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Comparison of thermal conductivity for HHT-24 CNF-based nanofluid using deionized water and ethylene glycol as based fluid

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ABSTRACT – Nanofluid are widely used in industrial applications due to their high thermal conductivity. In this experiments, thermal conductivity of various ratio carbon nanofiber based-nanofluid both in ethylene glycol and deionized water were investigated. The thermal conductivity of 1.0% CNF volume concentration at 40^0C for deionized water-based is 0.745 W/m.K while ethylene glycol-based is 0.349 W/m.K. It shows that deionized water-based recorded higher thermal conductivity compared to ethylene glycol-based. This is due to the effect of some parameter such as particle volume fraction, size and the temperature of thermal conductivity.

1. INTRODUCTION

Nanofluids are the mixture of nanoparticles, dispersing agent and based fluid in a solution. These fluids are stable colloidal suspensions of nanoparticles such as nanotube or nanofiber in base fluid. Choi and Eastman primarily studied nanofluids at Argonne National Library [1].

The potential of nanofluids as a new medium in enhancing heat transfer are closely related to their thermal conductivity. Choi et al. [2] proposed that thermal conductivity of nanofluid is higher compared to those currently used heat transfer fluids thus lead to the enhancement of heat transfer. However, the value of thermal conductivity for nanofluids might be differ according to the base solution use as the conductivity of the base solution itself play an important roles in determining the thermal conductivity result. Research from Ding et al. [3] conclude that the enhanced thermal behaviour of nanofluids could provide a basis for an enormous innovation for heat transfer intensifiction. This is a major importance to a number of industrial sectors including transportation, power generation, as well as heating, cooling, ventilation and air-conditioning. In this study, the thermal conductivity of water based and ethylene glycol based is compared.

2. METHODOLOGY

The nanoparticles used in this experiment are Pyrograf III Carbon Nanofiber High-Heat Treated (HHT-24). HHT-24 carbon nanofibers were produced by Pyrograf Products Inc. Nanofluids were prepared by mixing the carbon nanofiber and polyvinylpyrrolidone (PVP) in two different based-solutions. Those are deionized water and ethylene glycol solution. The samples were homogenized by using Digital Homogenizer LHG-15 for 3 minutes at 10000 rpm. The purposes of homogenization are to ensure the solid particles inside are uniformly dispersed. Next, the nanofluids sample undergoes ultrasonication cleaning process by being ultrasonicated using ultrasonic cleaner for about an hour at 25ºC at the highest frequency. The ultrasonicator removes any contaminants in the nanofluid. The samples were then homogenized once again for five minutes at 2000 rpm. The thermal conductivity of the nanofluids was measured at three different temperatures (6ºC, 25ºC, 40ºC) using KD-2 Pro Thermal Properties Analyser from Decagon Devices Inc. All samples were tested for thermal conductivity after being well homogenized to avoid any sedimentation which can affect the result.

3. RESULTS AND DISCUSSION

The thermal conductivity of nanofluid is tested and the data were shown at Figure 1. Table 1 show the percentage enhancement of ethylene glycol based nanofluids for three different temperatures (6^0C, 25^0C, and 40^0C) and the usage of 40% of PVP.

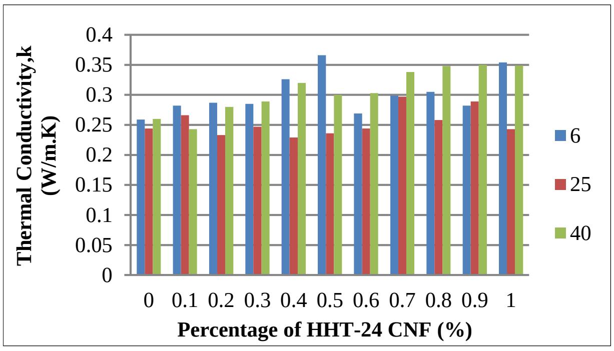

Figure 1 Thermal Conductivity for different temperature of ethylene glycol based nanofluid

The thermal conductivity of the nanofluid samples then compared with the thermal conductivity of the standard sample by calculating the enhancements of nanofluid through Equation 1:

$$\% \text{ of enhancement} = \frac{\text{T.C of samples} - \text{T.C of coolant/water}}{\text{T.C of coolant/water}} \times 100 \quad (1)$$

Table 1: Percentage of thermal conductivity enhancements for ethylene glycol based nanofluid

CNF %	Percentage of Enhancement (%) at temperature (°C)		
	6	25	40
0.1	8.88	9.02	-6.54
0.2	10.81	-4.51	7.69
0.3	10.04	1.22	11.15
0.4	25.87	-6.14	23.07
0.5	41.31	-3.28	15.38
0.6	3.86	0.41	15.21
0.7	15.44	22.22	28.52
0.8	17.76	6.17	32.32
0.9	8.88	18.93	33.08
1.0	36.68	0	32.70

The result of thermal conductivity and percentage enhancement of carbon nanofibers deionized water based nanofluids with the different percentage of PVP compared to ethylene glycol based nanofluids is show at Figure 2 and Table 2 respectively. The PVP used for the water-based nanofluid formulation is PVP with 10% weight of CNF.

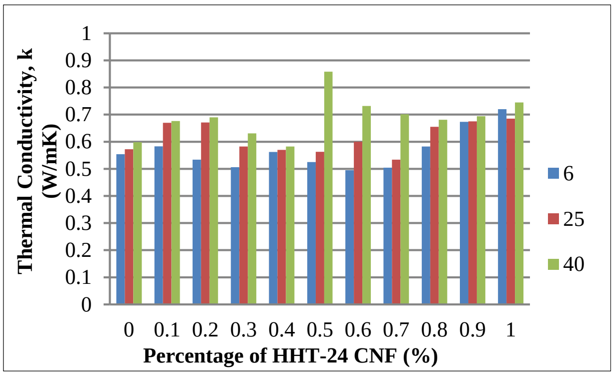

Figure 2 Thermal conductivity for different temperature of deionized water-based nanofluid

Then, the enhancement percentage is calculated according to the percentage of enhancement formula as stated in (1) for deionized water-based. Table 2 shows the tabulated data of percentage of thermal conductivity enhancement for deionized water-based nanofluid at different temperature.

At the tested concentrations, thermal conductivity increases with nanoparticle volume fraction, ϕ for both cases. From the result, it can be seen that deionized water recorded the higher thermal conductivity compared to ethylene glycol. However, in term of percentage enhancement, ethylene glycol recorded more percentage enhancement of thermal conductivity compared to deionized water. This is because; pure ethylene glycol has a specific heat capacity about one-half that of deionized water thus reducing the thermal conductivity of pure ethylene glycol. However, the mixture of ethylene glycol and water at rate 50/50 could increase the thermal conductivity [4].

Table 2: Percentage of thermal conductivity enhancements for deionized water-based nanofluid

CNF %	Percentage of Enhancement (%) at temperature (°C)		
	6	25	40
0.1	2.59	2.14	16.55
0.2	7.96	19.64	18.97
0.3	-1.11	19.82	8.79
0.4	4.07	3.93	0.34
0.5	-2.78	0.53	47.93
0.6	-8.33	-11.61	26.20
0.7	-6.67	-4.64	20.86
0.8	7.78	16.96	17.41
0.9	24.62	20.54	19.66
1.0	33.33	22.32	28.45

4. CONCLUSIONS

In general, adding solid nanoparticles increases thermal conductivity of nanofluid either for water based or ethylene glycol based nanofluids. Nanofluids with higher volume fraction rate of CNT possess high thermal conductivity compared to the pure base solution itself.

5. REFERENCES

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