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Editorial

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Editorial

Advances in the Development of New Heat Transfer Fluids Based on Nanofluids

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1. Overview

The global energy and environmental crises are the most urgent issues confronting humanity in the coming years. The complexity of the problems involved necessitates employing different strategies in a wide range of scientific and technological topics. In this context, the last ten years have seen the development of great interest in new, high-efficiency heat transfer fluids, capable of improving the performance and efficiency of energy systems used in civil, industrial, electronics, and transport sectors, namely: nanofluids. Nanofluids are colloidal suspensions made of a traditional base fluid (water, oil, etc.) and suspended solid nanoparticles (Al_2O_3, CuO, etc.) that can improve the thermal conductivity and heat transfer properties of the base fluids. A brief analysis of recent research about nanofluids is presented. This topic is growing in importance, and many works have been published so far exploring different aspects. In particular, the work by Colangelo et al. [1] is a review of the experimental convective thermal performance of various nanofluids obtained in different working conditions (turbulent and laminar) with an in-depth focus on the experimental setups used for the scientific campaigns. The authors highlighted that in the examined works, the nanofluids always showed a significant improvement in the convective heat transfer coefficient, but with big data dispersion. This behavior depended on boundary conditions and the different experimental apparatuses used in the experiments. In general, the results showed the presence of a critical value of the Reynolds number or nanoparticle concentrations that limited the convective heat transfer performance of the nanofluids.

Even if the experimental campaigns are many, they are at lab-scale dimensions with only a few examples of real full-scale systems using nanofluids. One of the most interesting is reported in the work by Milanese et al. [2]. In their work, they carried out an experimental campaign (from February 2020 to March 2021) using a nanofluid based on Al_2O_3 nanoparticles in an HVAC system of an educational building. Using the experimental results, they compared the performance of two HVAC systems (one with nanofluid and the other without) operating simultaneously under identical working conditions. They observed that the coefficient of performance with nanofluid increased on average by 9.8% in winter and 8.9% in summer, with average daily peaks of 15%. Furthermore, comparing the performance of the same HVAC system working with nanofluid or traditional heat transfer fluid showed a mean increase in COP of 13%.

Another important application of nanofluids is as working fluids in solar thermal collectors, as in the experimental work by Boldoo et al. [3], where they experimentally investigated the thermophysical properties of $Co_{0.5}Zn_{0.5}Fe_2O_4$ and water magnetic nanofluid. With their work, they found that the photothermal energy conversion performance enhanced with the nanofluid concentration and exposure time. In particular, they found that after 120 min of exposure, the photothermal energy conversion efficiency of the nanofluid was 52.7%, 53.5%, 55%, and 52.2% at increasing concentrations of 0.25, 0.5, 0.75, and 1 wt% of nanoparticles, respectively.

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Magnetic hybrid nanofluid has been also studied in the work by Dhia Massoudi et al. [4]. Their work shows a numerical simulation (using the COMSOL Multiphysics software 5.6) of the natural convection heat transfer behavior of a hybrid nanofluid (Ag/Al_2O_3) in a W-shaped inclined enclosure. In particular, the analyzed enclosure contained a porous medium with the nanofluid in the contemporary presence of uniform generation or absorption of heat and a magnetic field.

The forced convection behavior of hybrid nanofluids in porous media was, instead, numerically investigated by Saghir et al. [5] at a constant flow rate and heating conditions. In particular, they investigated four different hybrid nanofluids: Al_2O_3–Cu, TiO_2–SiO_2, FWCNT–Fe_3O_4, and ND–Fe_3O_4. All the investigated nanofluids showed good behavior in cooling and the best performance, combining heat transfer with pressure drop, was obtained using ND–Fe_3O_4 nanofluid with a concentration of 0.2% in water–ethylene glycol.

In the work of Ahmad et al. [6], both a numerical investigation (using Ansys Fluent) and experimental analysis were carried out to evaluate the thermal performance of SiC–water and Al_2O_3–water nanofluids inside a circular tube with constantly increased PR twisted tape. The main results of their study were an increase in heat transfer performance. The use of a constantly increased pitch ratio twisted tape, with a dynamic pitch ratio, generated higher secondary vortices at the inlet. Instead, a higher pitch ratio to the outlet yielded an improvement in the overall enhancement ratio. The overall enhancement ratio improved up to 10% with the use of SiC–water nanofluid compared to the use of the constantly increased pitch ratio twisted tape only.

The study of Chaabane et al. [7] added new scientific knowledge to the numerical studies of the free convection of nanofluids inside a cavity with a D_2Q_9 mesoscopic approach LBM. The numerical simulation was carried out using copper water nanofluid. The obtained results highlighted that the local Nusselt number increased using partially sinusoidal thermal boundary conditions and that heat transfer increased in an evident way employing a sinusoidal excitation.

Khan et al. [8], in their work, discussed a new model for hybrid Cu–Al_2O_3 in water nanofluid for flow and heat transfer in convergent/divergent oblique channels. In their work, they proposed a new set of nonlinear equations with the implementation of self-similar variables. Their results, being applicable to a wide range of engineering cases, confirmed the reliability of the model, through a comparison between their model with scientific literature.

The scientific works on this topic are many, but there is a lot of room to explore many physical aspects that are still without a clear answer under both theoretical and experimental points of view.

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