameters on the wall shear stress, volumetric flow rate, temperature and velocity fields. It was observed that an increase in the empty spaces or voids present in the artery (porosity) and the magnetic number appreciates both blood temperature and its velocity significantly. It is believed that the implementation of the present investigation will assist in preparing and forecasting for a corrective procedures.

Keywords: Blood flow, Stenosis, MHD, Porosity, Axial Velocity.

Nomenclature

R_0	:	Radius of normal tube,	$R(z)$	:	Radius of stenotic region
L	:	Length of the artery,	L_0	:	Length of stenotic region
u	:	Velocity in θ direction,	v	:	Velocity in r direction
w	:	Velocity in z direction,	σ	:	Magnetic field intensity
B_0	:	Applied magnetic field,	k_1	:	Porous parameter
$\frac{\partial P}{\partial z}$	:	Pressure gradient,	g	:	Acceleration due to gravity
T	:	Temperature,	k_2	:	Thermal conductivity

Introduction

Some heart diseases related to arterial circulation includes; Carotid Artery Disease, Peripheral Artery Disease (PAD), Coronary Artery Disease (CAD). Most of which atherosclerosis as the risk factor. Atherosclerosis is the hardening of the arteries caused by the build-up of plaques resulting to stenosis and hardening in the arteries. This blockage plaques, can be due to deposits of fats, calcium, cholesterol, etc. Various medical procedures can be used in correcting stenosis in an artery. An artery becomes stenosed when the lumen width is constricted due to deposition of plaques. Stenosis leads to a shortage in the amount of blood that is able to pass through an artery and hence a deficit in the supply of blood to the destination organ. The understanding of blood flow can be very useful in preparing for these corrective procedures. Thus the need for this investigation of heat transfer in the assumed flow region becomes necessary.

Series of research has been carried out on blood flow in arteries regarding blood as either non-Newtonian/Newtonian. Jain, Sharma and Singh (2010) presented the MHD effect on the blood flow in a stenosed artery, where artery was regarded as a porous medium. With mild stenosis, Shukla, Parihar and Gupta (1980) studied the bio-rheological properties of blood motion through an artery, an axisymmetric shape blood flow examination through mild stenotic artery by Pokhrel, Kafle, Kattel and Gaire (2020), and inclined tapered stenosed porous inclined artery investigation by Abubakar and Adeoye (2020) with magnetic field and radiation impact suggested that radiation parameter has the

tendency of affecting the blood energy and motion positively, and that, rise in velocity and temperature resulted from a hike in magnetic parameter. The effect of magnetohydrodynamics on blood flow was investigated by Ilyani, Amin and Hayat (2010), with the assumption of blood been considered as micropolar fluid. With the finite difference approach the model flow distributions were obtained, thus discovered that magnetic impact slow down the blood flow rate.

Unsteady pulsatile atrial stenosed blood flow under the chemical reaction and radiation influence with permeable wall subjected to MHD two phase blood flow was presented by Karthikeyan and Jeevitha (2019). In a paper by Mohan, Prasad, Varshney and Gupta (2013), blood flow was assumed flowing in cylindrical geometry while presenting the effect of porous medium and magnetic field on blood flow through artery. Analytical expressions for the flow fields via Laplace and finite Hankel transforms shows a decrease in velocity distribution, flow rate and fluid acceleration as magnetic field parameter rise. Numerical computation and simulations of the flow of blood in an elastic tube with mass transfer in the presence of multiple stenoses was presented by Alsemiry, Sarifuddin, Mandal, Sayed and Amin (2020). In their study, they highlighted that number of recirculation regions increases due to the multiple stenoses and pulsatile inlet conditions also, at the throat it results to an increase in the rate of mass transfer. However, there is an expectation of more mass accumulation which leads to additional stenosis. In the study presented by Roy, Saha, Hossain and Gorla (2020), they discovered that increase of the stenosis causes an increase in the size of the vortices and when there is a change in the position of the upper stenosis the vortices size increases.

Sharma, Gaur and Biswas (2018) studied pulsatile bio-magnetic blood flow through a channel containing a porous medium. The magnetic field was considered uniform and applied to the surface. The energy and momentum equations were analyzed via a finite difference scheme. Heat and mass transfer with alterations in pulsatile bloodstream through asymmetric stenosed artery was analyzed by Sweed, Mekheimer, EL-Kholi and Abdelwahab (2020). In their research, blood is taken as two-phase system comprises of red blood cells and blood plasma and the influence of pulsatile blood flow in stenosis artery are studied. Nadeem, Akbar and Hayat (2011) investigated the Newtonian biomagnetic fluid through a tapered porous artery with stenosis while Sharma, Gaur, Sharma (2019) studied the influence of radiation on MHD blood flow with thermal and mass diffusion through a tapered stenosed porous artery. Alsagri et al. (2019) examined the effect of heat transport and MHD on thin film of human blood with carbon Nanotubes (CNTs) nanofluids over a stretchable upright cylinder. Also, Raju and Reddy (2019) studied the influence of chemical reaction, thermo-diffusion on MHD convective Heat transfer flow of an electrically conducting fluid through a porous medium. Under the influence of body acceleration, MHD and chemical reaction, Mwapinga, Mureithi, Makungu and Masanja (2020) investigated the arterial pulsatile blood flow and mass transfer in a stenosed artery. They noted that the increase in body acceleration leads to the increase in the velocity and an increase in chemical reaction parameter decreases the concentration profile. Trpathi and Sharma (2018) highlighted two-phase blood flow with the effect of heat and mass transfer in the presence of variable magnetic field with the effects of joule heating and variable viscosity.

