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Editorial

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Thermal storage/management system with phase change materials for building

During the processes of melting or solidification, phase change materials (PCMs) can store or release a significant amount of latent heat. Therefore, PCMs can be used in building to solve the mismatch between energy supply and demand in time, space, and intensity. Moreover, it is also used to recover residual heat and waste heat of buildings to improve the building energy efficiency. The temperature of PCMs can be stably maintained during the melting/solidification; thus, PCMs can be used for thermal management, such as adjusting the temperature of the photovoltaic-thermal (PVT) system to improve the power generation efficiency and employing phase change wall (PCW) to adjust the indoor air temperature. Moreover, PCW can not only reduce the capacity of the air-conditioning system but also reduce the fluctuation range of the indoor air temperature and thus improve human body comfort. Therefore, this special collection features recent PCM-related research works in the field of building energy efficiency. The selected 14 papers illustrate the broad impacts of PCM techniques in this challenging area.

Three papers reviewed previous work about PCM application in buildings. "A review on phase change material application in building" by Y Cui et al.[1] presents a review on PCM application situations in building, and several aspects are discussed: major applications in building, thermal-physical properties, and effects of application. "Review on application of phase change material in water tanks" by L Xie et al.[2] reviews the research on the water tank integrated with PCM in terms of existing research methods and heat transfer enhancing technologies and then summarizes the applications of various PCM-based water tanks. Finally, the further research suggestions on the PCM-based water tank are proposed. "A review about phase change material cold storage system applied to solar-powered air-conditioning system" by L Zheng et al.[3] is a novel investigation of the PCMs usage in cold storage system, the PCM cold storage working principles and features that are applied in the different solar-powered air-conditioning systems.

Three papers of this collection concern preparation and application of new PCMs. New microencapsulated PCMs applications in construction material and with fabric clothing are, respectively, proposed by X Han et al.[4,5] in the papers of "Experimental study on effect of microencapsulated phase change coating on indoor temperature response and energy consumption" and "Experimental studies on phase change and temperature-adjusting performance of phase change fabric clothing." Capric acid/expanded perlite form-stable PCMs were prepared by vacuum adsorption in the paper of "Thermal properties of phase change cement board with capric acid/expanded perlite form-stable phase change material."[6] The phase change cement boards were prepared by adding capric acid/expanded perlite into cement mortar, and their thermal properties were tested.

In the topic of thermal storage device, experimental and theoretical researches are both involved. The performances of the PCM thermal energy storage tank during the heat charging processes are investigated experimentally, and a series of experiments are carried out under different heat transfer fluid flow rates and distances between PCM plates in the paper of "Heating storage performance of a water tank-combined phase change material: An experimental case study."[7] It is found that water flow rate of $1.3\,m^3/h$ is taken as the optimal working condition, and the 3-cm plate distance is considered as the optimal design. Another paper named "Numerical study of the influences of geometry orientation on phase change material's melting process"[8] reveals how the melting rate could be affected by changing the orientation of a rectangular PCM container with a constant temperature boundary. The transient melting processes of lauric acid in a two-dimensional (2D) rectangular container with five orientations were simulated using the computational fluid dynamics software. The computational fluid dynamics model was validated against the available experimental data obtained from published literature. A thermal energy storage system using U-tube heat exchanger is proposed in the paper of "Numerical investigation of dynamic melting process in a thermal energy storage system using U-tube heat exchanger"[9] and compared with the system using single-tube heat exchanger. Based on the enthalpy-porosity method, three-dimensional (3D) numerical models using computational fluid dynamics approach are developed to simulate the dynamic melting of PCM in the two systems. The article of "A wet-bulb temperature-based control method for controlling the heat balance of the ground soil of a hybrid ground-source heat pump system"[10] proposed several control methods for a hybrid ground-source heat pump system, a TRNSYS platform of the system is developed, and simulations are carried out to investigate the system performance under the proposed control method.

With a focus on the thermal and humidity performance improvement of building wall, four papers are selected in this special collection. The field tests for the composite envelope lightweight building integrated with composite PCM layer were carried out by X Long et al.[11] The performance is compared with the buildings with ordinary structure under summer, winter, and transition climate. The annual load of model building with PCM composite exterior wall is 23.85% less than that of ordinary model building. Hygroscopic materials are used in the building wall for moderating indoor humidity and saving energy. Theoretical moisture penetration depth (TMPD) model and effective moisture penetration depth (EMPD) model are developed to calculate the TMPDs in the paper of "Application analysis of theoretical moisture penetration depths of conventional building material."[12] In the article of "Generalized design principle and method for a non-balanced thermal insulation system in building envelope,"[13] a generalized non-balanced thermal insulation system for building envelope was developed to solve the problem that walls in different orientations have the same thermal insulation performance under the current design standard in China, which causes different heat fluxes across the walls and is not conducive to optimizing the use of available solar energy. Considering the Lhasa region as a case study, the testing of an indoor thermal environment in winter was conducted, and a novel non-balanced thermal insulation system was built. The objective of the paper named "Numerical simulation of conjugate convection combined with the thermal conduction using a polynomial interpolation method"[14] is to develop a new correlation to estimate the number of Nusselt predictions, to facilitate the design of the walls of buildings. Moreover, a FORTRAN program was developed to control the equation of high order. This method is for predicting exchange coefficient and estimating Nusselt number of convection to optimize the design of walls in buildings.

The selected papers allow readers to have a representative idea of ongoing research in this field and motivate further work toward the development of new techniques for thermal storage/management system with PCMs for building.

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