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Effect of Treatment Parameter on Oscillatory Flow of Blood Through an Atherosclerotic Artery with Heat Transfer

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Abstract

This research work has been carried out to investigate the influence of treatment parameter on flow of blood in a stenosed artery in the presence of magnetic field with heat transfer. The momentum equation governing the flow field has been solved by scaling it to dimensionless structure with the aid of some dimensionless parameters. The equations have been analytically solved using modified Bessel equation and by the method of undetermined coefficients in order to obtain the temperature profile and velocity profile of the blood flow. The characteristics of the flow have been derived for a certain set of values R_T, Da, θ, Gr, Re, Pr, ω, δ involved in the model analysis and are presented graphically with the help of software Mathematica. Moreover the velocity of the blood is adopting a wavy pattern as the values of the parameters vary. The study can be useful in providing a perception of the treatment caused by the superfluous consumption of fatty foods hence decreasing the risk of cancer, hypertension and many heart related diseases.

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Keywords: Blood flow, Heat Transfer, Atherosclerosis, Treatment, Darcy number

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1. Introduction

The blood is regarded as a thick red liquid comprising of red blood cells, white blood cells and platelets which are circulating in through arteries and veins in a human body. It has a strong nourishing effect and serves as one of the most important substance constituting the human body. As now-a-days, heart diseases due to thickening of blood carrying artery is very common which causes the accumulation of fatty substances in the lumen which in turn tends to block the side walls of the veins and artery which is due to the pulsating nature of the heart. Furthermore, the most important function of the heart is pumping the blood throughout the circularity system and to supply oxygen to organs of the body.

Severe stenosis may lead to critical flow conditions of blood by reducing the blood supply and resulting in serious consequences called carotid artery blockage which is one of the eminent factors contributing to fatal hemorrhages and hypertension. Regarding this, Atherosclerosis, the leading killer disease of the 21^{st} century which is due to the hardening of the artery caused by the waxy substances, cellular wastes, calcium and cholesterol that leads to narrowing of the arterial walls resulting in brain damage or even death. Nevertheless, the significance of

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additional factors cannot be neglected but the diet contributing to atherosclerosis is turning out to be a grave concern as the uncontrolled intake of greasy and oily food enhances the risk of developing such chronic diseases.

Over the decades, a lot of mathematicians and scientists have done ample of research on the blood flow with heat transfer in human circulatory system and have discovered a handful of useful results. Some of them supporting this research work are Bunonyo *et al.* [1] studied the impact of treatment parameter on blood flow in an atherosclerotic artery. Bhatti *et al.* [2] examined the heat transfer analysis on peristaltic induced motion of particle fluid suspension with variable viscosity: clot blood model. The influence of blood flow in large vessels on temperature distribution in hyperthermia was analyzed by Lagendijk [3]. Srivastava [4] discussed the analysis of flow characteristics of blood flowing through an inclined tapered porous artery with mild stenosis under the influence of inclined magnetic field. Bunonyo and Amos [5] did the research on treatment and radiation effects on oscillatory blood flow through a stenosed artery. The study of slip effects on the unsteady MHD pulsating blood flow through porous medium in an artery under the effect of body acceleration was carried out by Eldesoky [6]. Makinde and Mhone [7] studied the heat transfer to MHD oscillatory flow in a channel filled with porous medium. Unsteady heat transfer to oscillatory flow through a porous medium under slip condition was investigated by Hamza *et al.* [8]. Choudhury and Das [9] analyzed the heat transfer to MHD oscillatory visco elastic flow in a channel filled with porous medium. Biswas and Chakraborty [10] gave the pulsatile flow of blood in a constricted artery with body acceleration.

Hanvey *et al.* [11] developed a model on heat and mass transfer in oscillatory flow of a non-Newtonian fluid between two inclined porous plates placed in a magnetic field. Plourde *et al* [12] looked into alterations of blood flow through arteries following atherectomy and the impact on pressure variation and velocity. Mathematical modeling of blood flow through vertebral artery with stenosis was studied by Ali *et al.* [13]. Mathur and Jain [14] discussed the mathematical model of non-Newtonian blood flow through artery in the presence of stenosis. Ali and Asghar [15] studied the oscillatory channel flow for non-Newtonian fluid. The study of heat transfer in the flow of blood has gained much importance due to its significant role in medical sciences and in the research field as well. Many researchers such as Bunonyo, Cookey and Amos [16] studied the modeling of blood flow through stenosed artery with heat in the presence of magnetic field. Ali and Ahmad [17] gave an analytical solution of unsteady MHD blood flow and heat transfer through parallel plates when lower plate stretches exponentially. The effect of radiative heat and magnetic field on blood flow in an inclined tapered stenosed porous artery was studied by Abubakar and Adeoye [18]. Lavanya [19] made an analytical study on MHD rotating flow through a porous medium with heat and mass transfer. Rawat *et al.* [20] considered the effect of magnetic field on oscillatory blood flow in multi stenosed artery.