Sankar and Yatim (2012) presented the comparative analysis of two mathematical models namely Casson and H-B fluid, for blood flow in tapered constricted arteries. The flow of blood through a catheterized artery with a mild stenosis at the wall and blood clot at the centre was studied by Saleem, Akhtar, Nadeem, Issakhov and Ghalambaz (2020). It was discovered that for a non-symmetric stenosis there is a quick increase in the fluid velocity compared to the symmetric stenosis. The increases in the height of mild stenosis and narrowing of the channel will leads to an increase in the velocity in the centre but it decreases in the case of a stenosed wall. A finite difference method was employed to solve the unsteady non-Newtonian momentum equations arising from the flow of non-Newtonian blood flow through a stenosed artery in a magnetic field by Ikbal, Chakravarty, Wong and Mandal (2009). Their result showed that the magnetic field significantly affects the flow characteristics.

Formulation of Problem

Consider an artery as a long cylindrical pipe and the stenosis is assumed to be cosine-shaped, with this, the governing equations (majorly momentum and energy equations) are formulated along with the following assumptions. Induced magnetic field is neglected with very small Reynold's number, No excess charge density. Blood is considered to be Newtonian, incompressible, steady, and laminar, with constant density and viscosity. Figure 1 pictured the Artery stenosis in cosine-shaped-with the impact of magnetohydrodynamic effect.

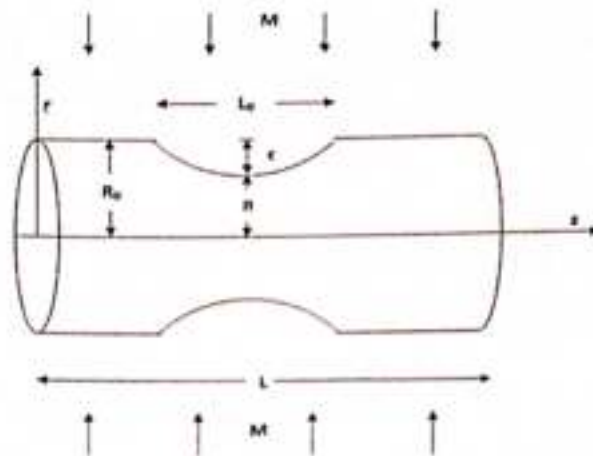


Figure 1: Artery stenosis geometry in cosine-shaped

The relation below gives the geometry of the stenosis Artery :

$$R = R_0 - \frac{\epsilon}{2} * \cos \left[\frac{2\pi}{L_0} \left(z - d + \frac{L_0}{2} \right) + 1 \right] \quad (1)$$

Governing Equations

The governing systems for the blood motion under influence of the transferred heat and magnetic field after applying the assumptions stated above are given in cylindrical co-ordinates as (Abubakar and Adeoye (2020) and, Sharma, Gaur and Sharma (2019), and Abubakar, Gbadeyan and Ojo (2019)):

The Continuity equation:

$$\frac{\partial w}{\partial z} = 0. \quad (2)$$

The Momentum equation:

$$\frac{\partial p}{\partial r} = 0 \quad (3)$$

$$\frac{1}{r} \frac{\partial p}{\partial r} = 0 \quad (4)$$

$$0 = -\frac{\partial p}{\partial z} + \mu \left(\frac{\partial^2 w}{\partial r^2} + \frac{1}{r} \frac{\partial w}{\partial r} \right) - \left(\sigma B_0^2 - \frac{\mu}{k} \right) w + g\beta(T - T_0). \quad (5)$$

The Energy equation:

$$k_2 \left(\frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} \right) + \mu \left(\frac{\partial w}{\partial r} \right)^2 = 0. \quad (6)$$

For convenience in solving the governing equations, we introduce the transformations:

$$y = \frac{r}{R_0} \text{ and } \theta = \frac{T - T_0}{T_0}, \alpha^2 = \frac{\sigma B_0^2 R_0^2}{\mu} - \frac{R_0^2}{k_1}, \eta_2^2 = \frac{R_0^2}{\mu} \frac{\partial p}{\partial z}, \eta_1^2 = \frac{g\beta R_0^2 T_0}{\mu}, U = \frac{\mu}{k_2 T_0}, \quad (7)$$

