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A STUDY OF PULSATILE INCLINED FLOW UNDER PERIODIC BODY ACCELERATION

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ABSTRACT

A mathematical model has been formulated to study the pulsatile inclined two-layer blood flow under periodic body acceleration with magnetic field. The effect of periodic body acceleration and magnetic field on the blood flowing through a uniform inclined cylindrical tube has been analyzed.

Keywords: Blood Flow, Couple Stress Fluid, Body Acceleration, Two-Layer, Magnetic Field, Inclined.

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1. INTRODUCTION

The human system may be subjected to body acceleration or vibration deliberated for example by making subject lie down on vibrating tables or more frequently unintentionally, for example during travel in water and land or in air and space. Vibrations are of two types, one is segmental vibration and the other is whole body vibration. Segmental vibration affects a specific organ or part of the body. The most common and widely studied type of segmental vibration exposure affects the hands and arms. Hand-arm vibration affects workers who operate chain saws, chipping tools, jackhammers, jackleg drills, grinders and many other hand-held tools. When the energy from vibration enters the body through a seat or a floor, it can affect the entire body or a group of organs. This is called whole-body vibration.

Inclined plane is useful in measuring shear-stress rate curves in the low shear rate region for fluids, which exhibits on slip at the solid surface. Further it is possible to detect even minor effects of wall slip by applying the same technique. Astarita et. al [1], have studied one dimensional gravity flow of a non-Newtonian fluid along a solid plane surfaces for a fluid exhibiting slip at wall Suzuki and Tanaka[2] have investigated the effect of non-Newtonian fluids along inclined plane. Rathod and Srikanth [3-4], have investigated the flow of Rivlin-Ericksen incompressible fluid through an inclined channel. Thus it has been shown that inclined plane is useful device to study some properties of non-Newtonian fluids. The pulsatile blood flow through a closed rectangular channel in the presence of micro-organisms for gravity flow along an inclined channel is studied by Rathod and Thippeswamy[5].

groups include operators of trucks, buses, heavy equipment and those who work on vibrating floors. Whole-body vibration can have immediate health effects such as fatigue, insomnia or headache that occur during or shortly after exposure. Prolonged exposure can affect the entire body, and lead to a variety of circulatory, muscular and respiratory disorders.

Due to physiological importance of body acceleration, many mathematical models have been proposed for pulsatile flow of blood with body acceleration [6-9] by considering blood as a Newtonian, non-Newtonian, power law, Casson and viscoelastic fluid. Rathod and Gopichand[10], have studied pulsatile flow of blood through a stenosed inclined tube under periodic body acceleration. Inclined Pulsatile flow of blood with periodic body acceleration is studied by Rathod and Niyaz[11]. Rathod and Habeeb [12], have studied Pulsatile two layered flow under periodic body acceleration and reported effects of periodic body acceleration on the flow.

The application of magnetohydrodynamics principles in medicine and engineering is of growing interest. Korchevski and Marochnik [13], suggested that there is a possibility of regulating movement of blood by the application of an external magnetic filed. The investigations by Barnothy [14] has observed that by the application of an external magnetic field the biological systems are greatly affected. Vardanyan [15] showed that the application of magnetic field reduces the flow of blood. Suri and Pushpa [16] studied the effect of static magnetic field on blood flow in a branch by mathematical simulation and it has been observed that within certain limits, the applied magnetic field reduces the shear stress parameter and changes the speed of blood. In recent years, Ramachandra Rao and Deshikachar [17] have given an excellent review of a good number of works concerning the effect of a magnetic field on the flow characteristics of blood. Thus, all these researchers have reported that the effect of magnetic field reduces the velocity significantly over the core.

In the present investigation an attempt has been made to study the pulsatile inclined two-layered blood flow under periodic body acceleration subjected to magnetic field. Analytical expression and for axial velocity, core, peripheral region and flow rate have been obtained.

2. FORMULATION OF THE PROBLEM

Let us consider a one-dimensional pulsatile inclined two layer flow of blood under periodic body acceleration with magnetic field by considering blood as a couple stress, non-Newtonian and incompressible fluid. Consider the flow as axially symmetric, steady and fully developed. The pressure gradient and body acceleration G are given by:

$$-\frac{\partial p}{\partial z} = A_0 + A_1\cos(\omega_1 t),\ t \ge 0 \qquad (2.1)$$

$$G = a_0\cos(\omega_2 t + \Phi),\ t \ge 0 \qquad (2.2)$$

Where A_0 is the steady-state part of the pressure gradient, A_1 is the oscillatory part of the pressure gradient, a_0 is the amplitude of body acceleration, Φ is its phase difference, z is the axial distance.

