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Optimization parameter for high thermal conductivity and heat transfer using ethylene glycol and water mixture MWCNT-OH based nanofluids

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ABSTRACT – The objective of this paper is to measure and analyze the thermal conductivity and heat transfer of ethylene glycol and deionized water mixture of MWCNT-OH based nanofluids (EG:DI;10:90) at three different temperatures (6°C, 25°C and 40°C). Two-step method is used in the preparation of nanofluids through mixing of the MWCNT-OH, base fluids and polyvinylpyrrolidone by dispersion process. The result shows the increment of thermal conductivity from 0.7590% to 13.42% and the enhancement of heat transfer is about 250%. Several issues are discovered to have affected the thermo-physical tests which are nanoparticles size, temperature, dispersion process and sedimentation of particles.

1. INTRODUCTION

Nanofluids is the suspension of nanoparticles of either metallic or non-metallic in the base fluid (ethylene glycol, *EG,* water, H_2O or oil) [1]. It plays an important role in addressing the issue of cooling system applications as it can enhance the thermal performance of fluids. This is due to the nanoparticle characteristics which have a high thermal conductivity, electrical conductivity, and heat transfer. However, H_2O base fluid has lower freezing point that which might lead to limitation in some cooling applications. Therefore, the mixture of H_2O and EG as heat transfer fluid is an alternative way to overcome this problem due to low freezing point of EG respectively. Hence, a number of studies have conducted the thermal properties of EG and H_2O mixture based nanofluids experiment and stated that the increment of thermal conductivity is about 9.8% to 17.89% for mixture of EG and H_2O at 50:50 wt% and 6.67% to 10.47% enhancement for 60:40 wt% (EG:DI) [2,3]. Whilst, for the heat transfer investigation which was performed at 50°C the mixture base of H_2O to EG (60:40) has 14.6% enhancement on 0.6% volume concentration of Al_2O_3 [4]. Wherefore, to fill the research gap, this research focuses on the thermal conductivity and heat transfer of -OH functionalized multiwalled carbon nanotube (MWCNT-OH) based nanofluids in the EG:DI mixture (10:90).

2. METHODOLOGY

Two-step method was use in the synthetization of nanofluids. The formulation of the nanofluid comprises of the MWCNT-OH developed by Nanostructures & Amorphous Material, Inc with a weight percentage, *wt%* range of 0.1 wt% till 1.0 wt% with an increment 0.1 wt% respectively. In order to stabilize the suspended particles of MWCNT-OH in the nanofluid, polyvinylpyrrolidone, *PVP* developed by Sigma Aldrich Co. with a 0.1 wt% is used. It is noted that the base fluid used is a mixture of EG and DI with a ratio of 10% and 90% respectively (EG:DI;10:90). This composition of CNT, base fluid and stabilizer undergoes dispersion process for five minutes through homogenization (Wise Tis HG-15D homogenizer) at 10000 rpm and ultrasonication (Branson 8510DTH Ultrasonic Cleaner) at 40 kHz. The stability of the nanofluids is determined through a stability test rig, *STR* [1]. In order to determine the thermo-physical properties of nanofluids, refrigerated water bath was used to conduct the thermo-physical test at three different temperatures (6°C, 25°C, and 40°C). TC-KD2 Pro was used in the thermal conductivity test where KS-1 sensor inserted to the nanofluids sample and reading was taken in one minute for three times. The accuracy value of this sensor is ±0.01 W/m.K. Heat transfer test is then conducted using copper coil submerged in the water bath at the designated temperature where the nanofluids is flowed through the coil by water pump and measured with Pico Data Logger. The temperature accuracy of Pico Data Logger is sum of ±0.2% of reading and ±0.5°C.

