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MICROPOLAR FLUID FLOW THROUGH POROUS NARROWTUBES IN THE PRESENCE OF THERMAL RADIATION

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INTRODUCTION AND RESEARCH AIM:

The human circulatory system consists of a complex network of blood vessels whose size ranges from 20µ to 500µ (microns) approximately. The main functions are transport of oxygen, removal of waste materials from body etc. It plays a fundamental role in tissue repair process some anomalous effects like Fahraeus Lindqvist effect, Fahraeus effect and existence of a cell free depleted layer near the wall are observed in micro circulation.

Recent investigations has given more attention towards thermal convection flows. The rate of thermal energy region to another region in several conductive and convective process. The thermal energy depends on the variation of temperature at the locomotion.

In thermal radiation energy transfer between two bodies depends upon absolute temperature variation. Thermal radiation has important applications in biomedical field, because of its application in biomedical area effect of thermal radiation with double diffusion has become an important topic to many researches.

Infrared radiations is one of the regularly used techniques for creation of heat treatment to different parts of human body. Infrared dilations are made up of electromagnetic waves. Electromagnetic waves lies between microwaves and visible light these are used in treating skin related problems. Any radiation entered into the skin depends on vascularity, radiation, wavelength etc. Few researches have studied thermal radiation on peristaltic motion [1-3]. The radiation has been linearised by Roseland [4].

Blood flow in narrow veins and arteries is treated as two fluid model. Blood behaves like two fluid model when it flows in small veins. Motion of blood follows hydrodynamic laws where speed of blood flow is proportional to pressure difference radius of the tube and fluidity.

The assumption of Newtonian behavior of blood is acceptable for high shear rate flow under diseased conditions blood exhibits non Newtonian properties and existence of a peripheral layer has been observed for the flow through tubes of small diameter [6,7,8]. This non Newtonian behavior is attributed to the particulate nature of blood.

Eringen [9] developed the theory of micro fluids which exhibits microscopic effects arising from the local structure and micro motions of fluid elements. There is a sub class of micro fluids namely micro polar fluids which support couple stress, body couples, micro rotational effect and micro rotational inertia. From a continuum point of view, the classical Navier-stokes equation are in capable to explain the theory of micro polar fluid as they contain no proper mechanism to account for cellular micro rotations.

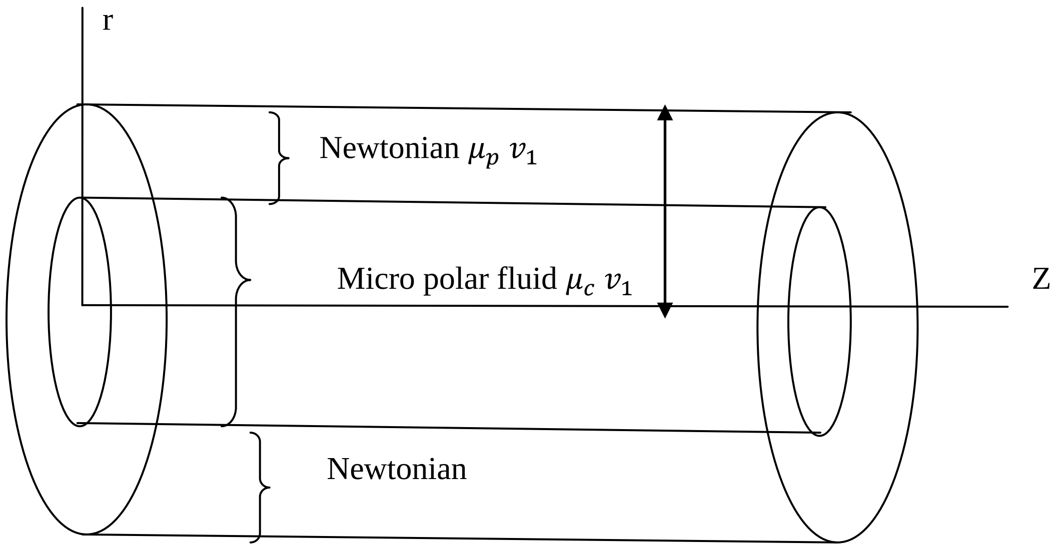
Ariman [10] studied on fluid with micro structure phenomenon of steady and pulsatile blood flow in a circular rigid arteriole. Akay and Kaye [11] studied extensively a numerical solutions of non steady stratified two phase flow of micro polar fluids in small diameter capillaries. Bhargava[12] has studied a fully developed mixed connection flow with heat sources in a vertical circular pipe.

Jeffrey fluid model which behaves like Newtonian and non Newtonian fluid depends up on the core region and peripheral region. Hayat[5] [etal] has investigated Jeffrey fluid in a circular tube.

Chaturani and Upadhya [13] has considered two layered model for blow flow in small diameters using micro polar fluids.Santhosh and Radhakrishnamacharya [14] has studied Jeffrey fluid flow through narrow presence of magnetic fields.

In this study a two layered model is considered for blood flow. The effect of thermal radiation on a two fluid model for the flow of micro polar fluid in porous tubes of small diameter has been investigated. It is assumed that core region consists of micro polar fluid and a Newtonian fluid in peripheral layer. Making assumptions of Chaturani and Upadhya [13], Iqbal and Mondal [15].The linearised equations of motions has been solved and solutions has been obtained the expression for velocity, shear stress, heat transfer were obtained and graphically represented.