Varshney, Katiyar and Kumar [21] studied the effect of magnetic field on the blood flow in artery having multiple stenosis. Elangovan and Selvaraj [22] gave the study of multiple stenosed artery with periodic body acceleration in presence of magnetic field. Transport of MHD couple stress fluid through peristalsis in a porous medium under the influence of heat transfer and slip effects was investigated by Sankad and Nagathan [23]. Tripathi and Sharma [24] studied the effects of variable viscosity on MHD inclined arterial blood flow with chemical reaction. Modelling of arterial stenosis and its applications to blood flow was given by Pralhad and Schultz [25]. Kot and Elmaboud [26] studied the unsteady pulsatile fractional Maxwell viscoelastic blood flow with Cattaneo heat flux through a vertical stenosed artery with body acceleration. The study of efficient hybrid block method for numerical solution of second order partial differential problems via the method of lines was done by Olaiya, Azeez and Modeebei [27]. In the present paper, the influence of treatment parameter on the blood flow with heat transfer is examined. It has been seen that the unsteady flow of blood in stenosed artery with heat transfer placed in magnetic field has gained much importance as it can be a treatment to the fatty substances stuck at the walls of the arteries which increases the risk of having atherosclerosis, hence giving rise to such research using mathematical model.

After studying the available literature, we have considered the effect of treatment parameter on the flow of blood through an atherosclerotic artery in the presence of magnetic field and heat transfer. The equations which govern the flow field are solved by using non dimensional parameters and a graphical approach has been studied which can be very useful in detection of heart related diseases which can be treated an early stage to avoid serious medical condition.

2. Material and Methods

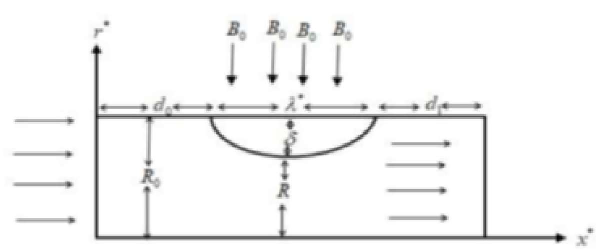

Figure 1. Geometry of the problem

Let us consider blood to be Newtonian, unsteady, electrically conducting, incompressible and viscous flowing past an atherosclerotic artery that is presumed to be a cylindrical polar channel $w'r', x')$, where r' and x' are the direction of the flow. This type of flow arises due to the pumping of the blood in the region of the heart (especially when the contraction of the heart takes place). Furthermore, the pressure gradient is in the horizontal direction and the magnetic field is taken perpendicularly to the direction of the flow of blood. The flow field is governed by the following equations which were given by Bunonyo and

Amos [1] are:

$$\rho \frac{\partial w'}{\partial t'} = -\frac{\partial p'}{\partial x'} + \frac{\mu}{r'} \frac{\partial}{\partial r'} \left(r' \frac{\partial w'}{\partial r'} \right) - \frac{\mu}{k'} w' - \sigma B_0^2 w' + \rho \beta_T (T' - T_8) \overline{g} \quad (1)$$

$$\frac{\partial T'}{\partial t'} = \frac{k_T}{\rho C_p} \left(\frac{\partial^2 T'}{\partial r'2} + \frac{1}{r'} \frac{\partial T'}{\partial r'} \right) - \frac{q'_r}{\rho C_p} (T' - T'_8) \quad (2)$$

The atherosclerosis region is supposed to be:

$$r' = R_0 - \frac{\delta'}{2} \left(1 + \cos 2 \frac{\pi x'}{\lambda} \right) \quad (3)$$

where

$$x' = d_0 + \frac{L_0}{2} \quad (4)$$

The boundary conditions are:

$$w' = 0 \,,\ T' = T_w \quad at \quad r' = 0$$

$$w' = 0 \,,\ T' = T_8 \quad at \quad r' = R \quad (5)$$

In order to write the governing equations in dimensionless form, some non-dimension variables are being introduced:

$$w = \frac{w'}{U_0}, t = \frac{t' U_0}{R_0}, Da = \frac{k'}{R_0^2}, Re = \frac{U_0 R_0}{v}, M = B_0 R_0 \sqrt{\frac{\sigma}{\mu}},$$
$$p = \frac{R_0^2 p'}{\rho v \lambda U_0}, x = \frac{x'}{\lambda}, \ \delta' = \frac{2\delta R_0}{R_T}, r = \frac{r'}{R_0}, Gr = \frac{g \beta_T R_0^2}{v U_0} T_8,$$
$$Rd = \frac{q'_r R_0^2}{\mu C_p}, Pr = \frac{\mu C_p}{k_T} \quad (6)$$

The equations (1) to (4) are solved using dimensionless parameter in (6), hence the following equations are obtained after dropping the primes:

$$Re \frac{\partial w}{\partial t} = -\frac{\partial P}{\partial x} + \frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial w}{\partial r} \right) - \frac{1}{Da} w - M^2 w + Gr\theta \quad (7)$$

$$Pr \frac{\partial \theta}{\partial t} = \left(\frac{\partial^2 \theta}{\partial r^2} + \frac{1}{r} \frac{\partial \theta}{\partial r} \right) - Rd Pr \theta \quad (8)$$

$$r = 1 - \frac{\delta}{R_T} (1 + \cos 2\pi x) \quad (9)$$

where $x = \frac{1}{\lambda} \left(d_0 + \frac{L_0}{2} \right)$

The boundary conditions in dimensionless form are:

$$w = 0, \quad \theta = 0 \quad \text{at } r = 0$$

$$w = 0, \quad \theta = 1 \quad \text{at } r = h \quad (10)$$

where $Re,\ Da,\ M,\ Rd, Gr, Pr$ are Reynolds number, Darcy's number, Hartmann number, Radiation parameter, Grashof number and Prandtl number respectively.

