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Review on Nanomaterials for Thermal Energy Storage Technologies

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Abstract: To optimize the utilization of thermal conversion systems, it is essential to integrate them with thermal energy storage. Among many types of base materials, the phase change materials are the most satisfactory mediums to store and release the thermal energy due to their high latent heat of fusion. In general, the phase change materials have low thermal conductivity. Nanoadditives have been investigated to further enhance the thermal properties of the phase change materials. This paper reviews the research development of the various types of phase change materials, nanoadditives, nanofluids, and nanocomposites as possible materials for efficient thermal energy storage. Some deficit in the literature has been noticed on the dispersion of various types of nanoparticles in the various types of base materials. It is also recommended that further studies are required to understand the stability of the nanofluids and nanocomposites due to a large number of thermal cycles.

Keywords: Nanoadditives, Nanomaterials, Nanocomposites, Nanofluids, Nanoparticles, TES, PCM.

1. INTRODUCTION

Energy storage plays important roles in conserving the over demand of energy for utilization during the demand. On the other hand, many types of energy sources are intermittent in nature like solar energy which is affected by cloudy and dusty weather, as well as the non availability during the night. In this sense, the thermal energy storages (TESs) play essential roles in heat recovery and contribute considerably in improving the performance of the thermal systems. TESs are simply contained mediums which are able to store the thermal energy (charging mode) and release the stored thermal energy (discharging mode) to compensate for the shortage in the main thermal source. Commonly, the storing medium is a fluid or phase change material (PCM). In general, the thermal conductivity of these TES-based materials is poor leading to a slow charging and discharging rate. The charging and discharging rate can be enhanced by applying the heat transfer enhancement methods. The literature shows numerous methods to enhance the thermal conductivity of the TES materials varying from extended surfaces and fins, bubble agitation, metal ring and metal matrix insertion, encapsulation, and many others; among them are the nanoadditives.

Nanomaterials are used as additives to enhance the properties of base materials. When they are added to the fluid, the produced mixture is denoted by nanofluid; while by adding the nanomaterials to PCM, the production is denoted by nanocomposites. Subsequently, they will be denoted by nanofluids/composites. Some review articles were published reporting progress on the enhancement in thermophysical properties investigated with different nanomaterials for different applications [1-4]. Many other reviews have emphasized the technological applications, synthesis and preparation methods in the production of nanomaterials [5-8]. The investigations on the characteristic mechanism enhancement (conductive and convective heat transfer) by these advanced materials have been carried out experimentally, numerically and theoretically. They have been aimed to determine the major phenomenon (Inter-layer surface and Brownian motion, particle aggregate etc.) which is responsible for the enhancement. The different synthesis methods of preparation and the characterization of nanofluids, suspension, and the convection and conduction heat transfer in nanofluids have been reported by [9-11]. Within the realm of nanomaterials for thermal energy applications, many researchers have focused on the thermal conductivity effectiveness of nanofluids/composites which can improve their thermophysical properties [12-17].

This paper focuses on the enhancement of TES by using nanomaterials as additives to the base storage materials. TESs as a whole and heat exchanger development in particular are mostly concerned with heating and cooling applications. The utilization of nanofluids/composites in heating and cooling processes is viewed in relation to different applications as grouped in Fig. (**1**).

The paper critically reviews the existing studies dealing with the use of nanofluids and nanocomposites in TES applications. The types and classifications of the nanomaterials have been presented and discussed. The synthesis methods used in the preparation of the nanofluids and nanocomposites are also presented and discussed.

2. CLASSIFICATION OF WORKING MATERIALS

This section presents and discusses the classification of the materials included in the process of TES enhancement.

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