FORMULATION OF THE PROBLEM:



Let us consider steady of two dimensional flow of a viscous in compressible micro polar fluid of temperature T_∞ past a heated porous tube of constant radius a and is a suction velocity $V_0(x)$ at plate. The flow in the tube is represented by a two fluid model of a core region of radius b, occupied by micro polar fluid and peripheral region of thickness ∈. Where $\in = a - b$. Let μ_c and μ_p be viscosities of Newtonian fluid in peripheral region and micro polar fluid in core region respectively. The flow is assumed to be in x direction and y axis is normal to it.

The constitutive equations of micro polar fluid is

$$\nabla . U = 0 \quad .... (1)$$

$$\rho(U\,.\nabla U) = -\nabla p + k\,\nabla X U + (\mu + k)\nabla^2 U \qquad ....(2)$$

$\rho_j(U.\nabla V) = -2kv + k\ \nabla XU - \gamma(\nabla X \nabla X \mathrm{V}) + (\alpha + \beta + \gamma)\,\nabla\,(\nabla.V)$ ……..(3)

Where ρ ⇢ Pressure

U ⇢Velocity

V ⇢Microrotation vector

j⇢ Micro gyration parameter

$$2\mu + k \geq 0\ , k \geq 0\,, 3\alpha + \beta + \gamma \geq 0\,, \gamma \geq |\ \beta|$$

As the flow is axially symmetric the flow variables are only in axial and radial directions.

Hence flow of velocity $U = (U_r\, 0\, U_z)$

Micro rotation vector $V = (0, V_{\theta,}\, 0)$

The equations governing the steady two dimensional flow of a incompressible micro polar fluid for the present problem are

Equation of continuity

$\frac{\partial v_r}{\partial r} + \frac{v_r}{r} + \frac{\partial v_z}{\partial_z} = 0$ .... (1)

Momentum equation

$v_r\,\frac{\partial v_r}{\partial r} + v_z\,\frac{\partial v_z}{\partial z} = v_\propto\,\frac{\partial^2 v_r}{\partial r^2} + \frac{s}{\rho}\,\frac{\partial \sigma}{\partial r} + g_o\beta(T - T_\infty) - \frac{v_\infty}{k'}\,(v_r - v_\infty) - \frac{b}{k'}\,(v_r - v_\infty)^2$ .... (2)

Angular momentum equation

$v_r\,\frac{\partial \sigma}{\partial r} + v_z\frac{\partial \sigma}{\partial z} = \frac{v_s}{\rho_j}\,\frac{\partial^2 \sigma}{\partial z^2} - \frac{s}{\rho_j}(2\sigma + \frac{\partial v_r}{\partial z})$ .... (3)

Energy equation

$v_r\,\frac{\partial T}{\partial r} + v_z\frac{\partial T}{\partial z} = \frac{k}{\rho c_p}\,\frac{\partial^2 T}{\partial z^2} - \frac{1}{\rho c_p}\,.\frac{\partial q_r}{\partial z}$ .... (4)

Where $v_r\,, v_z$ velocity components along $r\ and\ z$ directions

$v_\propto = \frac{\mu + s}{\rho}$ is apparent kinematic viscosity

µ ⇢ coefficient of dynamic viscosity

s ⇢ Micro rotation couping coefficient

ρ ⇢ Mass density of fluid

σ ⇢ Micro rotation

b ⇢ Empirical constant

k' ⇢ Darcy permeability

It is assumed that flow is in Z direction and hence velocity component $v_r = 0$ consequently governing equations to the flow of fluid reduces to in core region

$$0 \le r \le b$$

$$\frac{\partial v_z}{\partial z} = 0$$

$$v_z \frac{\partial v_z}{\partial z} = \frac{s}{\rho}\frac{\partial \sigma}{\partial r} + g_o\beta\,(T - T_\infty) - \frac{v_\infty}{k'}\,(-v_\infty) - \frac{b}{k}\,v_\infty^2$$

$$v_z \frac{\partial \sigma}{\partial z} = \frac{v_s}{\rho_j}\frac{\partial^2 \sigma}{\partial z^2} - \frac{s}{\rho_j}(2\sigma + \frac{\partial v_r}{\partial z})$$

$$v_z \frac{\partial T}{\partial z} = \frac{k}{\rho c_p}\frac{\partial^2 T}{\partial z^2} - \frac{1}{\rho c_p}.\frac{\partial q_r}{\partial z}$$

Let $v_z(r) = v_1(r)$ be the velocities in peripheral and core regions respectively .Then governing equations corresponding to peripheral region and core regions are deduced respectively.

Boundary conditions:

The conditions for peripheral regions $b \le r \le a$ and for the core region $0 \le r \le b$

SOLUTION METHODOLOGY:

By using similarity transformations the governing equations are reduced to partial differential equations and using finite element techniques the expression for velocities in core and peripheral region has been obtained also flow flux, effective viscosity radiation effects have been studied.

CONCLUSION:

The key out comes of results show that as porosity increases velocity of fluid decreases in core region and also velocity of fluid decreases in core part as thermal radiation increases as diameter of tube increases velocity and flow flux has started increasing. As array number increases the increase in effective viscosity with tube radius is not very significant for value of tube radius larges than 50μm

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