Experimental study of Thermophysical properties of Carboxylic acid group functionalized MWCNT nanofluid

Raju Jadar[a], K.S.Shashishekar[a], S. R. Manohara[b],

[a]Department of Mechanical Engineering, Siddaganga Institute of Technology, Tumakuru-572103, India
[b]Nano-Composites and Materials Research Lab, Department of Physics, Siddaganga Institute of Technology, Tumakuru-572103, India

---***---

Abstract – E*thylene glycol, engine oil and water are normally used in automobile radiator as a coolant. These coolants have meager heat transfer rates because of their lower thermal conductivity. This drawback can be resolved by using the nanoparticle dispersion having high thermal conductivity in host coolants. The purpose of this research is to investigate standardized and the best stable nanofluids with different weight by volume percentage that shows the outstanding result in thermal properties. For this study, the usage of Carboxylic acid group functionalized multiwall carbon nanotubes as nanoparticles and deionized water as based fluids were investigated for thermal properties. The different weight by volume concentration and temperature were used in this study and this will affect the viscosity, thermal conductivity. As a result, the thermal conductivity of nanofluids were increased when the temperature as well as particle volume concentration increased. Further that, the viscosity of Carboxylic acid group functionalized MWCNT nanofluid seem to decrease when the temperature was increased.*

***Key Words*: MWCNT, Density, Thermal conductivity, Viscosity**

1. INTRODUCTION

Nanofluids are a novel collection of thermal fluids which have their identifiable specific features that affect their behaviour. One of these features is the response of nanofluids to the temperature difference. The nanofluids have been found to hold superior Thermophysical properties such as viscosity, specific heat and thermal conductivity as compared to those of host fluids like oil or water. Choi and Eastman [1] have reported that, the nanoparticle dispersion improved the thermal conductivity of fluids Due to their enriched properties as thermal transfer fluids for instance, nanofluids can be used in engineering applications like automobile area, refrigerator and solar devices. Moreover, it also being used in computers as well as power plant cooling systems. The observation on the nanofluids thermal properties, the temperature and particle volume concentration are significantly affected their thermal properties. The thermal conductivity of nanofluid increases with increasing the temperature [2- 8].The results proposed the use of nanofluids as a coolant for devices with high energy density where the cooling fluid works at a temperature higher than room temperature. Moreover, the viscosity of nanofluids also improved with accumulative concentration and decreasing temperature [3] meanwhile the specific heat capacity of nanofluids decreases with an increase in particle volume concentration and an increase in temperature [4].

2. EXPERIMENTAL

2.1 Materials

Carboxylic acid group functionalized multiwall carbon nanotubes [F-MWCNT] (outer diameter: 20 nm, inner diameter: 16 nm, length: 20 ▯ m purity > 97 %, COOH content: 1.8%, specific surface area: 189 m2/g, United Nanotech Innovations Private Limited, Bengaluru, India) was used in this study. Deionized water (DI water) as a base fluid throughout the present work.

2.2 Preparation of Nanofluids

F-MWCNT nanofluid having different weight by volume concentration was prepared by dispersing a known quantity of F-MWCNT in Deionized water as base fluid using an ultrasonic bath sonicator (Make: Life Care Instruments Pvt. Ltd, Mumbai, Model: MT-4.5) for about 3 hours. Low concentration of F-MWCNT was chosen, since higher concentration will increase the viscosity and also avoid the agglomeration of MWCNT.

2.3 Thermal Properties Test

To identify the thermal properties of Carboxylic acid group functionalized MWCNT nanofluid, numerous tests to be conducted such as density, viscosity, thermal conductivity, and specific heat. These tests were conducted at five different temperatures from 40 °C to 80°C and different concentration from 0.02 to 0.1%. For thermal conductivity investigation, the guarded hot plate device [Make: ARB Educational equipment, India] was used to measure the nanofluid thermal conductivity. It was set in manual mode. It consists of two heaters, one is a central heater and another one is guarded heater ring. This apparatus is designed and fabricated with IS 3346-1996.For the viscosity test, the

Redwood viscometer apparatus [Make: AIMIL, India] was used. The viscosities of the multi-wall carbon nanotube nanofluid at different weight by volume fractions and at different temperatures are measured. In the meantime, for specific heat test, it was conducted by employing the guarded hot plate device. The specific heat capacity determines the convective flow of the nanofluid and it essentially depends on the volume fraction of the MWCNT nanoparticles.

