Thermal conductivity and heat transfer of MWCNT-OH ethylene glycol based nanofluids

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ABSTRACT – The purpose of this study to investigate the thermal conductivity and heat transfer coefficient of MWCNT-OH ethylene glycol based nanofluids at 6°C, 25°C and 40°C. This research used two-step method in preparing the nanofluids. The results of this study reveal that these nanofluids gained thermal conductivity and heat transfer coefficient enhancement by 2.232% to 20.10%. Meanwhile, the heat transfer coefficient shows an enhancement with the increase in weight loading and temperature. Factors that affects these results are surfactant, stability, dispersion process, nanoparticle size and surface area of MWCNT-OH nanoparticles. These results proved that the seed of MWCNT-OH nanoparticles have enhanced the thermal performances of the nanofluids.

1. INTRODUCTION

Low thermal performance is a characteristic of conventional fluid such as ethylene glycol, deionized water and oil. This characteristic results in a limitation for thermal performance enhancements. Hence, nanotechnology related to nanofluids is used as an initiative to solve this problem. Nanofluids is defined as a suspension of nanometer sized particles in base fluids. In addition, higher thermal conductivity of nanofluids within ranges 1800 W/m.K to 2000W/m.K results in the enhancing of the thermal performance of base fluids. Past literatures reported that the base fluids’ thermal conductivity and heat transfer coefficient are improved with the inclusion of nanoparticles [1]. The enhancement of thermal conductivity is about 23% and 3.2% to 10% for ethylene glycol and deionized water based nanofluids with inclusion of multiwalled carbon nanotube (MWCNT). Meanwhile, heat transfer coefficient of Al2O3 nanofluids is 57% higher than distilled water [2]. However, thermal performances on nanofluids still lacks the data as well as contradictory with the other researchers. Hence, investigations of thermal conductivity and heat transfer on ethylene glycol based nanofluids with seeding of hydroxyl functionalized multiwalled carbon nanotube (MWCNT-OH) are the focus of this research.

2. RESEARCH METHODOLOGY

2.1 Preparation of nanofluids

Two-step method is used in this investigation by using of MWCNT-OH, polyvinylpyrrolidone (PVP) surfactant and ethylene glycol. The weight percentage (wt%) of PVP surfactant is 10% from wt% of nanoparticles where range of wt% of nanoparticles is from 0.1 wt% till 1.0 wt%. These materials undergo dispersion process which were homogenized by Wise Tis HG-15D at 10000 rpm and ultrasonic by Branson 8510DTH Ultrasonic Cleaner at 40 kHz for 5 minutes. The nanofluids is next tested by a stability test rig (STR) and ZEISS inverted microscope as to ensure the stability of the dispersion. Stable nanofluids then undergoes thermal conductivity test and heat transfer test at three different temperatures (6°C, 25°C and 40°C). The thermal conductivity test uses TC-KD2 Pro thermal properties analyzer and KS-1 sensor from Decagon Devices, Inc. These devices have ASTM D5334-14 and IEEE 442-03 verification standard. Heat transfer coefficient is tested using heat transfer rig (HTR) and Pico Data Logger as to measure the values. Three best samples of nanofluids is selected to go through heat transfer coefficient test.

3. RESULTS AND DISCUSSION

3.1 Thermal conductivity

Figure 3.1 shows the thermal conductivity of MWCNT-OH ethylene glycol based nanofluids for three different temperatures. As can be seen, on 0 wt.% weight loading is the baseline values of ethylene glycol at 6°C, 25°C and 40°C which 0.2070 W/m.K, 0.2195 W/m.K and 0.2243 W/m.K. The inclusion of MWCNT-OH
nanoparticles enhances the nanofluids’ thermal conductivity of the ethylene glycol. Thermal conductivity of nanofluids fluctuates with the increment of weight loading. The figure shows linear trend for all the temperatures which is in positive results with the thermal conductivity which in turn is directly proportional to weight loadings. The lowest thermal conductivity occurs on 0.1 wt.% of MWCNT-OH concentrations for each temperature. It is found that the highest thermal conductivity for 6°C, 25°C and 40°C is occurring on 1.0 wt.% concentrations. Based on the figure, the nanofluids’ thermal conductivity starts to decline on concentration of 0.5 wt.% for each temperature. In this research, thermal conductivity is enhanced from 2.323% to 20.10% with the inclusion of MWCNT-OH nanoparticles in base fluid. It proved that the inclusion of nanoparticles has enhanced the thermal conductivity.

3.2 Heat transfer coefficient

Heat transfer coefficient on MWCNT-OH ethylene glycol based nanofluids has been postulated in Figure 3.2. Three weight loading of nanofluids selected are 0.8 wt.%, 0.9 wt.% and 1.0 wt.% of MWCNT-OH weight loading. On standard of heat transfer coefficient for ethylene glycol are recorded at 114.49 kW/m².K, 115.20 kW/m².K and 122.35 kW/m².K for 6°C, 25°C and 40°C. The highest heat transfer coefficient value is on concentration 1.0 wt.% for each temperature. Temperature 40°C (205.90 kW/m².K) is leading the heat transfer coefficient and followed by 25°C (194.28 kW/m².K) and 6°C (184.93 kW/m².K). Despite that, the lowest heat transfer coefficient occurs on concentration 0.8 wt.% for each temperature which has a value of 115.15 kW/m².K, 121.56 kW/m².K and 133.33 kW/m².K for 6°C, 25°C and 40°C. To sum it up, heat transfer coefficient of MWCNT-OH ethylene glycol based nanofluids increases with increment of weight loading and temperatures.

Hence, these results of thermal performances are affected by several factors. In fact, good thermal conductivity values can give greater heat transfer coefficient performance [3]. Literature stated that the inclusion of small amount of surfactant can increase thermal conductivity and heat transfer coefficient [4]. In addition, surfactant also can avoid or decreases the agglomeration form and achieve the nanofluids’ stability.

The stability of nanofluids is a crucial factor in thermal performances where greater stability of nanofluids can give better thermal performance. Meanwhile, dispersion process can break down and reduce the agglomeration nanoparticles in base fluids where agglomeration nanoparticles can influence the thermal conductivity and heat transfer coefficient by decreasing the thermal performance. Moreover, small size and high surface area of nanoparticles also can enhance the thermal performance as the MWCNT-OH nanoparticles’ surface area is about 40 cm²/g to 300 cm²/g [5].

4. CONCLUSIONS

In this research, seeding of MWCNT-OH nanoparticles in ethylene glycol has enhanced the thermal performances specifically thermal conductivity and heat transfer coefficient. The thermal conductivity of nanofluids is enhanced by 2.232% to 20.10%. Meanwhile, heat transfer coefficient is improved with great thermal conductivity results where the three best samples of nanofluids are 0.8 wt.%, 0.9 wt.% and 1.0 wt.% The heat transfer coefficient is improved with high weight loading and temperatures. Several factors which influence the thermal performances are surfactant, stability, dispersion process, nanoparticles size and as well as surface area of MWCNT-OH nanoparticles.

REFERENCES