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Effect of magnetic field-dependent thermal conductivity on natural convection of magnetic nanofluid inside a square enclosure

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Abstract

Purpose: The purpose of this paper is to investigate the convective heat transfer of magnetic nanofluid (MNF) inside a square enclosure under uniform magnetic fields considering nonlinearity of magnetic field-dependent thermal conductivity. Design/methodology/approach: The properties of the MNF (Fe3O4+kerosene) were described by polynomial functions of magnetic field-dependent thermal conductivity. The effect of the transverse magnetic field (0 < H < 105), Hartmann Number (0 < Ha < 60), Rayleigh number (10 <Ra <105) and the solid volume fraction (0 < φ < 4.7%) on the heat transfer performance inside the enclosed space was examined. Continuity, momentum and energy equations were solved using the finite element method. Findings: The results show that the Nusselt number increases when the Rayleigh number increases. In contrast, the convective heat transfer rate decreases when the Hartmann number increases due to the strong magnetic field which suppresses the buoyancy force. Also, a significant improvement in the heat transfer rate is observed when the magnetic field is applied and φ = 4.7% (I = 11.90%, I = 16.73%, I = 10.07% and I = 12.70%). Research limitations/implications: The present numerical study was carried out for a steady, laminar and two-dimensional flow inside the square enclosure. Also, properties of the MNF are assumed to be constant (except thermal conductivity) under magnetic field. Practical implications: The results can be used in thermal storage and cooling of electronic devices such as lithium-ion batteries during charging and discharging processes. Originality/value: The accuracy of results and heat transfer enhancement having magnetic field-field-dependent thermal conductivity are noticeable. The results can be used for different applications to improve the heat transfer rate and enhance the efficiency of a system. © 2018, Emerald Publishing Limited.

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