On substituting the transformations in equation (7) into (5) and (6), we have

$$y \frac{\partial^2 w}{\partial y^2} + \frac{\partial w}{\partial y} - \left(\frac{\sigma B_0^2 R_0^2}{\mu} - \frac{R_0^2}{k_1} \right) y w - \frac{R_0^2}{\mu} \frac{\partial p}{\partial z} y + \frac{g\beta R_0^2 T_0}{\mu} y \theta = 0. \quad (8)$$

and

$$y \frac{\partial^2 \Theta}{\partial y^2} + \frac{\partial \Theta}{\partial y} + \frac{\mu}{k_2 T_0} y \left(\frac{\partial w}{\partial y} \right)^2 = 0.$$

substituting the variables in (7) into (8) and (9) to obtain:

$$y \frac{\partial^2 w}{\partial y^2} + \frac{\partial w}{\partial y} - \alpha^2 y w - \eta_2^2 y + \eta_1^2 y \Theta = 0.$$

and

$$y \frac{\partial^2 \Theta}{\partial y^2} + \frac{\partial \Theta}{\partial y} + U y \left(\frac{\partial w}{\partial y} \right)^2 = 0.$$

subjected to the boundary conditions:

$$\left. \begin{array}{lll} \text{at } y = 0, & \frac{\partial w}{\partial y} = 0, & \frac{\partial \Theta}{\partial y} = 0. \\ \text{at } y = \frac{R(x)}{R_0}, & w = 0, & \Theta = 0. \end{array} \right\}$$

3 Solution of Problem

To obtain an approximate expression of the flow distributions, the semi-analytical technique Differential Transform Method (DTM) is utilized on the dimensionless systems of equations (10) and (11) with the boundary conditions in (12). Consider an analytic and continuously differentiable function $z(x)$.

Let:

$$z(x) = \frac{1}{k!} z^{(k)}(x_0).$$

The function $z(k)$ is called the transformed function, while the inverse function of $z(k)$ is as thus:

$$z(x) = \sum_{k=0}^{\infty} z(k)(x - x_0)^k.$$

By equation (13) and (14), we simplify:

$$z(x) = \sum_{k=0}^{\infty} \frac{1}{k!} z^{(k)}(x_0)(x - x_0)^k.$$

If we take x_0 to be 0, (15) becomes:

$$z(x) = \sum_{k=0}^{\infty} \frac{1}{k!} z^{(k)}(0)x^k.$$

and (14) is then expressed as:

$$z(x) = \sum_{k=0}^{\infty} Z(k)x^k.$$

In real application, however, the function $z(r, s)$ can be expressed as a finite series by:

$$z(x) = \sum_{k=0}^n Z(k)x^k.$$

Suppose the transformation of $w(y)$ and $\Theta(y)$ are $W(k)$ and $V(k)$ respectively. Equation (10) and (11) are re-written as follows:

$$y \frac{\partial^2 w}{\partial y^2} + \frac{\partial w}{\partial y} - \alpha^2 y w - \eta_2^2 y + \eta_1^2 y \Theta = 0.$$

and

$$y \frac{\partial^2 \Theta}{\partial y^2} + \frac{\partial \Theta}{\partial y} + U \left(\frac{\partial w}{\partial y} \right)^2 = 0,$$

to obtain their differential transforms respectively as follows:

$$\sum_{m=0}^k \delta(m-1)(k-m+2)(k-m+1)W(k-m+2) + (k+1)W(k+1) - \alpha^2 \sum_{m=0}^k \delta(m-1)W(k-m) - \eta_2^2 \delta(k-1) + \eta_1^2 \sum_{m=0}^k \delta(m-1)V(k-m) = 0,$$

and

$$\sum_{m=0}^k \delta(m-1)(k-m+2)(k-m+1)V(k-m+2) + (k+1)V(k+1) + U \sum_{m=0}^k \delta(m-1) \sum_{l=0}^{k-m} (l+1)W(l+1)(k-m-l+1)W(k-m-l+1) = 0.$$

Implementing equation (13) results:

$$W(0) = \frac{1}{0!} w(y)|_{y=0} = w(0) = a_1.$$

$$V(0) = \frac{1}{0!} \Theta(y)|_{y=0} = \Theta(0) = a_2.$$

$$W(1) = \frac{1}{1!} w'(y)|_{y=0} = \frac{\partial w}{\partial y}|_{y=0} = 0.$$

$$V(1) = \frac{1}{1!} \Theta'(y)|_{y=0} = \frac{\partial \Theta}{\partial y}|_{y=0} = 0.$$

From (19), we obtain: For $k \geq 1$,

$$W(k+1) = \frac{\alpha^2 W(k-1) - \eta_1^2 V(k-1) + \eta_2^2 \delta(k-1)}{(k+1)^2}, \quad (21)$$

and from (20), we obtain: For $k \geq 1$,

$$V(k+1) = \frac{-U \sum_{l=0}^{k-1} (l+1) W(l+1)(k-l) W(k-l)}{(k+1)^2}. \quad (22)$$

The solutions of equations (7) and (8) with boundary conditions (12) using the differential transform method is given as:

$$w(y) = a_1 + \frac{\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2}{4} y^2 + \frac{\alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)}{64} y^4 + \frac{\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{2304} y^6, \quad (23)$$

and

$$\tau(y) = a_2 + \frac{-U(\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{64} y^4 + \frac{-U \alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{576} y^6. \quad (24)$$

Expressing them as functions of r , we have:

$$w(r) = a_1 + \frac{\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2}{4} \left(\frac{r}{R_0}\right)^2 + \frac{\alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)}{64} \left(\frac{r}{R_0}\right)^4 + \frac{\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{2304} \left(\frac{r}{R_0}\right)^6, \quad (25)$$

and

$$\Theta(r) = a_2 - \frac{U(\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{64} \left(\frac{r}{R_0}\right)^4 - \frac{U \alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{576} \left(\frac{r}{R_0}\right)^6. \quad (26)$$

However, due to long lengths of results for the value a_1 and a_2 obtained via the boundary conditions with Maple software, we decided not to include the output.