The pulsatile couple stress equation Stokes[26] , in cylindrical polar coordinates under the periodic body acceleration with magnetic field can be written in the form:

$$\rho_1\frac{\partial u_1}{\partial t} = -\frac{\partial p}{\partial z} + \rho_1 G + \mu_1\nabla^2 u_1 - \eta\nabla^2(\nabla^2 u_1) - \sigma B_0^2 u_1 + \rho_1 g\sin\theta \qquad (2.3)$$

$$\rho_2\frac{\partial u_2}{\partial t} = -\frac{\partial p}{\partial z} + \rho_2 G + \mu_2\nabla^2 u_2 - \sigma B_0^2 u_2 + \rho_2 g\, sin\theta \qquad (2.4)$$

3. REQUIRED INTEGRAL TRANSFORM

The finite Hankel transform, defined by Tranter[14], over the interval (0,h) is,

$$u^*(\lambda_n, t) = \int_0^h r\, u\, J_n(r\lambda_n)\, dr \qquad (3.1)$$

and its inverse transform is

$$u(r,t) = \frac{2}{h^2}\sum_n u^*(\lambda_n)\frac{J_n(r\lambda_n)\lambda_n^2}{J_n^2(h\lambda_n)(s^2+\lambda_n^2)} \qquad (3.2)$$

The Hankel transform over the interval (h, 1), defined by Tranter[14],

$$u^*(\lambda_n,t) = \int_h^1 r\,u\,B_n(r\lambda_n)\,dr \qquad (3.3)$$

and its appropriate inverse transform is

$$u(r,t) = \frac{\pi^2}{2}\sum_n \frac{\lambda_n^2 J_n^2(\lambda_n)}{J_n^2(h\lambda_n) - J_n^2(\lambda_n)}\, u^*(\lambda_n) B_n(r\lambda_n) \qquad (3.4)$$

where, $B_n(\lambda_n r) = J_n(\lambda_n r)Y(\lambda_n h) - Y(\lambda_n r)J_n(\lambda h)$

λ_n are positive roots of the equation $J_n(\lambda_n)Y_n(\lambda_n h) - Y_n(\lambda_n)J_n(\lambda h)$

and J_n and Y_n are the Bessel's functions of first and second kind of order n respectively.

The Laplace transform of any function is defined as:

$$\bar{f}(s) = \int_0^\infty e^{-st} f(t)\,dt, \qquad s > 0 \qquad (3.5)$$

4. ANALYSIS

Applying the Laplace transforms (3.5) to equation (2.6) in light of (2.8,a,c,d) which gives,

$$\bar{\alpha}^2\alpha\left(s\bar{u}_1 - u_1(r,0)\right) = \frac{\bar{\alpha}^2 A_0}{s} + \frac{\bar{\alpha}^2 g\sin\theta}{s} + A_1\bar{\alpha}^2\frac{s}{s^2+1} + \bar{\alpha}^2 a_0\left(\frac{s\cos\phi - b\sin\phi}{s^2+b^2}\right) + \bar{\alpha}^2\nabla^2\bar{u}_1 - \nabla^4\bar{u}_1 - \bar{\alpha}^2 H^2\bar{u}_1 \qquad (4.1)$$

next applying the finite Hankel transform (3.1) to (4.1) which gives as,

$$\bar{u}_1^* = \left\{\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}\left[\frac{A_0}{s} + \frac{g\sin\theta}{s} + A_1\frac{s}{s^2+1} + \frac{a_0(s\cos\phi - \sin\phi)}{s^2+b^2}\right]\right]\left[h\lambda_n J_1(h\lambda_n)(\bar{\alpha}^2+\lambda_n^2) + \frac{2}{h^2}J_0(h\lambda_n) - \frac{\lambda_n J_1(h\lambda_n)}{h}\right]\bar{u}_2 + mx\Big\}\frac{1}{[sm + \bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4]} \qquad (4.2)$$

now rearranging the terms to take inverse Laplace transform

$$\bar{u}_1^* = \Big\{\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}\Big[\frac{A_0}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}\left(\frac{1}{s} - \frac{1}{s+h_1}\right) + \frac{g\sin\theta}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}\left(\frac{1}{s} - \frac{1}{s+b_1}\right) +$$

