Thermo-Physical Properties of Al_2O_3 and Preparation Technique

S. Baskar and L. Karikalan

Abstract Nanofluid is considered to the next invention of transfer of heat from the fluid which is providing and stimulating the possibility to increase heat transfer characteristics as compared to the base fluid of water. The experimental work of the paper in ethylene glycol (EG)-based Al_2O_3 nanofluid along with SDBS which acts as the surfactant was carried out. There are three various concentrations used as 0.1%, 0.15%, and 0.25%. The particle sizes show that the power on thermal conductivity variant along with volume concentration increases than the base fluid. The measured nanoparticles' sizes are <50 nm. In addition, the fluid thermal conductivity is expected at isothermal process. From the observation, the nanofluid viscosity increases with changeable in the volume concentration. The thermal conductivity of the nanofluid also was improved while increase in volume concentration. The particle sizes show the power on thermal conductivity variant along with volume concentration.

Keywords Nanofluid · Thermal conductivity and viscosity

1 Introduction

Nanomaterial are the materials which are science-based and move toward the nanotechnology. It deals the features of the nanoscale especially their various properties like viscosity, thermal conductivity, density, specific heat and shear stress, etc. The nanoscale size is less than 1/10 of micro-meter in least one dimensioned. The catalytic activities are also revealing innovative method in biomaterials [1]. There are different methods which are available to make the nanoparticles by using ball mill mechanism. In cold conditions, heat transfer processes the secondary refrigerants playing important role [2]. In that, ethylene glycol or brine solution has important

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A. Arockiarajan et al. (eds.), *Advances in Industrial Automation and Smart Manufacturing*, Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-981-15-4739-3_61

role. The secondary refrigerant carried the heat from the primary source is given, and it is recirculated again and again in order to minimize the primary refrigerants with respect to environmental concerns. It is desirable to the thermal energy by utilizing the ethylene glycol [3]. In commercial and large industrial plants, the secondary refrigerants are widely used. In this case, indirect cooling is attained by secondary refrigerant than the direct cooling. When the temperature requirements of the different parts in a large building are varied, these dissimilar temperatures can be sustained by monitoring the amount of brine solution. The heat is carried by secondary refrigerant by the help of pipes. The use of brines is advisable in order to keep coil and pipe encompassing a toxic refrigerants absent from load place [4].

In order to operate these fluids in secondary refrigeration circuit, an anti-freeze agent should be added in order to avoid freezing particularly in the case of water. However, the additions of the anti-freezing medium in the water severally have a greater influence in thermal transfer properties few as decreased in thermal conductivity, increased in viscosity, etc. In the case of other refrigerants like propanol, ethylene glycol is directly used in the secondary refrigeration circuit without addition of the anti-freeze medium, but they possess the less thermal conductivity that reduces the effectiveness of secondary refrigeration loops.

2 Nanofluids

The modern technology provides the chance to manufacture the nanoparticles which are relatively dissimilar from the close relative material in thermal, mechanical, and electrical properties. The nanofluid expertise is joined with new heat transfer studies in various fields. Generally, the suspended size of the nanoparticles in the nanofluid is less than 100 nm [5]. The size of the particles is large which tends to block the flow in particularly the narrow channel, and the fluid pressure drop is increasing significantly [6]. The nanofluid thermal conductivity is enhanced based on nanoparticle concentrations which is higher particle volume concentrations resulting the higher enhancement.

In recent years, the carbon nanotubes receive much attention among the thermal engineers appropriate to its outstanding thermal, mechanical, and electrical properties. The CNT are classified into two types, namely single-walled nanotubes and multi-walled nanotubes. The single-walled carbon nanotubes (SWCNT) having a diameter in the range of 1 nm [7]. The multi-walled carbon nanotubes (MWCNT) consist of several rolled layer of graphite. The scope of the experimental work is to discover the heat transfer characteristics of nanofluids in favor of heating/cooling applications [8].

3 Properties

The nanoparticles are of immense scientific attention as they are successfully a bridge between bulk materials and molecular structure. A bulk material having physical properties in spite of size is observed.

3.1 Nanofluids Thermal Conductivity

The nanofluids thermal conductivity is playing major role in heat transfer character of heating/cooling applications. The maximum concentrations of nanoparticles are giving greater heat transfer capable in the nanofluid. The experimental work concludes that the nanofluids' thermal conductivity depends on the various factors, namely particle size, volume concentration of the particle, shape of the particle, material, temperature, and base fluid.