Volumetric Flow Rate

With r and w being the obtained artery radius and axial velocity respectively, then the volumetric flow rate of the problem is as thus:

$$Q_v = 2\pi \int_0^R r w dr, \quad (27)$$

Substituting equation (25) into (27), then integrate results:

$$\begin{aligned} Q_v &= 2\pi \int_0^R r \left(a_1 + \frac{\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2}{4} \left(\frac{r}{R_0}\right)^2 + \frac{\alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)}{64} \left(\frac{r}{R_0}\right)^4 + \frac{\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{2304} \left(\frac{r}{R_0}\right)^6 \right) dr \\ &= 2\pi \int_0^R \left(a_1 r + \frac{\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2}{4} \left(\frac{r^3}{R_0^2}\right) + \frac{\alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)}{64} \left(\frac{r^5}{R_0^4}\right) + \frac{\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{2304} \left(\frac{r^7}{R_0^6}\right) \right) dr \\ &= a_1 \pi R^2 + \frac{\pi (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) R^4}{8 R_0^2} + \frac{\pi \alpha^2 (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) R^6}{192 R_0^4} \\ &\quad + \frac{\pi (\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2) R^8}{9216 R_0^6} \end{aligned} \quad (28)$$

likewise the values a_1 and a_2 are substituted in equation (28) to the volumetric flow rate expression.

Wall Shear Stress

The blood flow wall stress τ_x is

$$\tau_s = \mu \left[\frac{\partial w}{\partial r} \right]_{r=R}$$

Evaluation equation (25) into (29), we obtain

$$\begin{aligned} \tau_s &= \mu \left[\frac{\partial}{\partial r} \left(a_1 + \frac{\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2}{4} \left(\frac{r}{R_0} \right)^2 + \frac{\alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)}{64} \left(\frac{r}{R_0} \right)^4 \right. \right. \\ &\quad \left. \left. + \frac{\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{2304} \left(\frac{r}{R_0} \right)^6 \right) \right]_{r=R} \\ &= \mu \left[a_1 + \frac{\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2}{2} \left(\frac{R}{R_0} \right) + \frac{\alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)}{16} \left(\frac{R}{R_0} \right)^3 \right. \\ &\quad \left. + \frac{\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{384} \left(\frac{R}{R_0} \right)^5 \right]_{r=R} \\ &= \mu \left[a_1 + \frac{\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2}{2} \left(\frac{R}{R_0} \right) + \frac{\alpha^2 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)}{16} \left(\frac{R}{R_0} \right)^3 \right. \\ &\quad \left. + \frac{\alpha^4 * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U * (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2}{384} \left(\frac{R}{R_0} \right)^5 \right] \\ &= \frac{\mu}{2} \frac{(\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) R}{R_0^2} + \frac{\mu}{16} \frac{\alpha^2 (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) R^3}{R_0^4} \\ &\quad + \frac{\mu}{384} \frac{(\alpha^4 (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2) + \eta_1^2 U (\alpha^2 a_1 - \eta_1^2 a_2 + \eta_2^2)^2) R^5}{R_0^6}. \end{aligned}$$

The final expression of the wall shear stress is obtain when the obtained values a_1 and a_2 are substituted.