$$\frac{A_1[\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4]}{[\bar{\alpha}^2(\lambda_n^2+H^2+m^2)+\lambda_n^4]}\left(\frac{s}{s^2+1} - \frac{1}{s+h} + \frac{m}{(s^2+1)[\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4]}\right) +$$

$$\frac{a_0[\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4]\cos\phi}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\left(-\frac{1}{s+h_1} + \frac{s}{s^2+b^2} + \frac{mb^2}{(s^2+b^2)[\bar{\alpha}^2(\lambda_n^2+H^2+m^2)+\lambda_n^4]}\right.$$

$$-\frac{a_0 b\sin\phi\, m_1}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\left(\frac{1}{s+h_1} - \frac{s}{s^2+b^2} + \frac{A_1[\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4]}{(s^2+b^2)m}\right)\Big] +$$

$$\left[h\lambda_n J_1(h\lambda_n)(\bar{\alpha}^2+\lambda_n^2) + \frac{2J_0(h\lambda_n)}{h^2} - \frac{\lambda_n J_1(h\lambda_n)}{h}\right]\bar{u}_2\frac{1}{m}\left(\frac{1}{s+h}\right) + \left(\frac{1}{s+h_1}\right)x\Big\}$$

Now taking inverse Laplace transform to (4.3) we get,

$$u_1^* = \Big\{\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}\Big[\frac{A_0+g\sin\theta}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}+\frac{A_1[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos t+m\sin t]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2]}+$$
$$\frac{a_0[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos(bt+\phi)+mb\sin(bt+\phi)]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\Big]-e^{-h_1t}\Big[\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}\Big\{$$
$$\frac{A_0+g\sin\theta}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}+\frac{A_1[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2]}+\frac{a_0[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos bt+mb\sin\phi]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\Big\}+[h\lambda_nJ_1(h\lambda_n)(\bar{\alpha}^2+\lambda_n^2)+\frac{2J_0(h\lambda_n)}{h^2}-$$
$$\frac{\lambda_nJ_1(h\lambda_n)}{h}]\frac{u_2}{m}+x\Big]\Big\}$$

now taking the finite Hankel inversion(3.2) gives the final solution as,

$$u_1(r,t)=\frac{2}{h^2}\sum_n\frac{J_0(r\lambda_n)\lambda_n^2}{J_0^2(h\lambda_n)(s^2+\lambda_n^2)}\Big\{\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}\Big[\frac{A_0+g\sin\theta}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}$$
$$\frac{A_1[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos t+m\sin t]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2]}+$$
$$\frac{a_0[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos(bt+\phi)+mb\sin(bt+\phi)]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\Big]-e^{-h_1t}\Big[\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}$$
$$\Big\{\frac{A_0+g\sin\theta}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}+\frac{A_1[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2]}+$$
$$\frac{a_0[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos bt+mb\sin\phi]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\Big\}+$$
$$\frac{\frac{1}{m}[h\lambda_nJ_1(h\lambda_n)(\bar{\alpha}^2+\lambda_n^2)+\frac{2}{h^2}J_0(h\lambda_n)-\frac{\lambda_nJ_1(h\lambda_n)}{h}]}{[1+\frac{2\lambda_n^2}{h^2J_0(h\lambda_n)(s^2+\lambda_n^2)}[h\lambda_nJ_1(h\lambda_n)(\bar{\alpha}^2+\lambda_n^2)+\frac{2}{h^2}J_0(h\lambda_n)-\frac{\lambda_nJ_1(h\lambda_n)}{h}]\frac{1}{m}]}$$
$$\frac{2\lambda_n^2}{h^2J_0(h\lambda_n)(s^2+\lambda_n^2)}\Big\{\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}\Big[\frac{A_0+g\sin\theta}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}+$$
$$\frac{A_1[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos t+m\sin t]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2]}+$$
$$\frac{a_0[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos(bt+\phi)+mb\sin(bt+\phi)]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\Big]-e^{-h_1t}\Big[\frac{hJ_1(h\lambda_n)\bar{\alpha}^2}{\lambda_n}$$
$$\Big\{\frac{A_0+g\sin\theta}{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}+\frac{A_1[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2]}+$$
$$\frac{a_0[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)\cos\phi+mb\sin\phi]}{[(\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4)^2+m^2b^2]}\Big\}+x\Big]\Big\}+x\Big\}\Big]\Big\}$$

where $m=\bar{\alpha}^2\alpha$, $\quad h_1=\dfrac{\bar{\alpha}^2(\lambda_n^2+H^2)+\lambda_n^4}{m}$, and

