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Editorial

Heat Transfer Enhancement Methods Applied in Energy Conversion, Storage and Propulsion Systems

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With the development of energy storage and conversion or advanced propulsion systems, heat transfer enhancement methods have become widely applied. For the requirement of clean power, lithium-ion batteries are considered to be the most important choice due to their safety, high-energy density and relatively long working life. Duan et al. [1] conducted a numerical study for the 3D temperature distribution of a lithium-ion battery with a liquid cooling system to ensure suitable working conditions for batteries. In the study, two main effects were considered: the channel size and inlet boundary conditions. They found that the cooling channel width had great effects on the maximum temperature.

Recently, magnetic fields have been widely used in refrigeration and warming applications requiring high heat transmission. For this purpose, magnetic nanofluids have been proposed to enhance heat transfer. Over a linear extending sheet, Hussain et al. [2] investigated the heat transfer characteristics of the magnetohydrodynamic nanofluid flow. In this study, water was the base fluid, with Zn and TiO_2 working as two different types of nanoparticles. This study aimed to investigate the effect of different influential parameters on temperature and flow field distributions for rotating nanofluid in a magnetic field. They found that the rotation could increase the heat flux and decrease friction drag. Another piece of work by this research group concerned rotating nanofluids in an oil-based engine using a two-phase nanoliquid model on an elastic surface [3].

As a renewable energy, concentrated solar power technologies are expected to play a key role in reducing pollution levels. Agyekum et al. [4] investigated two kinds of heat transfer fluids under two power cycles, i.e., supercritical CO_2 and Rankine. Based on the results, the sCO_2 system was proven to be more economically feasible compared to the Rankine system.

Hydrogen is also a viable choice for reducing greenhouse gas emissions, which is a topic that has generated a lot of attention from researchers. There are several methods for the production of hydrogen, including coal gasification, methane cracking, water electrolysis and the partial oxidation of hydrocarbons. Recently, methane pyrolysis in molten metals/salts has been widely investigated, having the advantage of preventing reactor coking and the existence of rapid catalyst deactivation in conventional pyrolysis [5]. Another advantage is the high heat transfer enhancement in the pyrolysis process caused by the large heat capacity of molten media.

Algehyne et al. [6] investigated heat transfer improvements in pseudoplastic materials using ternary hybrid nanoparticles over a stretched porous sheet. The model of energy conservation was built based on a normal heat conduction model focusing on heat generation/absorption. The proposed method was validated by the published findings, and an excellent agreement was found.

Solar energy is considered to be the most appropriate energy source, and has been exploited in different forms, such as in solar air heaters, which realize the conversion of solar energy into thermal air energy. To enhance the thermal performance, Alam at al. [7]

added protrusion ribs to the absorber of solar air heaters. These ribs could enhance the heat transfer of the flowing air without causing a significant pressure drop. The roughness on the absorber could be produced by indenting the device without adding additional mass.

For energy storage applications, the latent heat of phase-change materials is a promising method, although their common disadvantage is their low thermal conductivity, which makes it difficult to use latent heat thermal energy storage. Behi et al. [8] used a tubular heat pipe to improve the heat transfer and increase the charging/discharging rate. The temperature distribution, liquid fraction and charging/discharging rates were discussed. The proposed heat pipe system significantly improved the heat transfer between the fluid and body frame in the operation environment.

Heat transfer enhancement methods are also used in propulsion systems [9] to realize the thermal protection of the engine, especially at high flight speeds. The enhancement of heat transfer in a perforated ribbed channel for blade cooling was investigated by Liu et al. [10]. They utilized steady-state liquid crystal thermography to measure the heat transfer coefficient over ribbed surfaces. It was found that the local heat transfer was enhanced 12–24% in the low heat transfer regions caused by recirculation, and the averaged heat transfer was enhanced by approximately 4–8%. With a small pressure drop penalty, the overall heat transfer performance was improved.

Liu et al. [11] also designed a type of perforated rib with inclined holes for internal cooling passages. This work aimed at furtherly improving the heat transfer of perforated ribbed channels with additional secondary flows caused by inclined hole arrangements. It was found that the penetrated flows mixed strongly with the mainstream flows at the perforated regions for the small inclined angle case. With an increased inclined angle, the penetrated flows approached the inclined direction and mixed with the main stream at the inclined side.

Overall, the enhancement of heat transfer is still widely used in the application of clean energy and energy storage and the conversion, as well as the thermal management of propulsion systems. One kind of heat transfer enhancement is the single-phase flow with increased heat conductivity, such as the use of nanofluids, which can work under certain special working conditions, such as in rotating engines and magnetic fields. Additionally, a convective heat transfer surface can be optimized to search for an improved heat transfer, including shape, flow path and turbulators. Another important method is the use of a two-phase flow, which absorbs plenty of energy during the phase-change process, such as heat pipes in the thermal management of lithium-ion batteries. Research works about the enhancement of heat transfer have been developed along the direction of novel materials, phase changes and multiscale structure designs.

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