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Heat Transfer Enhancement with Rising Air Bubbles in Graphene Oxide (GO) Nanofluid

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Extended Abstract

Nanofluid enhances heat transfer by adding highly thermally conductive nanoparticles into base fluid to increase its thermal conductivity. However, the viscosity of nanofluid is typically higher than base fluid, and natural convection heat transfer deteriorates in nanofluid at high nanoparticle concentrations [1-8]. Rising air bubbles in a liquid medium, on the other hand, can enhance heat transfer over a heated surface due to the vortex-induced mixing from the bubble rising motion [9-12]. Nevertheless, the synergistic effect of the two has never been explored in enhancing heat transfer. This study investigates the effectiveness of bubble rising in graphene oxide (GO)-nanofluid in heat transfer enhancement. The high thermal conductivity of the GO nanoparticles (670 W/(m·K)) [13] can improve the heat dissipation rate, and the bubble rising motion can reduce the agglomeration and sedimentation rates of the nanofluid. The bubble-induced mixing effect also could dissipate heat more effectively in the GO-nanofluid.

A bespoke vertical water column was constructed for this study. A constant heat flux of 2.7 kW/m^2 was applied to the polyimide thermofoil heater to heat an aluminium surface that is attached to one side of the column wall. Five thermocouples were used to measure the temperature changes across the heated surface. Air bubbles were generated and injected into the water column using a syringe pump and a tube. Air bubbles were injected at air injection rates of 6, 18 and 36 ml/min into the GO-nanofluid with GO concentration fixed at 100 ppm. The heat transfer performance was quantified by the average heat transfer coefficient (h) between the heated surface and the surrounding fluid.

The thermal conductivity of the GO-nanofluid was calculated by using empirical correlation developed by Kanti et al. [14]. The calculated thermal conductivity was 0.640 W/(m·K), which was 4% higher than water of 0.615 W/(m·K) [15] at 30 °C. An enhancement in h of 22% (524 $W/(m^2 \cdot K)$) was attained for bubble rising in GO-nanofluid at 6 ml/min air injection rate compared to only deionised water used (428 $W/(m^2 \cdot K)$). Moreover, the h values increased with increasing air injection rates. At an air injection rate of 18 ml/min, the h achieved was 634 $W/(m^2 \cdot K)$, representing a 48% enhancement compared to the base case. The GO-nanofluid recorded the highest h of 1044 $W/(m^2 \cdot K)$ with an enhancement of 144% when the air injection rate was 36 ml/min. When the air injection rate increased, more bubbles were generated and rising at higher velocity, thus inducing stronger mixing effects for effective heat dissipation.

This study demonstrates the effectiveness of combining rising bubble and GO-nanofluid in improving heat transfer between a heated surface and a surrounding fluid. The investigations of nanofluid concentrations on the degree of heat transfer enhancement are recommended for future work.

Keywords: Graphene oxide (GO); nanofluid; rising bubble; heat transfer; convection

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