$$x=\frac{h\sum_n\frac{\lambda_n\bar{\alpha}^2}{(s^2+\lambda_n^2)}[A_0+A_1+a_0\cos\phi+g\sin\theta]J_1(h\lambda_n)}{\Big\{[\lambda_n^4+\bar{\alpha}^2(\lambda_n^2+H^2)]-\frac{2\lambda_n^2}{h^2(s^2+\lambda_n^2)}[\frac{2}{h^2}-\frac{\lambda_nJ_1(h\lambda_n)}{hJ_0(h\lambda_n)}+h\lambda_n(\lambda_n^2+\bar{\alpha}^2)\frac{J_1(h\lambda_n)}{J_0(h\lambda_n)}]\Big\}}\frac{J_0^2(h\lambda_n)+J_1^2(h\lambda_n)}{J_0^2(h\lambda_n)}$$

Next applying the Laplace transform(3.5) to (2.7) in the light of (2.8b,c,d,e),obtained,

$$\bar{\alpha}^2\left(s\bar{u}_2-u_2(r,0)\right)=\frac{A_0}{s}+\frac{g\sin\theta}{s}+A_1\frac{s}{s^2+1}+a_0\left(\frac{s\cos\phi-b\sin\phi}{s^2+b^2}\right)+\nabla^2\bar{u}_2-H^2\bar{u}_2 \quad (4.6)$$

now applying the finite Hankel transform (3.3) to (4.6) and rearranging the term as,

$$\bar{u}_2^* = \Big[\frac{A_0+g\sin\theta}{(\lambda_n^2+H^2)}\left(\frac{1}{s}-\frac{1}{s+h_2}\right)+\frac{A_1(\lambda_n^2+H^2)}{[(\lambda_n^2+H^2)+\alpha^2]}\left(\frac{s}{s^2+1}-\frac{1}{s+h_2}+\frac{m}{(s^2+1)(\lambda_n^2+H^2)}\right)+$$
$$\frac{a_0[(\lambda_n^2+H^2)\cos\phi}{[(\lambda_n^2+H^2)^2+\alpha^2b^2]}\left(-\frac{1}{s+h_2}+\frac{s}{s^2+b^2}+\frac{\alpha b^2}{(s^2+b^2)(\lambda_n^2+H^2)}\right)-\frac{a_0 b\sin\phi\,\alpha}{[(\lambda_n^2+H^2)^2+\alpha^2b^2]}\Big($$
$$\frac{1}{s+h_2}-\frac{s}{s^2+b^2}+\frac{(\lambda_n^2+H^2)}{(s^2+b^2)\alpha}\Big)\Big]\frac{1}{\lambda_n}[hB_0'(h\lambda_n)-B_0'(\lambda_n)]+[hu_2(h,t)B_0'(h\lambda_n)]\frac{1}{\alpha^2}\left(\frac{1}{s+h_2}\right)$$
$$+YZ\frac{1}{\alpha^2}\left(\frac{1}{s+h_2}\right) \qquad (4.7)$$

now taking inverse Laplace transform to (4.3)to (4.7) and rearranging the term to take finite inverse transform as,

$$u_2^* = \Big[\frac{A_0+g\sin\theta}{(\lambda_n^2+H^2)}+\frac{A_1[(\lambda_n^2+H^2)\cos t+\alpha^2\sin t]}{[(\lambda_n^2+H^2)^2+(\alpha^2)^2]}+$$
$$\frac{a_0[(\lambda_n^2+H^2)\cos(bt+\phi)+\alpha^2 b\sin(bt+\phi)]}{[(\lambda_n^2+H^2)^2+(\alpha^2)^2 b]}\Big]\frac{1}{\lambda_n}[hB_0'(h\lambda_n)-B_0'(\lambda_n)]$$
$$-e^{-h_2t}\Big[\frac{[hB_0'(h\lambda_n)-B_0'(\lambda_n)]}{\lambda_n}\left\{\frac{A_0+g\sin\theta}{(\lambda_n^2+H^2)}+\frac{A_1[\lambda_n^2+H^2]}{[(\lambda_n^2+H^2)^2+(\alpha^2)^2b^2]}\right\}+\frac{1}{\alpha^2}\Big\{h\lambda_n u_2(h,t)$$
$$B_0'(h\lambda_n)\Big\}-YZ\Big\}\Big] \qquad (4.8)$$

now taking the inverse Hankel transform(3.4) to (4.8),which gives final solution as, where $h_2=\dfrac{\lambda_n^2+H^2}{\alpha^2}$,