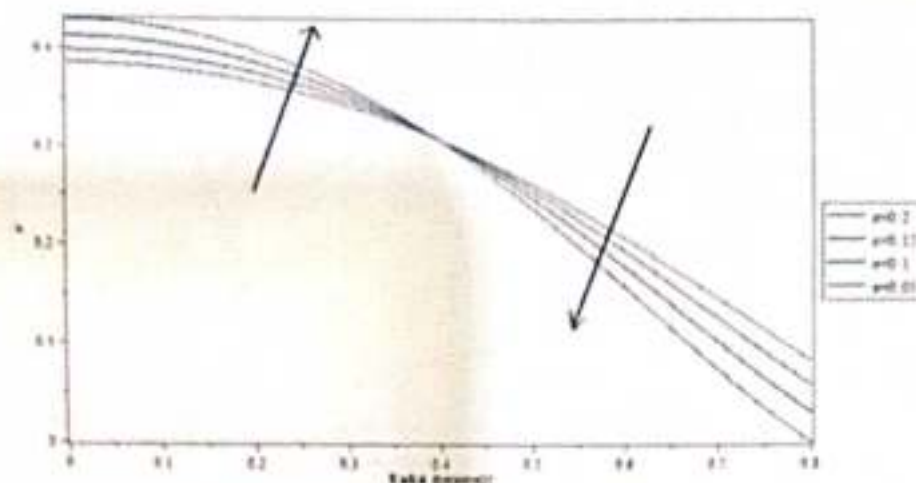
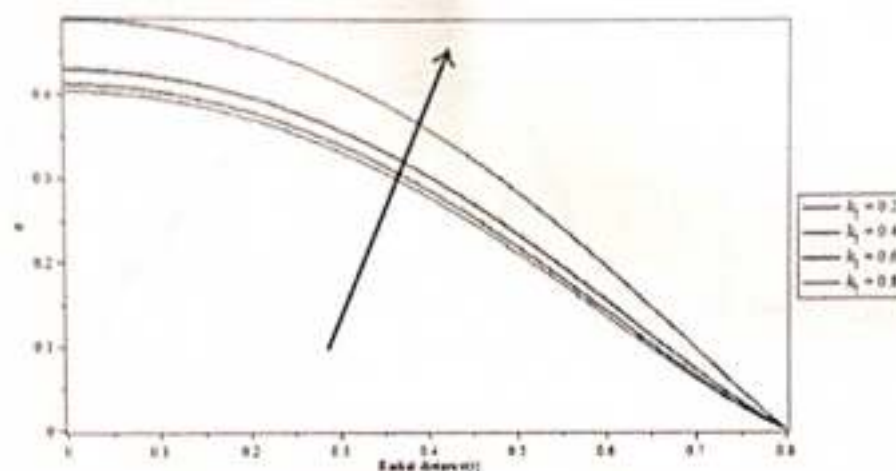
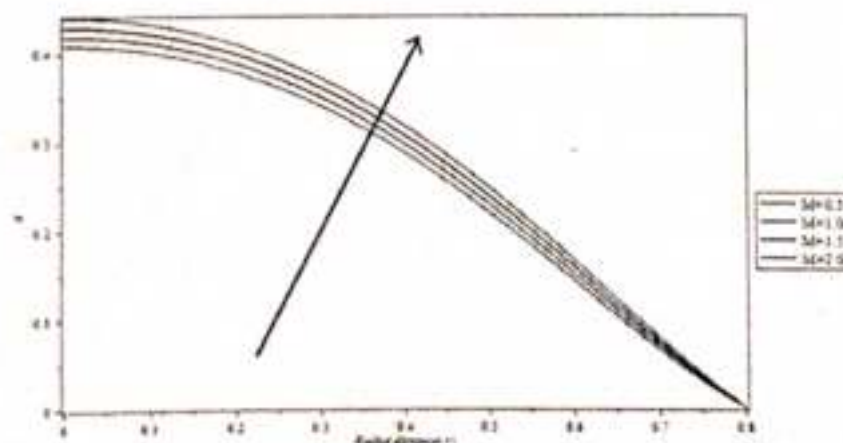
Discussion of Results

We use numerical values from previous literature to simulate the effects of flow parameters on the flow distributions. The following are the values used: $\partial P / \partial z = 0.3, M = 1.5, \mu = 0.06, R = 0.8, R_0 = 1.0, k_2 = 1.7 * 10^{-2}, k_1 = 0.4, g = 9.81, \beta = 2.14 * 10^{-4} * 1060$

(Abubakar and Adeoye, 2020, Alsemiry et al. 2020, Pokhrel et al. 2020).

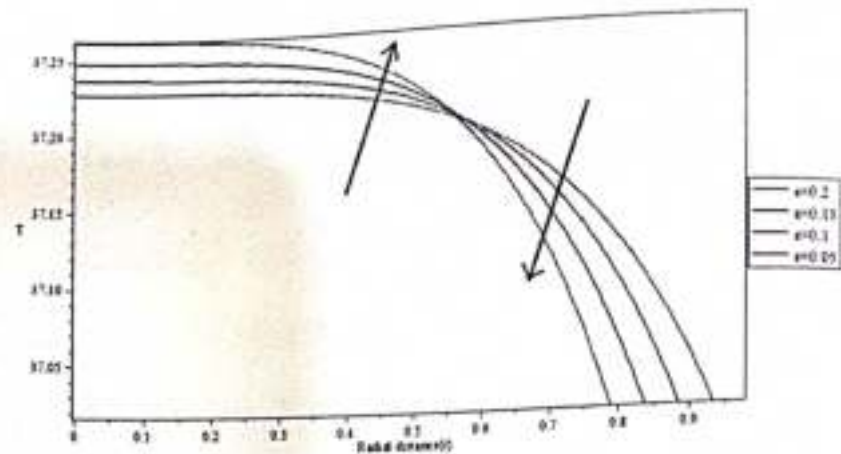
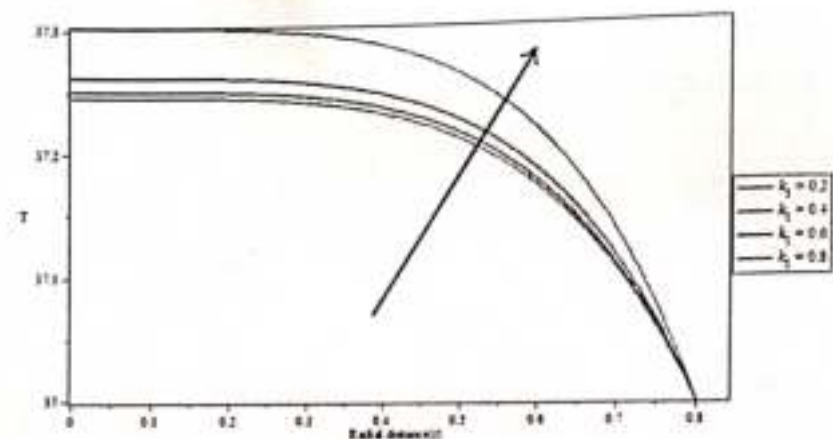
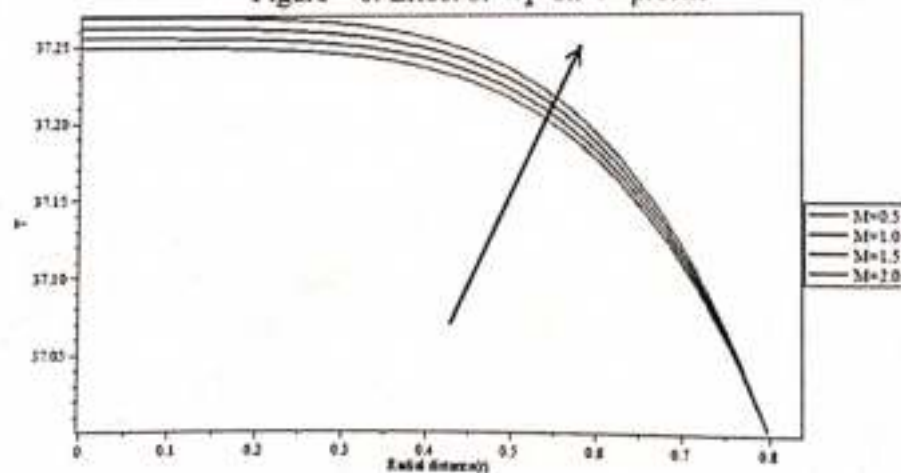
Impact of flow parameters on Velocity Profile

