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Experimental and Simulation Study of Thermal Performance of Phase Change Materials for Building Energy Storage

As building energy consumption continues to account for a significant portion of global energy use, improving energy efficiency in buildings has become critical to addressing energy shortages and environmental challenges. Phase change materials (PCMs) have attracted significant attention in building passive energy-saving and thermal storage applications due to their ability to absorb and release large amounts of latent heat during phase transitions. By integrating PCMs into building structures, thermal energy can be regulated and balanced under daily or seasonal temperature variations, reducing the demand for heating and cooling systems and improving indoor thermal comfort.

The thermal performance of PCMs, including phase transition temperature, latent heat capacity, thermal conductivity, and cycling stability, directly influences their storage efficiency and service life in buildings. Therefore, systematic experimental characterization and simulation analysis of PCM thermal behavior are essential for guiding the design and optimization of building energy storage systems. Experiments provide real material response data, while numerical simulations allow prediction of thermal behavior under various operating conditions and support design decision-making.

This study aims to investigate the thermal performance of PCMs in building energy storage by combining experimental measurements and numerical simulations. By characterizing material thermophysical properties, simulating phase change processes, and analyzing the thermal performance of building energy systems, this research provides theoretical guidance and technical support for the effective application of PCMs in energy-efficient buildings, contributing to sustainable building design and low-energy consumption strategies.