Numerical study of natural convection heat transfer in a horizontal cylindrical annular space with a porous envelope using various nanofluids: a recent of literature review

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Abstract

This evaluation assesses the convective heat transfer in the horizontal cylindrical annulus surrounded by a porous layer containing nanofluids, which are employed in commercial thermal-management systems such as electronics cooling and energy storage. The paper analyzes horizontal cylindrical domains, which have not previously been considered in the literature, despite their broad practical applications relative to other configurations examined in previous studies. Interactions between nanofluids (such as copper, silver, aluminum oxide, and titanium dioxide in water) and porous medium are analyzed, paying attention to significant variables, including the Rayleigh number($Ra = 10^3$-10^6), nanoparticle volume fraction($0 \leq \varphi \leq 0.1$), and the shape of the heat source. **Conclusion:** The outcomes show that silver nanofluids (Ag) exhibit the largest enhancement in heat transfer (23% at $\varphi = 0.1$), owing to their high thermal conductivity (424 W/m·K). However, an increase in the length of heat sources reduces convective efficiency by 15% due to flow stagnation zones; this trend is particularly pronounced in vertical geometries. The porous shell exhibits a dual influence: facilitating heat exchange in the low Rayleigh number range (10^4–10^5) owing to greater interactions between the fluid and nanoparticles, and concurrently suppressing floating particles in the higher Rayleigh number range (10^6). The study evaluates solutions to overcome challenges in the existing setup, including nanoparticle clustering in permanent assemblies and turbulence-related effects, and recommends future directions, including hybrid nanofluids (for instance, silver-carbon nanotube blends) and mathematical analysis of numerical models. The review bridges the gap between theoretical and practical needs, thereby benefiting the design of environmentally friendly thermal systems based on nanofluid-porous medium combinations.

Keywords: Natural convection, nanofluids, horizontal cylindrical annulus, porous media, heat transfer enhancement