A Computational Study on Heat Transfer in a Couple-Stress Fluid in a Channel Packed with Porous Material Under the Local Thermal Nonequilibrium Model: Constant Heat Flux

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Abstract

The present study deals with enhancement in heat transfer in a thermally developing region under the local thermal non-equilibrium (LTNE) model with the axial conduction effect in a duct packed with a porous medium with a magnetic field in the transverse direction of fluid flow. The unidirectional flow in the porous region is associated with the behaviour of the couple-stress fluid. The channel walls are exposed to a constant heat flux. Specific well-known parameters define the system, these being Darcy number (Da), couple stress parameter (s), thermal conductivity ratio (κ), Hartmann number (M), and Biot number (Bi). Numerical solutions have been obtained. Plots are given for the dimensionless velocity profiles, dimensionless temperature profiles in the fluid and solid phases, wall temperature, and the local Nusselt number at the parallel plate channel, which has been displayed. The onset of a fully developed thermal field condition is established. The parametric structure of this study permitted mapping the LTNE and local thermal equilibrium (LTE) areas across a wide range of these dimensionless parameters. As the viscosity increases, there is a decrease in the local heat transfer coefficient under LTNE.

Keywords: Couple stress fluid, Local thermal non-equilibrium model, Axial conduction, Hartmann number, Biot number, Thermal conductivity ratio.