$$u_2(r,t)=\frac{\pi^2}{2}\sum_n\frac{\lambda_n^2J_0^2(\lambda_n)}{J_0^2(h\lambda_n)-J_0^2(\lambda_n)}B_0(r\lambda_n)\Big[\Big\{X_1\frac{1}{\lambda_n}[hB_0'(h\lambda_n)-B_0'(\lambda_n)]\Big\}-$$
$$e^{-h_2t}\Big\{[X_2\frac{1}{\lambda_n}[hB_0'(h\lambda_n)-B_0'(\lambda_n)]\Big]-\frac{1}{\alpha^2}[hB_0'(h\lambda_n)\frac{\pi^2}{2}\sum_n\frac{\lambda_n^2J_0^2(\lambda_n)}{J_0^2(h\lambda_n)-J_0^2(\lambda_n)}B_0(h\lambda_n)\Big\{$$
$$X_1\frac{1}{\lambda_n}[hB_0'(h\lambda_n)-B_0'(\lambda_n)]-e^{-h_2t}\Big[X_2\frac{1}{\lambda_n}[hB_0'(h\lambda_n)-B_0'(\lambda_n)\}+\frac{YZ}{\alpha^2}\Big]\Big\}$$
$$\frac{1}{[1-\dfrac{\lambda_n^2J_0^2(\lambda_n)B_0(h\lambda_n)}{J_0^2(h\lambda_n)-J_0^2(\lambda_n)}\dfrac{1}{\alpha^2}h\lambda_nB_0'(h\lambda_n)e^{-h_2t}]}-YZ\Big]\Big\}\Big]$$

$$X_1=\Big[\frac{A_0+g\sin\theta}{(\lambda_n^2+H^2)}+\frac{A_1[(\lambda_n^2+H^2)\cos t+\alpha^2\sin t]}{[(\lambda_n^2+H^2)^2+(\alpha^2)^2]}+\frac{a_0[(\lambda_n^2+H^2)\cos(bt+\phi)+\alpha^2b\sin(bt+\phi)]}{[(\lambda_n^2+H^2)^2+(\alpha^2)^2b^2]}\Big]$$

$$X_2=\frac{A_0+g\sin\theta}{(\lambda_n^2+H^2)}+\frac{A_1[(\lambda_n^2+H^2)}{[(\lambda_n^2+H^2)^2+(\alpha^2)^2]}+\frac{a_0[(\lambda_n^2+H^2)\cos\phi+\alpha^2b\sin\phi]}{[(\lambda_n^2+H^2)^2+(\alpha^2)^2b^2]}$$

$$Y=\frac{\pi^2}{2}\sum_n\frac{\lambda_n^2J_0^2(\lambda_n)\left\{h\lambda_nu_2(h)B_0'(h\lambda_n)+\dfrac{1}{\lambda_n}[A_0+A_1+a_0\cos\phi][hB_0'(h\lambda_n)-B_0'(\lambda_n)\right\}}{\left\{J_0^2(h\lambda_n)-J_0^2(\lambda_n)\right\}(\lambda_n^2+H^2)}$$

$$Z=\frac{1}{2}\Big[\{Y_0^2(h\lambda_n)J_1^2(\lambda_n)+J_0^2(h\lambda_n)Y_0^2(\lambda_n)+J_0^2(h\lambda_n)Y_1^2(\lambda_n)\}-h^2\{Y_0^2(h\lambda_n)J_0^2(h\lambda_n)+$$
$$J_1^2(h\lambda_n)Y_0^2(\lambda_n)+J_0^2(h\lambda_n)Y_1^2(h\lambda_n)\}\Big]-\frac{2J_0^2(h\lambda_n)Y_0(\lambda_n)}{(1-\lambda_n)}\Big[\frac{1}{\lambda_n}\{Y_0(\lambda_n)J_1(\lambda_n)-$$
$$hY_0(h\lambda_n)J_1(h\lambda_n)\}-\{Y_0(\lambda_n)J_1(\lambda_n)-hY_0(h\lambda_n)J_1(h\lambda_n)\}\Big]$$

The expression for the flow rate Q, which is the volume of the suspension flowing per unit time across a cross-section of the tube, for two phase fluid is given by the equation

$$Q = Q_1 + Q_2$$

where $Q_1 = 2\pi \int_0^h r\, u_1\, dr \quad and \quad Q_2 = 2\pi \int_h^1 r\, u_2\, dr$

then $Q_1 = \dfrac{2\pi h J_1(h\lambda_n)}{\lambda_n J_0(h\lambda_n)} u_1(h,t)$ and $Q_2 = \dfrac{2\pi [h B_0^{/}(h\lambda_n) - B_0^{/}(\lambda_n)]}{\lambda_n B_0(h\lambda_n)} u_2(h,t)$

