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Original Article

Entropy analysis and mixed convection of nanofluid flow in a pillow plate heat exchanger in the presence of porous medium

Gengyun Tian [a], Chunlin Tian [a], As'ad Alizadeh [b], Nima Shirani [c], Navid Nasajpour-Esfahani [d], Mahmoud Shamsborhan [e], Sh. Baghaei [c]

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Abstract

A pillow plate heat exchanger (PPHE) is one of the types of heat exchangers that haven't received the attention they deserve despite their high efficiency and operational capability. A unique feature of PPHEs is their pillow-shaped structure, which is achieved through hydroforming. In light of this, scholars have been interested in analyzing and optimizing the thermo-hydraulic properties of PPHEs. In this study, the interior of the PPHE was occupied with a permeable substance with a high porosity percentage ($0.9034 \leq \varepsilon \leq 0.9586$ and $0.00015 \leq dp \leq 0.00065$) and saturated with Ag-water ($0 \leq \phi \leq 0.06$) nanofluid, which has a profound influence on the heat transfer rate of PPHEs. In order to analyze the determinants affecting the heat transfer rate of PPHEs under these conditions, the governing equations were solved using the finite volume method and also the Brinkman-Forchheimer-extended Darcy equation. According to the results, heat transfer is enhanced in PPHE when using a permeable medium with high porosity and a small pore size. That is, PPHEs transfer heat more efficiently when they are placed in a denser porous medium because heat conduction is boosted. Moreover, due to the increased thermal conductivity of the nanoparticles, the application of nanoparticles to the base fluid also enhanced heat transfer and Nusselt number. However, decreases in friction factor and entropy generation were observed with increasing porosity, pore size, and Darcy number, due to reduced flow resistance. A decrease in Richardson number also results in a decrease in friction factor and entropy generation. At the wake region of welding spots, the velocity has reached its lowest values; consequently, this led to a reduction in the heat transfer rate. Nevertheless, within dense porous media, at the lower