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Thermal conductivity enhancement of TiO_2 nanofluid in water and ethylene glycol (EG) mixture

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The need to study nanofluid properties has increased over these past centuries in order to provide better understanding on nanofluid thermal properties and behaviour. Due to its ability to improve heat transfer compared to conventional heat transfer fluids, nanofluids as a new coolant fluid have widely been investigated. This study presents the thermal conductivity enhancement of titanium dioxide (TiO_2) nanoparticles dispersed in mixture of water and ethylene glycol (EG). The nanofluids have been prepared for volume concentrations from 0.5 to 1.5%. The thermal conductivity measurement of the nanofluid has been performed using KD2 Pro Thermal Properties Analyzer at working temperatures of 30 to 80 °C. The measurement gives 15.35% maximum enhancement of thermal conductivity at 1.5% volume concentration and temperature of 60 °C. The results show that the thermal conductivity increases with the increase of nanofluid concentration and temperature. Also, the nanofluids provide enhancement in thermal conductivity compared to their base fluid of a water/EG mixture in 60:40 ratio. Therefore, the addition of TiO_2 nanoparticles dispersed in the base fluid of a water and EG mixture will enhance the effective thermal conductivity of the nanofluid. The new thermal conductivity correlation of TiO_2 nanofluids is developed for a wide range of temperatures and concentrations with maximum deviation of 4.65% and average deviation of 1.37%.

Keywords: Nanofluid, Titanium dioxide, Thermal conductivity enhancement, Ethylene glycol

1 Introduction

Nanofluid is prepared by dispersing nanoparticles in based fluids such as water, EG and engine oil. This new class of fluid provides higher enhancement in the thermal performance compared to their based fluids. In terms of their stability, nanofluid has better stability than those fluids as it contains macro or mili-sized particles, which is the advantage of using nanofluids. Besides that, it possesses a higher thermal conductivity than the based fluids themselves which offers potential benefits in the engineering field that involvesthe cooling process. The study on the thermal conductivity of a fluid plays a vital role in the improvement of energy-efficient heat transfer equipment. Numerous theoretical and experimental studies on the thermal ability of liquids to suspendnano-sized particles have been conducted since the early 90's through the determination of thermal conductivity and viscosity of the nanofluids such as Al_2O_3, SiO_2 and TiO_2 in water based[1]. Later, many researchers used different types of nanoparticles to investigate the rheological behaviour of the nanofluids. A study on thermal properties using Fe_3O_4 nanoparticles dispersed in a mixture of EG and water found that the thermal conductivity of nanofluids increased as concentration and temperature of the nanofluids increased[2]. Apart from these two outstanding factors, the types of nanoparticles used also contribute to the thermal conductivity enhancement as well as particle size and stability of the nanofluid[3,4].

The previous work to study the EG based nanofluids was done using nanoparticles such as copper (Cu), zinc oxide (ZnO), alumina (Al_2O_3) and aluminium nitride (AlN). In EG based γ-Al_2O_3 nanofluid, it was proven that the nanofluid provides better heat transfer enhancement than water based γ-Al_2O_3 in a study of heat transfer behaviour in a uniformly heated tube[5]. A study where the investigation is focused on thermal conductivity, leads to the findings that the thermal conductivity of nanofluid follows the behaviour of based fluid (EG) where the maximum thermal conductivity is at approximately the same temperature in pure based fluids[6]. Other factors that affect the thermal conductivity are particle shape and aggregation[7]. A study on TiO_2 nanofluids in EG based found that the nanofluid exhibits higher thermal conductivity, behave as Newtonian fluid and at low Reynolds number, the convective heat transfer deteriorates[8]. The enhancement of thermal conductivity will

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