3. Method of Solution

The flow of blood through the arteries and veins is generally governed by the pumping action of the heart which in turn gives rise to oscillatory flow of blood, therefore the solution can be assumed to be of the form:

$$w = w_0 e^{i\omega t} \quad (11)$$

$$\theta = \theta_0 e^{i\omega t} \quad (12)$$

The pressure gradient can be represented by:

$$\frac{\partial P}{\partial x} = -P_0 e^{i\omega t} \quad (13)$$

where P_0 is the pressure constant and ω represents the angular frequency of the oscillations. Now putting equations (10-12) into equations (7-9), we get:

$$\frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial w_0}{\partial r} \right) - \left(\frac{1}{Da} + M^2 + Rei\omega \right) w_0 = -P_0 - Gr\theta_0 \quad (14)$$

$$\left(\frac{\partial^2 \theta_0}{\partial r^2} + \frac{1}{r} \frac{\partial \theta_0}{\partial r} \right) - \eta^2 \theta_0 = 0 \quad (15)$$

where $\eta^2 = (Rd + i\omega) Pr$

The corresponding boundary conditions can be given as:

$$w_0 = 0 \,, \quad \theta_0 = 0 \quad \text{at } r = 0$$

$$w_0 = 0, \quad \theta_0 = e^{-i\omega t} \quad \text{at } r = h \quad (16)$$

where $\beta^2 = h^2 (Rd + i\omega) Pr$

Applying the transformation $\xi = r/h$ in the equation (15) and (16), we have:

$$\frac{\partial^2 \theta_0}{\partial \xi^2} + \frac{1}{\xi} \frac{\partial \theta_0}{\partial \xi} - \beta^2 \theta_0 = 0 \quad (17)$$

$$w_0 = 0, \quad \theta_0 = 0 \quad \text{at } \xi = 0$$

$$w_0 = 0, \quad \theta_0 = e^{-i\omega t} \quad \text{at } \xi = 1 \quad (18)$$

Hence equation (17) can be re-written as:

$$\xi^2 \frac{\partial^2 \theta_0}{\partial \xi^2} + \xi \frac{\partial \theta_0}{\partial \xi} - \beta^2 \xi^2 \theta_0 = 0 \quad (19)$$

The above equation represents a modified Bessel differential equation therefore its solution can be given as:

$$\theta_0 (\xi) = A\ I_0 (\beta \xi) + B\ K_0 (\beta \xi) \quad (20)$$

where I_0 and K_0 are modified Bessel function of zero order. Here $B = 0$, as the solution is bounded at $r = 0$, hence otherwise $\theta_0 (\xi)$ will not be finite. Therefore equation (20) will be reduced to:

$$\theta_0 (\xi) = A\ I_0 (\beta \xi) \quad (21)$$

Solving (21) subject to conditions given in the equations (18), we have:

$$\theta_0(\xi) = \frac{I_0(\beta\xi)}{I_0(\beta)} e^{-i\omega t} \tag{22}$$

Hence substituting equation (22) into equation (12), we have:

$$\theta(\xi) = \frac{I_0(\beta\xi)}{I_0(\beta)} \tag{23}$$

Again, applying the transformation $\xi = r/h$ in the equation (14) and using (23), we have:

$$\frac{\partial^2 w_0}{\partial \xi^2} + \frac{1}{\xi}\frac{\partial w_0}{\partial \xi} - \varphi\, w_0 = \chi \tag{24}$$

where $\varphi = h^2\left(\frac{1}{Da} + M^2 + Rei\omega\right)$ and $\chi = h^2\left(-P_0 - Gr\,\frac{I_0(\beta\xi)}{I_0(\beta)} e^{-i\omega t}\right)$

Hence the homogeneous solution of equation (24) is:

$$\frac{\partial^2 w_0}{\partial \xi^2} + \frac{1}{\xi}\frac{\partial w_0}{\partial \xi} - \varphi\, w_0 = 0 \tag{25}$$

Equation (25) can be re-written as:

$$\xi^2\frac{\partial^2 w_0}{\partial \xi^2} + \xi\frac{\partial w_0}{\partial \xi} - \varphi\, \xi^2 w_0 = 0 \tag{26}$$

Equation (26) represents a modified Bessel differential equation therefore its solution can be given as:

$$w_{0_h}(\xi) = C_1 I_0(\sqrt{\varphi}\,\xi) + C_2 K_0(\sqrt{\varphi}\,\xi) \tag{27}$$

