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Physical Characteristics of Laminar and Non Laminar Fluid Flows through Porous Medium

Ruchi Gupta[1], Hambeer Singh[2]
[1]Assistant Professor (Department of Mathematics), Manav Rachna University Faridabad
ruchigupta@mru.edu.in

[2]Professor (Department of Applied Science), Rawal Institutions Faridabad
drhambeer@gmail.com

Abstract: In this paper we have investigated the physical characteristics of laminar and non laminar fluid flows through porous medium. We have investigated velocities, pressure in the direction of fluid motion.

***Key words**: - Laminar flow; viscous incompressible fluid; uniformly porous pipe.*

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Introduction:

The solution of the problem of laminar flow in a uniformly porous channel has been discussed by various authors. For a general boundary shape and for a prescribed suction or injection, it is necessary to solve the system of partial differential equations. In the case of channel and pipe flows. *Berman*[1] studied for constant suction or injection at the walls. *Ahmad and K.C. Sharma*[2] analysis flow of non-Newtonian fluid in a helical pipe with an elliptical cross-section. *Bolinder*[3] in (1996) employed a series expansion method to determine the first order terms in curvature ε and torsion η of fully developed laminar flow in a helical rectangular duct of aspect ratio two. His main conclusions are that the flow in a helical duct with a finite torsion is obtained as a superposition of the flow. In toroidal duct with zero torsion and a straight twisted duct; that the secondary flow in helical non-circular ducts for sufficiently small Reynolds number dominates torsion effects; and the increasing Reynolds number, the secondary flow eventually is dominated by effects due to the curvature.

Lvo, Leung, ChanandWong[4] discussed flow and forced convection characteristics of turbulent flow through parallel plats with periodic transverse rids. *GreshoP.M*[5]. Studied incompressible fluid dynamics; some fundamental formulation issues. *KohY – MandBradshaw*[6] have investigated the numerical solution of two-dimensional or axi-symmetrical incompressible flow using the vorticity equations. *KohY – M.*[7] expressed the pressure distribution around unsteady boundary layers. *R.Mikulevicius and Rozovskii*[8] studied stochastic Navier-Stokes equations for tubular flows. *Xing, J, Sheroi, R.A, WilsonPA*[9] analyzed fluid flow through porous medium subjected to a boundary condition of variable pressure.

The purpose of the present paper is to investigate the Laminar and Non Laminar fluid flows through porous medium, which is bounded by vertical porous plate with periodic suction at constant temperature.

NOMENCLATURE

u=axial velocity component
v=radial velocity component
$\rho =$ Density of fluid
p=pressure
$r_w =$ Radius of pipe
r=radial coordinate
$v_w =$ Velocity of fluid through porous walls

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ν = Coefficient of kinematic viscosity

Formulation and solution of Problem:

For a viscous incompressible fluid in steady flow the Navier-Stokes equation with negligible body forces in Cartesian coordinates are

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial r}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\frac{\nu}{r}\left[\frac{\partial}{\partial r}\left(r\frac{\partial u}{\partial r}\right)+\frac{\partial}{\partial x}\left(r\frac{\partial u}{\partial x}\right)\right] \quad (1)$$

$$u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial r}=-\frac{1}{\rho}\frac{\partial p}{\partial r}+\frac{\nu}{r}\left[\frac{\partial}{\partial r}\left(r\frac{\partial v}{\partial r}\right)+\frac{\partial}{\partial x}\left(r\frac{\partial v}{\partial x}\right)-\frac{v}{r}\right] \quad (2)$$

The equation of continuity is

$$\frac{\partial}{\partial x}(ru)+\frac{\partial}{\partial r}(rv)=0 \quad (3)$$

The boundary conditions at the wall require the tangential velocity to be zero and the radial velocity (to be prescribed) v_w suction or injunction.

The boundary conditions for this flow are

$$\left.\begin{array}{lll} r=0, & \frac{\partial u}{\partial r}=0, & v=0 \\ r=r_w, & u=0, & v=v_w \end{array}\right\} \quad (4)$$

By equation (3)

$$r\frac{\partial u}{\partial x}+u\frac{\partial r}{\partial x}r\frac{\partial v}{\partial r}+v=0 \quad (5)$$

Appling boundary conditions in equation (1)

$$u\frac{\partial u}{\partial x}=-\frac{1}{\rho}\frac{\partial p}{\partial x}$$

$$\int u\partial u=-\int\frac{1}{\rho}\partial p$$

$$\frac{u^2}{2}+\frac{p}{\rho}=C_1 \quad (6)$$

Where r= r_0, u=0, v= v_0

v_0 Stands for suction and injunction

from equation (2)

$$0=-\frac{1}{\rho}\frac{\partial p}{\partial r}+\frac{\nu}{r}\left[-\frac{v}{r}\right]$$

$$0=-\frac{1}{\rho}\frac{\partial p}{\partial r}-\frac{v^2}{r^2}$$

$$\frac{1}{\rho}\frac{\partial p}{\partial r}=-\frac{v^2}{r^2}$$

$$\frac{1}{v^2\rho}\int\partial p=\int\frac{\partial r}{r^2}$$

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$$\frac{1}{\rho\nu^2}p = -\frac{1}{r} + C_2$$

$$p = \left(-\frac{1}{r} + C_2\right)\rho\nu^2 \qquad (7)$$

put the value of p in equation (6)

$$\frac{u^2}{2} + \left(-\frac{1}{r} + C_2\right)\nu^2 = C_1$$

$$\frac{u^2}{2} = C_1 - \nu^{(2)}\left(-\frac{1}{r} + C_2\right)$$

$$\frac{u^2}{2} = C_1 + \frac{\nu^2}{r} - C_2\nu^2$$

$$u^2 = 2\left(C_1 + \frac{\nu^2}{r} - C_2\nu^2\right)$$

$$u = \sqrt{2\left(C_1 + \frac{\nu^2}{r} - C_2\nu^2\right)} \qquad (8)$$

From equation (5)

$$\nu = 0 \qquad (9)$$

Where C_1 and C_2 are constants whose values can be determined with the help of initial and final conditions

Results and Remarks

Equation (7) shows that pressure is the function of r so that the motion is unsteady and flow is non-laminar. i.e. the turbulent motion. Equation (8) also represents the non laminar motion. However equation (9) shows the steady motion.

According to the evidence gathered in the previous years, although this work has a lot of potential, it is currently in its early stages and can only be considered as a prototype. We need to further analyze the physical characteristics of laminar and non laminar fluid flows through porous medium. It becomes more sensible to ensure that we fortify the results of these endeavors.

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