Figures 2, 3 and 4 respectively portrays the variation of stenosis height (ϵ), porosity number (k_1) and magnetic field parameter (M) on axial velocity. Noticeably in Figure 2, the flow velocity increases within the arterial region $0 \leq r \leq 0.4$, but decreases within the other half region. This is relating the physical instance of rise and fall of blood flow to a continuous growth of stenosis length. Concurrent magnification on the flow velocity (w) is revealed as both porosity and magnetic field impact is escalated (see Figure 3 and 4 respectively). Physically, velocity is enhanced to a large porous medium, thus a higher value of k_1 displaced a rise on the velocity throughout the flow domain as the same impact is portray for magnetic parameter due to Lorentz force influence.

Figure 2: Effect of ϵ on w profileFigure 3: Effect of k_1 on w profileFigure 4: Effect of M on w profile

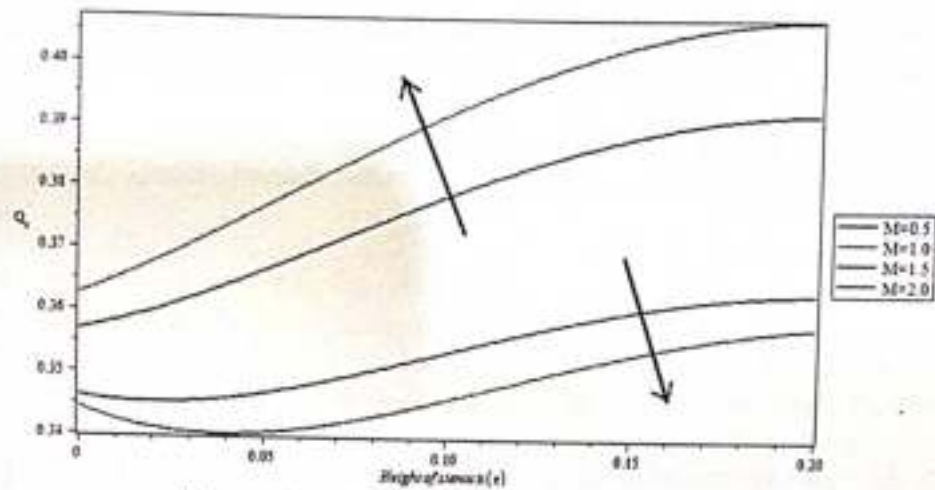
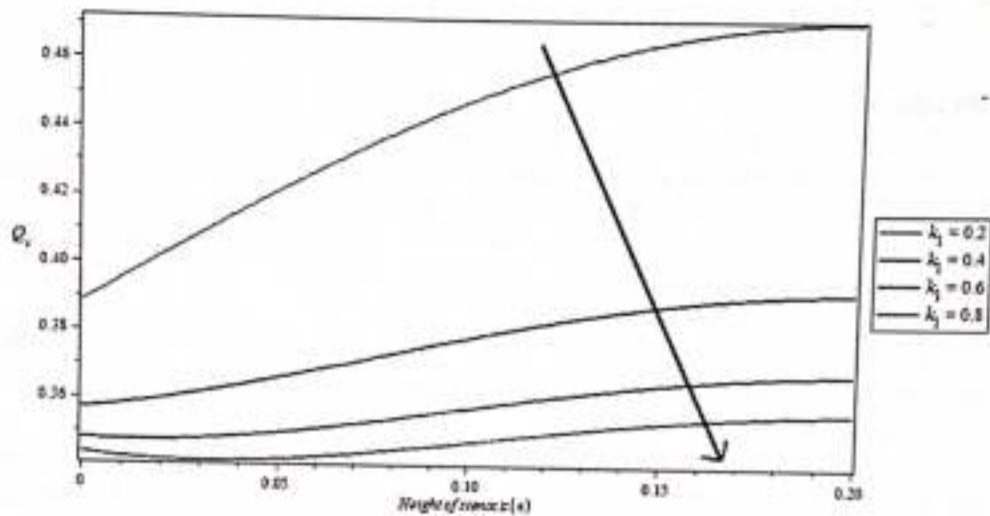
Impact of flow parameters on Blood Temperature

Figures 5, 6 and 7 respectively indicate the variation of stenosis height (ϵ), porosity number (k_1) and magnetic field parameter (M) on the blood flow temperature. As obtained on velocity field, corresponding impact of ϵ , k_1 and M is picture on the temperature field too. This in indicates a faster energy diffusivity of blood to continuous introduction of ϵ , k_1 and M accordingly.

