



Convection flow of NE-phase change material-water mixture in evacuated tube solar collector manifold: Numerical analysis of MHD double-diffusive convection and exothermic reaction

Mohammed Azeez Alomari ^{a, b} , Ahmed M. Hassan ^c , Qusay H. Al-Salami ^d ,
Farah Q.A. Alyousuf ^e , Faris Alqurashi ^f, Mujtaba A. Flayyih ^g

Show more

Add to Mendeley Share Cite

<https://doi.org/10.1016/j.icheatmasstransfer.2024.108194>

[Get rights and content](#)

Abstract

This study investigates the convection flow of nano-encapsulated phase change material (NEPCM)-water mixture in an evacuated tube solar collector manifold, focusing on the effects of magnetohydrodynamic (MHD) double-diffusive convection and exothermic reaction. Computational fluid dynamics simulations using the Galerkin finite element method were employed to analyze temperature and concentration distributions, fluid flow, melting zone of PCM nanocapsules, Nusselt number, Sherwood number, entropy generation, and thermal performance. The numerical analysis considers a range of dimensionless parameters, including Rayleigh number ($Ra = 10^3 - 10^5$), Lewis number ($Le = 0.1 - 10$), buoyancy ratio ($Nz = 1 - 5$), nanoparticle concentration ($\phi = 0.01 - 0.035$), fusion temperature ($\theta_f = 0.1 - 0.9$), Stefan number ($Ste = 0.1 - 0.9$), Hartmann number ($Ha = 0 - 50$), magnetic field inclination angle ($\gamma = 0^\circ - 90^\circ$), and Frank-Kamenetskii number ($FK = 0 - 2.5$). Results show that increasing Ra enhances the average Nusselt number (Nu_{av}) by up to 156.1% and the average Sherwood number (Sh_{av}) by up to 104.5%, while increasing the total entropy generation by up to 13,155%. Increasing FK reduces Nu_{av} by up to 42.2% but increases Sh_{av} by up to 13.1%. The Lewis number and buoyancy ratio significantly influence the hydrothermal performance, with Nu_{av} exhibiting non-monotonic behavior and Sh_{av} increasing by up to 240.9% as Le increases. The nanoparticle concentration enhances Nu_{av} by up to 49.7%. Interestingly, the magnetic field effects are less pronounced than in previous studies, with Ha having a minor impact on Nu_{av} and Sh_{av} . These findings have significant implications for the design and optimization of evacuated tube solar collectors and other thermal energy storage systems, potentially leading to improved efficiency and performance in real-world applications.