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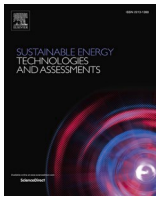

Role of phase change materials in thermal energy storage: Potential, recent progress and technical challenges

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ABSTRACT

Thermal energy storage (TES) using phase change materials (PCM) have become promising solutions in addressing the energy fluctuation problem specifically in solar energy. However, the thermal conductivity of PCM is too low, which hinders TES and heat transfer rate. In recent days thermally enhanced PCMs are a promising candidate for TES and heat transfer applications. This research designates the review on various thermal conductivity and heat transfer enhancement techniques of PCMs like, increasing the heat transfer area, use of various highly conductive porous foam materials (copper, aluminium, nickel, graphite, and carbon), mix of materials, use of multiple PCM and nano dispersed PCM (Copper oxide (CuO), Aluminium dioxide (Al_2O_3), Carbon nanotubes (CNTs), graphene, etc.). Also, the long-term stability, phase segregation and super colling are extensively discussed. Furthermore, energy storage applications of highly conductive PCMs in advanced fields like solar thermal system, desalination units, pharmaceutical industry, fabrics, food processing, battery thermal management etc are discussed. It has been observed that porous materials/foam dispersed PCM had better heat transfer/storage capacity (thermal conductivity 2–500 times more). In addition, organic PCMs have been widely used, due to its long-term stability, low or no supercooling, less or no corrosion, and recyclability. The highly stable thermally enhanced PCMs are used for long-term TES/heat transfer applications.

Introduction

The global electricity demand, escalating fossil fuel prices, and serious problems about global warming have re-energized the idea of aggressively migrating to renewable energy (RE) sources, particularly over the past two decades [192]. Out of all other renewable energy sources, solar energy is the most efficient energy source, as it is environmentally friendly, readily available, and readily accessible in abundant quantity [4]. Thermal, and electrical energy can all be easily converted from solar energy [174]. While systems for converting solar energy into electrical energy have made significant development, their high capital cost and low conversion efficiency are the primary impediments to widespread adoption. Various ways have been constantly pursued over the years to increase the efficiency of solar energy generation and make it a more cost-effective technology [182]. Heat storage in various materials diminishes the greenhouse effect.

The thermal energy storage (TES) method also improves the performance of many devices in various industries. Phase change materials (PCM) are excellent materials for storing thermal energy. PCMs are latent heat storage materials(LHS) that absorb and release large amounts of heat during changing the phase changes from solid to liquid or liquid to solid [225]. The performance of TES and heat transfer depends on the thermal conductivity of the substance. The main drawback of the PCM is lower thermal conductivity; due to its lower thermal conductivity, the storage performance and heat transfer rate are low. Therefore, more researchers are suggested different methods to improve the TES and heat transfer. For example, by using, increasing heat transfer area [24,28,30], using foams [34,34,120,133;142;172], dispersing nanoparticles [79;153,202,209], use of multiple PCMs [163] mixing of materials etc. [150;176;208]. The thermophysical properties of metal oxide dispersed PCM was characterized by [80]. the researcher used four different types (TiO_2, Fe_2O_3, SiO_2, and ZnO) of nanoparticles and dispersed them with magnesium nitrate hexahydrate PCM. The developed composite thermal conductivity was enhanced 147.5%, 55%,

Abbreviations: CNTs, Carbon nanotubes; COP, Coefficient of Performance; ES, Energy storage; FMWCNTs, Functionalized multi-walled carbon nanotubes; HVAC, Heating, ventilation and Air Conditioning; LH, Latent heat; LHS, Latent heat storage; MWCNTs, Multi-walled carbon nanotubes; NDPCM, Nano dispersed phase change materials; PCM, Phase change materials; PEG, Poly ethylene Glycol; PEM, Polymer Electrolyte Membrane; RE, Renewable energy; TES, Thermal energy storage.

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