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Editorial

Effective Tools for Low-Grade Thermal Energy Storage and Utilization

Introduction

Low-grade thermal energy, such as industrial waste heat, geothermal energy, and solar thermal energy, has the potential to be a valuable resource in contributing to energy conservation and improving energy efficiency. Unfortunately, much of this energy remains untapped, leading to increased environmental pollution without any benefits to production processes. The effective storage and utilization of low-grade thermal energy can significantly improve energy efficiency and reduce carbon emissions. This special issue aims to provide a platform for researchers to share their latest findings and advancements in low-grade thermal energy storage and utilization and promote the development and implementation of innovative technologies and policies in this area.

Overview of Selected Articles

This special issue published three research articles. These were mainly divided into the following categories: advanced materials for low-grade thermal energy storage and utilization thermal energy storage, integrated systems, economic and environmental assessments of low-grade thermal energy storage and utilization technologies.

1. "**Flow and heat transfer performance of liquid metal in mini-channel and verification of geometric parameter optimization**" by Xiang *et al*. contributes to novel and efficient heat dissipation method towards chips employing a novel liquid metal ($Ga_{61}In_{25}Sn_{13}Zn_1$) as coolant.
2. "**Thermal-economic analysis of an Organic Rankine Cycle system with direct evaporative condenser**" by Yu *et al*. proposed an ORC system using direct evaporative condenser for recover low-temperature waste heat to realize performance enhancement. Then its dynamic performance was investigated and evaluated based on the actual climatic condition, which is beneficial for its performance optimization.
3. "**Non-Saturated 3E (Energy, Exergy, and Economic) Analysis of Carnot Battery Systems Based on Organic Rankine Cycle**" by Ma and Yang proposed a novel Carnot battery system based on a dual-function unit and establish thermodynamic and economic models. A comprehensive performance analysis of the system is conducted considering the unsaturated operating conditions.

Integration of Themes

The low-grade thermal energy storage and utilization is ever-increasingly being acknowledged as an effective tool to save energy and improve energy efficiency. Many studies have focused on advanced materials and technologies for low-grade thermal energy storage and utilization. The problems faced by the materials for low-grade thermal energy storage and utilization are to enhance their baseline efficiency, which can be improved to develop novel materials and optimal structural. The organic Rankine cycle (ORC) system for power generation has proven to be an effective technology for the -grade thermal energy. However, the larger applications of the ORC system are facing the challenge in terms of system integration, reliability, dynamic performance and economic barriers. Rankine-based Carnot batteries are considered a promising solution to electricity storage in view of their high energy density at a low temperature. A key way for elevating the overall efficiency of the technologies of the low-grade thermal energy storage and utilization is to reveal the intricate interplay between materials, structures, and integrated systems.

Future Directions

With the ever-increasing concerns on the environmental problems and the evolution of the energy system, the attention to low-grade thermal energy storage and utilization will continue to grow. Thus, more and more attention should been paid to develop advanced materials and technologies for low-grade thermal energy storage and utilization, improve the efficiency of low-temperature heat utilization and storage technologies. The Economic and environmental assessments of low-grade thermal energy storage and utilization technologies are vital to ensure the applicability and sustainability goals of this system in application.

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