3. RESULTS AND DISCUSSION

The experimentations were conducted to measure thermal properties of MWCNT nanofluids in the particle volume concentration ranges from 0.02% to 0.1 % and the temperature ranges from 40 °C to 80 °C. Based on Table 1 and Table 3, the thermal conductivity of nanofluids increases when temperature and volume concentration increase same like specific heat. But for viscosity based on Table 2, it will decrease when the temperature is high. The density of MWCNT nanofluid decreases with increasing the temperature and increases with increasing the volume concentration

Table -1: Thermal conductivity for MWCNT nanofluids

Volume concentration of Nanofluids (vol/wt %)	Experimental Thermal conductivity reading at different temperature (W/m.K)				
	40 °C	50°C	60 °C	70°C	80 °C
0.02	0.675	0.69	0.698	0.708	0.711
0.04	0.712	0.73	0.742	0.754	0.766
0.06	0.785	0.8	0.812	0.825	0.837
0.08	0.847	0.86	0.879	0.890	0.906
0.1	0.928	0.94	0.953	0.972	0.989

Table- 2: Viscosity for MWCNT nanofluids

Volume concentration of Nanofluids (vol/wt %)	Experimental Viscosity reading at different temperature (N-s/m^2)				
	40 °C	50°C	60 °C	70°C	80 °C
0.02	0.0006981	0.000587	0.0005	0.00044	0.0003802
0.04	0.0007183	0.000602	0.00051	0.00044	0.0003905
0.06	0.0007509	0.000629	0.00054	0.00046	0.0004082
0.08	0.0007836	0.000656	0.00059	0.00048	0.000426
0.1	0.0008162	0.000684	0.00061	0.00053	0.0004437

4. CONCLUSIONS

From the above results it was concluded that the thermal conductivity of Carboxylic acid group functionalized MWCNT nanofluid was increased with temperature increment and increase of particle volume concentration. The viscosity of MWCNT nanofluid becomes much more dependent on the volume fraction of nanoparticles and base fluids also with the temperature. At low volume fraction, the viscosity of the base fluids are dominated and the viscosity increased when the temperature is decreased. These conditions vice versa when the concentration of nanoparticle and temperature is high

REFERENCES

[1] Choi S. U. S., Eastman J. A., Enhancing Thermal Conductivity of Fluids with Nanoparticles, ASME International Mechanical Engineering Congress & Exposition, USA, 1995.

[2] L.S. Sundar and K.V. Sharma, "Thermal conductivity enhancement of nanoparticles in distilled water," International Journal of Nanoparticles, vol. 1, no. 1, 66–75, 2008.

[3] Y. Ding, H. Alias, D. Wen & R.A. Williams, "Heat transfer of aqueous carbon nanotubes," International Journal of Heat and Mass Transfer, vol. 49, pp. 240, 2005.

[4] D.P. Kulkarni, R.S. Vajjha, D.K. Das and D. Oliva, "Application of aluminium oxide nanofluids in diesel electric generator as jacket water coolant," Applied Thermal Engineering, vol. 28, pp. 1774-1781, 2008.

[5] X.Q. Wang and A.S. Mujumdar, "Heat transfer characteristics of nanofluids: A review," International Journal of Thermal Sciences, vol. 46, no. 1, pp. 1-19, 2007.

[6] P.C. Mishra, S.K. Nayak and S. Mukherjee, "Thermal conductivity of nanofluids," International Journal of Engineering Research and Technology, vol. 2, no. 9, pp. 734-745, 2013.

[7] A. Ghadimi, R. Saidur and H.S.C. Metselaar, "A review of nanofluid stability properties and characterization in stationary conditions," International Journal of Heat and Mass Transfer, vol. 54, no. 17, pp. 4051-4068, 2011.

[8] S.K. Das, S.U.S. Choi, W. Yu and T. Pradeep, Nanofluids Science and Technology. New Jersey: John Wiley & Sons Inc.; 2007.