3. RESULTS AND DISCUSSION

3.1 *Thermal conductivity*

Figure 1 shows the thermal conductivity of nanofluids with the formulated concentrations at three different temperatures. It is observed that the thermal conductivity of the nanofluids is higher than the base fluid (0 wt%) for all temperatures level and the straight line is represented the standard values for the base fluid. The results in the Figure 1 indicate the higher thermal conductivity for all temperatures occurred on 0.7 wt%, 0.8 wt% and 0.9 wt%. At 40°C, 0.9 wt% of MWCNT-OH has the highest thermal conductivity compared to the others sample where the value is 0.6340 W/m.K and the enhancement is approximately 13.42%. Whilst, at 25°C for 0.1 wt% of MWCNT-OH has the lowest thermal conductivity value which is 0.5310 W/m.K and the thermal conductivity enhancement is only 0.7590%.

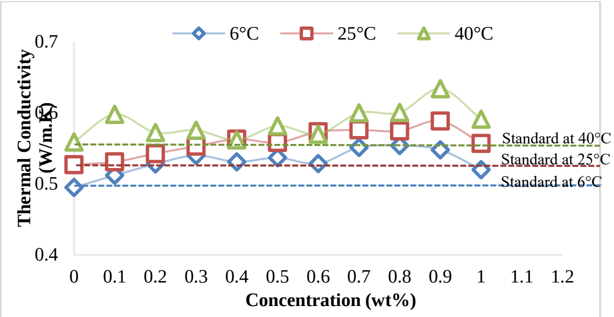

Figure 1 Thermal conductivity of EG:DI based nanofluid.

3.2 *Heat transfer*

Figure 2 presents the temperature differences for MWCNT-OH concentration at 0.7 wt%, 0.8 wt% and 0.9 wt% at 6°C, 25°C and 40°C. These concentrations were selected for the heat transfer test due to their enhancement in the thermal conductivity test results in the highest among the others concentration. Closer inspection of the figure shows at 40°C for 0.7 wt% has the highest temperature differences and the heat transfer enhancement is about 250%. 0.8 wt% of MWCNT-OH results in a lower temperature difference for 6°C and 25°C as compared to the standard.

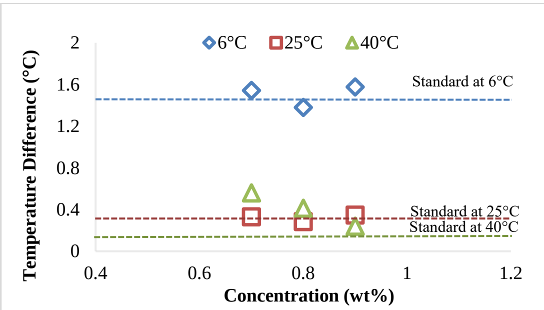

Figure 2 Temperature differences at 6°C, 25°C and 40°C.

Thermal conductivity and heat transfer property are related to each other where higher thermal conductivity can give the better result in heat transfer test. These enhancements can be due to the characteristic of MWCNT-OH having a small size and large surface area where the outer diameter is about 10 nm to 30 nm and the inner diameter is 5 nm to 10 nm and resulting in a higher thermal conductivity due to a larger heat absorption and capacity [5]. Besides, thermo-physical properties strongly depend on the temperature where the highest enhancement occurs at 40°C for both experiment as the high temperature can make the nanoparticles is more active which enables more energy transfer. Meanwhile, the crucial factor is the dispersion process where the vibration from the ultrasonic and homogenizer can make the nanoparticles dispersed well in the fluids and achieved the stability [1]. However, the sedimentation form at a certain period can decrease the thermo-physical properties as nanofluids have more than one-month lifetime of stability. This fact is justified on some concentrations of the nanofluids which exhibits no enhancements in thermo-physical properties.

4. CONCLUSION

In conclusion of MWCNT-OH nanoparticles into the base fluid (EG:DI;10:90) can enhance the thermo-physical properties is proved where the thermal conductivity enhancement is about 0.7590% at 0.1 wt% (25°C) and 13.42% at 0.9 wt% (40°C). Whilst, the heat transfer enhancement is about 250% at 0.7 wt% for 40°C. Factor that influenced these thermo-physical results are the small size and large surface area of MWCNT-OH, high temperatures that enable the nanoparticles become more active and transfer more energy, the dispersion process and as well as the sedimentation form in nanofluids.

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