Here $C_2 = 0$, as the solution is bounded at $\xi = 0$, therefore equation (27) will be reduced to:

$$w_{0_h}(\xi) = C_1 I_0(\sqrt{\varphi}\,\xi). \tag{28}$$

Now solving equation (24) to the particular solution by using the method of undetermined coefficients, we obtain:

$$w_{0_p}(\xi) = \frac{h^2 P_0}{\varphi} + Gr\,\frac{h^2 I_0(\beta\xi)}{\varphi I_0(\beta)} e^{-i\omega t} \tag{29}$$

Further the general solution is:

$$w_{0_g}(\xi) = w_{0_h}(\xi) + w_{0_p}(\xi) \tag{30}$$

Putting the values of equations (28) and (29) into (30), we get:

$$w_{0_g}(\xi) = C_1 I_0(\sqrt{\varphi}\,\xi) + \frac{h^2 P_0}{\varphi} + Gr\,\frac{h^2 I_0(\beta\xi)}{\varphi I_0(\beta)} e^{-i\omega t} \tag{31}$$

Substituting from (18) into (31) to calculate the value of C_1, we have:

$$C_1 = -\frac{P_0 h^2}{\varphi} - \frac{Grh^2 e^{-i\omega t}}{\varphi I_0(\beta)} \tag{32}$$

Keeping the value of C_1 in equation (31), we have:

$$w_0 = \frac{P_0 h^2}{\varphi}\left\{(1 - I_0(\sqrt{\varphi}\,\xi)) + \frac{Grh^2 e^{-i\omega t}}{\varphi I_0(\beta)}\left(I_0(\beta\xi) - I_0(\sqrt{\varphi}\,\xi)\right)\right\} \tag{33}$$

The final form of general equation of the velocity profile by using equation (33) in (11), we obtain:

$$w_\xi = \left[\frac{P_0 h^2}{\varphi}\left\{(1 - I_0(\sqrt{\varphi}\,\xi)) + \frac{Grh^2 e^{-i\omega t}}{\varphi I_0(\beta)}\left(I_0(\beta\xi) - I_0(\sqrt{\varphi}\,\xi)\right)\right\}\right] e^{i\omega t} \tag{34}$$

The expressions representing the profile for temperature and velocity are given by the equations (23) and (34) respectively.

4. Results and Discussion

This study is carried out in view of combined effects of various parameters on blood flow flowing past an atherosclerotic artery. Authors have derived the numerical results for velocity profile and temperature profile. The results calculated above are obtained for different values of parameters like Radiation parameter, Prandtl number, Treatment parameter, Reynolds number, Darcy number, Grashoff number, height of the stenosis and Hartmann number.

In this paper, the velocity profile is calculated for Rd, R_T, Pr, M, t, Gr, Da, δ, ω *and* Re as it is shown in Figures 1 to 10. It is clear from Figure 1 that the impact of Radiation parameter dominates the flow of blood and as the value of Rd increases the velocity takes a decreasing pattern. In addition, the velocity increases and attains a maximum position for different values of Radiation parameter, viz, $Rd = 0.2, 0.4, 0.6, 0.8, 1.0$ and then it starts to decrease in a converging manner and comes down to zero as r approaches 1.

Figure 2 is obtained for various values of Prandtl number. On increasing the Prandtl number ($Pr = 3, 5, 7, 9, 11$) an increase in the blood velocity is observed. Furthermore, the amplitude of the velocity profile keeps on increasing and reaches a maximum point and then it starts to decrease and converges at a same point. In Figure 3, the treatment parameter highly impacts the flow of blood as at first the velocity shows pulsating character for $R_T = 0.1$ and then starts decreasing as the parameter R_T increases in the arterial channel. The treatment parameter controls the plague that is build up in the arterial section due to the consumption of fatty and oily food. The results obtained shows an obvious reading according to the physical behavior of human body and the velocity of the blood depends on the doses of treatment parameter values. Figure 4 expresses the curve for various values of Reynolds number ($Re = 5, 10, 15, 20, 25$). The velocity of the blood takes a curvilinear pattern and the velocity decreases in a regular trend as the Reynolds number increases. The graph attains a maximum position at $r = 0$ and gradually starts to drop and further converges to a point $r = 1$.

