**A MATHEMATICAL MODEL TO STUDY THE EFFECT OF POROUS PARAMETER ON BLOOD FLOW THROUGH AN ATHEROSCLEROTIC ARTERIAL SEGMENT HAVING SLIP VELOCITY**

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**Abstract**

This theoretical investigation focusses on blood flow through a multiple stenosed human artery under porous effects. A mathematical model is developed for estimating the effect of porous parameter on blood flow taking Harschel-Bulkley fluid model (to account for the presence of erythrocytes in plasma) and artery as circular tube with an axially non-symmetric but radially symmetric mild stenosis. The mathematical expression for the geometry of the artery with stenoses is given by the polynomial function model. The velocity slip condition is also given due weightage in the investigation. It is necessary to study the blood flow through such type of stenosis to improve the arterial system.

**Keywords***: stenoses, stenotic geometry, stenotic height, H-B fluid model, Darcy’s number, fluid index parameter, slip velocity, flow flux*

**INTRODUCTION**

Among all the fatal diseases of the human body, circulatory disorders are still a major cause of morbidity or death. A systematic study on the rheological and hemodynamic properties of the streaming blood with the mechanical behavior of blood vessel walls could play a significant role in the basic understanding, diagnosis and treatment of many cardiovascular, cerebrovascular and arterial diseases.

Sankar and Hemlatha (2007) presented an analytical study on the pulsatile flow of blood through catherized artery by modeling blood as Harschel-Bulkley fluid and the catheter and artery as rigid coaxial cylinders. The output of the study established decrease of velocity and flow rate and increase of wall shear stress and longitudinal impedance for the increase in value of yield stress with other parameters fixed. The pulsatile flow of blood through mild stenosed artery was investigated by Sankar and Lee (2009) considering the HB model of blood. They observed that the plug core radius, pressure drop and wall shear stress increase with the increase of yield stress and the stenosis height.

Nanda *et. al*. (2017) developed a mathematical model for studying blood flow through an elastic artery with the consideration of slip velocity at the inner wall of the artery. The study reveals considerable alterations in flow characteristics due to the presence of elastic property of blood vessel wall and the presence of velocity slip at the wall.

**MATHEMATICAL FORMULATION OF THE PROBLEM**

Let us consider the axisymmetric flow of blood through a a uniform circular artery with an axially non-symmetric but radially symmetric mild stenosis specified at the position shown in Fig. 1.

 The geometry of the stenosis assumed to be manifested in the arterial segment is given by  where

 Radius of the tube with stenosis  Radius of the tube without stenosis  Length of the artery  Length of the stenosis  Max. height of the stenosis in the lumen   Stenosis shape parameter   Location of the stenosis in the artery and 

**METHOD OF SOLUTION**

The constitutive equation in one dimensional form for Herschel-Bulkley fluid in terms of the axial velocity of blood  with the shearing stress is given by  where  measure of yield stress  the strain rate   viscosity coefficient of blood flow behavior index  radius of artery and  pressure gradient [The values of for blood flow problems are generally taken to lie between 0.9 and 1.1]

 (Basu Mallik & Nanda S. [9])

The Darcy’s equation governing the flow of blood through a porous media is given by  where porous parameter,  viscosity coefficient of blood

The present mathematical model is devoted to estimate the effect of porous parameter on blood (treated as an incompressible non-Newtonian fluid) flow. The governing Navier- Stokes equation in cylindrical polar co-ordinates is given by 

The continuity equation is 

**NUMERICAL RESULTS AND DISCUSSION:**

In order to have an estimate of the qualitative and quantitative effects of the physical and rheological parameters involved in the analysis, it is necessary to quantify them. The values of different material constants and other parameters have been taken from standard literatures.  Computer codes are developed and the graphs are plotted using MATLAB 8.5.



Fig. 1: Variation of flow velocity with radial distance

The variation of flow velocity with radial distance for (fluid index parameter) = 0.95, 1.00, 1.05 is exhibited in Fig. 1. In the normal stage, the flow velocity should be minimum in the vicinity of the flow boundary but the trend may be justified due to the presence of stenosis in the arterial segment. The tendency is similar for  = 0.95, 1.00, 1.05.

**CONCLUSION**

It is now established that lifesaving medicines applied for treatment of many fatal diseases like cancer, diabetes, heart failure damage some other organs /cells of the human body. If the location of the stenosis is detected without any surgery, then appropriate medicine may be sent to the affected area/cells with the help of Nano technology. This may open a new dimension in the treatment of some fatal diseases and more and more theoretical as well as experimental research in this field are suggested to overcome the restrictions imposed on the analysis. Also, the outcome of this analysis may be shared for further investigation in this emerging field and for providing primary support to the deceased where adequate medical/surgical support is not available.

**REFERENCES:**

1.Charm, S.E. and Kurland, G.S. “Blood Rheology in Cardiovascular Fluid Dynamics”, Academic Press, London (1965)

2.Astrita, G. and Marrucci, G. Principles of Non-Newtonian Fluid Mechanics, McGRaw –Hill, New York, USA (1974).

3. Liepsch, D. W. “Flow in tubes and arteries – A comparison”. Biorheology, **23**, 395-433 (1986)

4.Ku, D. N., Blood flow in arteries, Ann. Rev. Fluid Mech, 29, 399-434, (1997)

5. McDonald, D.A. Blood flow in arteries, Edward Arnold Publishers, London (1974)

6. Sankar, D.S. and K. Hemlatha; “Pulsatile flow of Harschel-Bulkley fluid through catherized arteries-a mathematical model”. Applied Mathematical Modeling, **31**, 1497-1517 (2007)

7. Shah, S. R.; “A math. Model. for the anal. Of blood flow through diseased blood vessels under the influence of porous parameter: J. Biosc. Tech., **4(6)**, 534-541(2013)

8. Kumar, S. “Study of blood flow using Power law and Harschel-Bulkley non-Newtonian fluid model through elastic artery”, Proceedings of ICFM, 229-235 (2015).