Figure 5: Effect of ϵ on T profileFigure 6: Effect of k_1 on T profileFigure 7: Effect of M on T profile

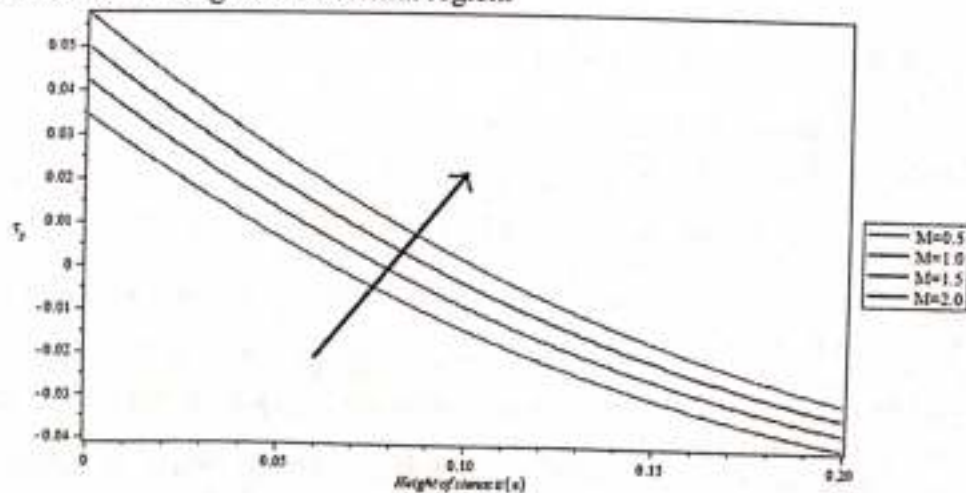
Impact of flow parameters on Volumetric Flow Rate

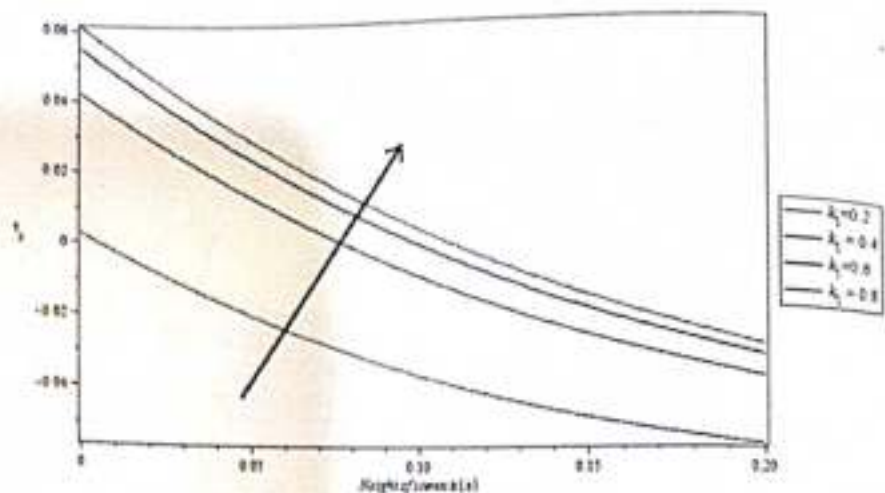
The graphical impact of the flow parameters namely, magnetic field and porosity parameters on the flow rate analysis were pictured in Figure 8 and 9 respectively. The experiment displayed a rise for higher values of M and a downsizing characterization for a small values of M . Whereas a reduction rate of is displayed as k_1 escalate.

Figure 8: Effect of M on Q profileFigure 9: Effect of k_1 on Q profile

4.4 Impact of flow parameters on Wall Shear Stress

Figures 10 and 11 respectively indicate the variation of distinct values of magnetic field parameter (M) and the porosity number (k_1) on the profile of τ_s . As earlier seen, increase in M and k_1 accelerates the blood flow throughout the arterial region.

Figure 10: Effect of M on τ_s profile

Figure 11: Effect of $k_1 \tau_x$ profile

5 Conclusion

In this work, the artery is modeled as a cylindrical long pipe and the stenosis is assumed to be cosine-shaped. The derived governing equation as based on the stated assumptions. To obtain expressions for the temperature and axial velocity among other flow distributions on the blood flow model, Differential Transform Method (DTM) was employed. We profiled the simulated results graphically, thus, the findings obtained are enumerated below:

- both blood velocity and temperature increases to a higher porous and magnetic field size, while stenosis height parameter gave an opposing characterization at both walls.
- minimal values of M and increasing number of k_1 downsized the blood flow rate, while larger value of M behaved contrarily.
- an increase in the empty spaces or voids present in the artery (porosity parameter) and the magnetization effect accelerated the wall shear stress accordingly.