Figure 5 illustrates that the growth of plague matter can cause many cardiovascular diseases which is quite clear from

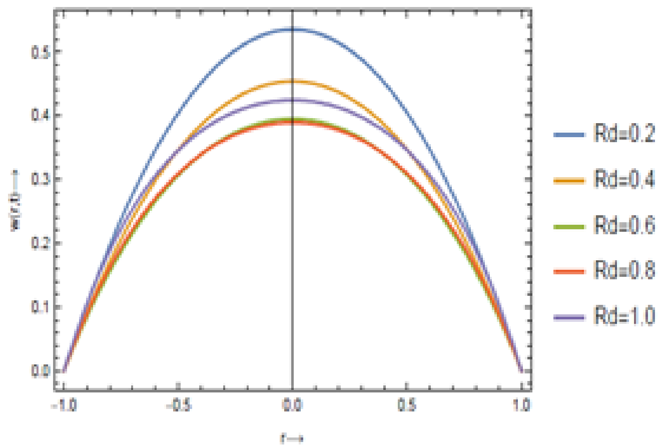

Figure 2. Effect of Radiation Rd on Blood velocity $w(r,t)$ with other parameters values $Pr = 21$, $Re = 2, R_T = 0.5$, $Gr = 15$ and variation of r

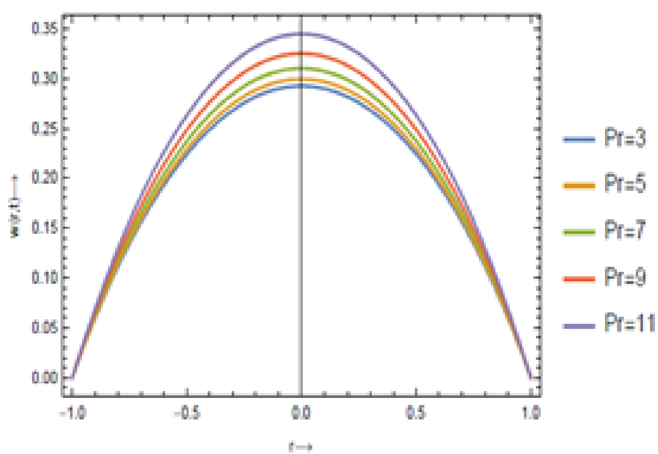

Figure 3. Effect of Prandtl number Pr on Blood velocity $w(r,t)$ with other parameters values $Rd = 2$, $Re = 2, R_T = 0.5$, $Gr = 15$, $t = 2$ and variation of r

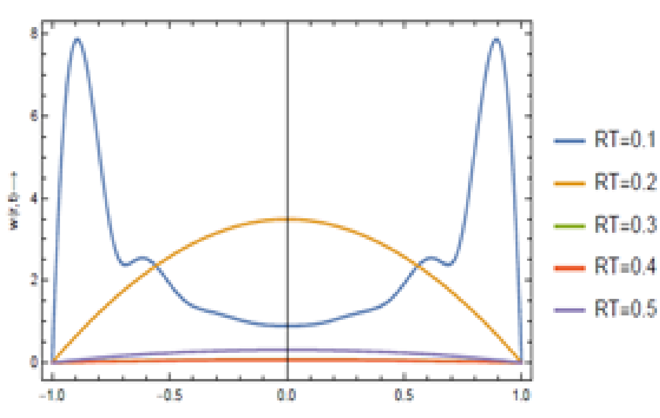

Figure 4. Effect of Treatment parameter R_T on Blood velocity $w(r,t)$ with other parameters values $Rd = 2$, $Re = 2, M = 2$, $Gr = 15$, $t = 2$ and variation of r

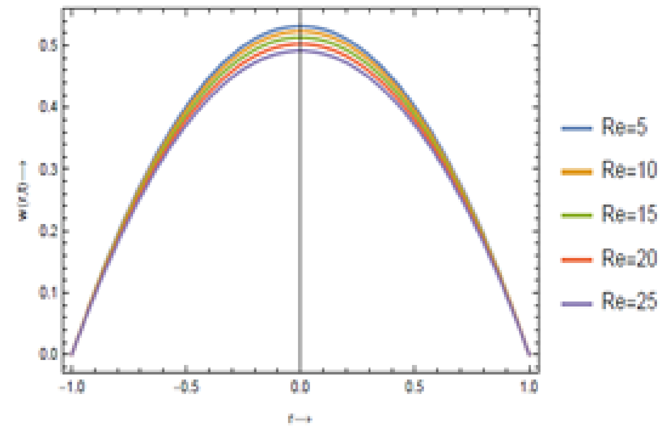

Figure 5. Effect of Treatment parameter R_T on Blood velocity $w(r,t)$ with other parameters values $Rd = 2$, $R_T = 0.5, M = 2$, $Gr = 15$, $t = 2$ and variation of r

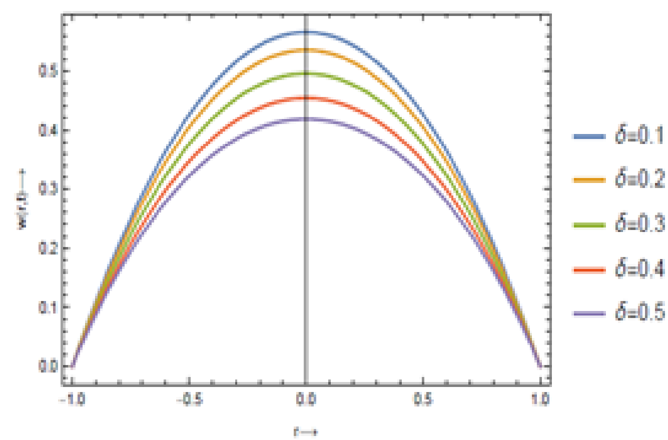

Figure 6. Effect of Height of Steonsis δ on Blood velocity $w(r,t)$ with other parameters values $Rd = 2$, $R_T = 0.5, M = 2$, $Gr = 15$, $t = 2$ and variation of r