5. RESULTS, DISCUSSION AND CONCLUSION

The present analytical study of the pulsatile two-layered blood flow under periodic body acceleration with magnetic field through a rigid, straight tube has been computed for derived expression of velocity of both the layers (core and plasma region)for different parameters such as amplitude of body acceleration a_0, steady state part of pressure gradient A_0, amplitude of oscillatory part A_1, time t, couple stress parameter $\bar{\alpha}$, womersely parameter α and Hartman number H . It is assumed that the blood flow consists of a core of radius 'h', represented by couple stress fluid and a peripheral plasma of thickness (1-h), represented by Newtonian fluid.

In Figs., 1- 4 & 6, the velocity profiles are drawn for different values a_0, A_0, A_1, t & α respectively and keeping other parameters constant. It has been observed that as the values of these parameters increases the velocity of both the layers are also increases.

In Fig.5, the velocity profiles are drawn for different values of couple stress parameter and keeping other parameters constant. It is of interest to note that velocities of both the layers (core and plasma region) first increase and then decreases as couple stress parameter increases.

In Fig.7.the velocity profiles are drawn for different values of Hartman Numbers. It is of interest to note that as Magnetic field increases the velocities decreases and the velocities are found to be maximum in the absence of Magnetic field.

The present mathematical model reduces to that of Rathod and Habeeb [26],model on substituting the Hartman as zero. Above results suggest that a proper understanding of interaction with blood flow may lead to a therapeutic use of controlled body acceleration. It is there for desirable to analyze the effects of different types of vibrations on different parts of the body. Such as knowledge of body acceleration could be useful in the diagnosis and therapeutic treatment of some health problems (joint pain, vision loss, and vascular disorder), to better design of protective pads and machines.
It is also seen that the fluid velocity is affected due to presence of magnetic field. When the magnetic field increases the fluid velocity decreases. This may help physiologists in understanding and controlling the blood flow in person suffering with one or other blood borne diseases.

CONFLICT OF INTERESTS

None.

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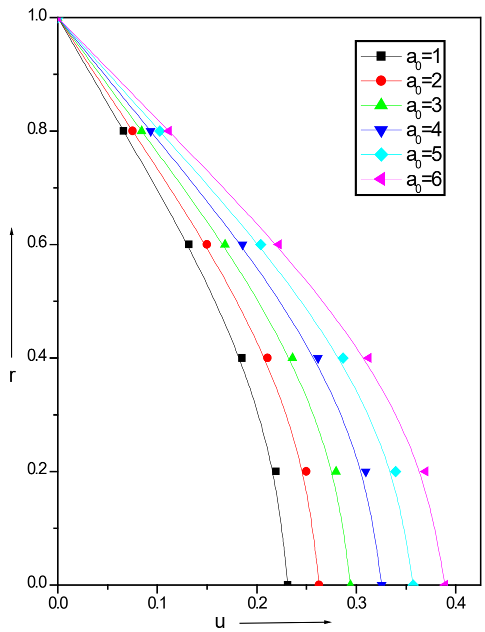

