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Heat Transfer and Hydrodynamic Study of Particulate Flow in Channel with Extended Surfaces

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Extended Abstract

Overheating is one of the main factors affecting the performance of electronic devices. Channels with extended surfaces have been used as a remedy for enhancing the heat transfer performance in such devices [1-4]. While the geometry of the blocks attached to the surface of the channel has been shown to have a significant effect on the heat removal efficiency, the properties of the coolant are also of great importance. Among different kinds of coolants, nanofluids have been shown to be effective owing to the thermophysical properties of the dispersed nanoparticles (NPs) in the base fluid [5, 6]. Hence, when considering the nanofluids as the coolants, understanding the hydrodynamics mechanisms associated with NPs flow is crucial. Among various models which exist in the literature, the single-component (SC) model is the one that has been used frequently. However, this model suffers from several shortcomings such as the homogenous NPs distribution assumption. On the other hand, the two-component (TC) model accounts for non-homogeneity of the distribution by solving a mass-transfer equation for the NPs concentration [7-9]. Also, Brownian motion and thermophoresis mechanisms are considered in the TC model, making this model more physically complete than the SC model [10]. In this research, the Lattice Boltzmann Modelling (LBM) technique with a D_2Q_9 configuration has been used to numerically solve the governing nanofluid flow and energy equations [11-15]. To handle the numerical instabilities associated with high Schmidt numbers, a modified LBM has also been used to solve the mass continuity equation [16]. We have shown, in the case of heat transfer enhancement in channels with extended surfaces, that the TC model results in more accurate results than the SC one due to accounting for the non-homogeneous distribution of the NPs in the system [1]. It has also been shown that geometrical parameters, for example, the height of the blocks, are a key control on heat transfer enhancement. The results reveal that the average Nusselt number varies non-monotonically with the height of the blocks, which exhibits a critical height value. The heat transfer flux depends on the interplay between the geometry, hydrodynamics, and NP distribution. Finally, the non-dimensional friction factor variation, as an important hydrodynamic parameter versus geometrical parameters, has been studied for both NP-free and NP-laden systems. Based on all the hydrodynamics and heat transfer results, a guideline for an optimal geometrical design is presented.

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