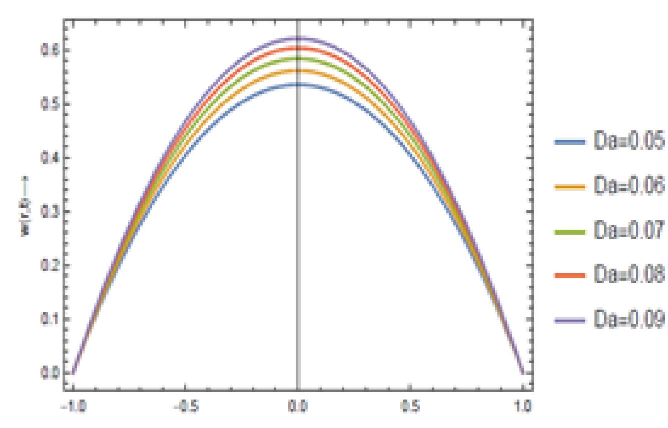

Figure 7. Effect of Darcy Number Da on Blood velocity $w(r,t)$ with other parameters values $Rd = 2$, $R_T = 0.5, M = 2$, $Gr = 15$, $t = 2$ and variation of r

the graph as the height of the stenosis increases the blood velocity declines. This retardation of blood in arteries and veins gives a crystal clear proof that the glands, organs and tissues of the human body gets famished from oxygen rich blood which ultimately results in hypertension and other cardiovascular prob-

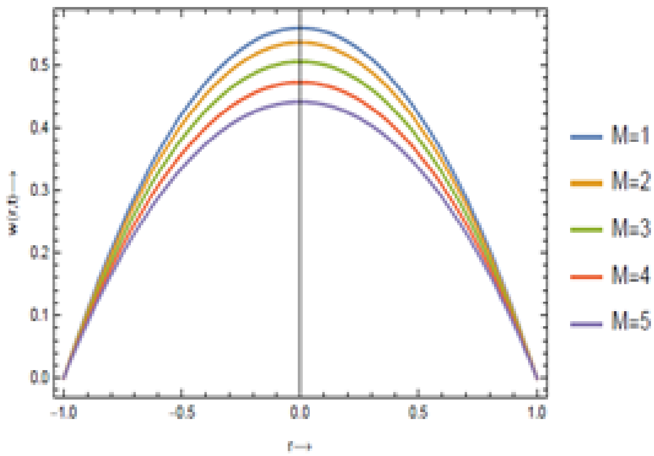

Figure 8. Effect of Hartmann Number M on Blood velocity $w(r,t)$ with other parameters values $Rd = 2,\ R_T = 0.5, Pr = 21,\ Gr = 15,\ t = 2$ and variation of r

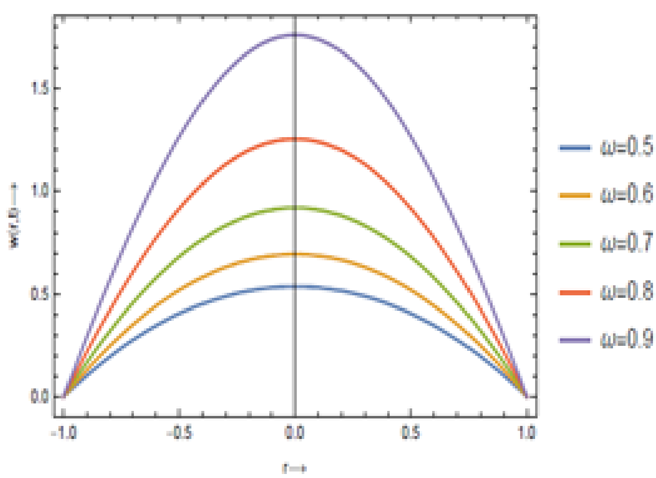

Figure 9. Effect of Oscillatory frequency ω on Blood velocity $w(r,t)$ with other parameters values $Rd = 2,\ R_T = 0.5, Pr = 21,\ Gr = 15,\ t = 2$ and variation of r

lems. The result comes out be very obvious from the fact that velocity becomes maximum at the midpoint and minimal at both the ends. Figure 6 explains the effect of Darcy's number of the flow of blood as the presence of porosity directly effects the flow. As the value of the parameter increases ($Da = 0.05, 0.06, 0.07, 0.08, 0.09$) the velocity shows an increasing pattern which reaches to an amplitude and then starts to converge at $r = 1$. The application of applied magnetic field holds utmost importance in the study of blood flow as it can be a cure to many heart related diseases. It is examined in Figure 7 that as the intensity of the magnetic is increased the blood velocity is decreased. It is because when the magnetic field is applied on the blood flow which is electrically conducting in nature, generates Lorentz force which makes the velocity of blood in arteries and veins to retard.

