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Chamkha, A.J., Selimefendigil, F.

MHD mixed convection of nanofluid due to an inner rotating cylinder in a 3D enclosure with a phase change material

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Abstract

Purpose: The purpose of this study is to numerically examine the mixed convection of CuO-water nanofluid due to a rotating inner hot circular cylinder in a 3D cubic enclosure with phase change material (PCM) attached to its vertical surface. Heat transfer and fluid flow characteristics were examined for various values of pertinent parameters. Design/methodology/approach: Finite element method was used in the numerical simulation. Influence of various pertinent parameters such as Rayleigh number (between 10^5 and 10^6), Hartmann number (between 0 and 100), angular rotational speed of the cylinder (between −50 and 50), solid nanoparticle volume fraction (between 0 and 0.04) and PCM parameters (height-between 0.2H and 0.8H, thermal conductivity ratio- between 0.1 and 10) on the convective heat transfer characteristics are numerically studied. Findings: It was observed that local heat transfer variations along the hot surface differ significantly for the cases with and without magnetic field where three distinct hot spots of peak Nusselt number are established when magnetic field is imposed. The average Nusselt number enhancement with the nanofluid at the highest particle volume fraction is 52.85 per cent at Hartmann number of 100, whereas its value is 39.76 per cent for the case in the absence of magnetic field. When the inner cylinder rotates, flow and thermal fields are affected within the cavity. The local heat transfer variations spread over the hot surface with cylinder rotation and 16.43 per cent of reduction in the average heat transfer is obtained with counter-clockwise rotation at 100 rad/sec. An enhancement in the PCM height and a reduction in the thermal conductivity of the PCM result in average heat transfer deterioration for the 3D cavity. The amount of the reduction is 43 per cent when the PCM height is increased from 0.2H to 0.8H, whereas 19.10 per cent enhancement in the heat transfer is achieved when thermal conductivity ratio (PCM) to the base fluid is increased from 0.1 to 10. Originality/value: Such configurations can be designed for convection control, and in our case, various methods are available. Some of the investigated methods can be used in applications where magnetic field already exists. Convection control study in 3D cavity gives more realistic results as compared to 2D configurations, and results of the current investigation may be used for the design, optimization and flow control of many thermal applications involving magnetic field effects. © 2018, Emerald Publishing Limited.

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