3.2 Particle Size and Material

There are various nanoparticle materials which are widely used to prepare the nanofluid preparation. In that, Al_2O_3, TiO_2, Ag, Cu, SiC, TiC, and CuO nanoparticles were regularly utilized in the research. The CNT is used due to its tremendous thermal conductivity. The water is used as base fluids for preparing the nanofluids. According to the Brownian motion of nanoparticle, it will affect the nanofluid thermal conductivity. The volume concentration of nanoparticle is investigated, and most of the researchers reported that rising nanofluid thermal conductivity increases the volume concentration of the nanoparticle. The majority of the works prove that the nanoparticles important parameters affect the thermal conductivity of the fluids. Lee et al. measured the nanofluid thermal conductivity of Al_2O_3 and CuO nanoparticle and establish that the nanofluid with CuO nanoparticle shows good improvement than the others. The nanoparticle size is one more essential fluid parameter of thermal conductivity. They are feasible to create nanoparticle at different sizes in the range between 5 and 99 nm. Eastman et al. accomplished that the nanoparticle sizes are main reason that affects the enhancement of thermal conductivity into the account. The general tendency is that the nanofluid thermal conductivity increases by diminishing the nanoparticle size. It is attained by the mechanism of Brownian motion of the nanoparticle. Though there is a significant quantity of opposing data, reducing thermal conductivity with declining of nanoparticle size is indicated.

3.3 Shape of the Particle

There is two important particles shape is available in the nanofluids study, one is spherical particle in addition to cylindrical particle. The cylindrical particles are frequently having a big length-to-diameter ratio. This type of method is used by Xie et al. for the nanofluids preparation. It was noted that the 4.3 vol.% water-based nanofluid through spherical particle have a thermal conductivity enhancement which is 14.9%, while 4.3 vol.% of the nanofluids among cylindrical particle have thermal conductivity enhancement which is 218%. As a result, it concludes that the cylindrical-shaped nanoparticles are giving superior thermal conductivity enhancement than the spherical-shaped nanoparticles. However, it has to be noticed that the Nanofluid with cylindrical particles decrease the viscosity than those with the spherical nanoparticle. Consequently, the pumping power increases.

4 Results and Discussion

4.1 SEM Image of 0.15 and 0.3 Vol.% Dispersed MWCNT in Base Fluid with 0.20% SDBS with Different Magnification Rates

The scanning electron microscope is used to identify the size of the nanoparticles in the nanofluid. The image is shown in Fig. 1 which is under the 30000× and 50000× magnifications ranges, respectively. The nanoparticles are agglomerated under the

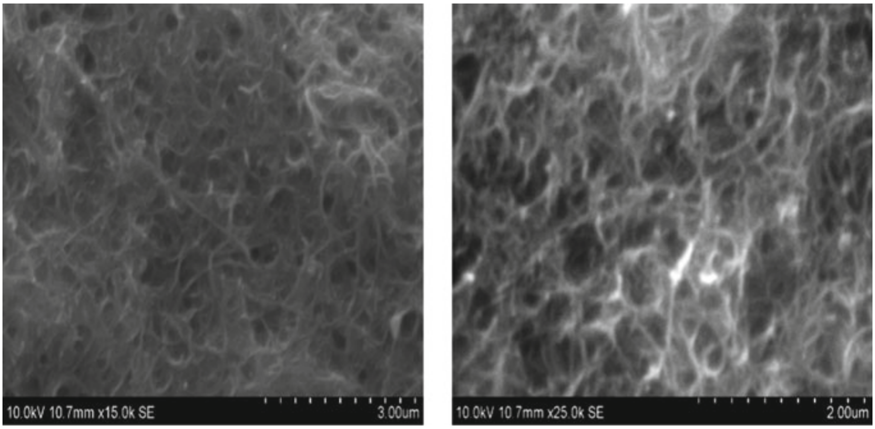

Fig. 1 SEM image of 0.15 vol.% dispersed nanoparticles in base fluid with 0.25% SDBS with different magnification rates

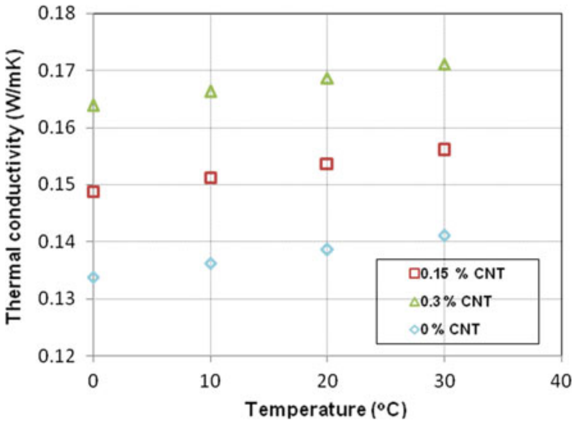

Fig. 2 Temperature versus thermal conductivity

atmospheric conditions which are of the micrometers in sizes. The shape of the individual nanoparticles was close to spherical.

4.2 *Temperature Effect on the Thermal Conductivity*

Figure 2 illustrate the effect of the nanofluid thermal conductivity at various temperatures. Hence, it is noted that thermal conductivity of nanofluid is increasing with increasing in temperature as well as increasing in concentrations also. The low and high thermal conductivity of fluid is as 0.134 W/mK, 0.149 W/mK, and 0.163 W/mK, respectively.

5 Conclusion

One of the methods to differ the thermo-physical properties and characteristics of fluids is found to be particularly effective in nanoparticles form, because of surface area-to-volume ratio enhancement. The experiment was done at different levels to investigate the effects of the thermo-physical properties and its performance. The experimental work is happening on the effect of various parameters, namely preparation time and nanoparticle size, etc.

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