Figure 8 represents the effects of oscillatory frequency parameter of the velocity of blood. As the frequency parameter increases ($\omega = 0.5, 0.6, 0.7, 0.8, 0.9$) the velocity also adopts an increasing pattern and every time the amplitude keeps on escalating for higher values of frequency parameter. In Figure 9, the influence of Grashoff number is observed and its impact on

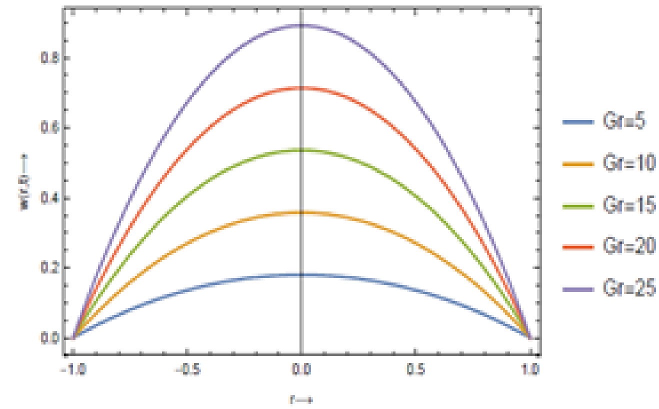

Figure 10. Effect of Grashoff Number Gr on Blood velocity $w(r,t)$ with other parameters values $Rd = 2,\ R_T = 0.5, Pr = 21,\ Da = 0.05,\ t = 2$ and variation of r

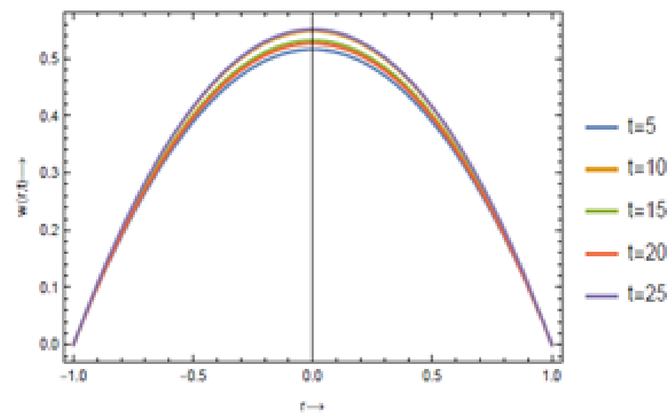

Figure 11. Effect of Time parameter t on Blood velocity $w(r,t)$ with other parameters values $Rd = 2,\ R_T = 0.5, Pr = 21,\ Da = 0.05,\ Gr = 15$ and variation of r

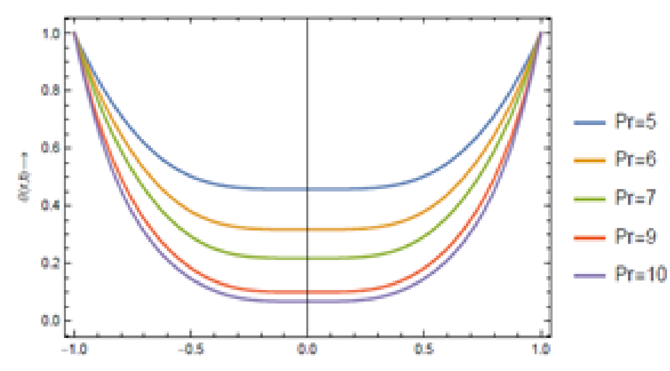

Figure 12. Effect of Prandlt Number Pr on Temperature Profile $\theta(r,t)$ with other parameters values $Rd = 2,\ R_T = 0.5, t = 2,\ \delta = 0.2$ and variation of r

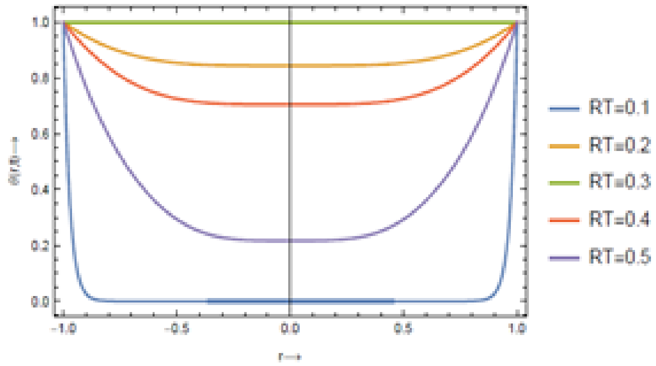

Figure 13. Effect of Treatment Parameter R_T on Temperature Profile $\theta(r,t)$ with other parameters values $Rd = 2,\ ,t = 2, \omega = 2\ \delta = 0.2$ and variation of r