Fig.1,Variation of velocity profile for different valves of a_0

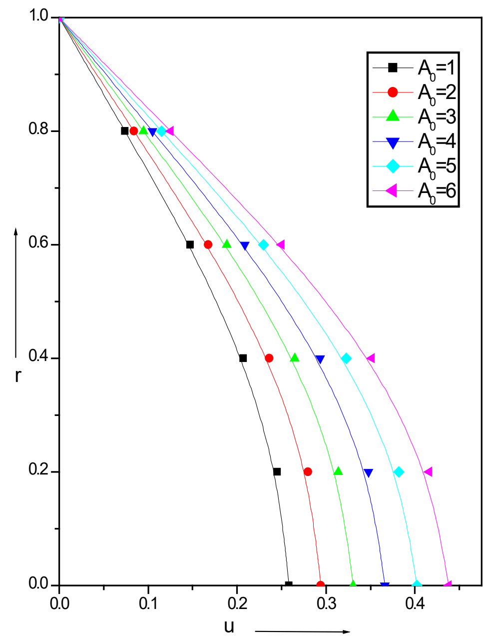

Fig.2,Variation of velocity profile for different valves of A_0

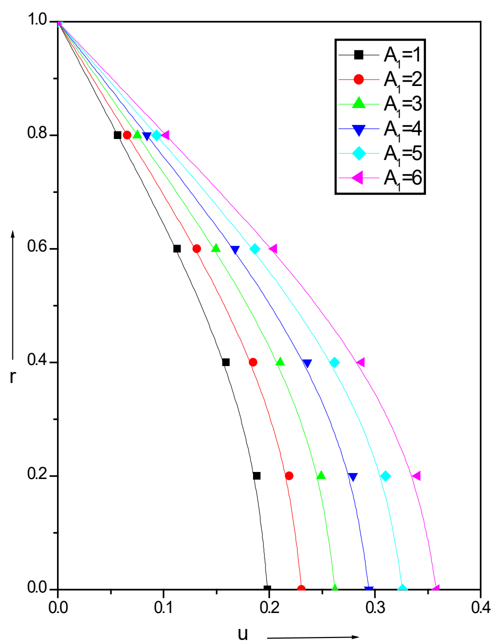

Fig.3,Variation of velocity profile for different valves of A_1

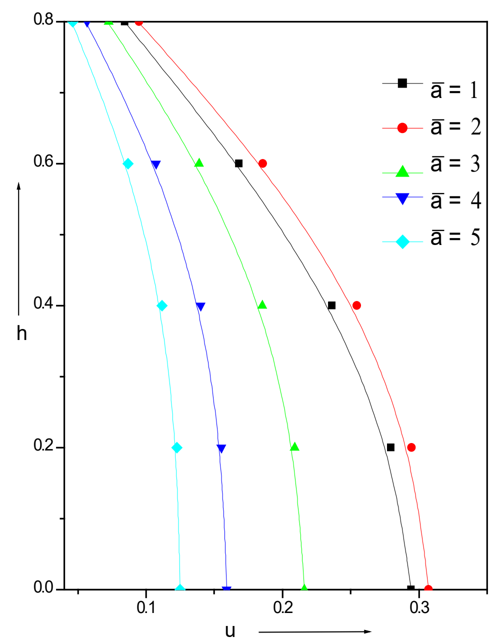

Fig.4,Variation of velocity profile for different valves of $\bar{a}$

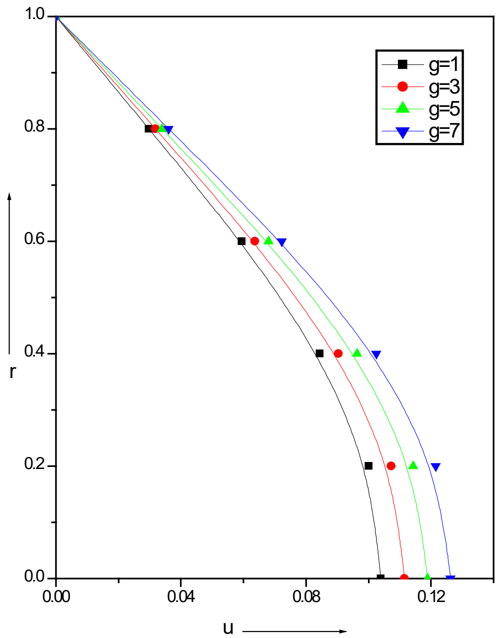

Fig.5, Variation of velocity profile for different values of g

