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ORIGINAL PAPER

Performance evaluation of polymer/clay nanocomposite thermal protection systems based on polyethylene glycol phase change material

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Abstract Phase change materials (PCMs) are substances with a high heat of fusion which, through melting and solidifying at specified temperatures, are capable of storing or releasing a large amount of thermal energy. This phenomenon can be utilized in designing the heat protective materials as well as in the thermal energy storage systems. In this work, effects of polyethylene glycol (PEG) as PCM and montmorillonite nanoclay, as a thermal property modifier in epoxy resin on the thermal protection performance of nanocomposites were studied. A special performance evaluation test was designed to study the top surface temperature behavior of prepared samples under back surface heating. Results indicated that increasing PCM content improved thermal protection performance, but lower thermal diffusivity was found for the sample containing 60 wt% of PEG, with a 31 % decrease in top surface temperature. These results show that increasing of top surface temperature of samples containing PCM was very slow when compared with the neat epoxy sample. A top surface temperature behavior of these samples shows a plateau in melting region of PCM which makes a delay time in temperature increment compared with that of the neat epoxy sample. Moreover, heat protection performances of low filled nanocomposite blends, i.e., nanocomposite blends with 5 and 7 wt% of clay in PEG have been improved about 10 % in comparison with EP/PEG60 blend.

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Introduction

Continuous increase in the level of greenhouse gas emissions and ascends in fuel prices are the main driving forces behind efforts to utilize various sources of renewable energies, more effectively [1]. One of the prospective techniques of storing solar energy and designing thermal protection systems is the application of phase change materials (PCMs). They are substances with a high heat of fusion which, through melting and solidifying at given temperatures, are capable of storing or releasing a large amount of thermal energy. This phenomenon can be utilized in designing the heat protective materials as well as in the thermal energy storage systems.

Phase change materials have important application prospects in many fields, such as aero-space, solar energy utilization, textiles, energy-saving building and heat exchangers [2]. It is clear that PCMs have low viscosity after melting which leads to leaching from the structure that is incorporated with. Therefore, some strategies were developed to keep the PCMs at constant volume and shape even after melting.

One of the approaches to avoid PMGs leaching from the structure is to blend them with convenient polymers. A polymeric matrix can keep the PCM in a compact form, even after melting, and suppress its leaching. For having a proper blend, it is necessary to choose a compatible polymer with the used PCM [2, 3]. Potential polymer matrices are polyethylene [4], polypropylene [5], styrene–ethylene–butylene–styrene (SEBS), styrene–isoprene–styrene (SIS), and styrene–ethylene–propylene–styrene (SEPS). For