Chapter 1
Numerical Study of Nanocomposites for Energy Applications

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ABSTRACT
Nanocomposites are defined as a combination of nanoparticles reinforced into the base material. They are of very small sizes (1nm = 10⁻⁹m) and possess higher thermal properties. They are widely utilized in different applications, like in energy, construction, biomedical, chemical, electronics, agriculture, cosmetics, etc. This chapter deals with the application of nanocomposites (SiC/Al₂O₃/B₄C/TiO₂/ZnO/SiO₂) in the field of energy applications by analyzing their properties (thermal-conductivity/density/specific-heat) using numerical models. The effect of nanoparticles reinforced wt. % concentration into a base material (Al6061/Al7075/H₂O) is also analyzed. Results show that nanocomposites have higher effective thermal conductivity and are suitable for high heat-releasing energy devices. It is found that the addition of nanoparticles increases the surface area to volume ratio, which further increases the energy transfer rate. Results show that nanocomposites with lower effective density are suitable when there is a requirement of reduction in weight for the same heat release application.

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INTRODUCTION

Nanocomposites are defined as a combination of nanoparticles reinforced into the base material. They are of very small sizes (1 nm = 10⁻⁹ m) and possess high thermal properties like thermal conductivity, heat capacity, etc. A lot of research is going in the field of nanocomposites behavior analysis under different conditions or applications. They have been widely utilized in different applications, like in energy, construction, biomedical, chemical, electronics, agriculture, paints, and cosmetics, etc. (Sharma, 2018; Santosh, 2016).

Development in the technology is resulting in the miniaturization of energy devices, these miniature devices generate a large amount of heat which need to be released to the atmosphere for proper functioning, they also need light weight material. As capabilities of the conventional materials are limited, we need new materials that can fulfill these requirements. Nanocomposites are these new materials which can surely fulfill these requirements and can be very helpful in the energy applications, as they possess enhanced thermal properties compared to conventional materials (Lee et al, 2010). Nanocomposites are utilizing in solar and other energy conservation devices. Literature in the field of solar cooling states that use of nanocomposites increases the rate of solar cooling by a considerable amount (Al-Shamani et al, 2014). Nanoparticles like Cu and Al₂O₃ reinforcement into the base material enhances the effective thermal conductivity and energy transfer rate (Santra, 2008; Lai 2011).

There are other numerous applications of the nanocomposites which have resulted in the start of new ventures/companies.

Methodology and Materials

Present work will deal with the application of nanocomposites like SiC (Silicon carbide), Aluminium oxide or alumina (Al₂O₃) and Boron carbide (B₄C), Titanium oxide (TiO₂), Zinc oxide (ZnO) and silicon oxide (SiO₂) in the field of energy. Properties of these different nanocomposites like thermal conductivity, density, specific heat, and thermal diffusivity are analyzed in detail with the help of numerical models available in the literature. Effect of addition of concentration of nanoparticles on the different base material like (Al6061/Al7075/H₂O) will also be analyzed. Table 1 represents the properties of these nanoparticles and base materials (Kosti, 2019).

Wide varieties of numerical models are available in the literature (Lee et al, 2010) to calculate the effective properties of the nanocomposites like thermal conductivity, specific heat, and density, but most of the studied area devoted towards the finding of effective thermal conductivity, as thermal conductivity is the parameter which largely affects the energy transfer rate but few studied are devoted towards the analysis of changes in density and specific heat. In the present study thermal conductivity
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