Study on viscosity of MWCNT dispersed in ethylene glycol at different operating conditions for thermal applications

M D Kathir Kaman*, M Cheralathan, Vedansh Sharma, Aditya Viswanathan

Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur- 603 203, Tamil Nadu, India

*Email: kathirkd@srmist.edu.in

Abstract: In recent times the development of nanotechnology has taken place at an unprecedented rate. Nano-fluids are one of the remarkable outcomes of the development of new technologies that can be used to increase the efficiency of thermal systems. Nanofluids, which consist of particles in nanometre size and a base fluid, have been hailed as a superior alternative compared to a common heat transfer fluid like water due to their better thermal properties and having many potential applications in many fields, especially in HVAC, electronic cooling, solar heating and cooling etc., The MWCNT-based nanofluid with water-ethylene glycol as base fluid is prepared by two-step method, the water and ethylene glycol are mixed in the ratio 80:20 and four different concentrations of nanofluids: 0% wt, 0.015% wt, 0.15% wt, 1.5% wt are prepared. Rheology analysis are made by using rheometer with temperature ranging from from 10° C to 50° C with steps of 10° C and shear rate was controlled with shear stress varying from 0 -10 N/m². The base fluid shows the Newtonian behaviour being shifted to Non-Newtonian Behaviour, specifically shear thinning behaviour. Rate of change of shear also changes with change in temperature and change in shear stress results change in viscosity with higher concentration of nanoparticles showing higher viscosity.

Key words: Dynamic viscosity, Rheometer, Nano fluids and Rheology.

1. Introduction

Energy conservation is one of the critical problems of the twenty-first century, and it will genuinely be one of the major good challenges inside the near destiny. consequently, scientists, engineers, and researchers are notably looking to deal with this important issue. Energy savings can be executed with the aid of the efficient use of it. Heat exchangers are thermal devices used to provide the flow of energy with two fluids which are maintained at different temperature and used in various industries such as Space, Refrigeration, air conditioning, manufacturing, electronics, automobiles, etc. The most common use of heat exchanger can be found in In-home application such as coolers, refrigerators air conditioners, etc In gas industry particularly for preheating of fluids and in automobile industries such as radiators and air conditioners in the car [1-9]. The outmoded approach to enhancing heat degeneracy is by increase the area of heat exchanger by changing better heat transfer and use a improved heat transfer fluids. Using the above-mentioned approach will result in an inevitable increase in the area or size of a thermal transport systems for improving the performance therefore, novel coolants with better
performance are needed to be discovered. Nano-fluids are one of the remarkable outcomes of the development of new technologies that can be used to increase the efficiency of thermal systems. Nano Fluids are a colloidal suspension of nano-sized particles that have a high specific area and high surface activity, which are homogeneously dispersed in a base fluid. The contemporary concept of the use of nanofluids in heat exchangers as heat transfer fluids which consist of suspended nanoparticles has been anticipated as a solution to the contests mentioned above [10]. As an example, experiments confirmed a significant change in thermal conductivity by means of dispersion of a less than 1% vol fraction of Copper nanoparticles or CNTs in ethylene glycol or oil through 40% and 150% [10]. Haisheng Chen et al. [11] using TiO2 nanoparticles in Ethylene Glycol base fluid has concluded that the EG based Nanofluids have a higher tendency to show Newtonian behaviour. S.M Fotukian et al. [12] has found that for increasing nanoparticle volume concentration, pressure drop increment is seen. For similar situation along with temperature increase it is noticed by Salma Hadeefadl et al. [13] thermal conductivity goes up along with temperature independence of density by using MWCNT nanoparticles.

2. Preparation of Nano fluids

The MWCNT-based nanofluid with water-ethylene glycol as base fluid is prepared by the so is called two-step method, where the nanoparticles is prepared in the process of dry powder by various methods such as CVD. Then the nanoparticles is dispersed into the base fluid and is mixed to form the nano fluid. This method is economical compared to so called One Step Method. First the water and ethylene glycol are mixed in the ratio 80:20 and then undergoes magnetic stirring to ensure optimum mixing of the solution. Then we add surfactant SDBS (Sodium Dodecyl Benzene Sulphonate) and the solution undergoes magnetic stirring for the same duration as the previous step. Addition of MWCNT nanoparticles into the prepared base fluid is done and undergoes magnetic stirring to ensure proper mixing of the solution for around 30 minutes. Ultrasonication is performed for around 180 minutes to ensure that the particle aggregates if any formed are broken down by application of high frequency ultrasonic waves. [14] 4 concentrations (by weight) of nanofluids: 0%, 0.015%, 0.15%, 1.5% will be used for analysis. To ensure the particle size and dispersion for MWCNT SEM analysis was performed. Figure 1 shows a SEM image of MWCNT.

![Figure 1. SEM image of MWCNT](image-url)
3. Rheological Properties Measurement of Nanofluid

Rheology is defined as the study of flow of matter particularly in liquids. Here the main rheological property to be assessed is viscosity where the analysis is done with the help of rheometer.

![Figure 2. Malvern Bohlin CVO Rheometer](image)

The prepared nanofluid’s rheological behaviour was analysed using Bohlin CVO Rheometer (Malvern Instruments Ltd) Figure 2, with temperature limits varying from 10° C to 50° C with steps of 10° C. The maintenance of desired temperature was done with help of Peltier Cooler whose heat generated was carried away by an external coolant. Calibration was performed before each experiment by using standard Brookefield Fluids for accuracy. Nanofluid was kept in the bottom plate of rheometer while ensuring the absence of air bubbles in the samples tested. Shear rate was controlled with shear stress varying from 0-10 N/m². The gap between the plates was kept in the region of 70-75 μm. The analysis only took place when the nanofluid reached desired temperature. To ensure that the data repeatability was achieved, each experimentation was performed at least two times

4. Results and Discussion

![Figure 3. Shear stress vs Shear rate at 20 degrees](image)
It is inferred from the graphical figures 3 and 4, (Shear Stress vs Shear Rate) that the base fluid shows Newtonian behaviour, in which direct proportionality between shear stress and shear strain is shown.

From the graphical comparison of Shear stress and Viscosity in figure 5, we can see the relation between concentration and viscosity being directly proportional and higher shear rate showed lower viscosity leads to enhance the heat transfer.
Also, we can see in the Viscosity and temperature graph in figure 6, that temperature increment shows reduction in viscosity and along with significant change in viscosity is followed due to change in nanoparticle concentration.

5. Conclusion

After performing the rheological behaviour, the following observations are identified,

1. It is being shown that Nano particle addition to the base fluid shows the Newtonian behaviour being shifted to Non-Newtonian Behaviour, specifically shear thinning behaviour. Rate of change of shear also changes with change in temperature, which shows the significance of temperature being played here.
2. Change in shear stress results change in viscosity with higher concentration of nanoparticles showing higher viscosity.
3. Temperature increment shows reduction in viscosity due to the fluid being in liquid state and along with significant change in viscosity is followed due to change in nanoparticle concentration.

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