References

- Abubakar J. U, and Adeoye A. D., (2020). Effects of radiative heat and magnetic field on blood flow in an inclined tapered stenosed porous Artery. *Journal of Taibah university for science*. 14(1):77-86.
- Abubakar J. U, Gbadeyan J. A. and Ojo J. B. (2019). Steady blood flow through vascular stenosis under the influence of magnetic field, *Centrepont J. (Science Edition)* 25(1):61-82.
- Alsagri A. S., Nasir S., Gul, T., Islam S., K.S. Nisar, Z. Shah and Ilyas Khan, (2019). MHD Thin Film Flow and Thermal Analysis of Blood with CNTs Nanofluid, *Coatings*, 9(3):175-192.
- Alsemiry R D, Sarifuddin, Mandal P K, Sayed H M, and Amin N, (2020). Numerical Solution of Blood Flow and Mass Transport in an Elastic Tube with Multiple Stenoses. *Hindawi BioMed Research Int.*, Article ID 7609562, 1-14.
- Ikbal A., S. Chakravarty K., Wong K. L., and Mandal P.K., (2009). Unsteady response of Non-Newtonian Blood Flow through a Stenosed Artery in a Magnetic Field. *J. Comp. and App. Math.*, 230(1):243-259.
- Ilyani A., Amin N. and Hayat T., (2010). Magnetohydrodynamic Effects on Blood Flow through an Irregular Stenosis. *Int. J. Numer. Meth. Fluids*, 67:1624-1636.
- Jain M., Sharma G. C., and Singh R., (2010). Mathematical Modelling of Blood Flow in a Stenosed Artery Under MHD Effect Through Porous Medium. *IJE Transactions B: Applications* 23:243-251.

- Karthikeyan D, and Jeevitha G, (2019). Heat and Mass Transfer on MHD Two Phase Blood Flow through a Stenosed Artery with Permeable Wall. *Int. J. Innovative Technol. Explor. Eng.*, 8(7):1224-1232
- Mohan V., Prasad V., Varshney N. K., and Gupta P., (2013). Effect of Magnetic Field on Blood Flow (Elastico-Viscous) Under Periodic Body Acceleration in Porous Medium. *IOSR-JM*, 6(4):43-48.
- Mwapinga A, Mureithi E, Makungu J, and Masanja V., (2020). MHD Arterial Blood Flow and Mass Transfer under the Presence of Stenosis, Body Acceleration and Chemical Reaction: A Case of Magnetic Therapy. *J. Math Informatics*, 85-103.
- Nadeem S., Akbar N. S., and Hayat T., (2011). Influence of Heat and Mass Transfer on Newtonian Biomagnetic Fluid of Blood Flow through Tapered Porous Arteries with Stenosis. *TiPM*, 91(1):81-100.
- Pokhrel P R, Kafle J, Kattel P, and Gaire H P, (2020). Analysis of blood flow through artery with mild stenosis. *J. Institute Sci. Tech.*, 25(2):33-38.
- Raju K. C. and Reddy B. S., (2019). Effect of Chemical Reaction, Thermo-Diffusion, Hall Effects on MHD Convective Heat and Mass Transfer Flow of a Viscous Fluid in a Vertical Channel Bounded by Stretching and Stationary Walls. *IJSIMR*, 7(4):12-24.
- Roy N C, Saha L K, Hossain M A, and Gorla R S R., (2020). Blood flow in a stenotic artery with temperature-dependent viscosity. *Heat Transfer*, 1-22.
- Saleem A, Akhtar S, Nadeem S, Issakhov A , and Ghalambaz M., (2020). Blood Flow Through a Catheterized Artery Having a Mild Stenosis at the Wall with a Blood Clot at the Centre. *Compu. Model. Eng. Sci.*, 125(2):565-577
- Sankar D. S. and Yatim Y., (2012). Comparative Analysis of Mathematical Models for Blood Flow in Tapered Constricted Arteries. *Abstract Appl. Anal.*, 1-35.
- Sharma M, Gaur R. K., and Sharma B. K., (2019). Radiation effect on MHD blood flow through a tapered porous stenosed artery with thermal and mass diffusion. *Int. J. Appl. Mech. Eng.*, 24(2):411-423
- Sharma M., Gaur R. K., and Biswas P., (2018). Effect of Slip Parameter on MHD Blood Flow and Heat Transfer through a Porous Medium with Variable Viscosity. *IJSER*, 7(4):729-737.
- Shukla J. B., Parihar R. S., and Gupta S. P., (1980). Biorheological Aspects of Blood Flow through Artery with Mild Stenosis: Effects of Peripheral Layer. *Biorh.*, 17:403-410.
- Sweed NS, Mekheimer KS, EL-Kholy A, and Abdelwahab AM, (2020) Alterations in pulsatile bloodstream with the heat and mass transfer through asymmetric stenosis artery: Erythrocytes suspension model. *Heat Transfer*, :1-29.
- Trpathi B, and Sharma B K, (2018). Influence of heat and mass transfer on two-phase blood flow with joule heating and variable viscosity in the presence variable of magnetic field. *Int. J. Comput. Meth.*, 17(3)