Abstract

Laminar forced convective heat transfer in the developing region of annuli subjected to constant temperature including viscous dissipation has been investigated. The problem in general is characterized by, radius ratio, R^*, Brinkman Number, *Br*, the Peclet number, *Pe* and the Reynolds number, *Re* or the Prandtl number, *Pr*.

The objective has been to examine the effectiveness of the recently proposed entry temperature that of an adiabatically prepared fluid, instead of the conventional uniform entry temperature. The problem involved studies in the thermally developing region while the flow is assumed to be hydrodynamically fully developed and viscous dissipation is included. The temperature of the adiabatically prepared fluid has been designated as the dissipative entry temperature in the present investigation. An analytical expression for the dissipative entry temperature has been obtained assuming the flow to be fully developed considering an adiabatic duct. It has been established that the bulk mean of the dissipative entry temperature, which offers the convenience of the uniform entry temperature, can be employed for $|Br| < 0.2$. Subsequently, analytical expressions for the temperature and the Nusselt numbers valid in the conduction limit when viscous dissipation has been included have been derived. The limiting temperature profiles provide the downstream boundary condition when elliptic form (when axial conduction is included) of the conservation of thermal energy is solved. The effect of axial conduction leads to a higher Nusselt numbers at lower Peclet numbers at a given normalized non-dimensional axial coordinate, $X^* = X/Pe$. The bulk mean dissipative entry temperature yields results comparable to those of the dissipative entry temperature for $|Br| < 0.2$ when axial conduction included also.

The temperature of the adiabatically prepared fluid has been obtained employing two dimensional descriptions for the velocity and temperature fields in the adiabatic duct. The effort required is comparable to the effort needed for obtaining numerical solutions to the laminar forced convection in annuli in the entrance region. The studies employing the two dimensional description established that modifying the entry temperature does not capture the details of the simultaneously developing flow and temperature fields adequately particularly when the Prandtl number is low.

Key words: adiabatic preparation of the fluid, viscous dissipation, entrance region, annular flows.