Abstract

The objective of the present studies has been to make available, hydrodynamic and thermal characteristics for laminar incompressible flow of a Newtonian fluid in channels partially filled with porous material. The porous material is assumed to be attached to the lower wall of the channel. Porous fraction, γ_p, has been defined as the ratio of the porous layer thickness to the distance between the walls of the channel.

Analytical or numerical solutions have been obtained for the following values of the parameters characterizing the different problems studied. Porous fraction γ_p: $0 \leq \gamma_p \leq 1.0$. Stress jump coefficient at the porous-fluid interface, β: $-0.7 \leq \beta \leq 0.5$. Darcy number, Da: 0.001 to 1.0. When axial conduction is considered, the Peclet number, Pe: 5 to 150. When viscous dissipation is included, the Brinkman number, Br: $-1.0 \leq Br \leq 1.0$. Numerical solutions have been obtained employing the Successive Accelerated Replacement scheme after validating the scheme.

Existence of an optimum porous fraction, γ_{pmax} for which maximum enhancement in the sum of fully developed Nusselt numbers on porous and fluid sides of the channel (subjected to constant heat flux) relative to the clear fluid channel value has been established. It has been found that γ_{pmax} decreases with increasing Darcy number and is practically independent of the axial location and Peclet number. Influence of the stress jump has been evaluated. Similar investigations have been made when the channel walls have been kept at constant temperature. In addition to the local Nusselt number values, energy gained (or lost) by the fluid and the energy transferred from the walls up to any desired axial distance have been presented.

A unified viscous dissipation function for the porous media has been developed from which the existing models for unidirectional flows follow. Additional models have been shown to be plausible when the flow and thermal fields are two-dimensional. Effects of viscous dissipation employing the clear fluid compatible model and form drag model have been studied. The results include the effects of viscous dissipation on temperature profiles, Nusselt numbers, energy gain (or loss) by the fluid and the energy transferred from the walls up to any desired axial distance. In general axial conduction effects are subdued when viscous dissipation is strong and vice versa. The thesis makes available quantitative estimate of axial conduction effects and viscous dissipation effects.

Key words: entrance region, forced convection, channels partially filled with porous media, axial conduction, viscous dissipation