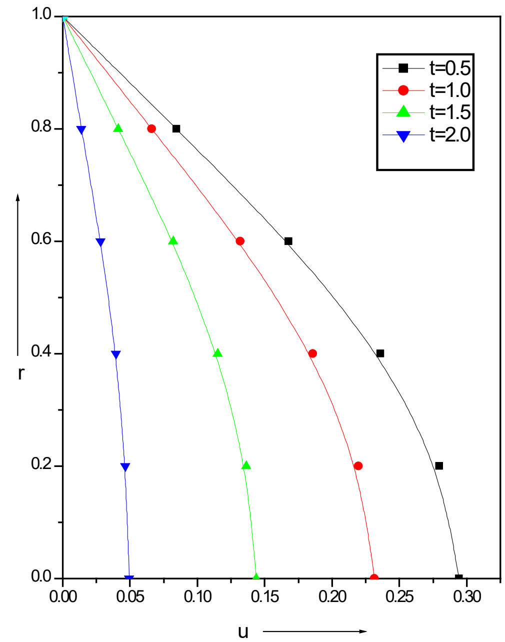

Fig.6, Variation of velocity profile for different values of t

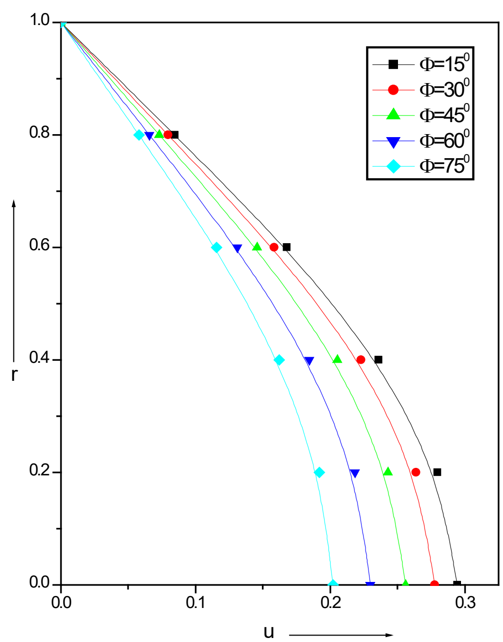

Fig.7, Variation of velocity profile for different values of ϕ

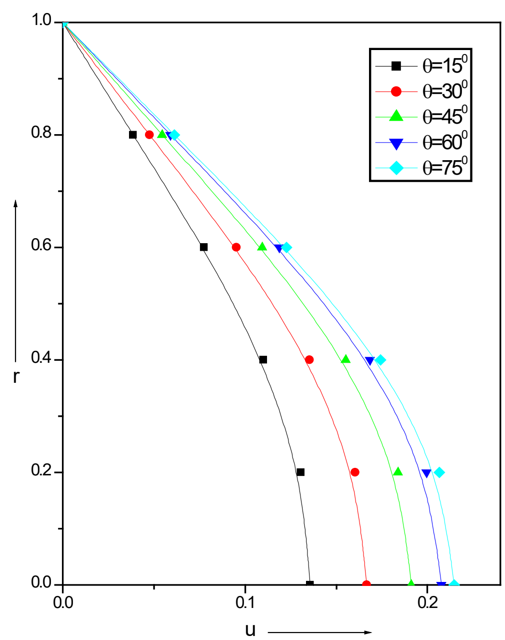

Fig.8, Variation of velocity profile for different values of θ

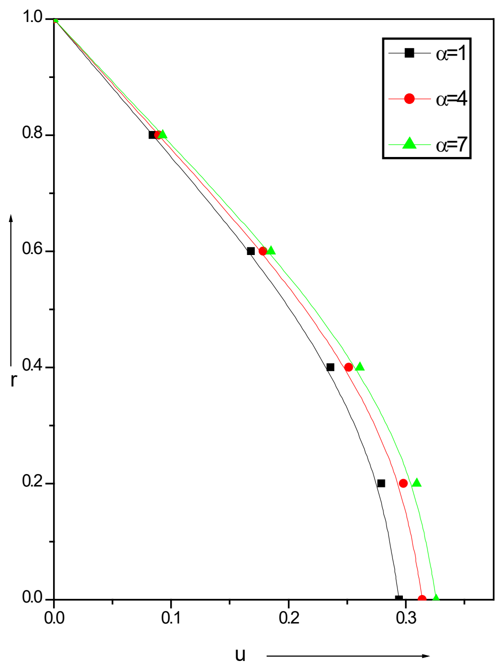

Fig.9, Variation of velocity profile for different values of α

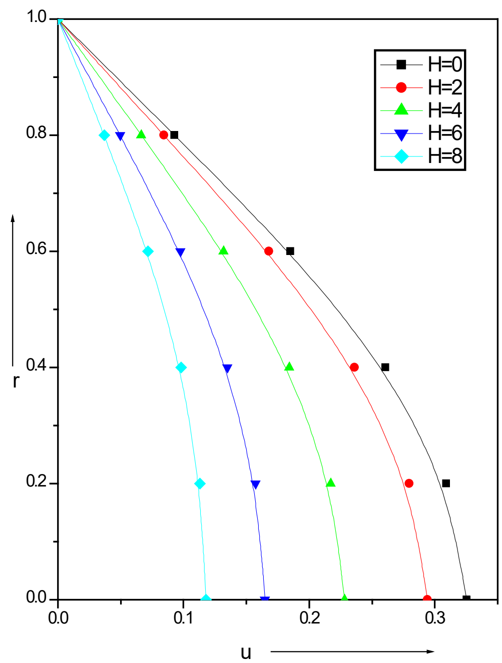

Fig.10, Variation of velocity profile for different values of H