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COMPARATIVE STUDY OF THE THERMAL PROPERTIES OF NANOPARTICLE-ENHANCED PHASE CHANGE MATERIALS FOR BUILDING ENVELOPE APPLICATIONS

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Abstract – Phase change materials (PCMs) are gaining attention for their potential to improve the thermal energy performance of building envelopes. However, PCMs generally have low thermal conductivity, which means they absorb and release heat at a slower rate. This can limit their effectiveness in applications where fast heat transfer is essential for maintaining desired temperatures. Additionally, the performance of PCMs depends heavily on their phase transition temperature. If the temperature in the building fluctuates significantly, PCMs may not operate effectively or activate at the right moments. This study investigates the enhancement of paraffin wax, a commonly used PCM, through the incorporation of various nanoparticles to address these limitations. Furthermore, this paper gives insight into the best option for nano-additives in building envelope applications in temperate climate zones. A series of experiments were conducted using a heat-flux apparatus to assess the impact of carbon nanotubes (CNTs) and zinc oxide (ZnO) nanoparticles on the thermal conductivity and phase transition characteristics of paraffin wax. Results indicate that the inclusion of CNTs, both multi-walled (MWCNT) and single-walled (SWCNT), significantly increases the thermal conductivity of paraffin wax, with improvements ranging from 10 to 100 times depending on the concentration and type of CNTs. Additionally, the incorporation of ZnO nanoparticles enhances the response to temperature fluctuations, improving the speed of thermal energy storage and release. ZnO also acts as a nucleating agent, reducing the phase transition time by 10–50 %. This study demonstrates that nanoparticles, particularly CNTs and ZnO, significantly enhance the thermal performance of paraffin-based PCMs, making them more suitable for efficient building envelope applications that require fast heat transfer and stable indoor temperatures.

Keywords – Carbon nanotubes; heat-flux apparatus; nano particles; phase change materials; thermal performance; zinc oxide nanoparticles