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NUMERICAL INVESTIGATION OF INTERNAL FLOW AND HEAT TRANSFER BETWEEN CYLINDER PIPES

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ABSTRACT This study is focused on the heat transfer enhancement caused by an axial movement of a cylinder pipe. In the present work, the forced convective heat transfer characteristics of thermally developing laminar flow between two long cylinder pipes is investigated by considering the effect of viscous dissipation for the case when heat sources were present at the inner cylinder wall that moves to the direction of the flow. Besides the effects of the moving cylinder velocity and viscous dissipation of the flowing fluid on the heat transfer characteristics, the effect of geometry of cylinders is considered. The body forces and the axial heat conduction are neglected.

A finite difference method approach is employed in order to obtain the velocity and temperature distributions of a hydrodynamically fully developed but thermally developing flow between two long cylinder pipes for the case of a uniform heat flux at the inner moving cylinder and a constant temperature on the fixed outer cylinder wall. The governing equations and the boundary conditions were reduced in dimensionless form and from the resulting equations we formed a set of algebraic equations. The solution zone was divided into cells in the radial and axial directions. Smaller meshes were applied at the entrance and at the cylinder walls. The numerical approach to solve the system equations was based on Gauss-Seidel method.

The results emphasize the significant effects of the velocity of the inner cylinder on heat transfer. The heat transfer improvement is demonstrated by comparing the Nusselt number values of stationary annular flows to the Nusselt numbers of annular flows with the moving inner cylinder having the same radius ratio. The Nusselt number enhances at the moving inner cylinder surface for the examined conditions as the inner cylinder moves to the flow direction whether the viscous dissipation is negligible or not. The amplitude of this enhancement of Nusselt numbers depends on the magnitudes of the velocity of the movement of the inner cylinder and the viscous dissipation. Brinkman number is used to characterize the viscous dissipation effect in this study. Brinkman number effect on Nusselt number at the heated inner cylinder weakens in the thermally developing region as the inner cylinder moves. However Brinkman number effect on Nusselt number on the outer cylinder wall that was kept at a constant temperature equal to the inlet temperature stays strong even if the inner cylinder moves. Fully developed Nusselt number at the inner cylinder decreases with an increase of Brinkman number and it has lesser values for narrower annuli for the considered parameters of this laminar flow study. For narrower annuli, the increment of the Nusselt number at the inner cylinder due to the increasing the axial velocity is lesser as viscous dissipation effect becomes more pronounced.