INFLUENCE OF POROSITY AND ELECTROKINETIC EFFECTS ON FLOW THROUGH MICROCHANNELS

Radha Narayanan*

ABSTRACT

Influence of electrostatic potential and porosity on flow through microchannels is analysed. Solving Navier Stokes equations effects of porosity and zeta potential on flow is analysed under various operating conditions.

Key words : heat transfer, porosity,zeta potential ,flow

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* Dept.of Electronics, Christ University

1.Introduction

Micro electromechanical systems involve fluid flow in microchannels. Flow through microchannels is important in designing microfluidic devices like cooling system of chips due to their higher heat transfer coefficient as discussed by Zhang etal[1]. Abhishek Jain [2] has presented analytical solutions for the effect of electrostatic potential in microchannels for a wide range of operating conditions.Elazhary [3] investigated the effect of EDL at the solid liquid interface on the liquid flow and heat transfer through a microchannel formed by two parallel plates.

In flow through microchannels interfacial effects are important.for example electrolytic flow in microchannels can be different from nonelectrolytic flows.

The study of flow through porous media has applications in nuclear cooling system .geophysics and petroleum engineering .Moreover human lung, small blood vessels are examples of flow through porous medium. Hence a numerical analysis of influence of porosity and electrokinetic effects is presented here.

The present work deals with modification of brinkman equations taking into account electrokinetic effects and numerically solving them using numerical method.

2.Mathematical formulation

The brinkman model of equations for porous media is applied to an infinite parallel channel .Debye –Huckel linear approximation is used for electric potential .

The equations are solved numerically with the following assumptions

1.The flow is laminar ,incompressible ,steady ,fully developed

2.Gravity forces are ignored

3.The fluid is Newtonian and its properties are independent of local field strength.

4.The ions are point charges ,with no concentration gradients

5.Zeta potential is assumed to be uniform

6.Viscous dissipation is neglected

7.The fluid is continuum The electrostatic potential Ψ is related to the local net charge density ρ by Poissons equation

$\partial^2\Psi/\partial y^2 = -\rho/\varepsilon$

Following A.Jain etal[2] the nonlinear dimensional second order equation is

$d^2\Psi/dy^2 = 2zen/\varepsilon \sinh(ze\Psi/kT)$

which is the boltzmann equation.

Debye –Huckel approximation

Debye –huckel parameter k depends only on liquid properties.At small electrolyte concentrations sinh can be approximated and equation reduces to

$d^2\Psi/dy^2 = k^2\Psi$.

The solution of the above equation is

$\Psi = \zeta/\sinh(k)\ \sinh(ky)$

Increased zeta potential increases relative charge density of ions near the walls which produces higher potential.

Solution of the governing equations.

The nondimensional brinkman model equation for the flow through a channel with porous media using the non dimensional parameters is

$d^2U/dY^2 - \sigma^2 U - Qd^2\Psi/dY^2 + \Gamma = 0$

where $\sigma = a^2/K, Q = 2nzea^2\zeta/\mu UL\quad \Gamma = -a^2/\mu U$

The equations are solved numerically using the boundary conditions

$d\Psi/dY = dU/dY = 0$ at $Y=0$, $U = 0, \Psi = \zeta$ at $Y=1$

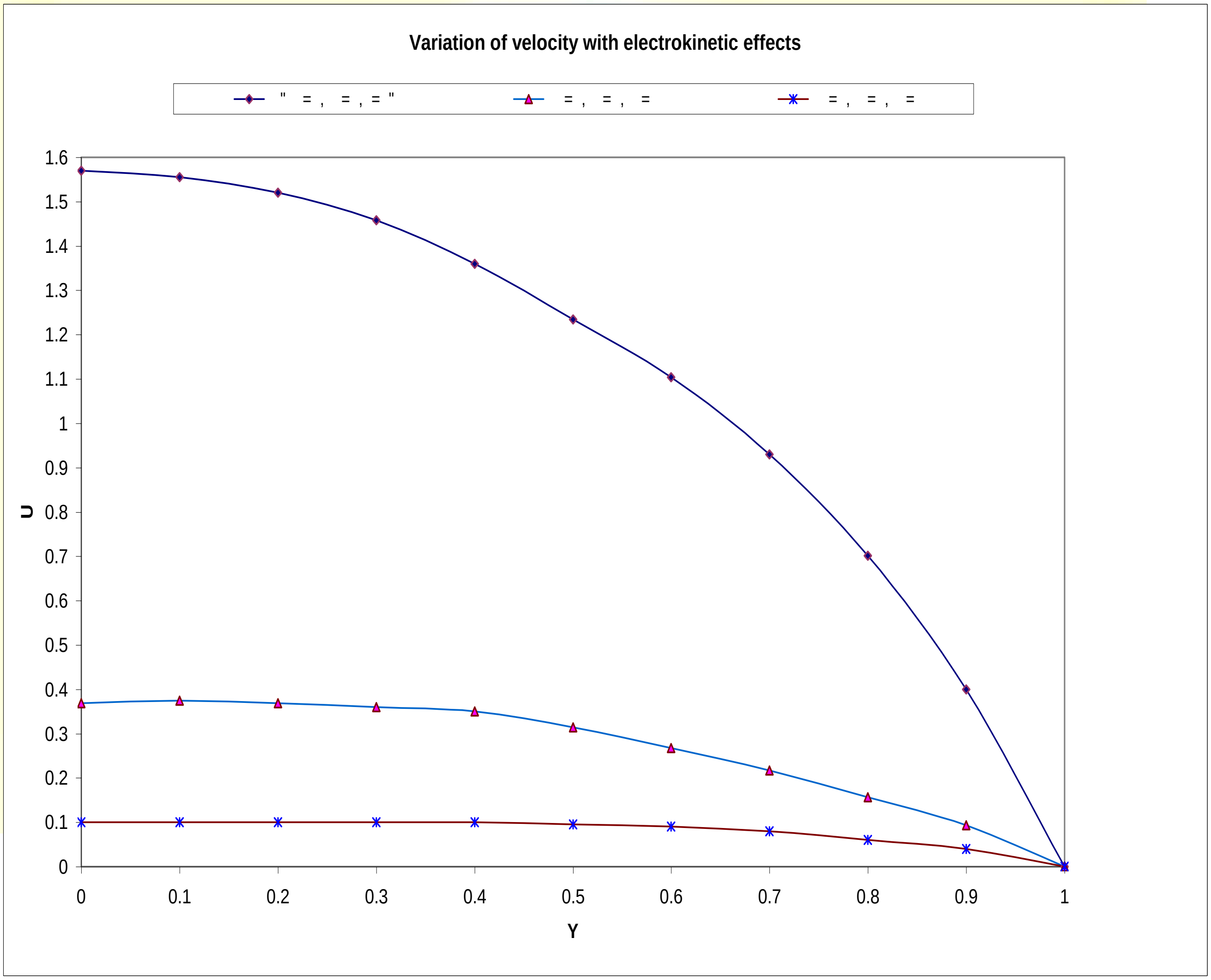
GRAPHS

Conclusions

The influence of porous media , electrokinetic effects and pressure are illustrated in the graphs.

The presence of EDL decreases the fluid velocity .

As porosity increases flow rate decreases further. In the presence of porosity higher value of pressure gradient shows that the flow is constant and only decreases near the wall.



Shortcut to graph.lnk

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