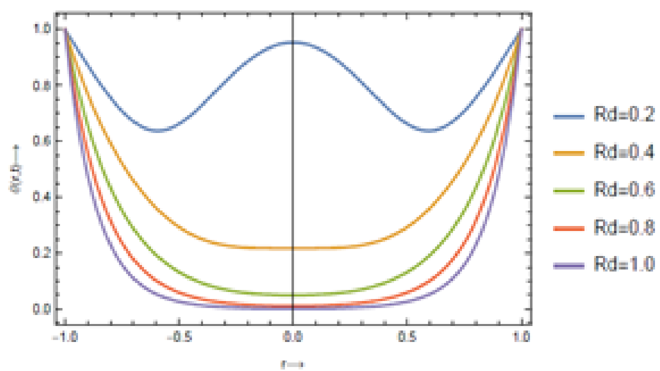

Figure 14. Effect of Radiation Parameter Rd on Temperature Profile $\theta(r,t)$ with other parameters values $R_T = 0.5,\ \delta = 2, t = 2, \omega = 2,$ and variation of r

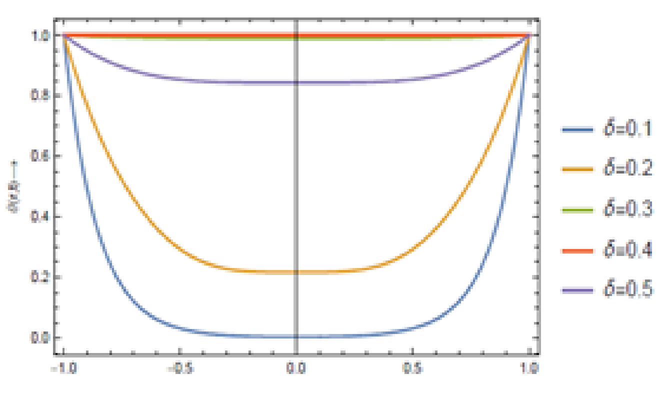

Figure 15. Effect of Height of Stenosis δ on Temperature Profile $\theta(r,t)$ with other parameters values $R_T = 0.5, Rd = 2, t = 2, \omega = 2,$ and variation of r

the velocity of blood is perceived. As the Grashoff number increases ($Gr = 5, 10, 15, 20, 25$), the velocity takes an increasing trend and the amplitude uniformly increases. Figure 10 explains the effect of time 't' on the flow of blood as the value of t is increased the value of velocity also increases which further takes a maximum value and then converges to a point at $r = 1$.

The influence of other parameters on the temperature profile can be seen from Figure 11 to Figure 16. The parameters

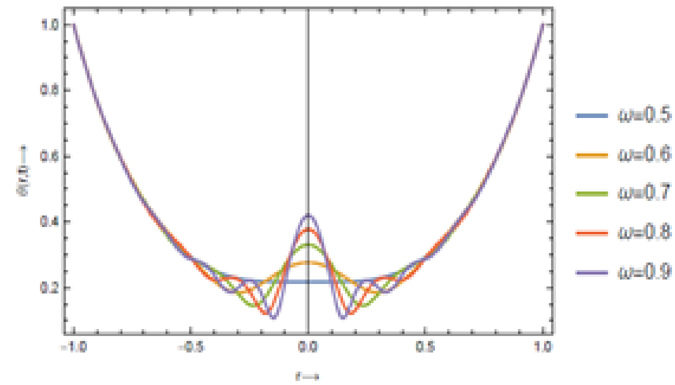

Figure 16. Effect of Oscillatory Frequency ω on Temperature Profile $\theta(r,t)$ with other parameters values $R_T = 0.5, Rd = 2, t = 2$ and variation of r

affect the temperature profile by increasing and decreasing it at different levels.

5. Conclusion

In the present study, we have investigated the influence of treatment parameter on the blood flowing past an atherosclerotic artery with heat transfer. On solving the mathematical model and carrying out the graphical study using the software Mathematica and furthermore the results have been discussed. The main conclusions of this work are as follows:

It is observed that the velocity takes a oscillatory pattern with increasing values of radiation parameter Rd, however the effect of other parameters can't be ignored.

The effect of Prandlt number causes the velocity of blood to increase as Pr increases.

The treartment parameter causes the flow of blood to retard which is due to the magnetic field that is applied on the surface portion however the contribution of other parameters cannot be neglected.

The height of the stenosis is responsible for the decreases in the blood flow through arteries which inturns lowers the oxygen level in the human body leading to plethora of cardiovascular issues.

The velocity of the blood decreases as the Reynolds number increases while other parameters are held.

The magnetic field intensity decelerates the blood flow in the human system which can be very useful in the detection of formation of plagues in arteries and veins, detection of tumors through MRI scan and detects the diseases in liver and bile duct.

The porosity factor holds great importance in circulation of blood flow through arteries as the porosity factor increases the velocity of blood increases and healthy oxygenated blood can reach different organs and tissues. Therefore the level of porosity factor can be maintained by implication of treatment parameter.

The velocity of the blood increases as frequency ω, Grashof number Gr, and time t increases. We can also conclude that the curvilinear pattern of the figures is because of the oscillatory nature of the blood flow in arteries and veins; however the presence of some prominent parameter affecting the flow of blood cannot be overlooked.

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