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Effect of shot blasting on droplet contact angle of carbon aided phase change nanocomposites

P. Ganesh Kumar[a], R. Prabakaran [b], D. Sakthivadivel [c], N. Thangapandian [d], R. Velraj[e] and Sung Chul Kim[a]

[a]School of Mechanical Engineering, Yeungnam University, Gyeongbuk, Republic of Korea; [b]Department of Automobile Engineering, Kongu Engineering College, Perundurai, Erode, India; [c]School of Mechanical Engineering, Vellore Institute of Technology, Vellore, India; [d]Department of Mechanical Engineering, St. Joseph's Institute of Technology, Chennai, India; [e]Institute for Energy Studies, Department of Mechanical Engineering, Anna University, Chennai, India

ABSTRACT
This experimental work deals with the measurement of the contact angle of the nanocomposites made of phase change material (PCM) OM 08 and multi-wall carbon nanotubes (MWCNTs) with different volume concentrations namely, 0.05%, 0.1%, 0.3%, 0.5%. Two different types of copper substrate, namely copper plate with and without shot blasting, were used in this study. It was identified that the droplet contact angles of the nanocomposites were increased with the increase in volume concentration. Also, an increase in the droplet contact angle was more predominant at the higher volume concentration of MWCNTs. The nanocomposite with 0.5 vol.-% of MWCNT has a maximum droplet contact angle of 42.1° and 40.01° respectively on the normal and SBS copper substrate. The use of the highly roughed SBS effectively reduced the contact angle of the nanocomposite by 2° and 2.3° during the first and second passes respectively.

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Contact angle; phase change materials; MWCNTs; shot blasting; roughness; nanocomposites; Zeta potential distribution; Thermal energy storage

Introduction

Nanocomposite consists of phase change material (PCM), and nano-level reinforcement can affect novel thermal properties. Nevertheless, the thermal properties of PCM nanocomposites, namely density, thermal conductivity, specific heat capacity, phase change enthalpy, and dynamic viscosity [1–6], have been broadly studied in the literature. A few research forecasts the relation between the wetting properties of nanocomposites with different parameters such as contact angle, surface tension, etc. The reduction in the stagnant contact angle is the main reason for the enhancement in critical heat flux owing to the formation of a nano-level coating on the heat transfer surface, i.e. the fluid wets surface more when the contact angle is lesser. The Nano coating formed over the heat transfer surface during the phase change process of nanocomposite/nanofluid could appreciably enhances the surface wettability [7]. In recent times, research based on the substrate's wetting phenomena concerning a specific fluid has received significant attention. Still, the literature pertaining to the contact angle of nanocomposites/nanofluids is limited [8–14].

Different methods for measuring the contact angle of the nanocomposites/nanofluids were discussed elsewhere [15,16]. Generally, a fluid located on a planar solid surface will produce a specific angle of contact between the solid and fluid [17–19]. The contact angle made by the fluid droplet over different surfaces like a flat surface, wire [20,21], and tube [22] were calculated and reported. The majority of the research carried out in the area of boiling of nanofluid has reported an increase in critical heat flux (CHF) due to the decrease in contact angle (enhanced surface wettability). Furthermore, PCM blends improve the convection heat transfer; meanwhile, there is direct surface contact between the PCM and the heat transfer fluid [23,24]. Hence, the colloidal stability and thermal transport properties of nanocomposites/nanofluids are the most vital parameters to understand the convective heat transfer performance in different applications.

Vafaei et al. [24] studied the effect of volume concentration and size of functionalized nanomaterials in the nanofluids along with substrate material (smooth glass and silicon) substrates have a significant part in the variant of the droplet contact angle. It was observed that the droplet contact angle raises with the volume concentration of the nanofluids. It was also observed that the decrease in the nanoparticle size significantly improves the droplet contact angle. Radiom et al. [25] experimentally measured the contact angle of TiO_2-demineralized (DI) water-based nanofluid at ambient temperature by using the pendant droplet method. They concluded that the contact angle increased with an increase of nanomaterials concentration. Chinnam et al. [26] experimentally studied

CONTACT P. Ganesh Kumar selgan.cad@gmail.com School of Mechanical Engineering, Yeungnam University, Gyeongbuk 712-749, Republic of Korea; Sung Chul Kim sungkim@ynu.ac.kr School of Mechanical Engineering, Yeungnam University, Gyeongbuk 712-749, Republic of Korea