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Editorial: Emerging Sustainable and Energy-Efficient Technologies in Heat Pumps for Residential Heating

Libor Pekař[1]*, Mengjie Song[2], Ning Mao[3], Hafiz Muhammad Ali[4], Wei Wu[5] and Jie Cai[6]

[1]Tomas Bata University in Zlín, Zlín, Czechia, [2]Beijing Institute of Technology, Beijing, China, [3]The University of Tokyo, Bunkyō, Japan, [4]King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, [5]City University of Hong Kong, Kowloon, China, [6]University of Oklahoma Norman, Norman, OK, United States

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Editorial on the Research Topic

Emerging Sustainable and Energy-Efficient Technologies in Heat Pumps for Residential Heating

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Edited and reviewed by:
Ellen B Stechel,
Arizona State University, United States

****Correspondence:***
Libor Pekař
pekar@utb.cz

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INTRODUCTION

Due to their advantages in energy efficiency and environmental friendliness, heat pumps have achieved good growth in terms of popularity in the past decades, rapidly becoming one of the most important solutions for efficient heating and one of the most attractive alternatives to replace fossil fuel heating systems (Hepbasli and Kalinci, 2009). With the pressure to reduce carbon emissions and increasing requirements for renewable energy, heat pumps will play a more important role in residential heating and will take on a significantly larger share of energy use. In recent years, to promote the application of heat pumps in residential heating, there has been a great deal of effort in applying and studying emerging sustainable and energy-efficient technologies in heat pumps (Song et al., 2019).

Compact structures have been proposed to increase efficiency by reducing cost and space, including microchannel heat exchangers and compact compressors. The frosting problem is one of the most important problems heat pumps face when in heating, and this mode attracts investigations (Song et al., 2018). The innovative design of multistage cycles and the development of new refrigerants also provide critical methods to solve the frosting problem and improve energy efficiency. Efforts have been made to develop hybrid heat pump systems that can integrate multiple types of heat pumps or apply various heat sources, especially renewable sources. To avoid the frosting problem, hybrid heat pump systems and hybrid systems with various heat sources have also been investigated to meet the different heating demands and advance efficiency objectives. Due to the complexity of the system and increasing demand from end-users, innovation of control strategies has been proposed with the dynamic modeling of heat pump systems, such as new data-based models (Lei et al., 2021) and new applications of artificially intelligent techniques (Abokersh et al., 2020). Meanwhile, efforts have also been made to develop huge low-cost sensors for data collection and robust dynamic heat pump models for optimum control or advanced intelligent control (Patyn and Deconinck, 2022). Such progress helps advance the sustainability and efficiency of heat pumps, and these recently developed technologies provide new insights into heat pumps. Hence, the aim of this Research Topic has been to present the leading research within high energy efficiency technologies and sustainable methods used by heat pumps for residential heating.

Content of the Collection

Within the Research Topic, 11 manuscripts were collected, and eight of these were accepted for publication. A high acceptance rate proves an excellent quality of submitted research reports. The accepted papers cover a wide range of problems across the Research Topic.

Jin et al. proposed a solution method to get stress intensity factors (SIF) along the crack front to assess the integrity of the nozzle structure with a crack under combined load in a nuclear reactor for thermal energy generation. It uses the stress on the crack surface and the response surface method to fit the stress under the framework of the linear superposition technique. The proposed solution was verified for a typical RPV with cracks under internal pressure, axial force, and global bending moment. It showed good agreement with the existing solutions under internal pressure.

Liu et al. developed a quick evaluation approach for reactor pressure vessels (RPVs) with defects exceeding acceptance standards based on the RSE-M to reduce the computational complexity and analysis time. The new method was applied to the RPVs with embedded defects and underclad semi-elliptical defects. The proposed evaluation approach was verified by the case of a typical RPV cylinder containing an embedded crack. All possible transients during the operation of nuclear power plants were considered, which gave confidence to the availability of the new approach.

In their novel study, Jia et al. used a new gravity-driven radiator as the indoor heating terminal of air source heat pumps (ASHPs), aiming to provide acceptable indoor comfort with improved energy efficiency. To confirm and quantify the performance improvement due to the proposed system retrofit, a field test was conducted to examine the system performance under real conditions. Results showed that the proposed radiator has a rapid thermal response, which ensures a fast heat output from the system. High energy efficiency was proved as well.

Wang et al. developed a novel direct expansion ASHP heating system with a gravity-driven radiator as a heating terminal to reduce energy consumption and improve the thermal comfort of indoor personnel. The results showed that the thermal response speed of the developed system was largely higher than that of the ASHP floor radiant heating system. They also indicated that integrating a cross-flow fan to the gravity-driven radiator can promote the thermal performance of the heating system obviously at the start-up stage due to the convection heat transfer of the radiator being highly enhanced.

Xia et al. enhanced a gravitational search algorithm (GSA) optimized by the least squares support vector machine (LSSVM) method for incipient fault diagnosis in centrifugal chillers. The obtained results were compared to those using the LSSVM classifier optimized by the conventional cross-validation method and particle swarm optimizer algorithm. Results showed that the best fault diagnosis performance could be achieved using the proposed GSA-LSSVM classifier. The overall average fault diagnosis accuracy for the least severity faults was reported to be over 95%.

Hou and Xu studied a cooling system based on the ejection refrigeration cycle, which collects the reaction heat and simultaneously controls the collector temperature around 100°C. An established thermodynamic model carried out performance analysis. Results showed the cooling system was able to provide cooling energy for the collector for fast cooling down the dust no longer than 620 s, which is 92% shorter than the time of the current collector, indicating the cooling system was effective and feasible.

Tang et al. performed a study on the division of frosting type and frosting degree in China. Based on the three-phase diagram of water and combined with the theory of phase change dynamics, the outdoor heat exchanger of the ASHP in the heating season was divided into four states, and the proportion of each state in a typical city in different climate zones was calculated. The results showed that more than 80% of the heating seasons had the frosting phenomenon.

Finally, Yang et al. designed energy efficiency multi-objective optimization of a forward-swept axial flow fan for heat pumps. The Bezier function parameterized the forward-swept curve on blade tops, and an ES model was established by integrating the radial basis function model and the Kriging model. Analysis of optimization results revealed that the optimized axial fan's flow rate and total pressure efficiency were improved to some degree.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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