EXPERIMENTAL VALIDATION OF THERMOPHYSICAL PROPERTIES OF AG-REFRIGERATION BITZER OIL BSE170 NANOFLUID

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ABSTRACT

Nanofluids have marked their place in the market of heat transfer fluids as superior coolants due to having optimal thermal properties and potential. Nanofluids are a new kind of fluids generated by suspending nanoparticles in base fluids. They have been found to possess enhanced thermophysical properties such as thermal conductivity, heat transfer coefficient, viscosity, and density. In this paper, various aspects of nanofluids including synthesis of nanofluids, experimental and analytical studies on the thermal conductivity and viscosity were investigated. The results showed the thermophysical properties have different parameters for each parameters. The refrigeration oil at various temperature ranging from 40-70°C under different volume concentrations (0.1, 0.2 & 0.5%) of nanoparticles. All experimental equipment are from famous brand in worldwide and will be informed further.

KEYWORDS: *Nanoparticles, Viscosity, Density, Thermal Conductivity, Ultrasonic*

I. INTRODUCTION

The most advantages of using nanofluid using to reach to higher heat transfer coefficient nanofluids in compare to in the base fluids. Xuan and Li [1] . The enhancement presented to 35% for the turbulent forced convective heat transfer of Cu-H2O nanofluid considering the volume conc. of 2.5 % . Based the results, the enhancement is lower for volume conc. Lai et al. [2]. Used ND/EG and ND/mineral oil based nanofluids and found 12% and 11% thermal conductivity increased at 0.88% and 1.9 conc., respectively. Xie et al. [3].

This experimental study was to discuss the dependence of thermal conductivity viscosity, density and specific heat of Ag–refrigeration oil in temperature ranges between 40-70°C under different volume concentrations (0.1, 0.2 & 0.5%) of nanoparticles. The subsequent sections present the method of preparation and characterization of nanofluids along with the results in detail.

II. PREPARATION OF NANOFLUIDS

The start the experimental studies with nanofluids, we need to know the best method to produce the suspension to be successful in preparation and be able to have better thermal properties for producing stable nanofluids. Some special requirements are essential (i.e.) negligible agglomeration of particles, uniform, durable and stable nanofluid and the chemical properties no change, etc. There are two primary systems embraced for the arrangement of nanofluids: single-step and two-advance strategies. Single step strategy all the while creates and scatters the nanoparticles legitimately into the base liquid medium which is reasonable for metallic nanofluids. The conglomeration issue can be much decreased with direct vanishing buildup strategy. This inactive gas method includes the vaporization of source material in a vacuum. In this procedure of arrangement, the buildup frames nanoparticles through direct contact between the base liquid and vapor. while a two stage technique applies better for nanofluids containing oxide nanoparticles. Albeit one stage technique has preferred strength over two stage strategy, the greater part of the investigations utilized two stage technique for the planning of nanofluids. Subramaniyan, R. Kamatchi , et al .[4, 5]. This is for the most part a direct result of its effortlessness in setting up the nanofluids and ease. In any case, the scattering strength of the planned nanofluids must be guaranteed with various solidness examination viz. Isoelectric Point (IEP), sedimentation, and Zeta potential Kwark et al. [6].

To convey The suspension we moreover used two phase procedure for late investigation Ag since it is artificially progressively enduring and its cost is less and besides it is adequately open. Ag/BSE170 suspension masterminded by two phase technique.

III. MATERIAL DATA

Refrigeration oil bitzer BSE170 as base fluid (made in Germany), and nanopowder made by us research factory, and both material have the following specifications (Table 1, 2).

Table 1. Properties of Nanoparticle

Particle	Silver Nano Powder
Avg. particle dia.	20 nm (TEM)
Density	3880 Kg/m³
Purity	99.99

Table 2. Properties of Base fluid

Base fluid	Refrigeration BSE 170 Oil Bitzer Germany

Table 3. Manufacturer base fluid properties

	Viskosity	Density	Specific heat	Heat conductivity
	mm²/s (cSt)	kg/m³	kJ/kgK	W/mK
HFKW / HFC – Standard				
BSE170				
40°C	170,0	957	1,92	0,1320
50°C	100,0	951	1,94	0,1312
60°C	62,0	944	1,96	0,1304
70°C	42,0	937	1,98	0,1296

IV. PARTICLE SIZE CHARACTERIZATION

Nanoparticles sizes typically checked by electron magnifying lens (TEM, TEM , SEM for nanofluids). The greater part of the announced investigations utilized TEM for portraying nanofluids. Particles estimate assumes an incredible job in upgrading warm conductivity of nanofluids. It speaks to the most huge distinction among nanofluids and micron-sized suspensions. The impact of nanoparticles measure isn't restricted to suspension soundness, yet stretches out to incorporate warm properties. The impact on upgrading warm conductivity of nanofluids was contemplated every now and again. It was found by Lee et al. [7]. A few better places were watched and found the middle value of data was acquired and investigated. The stable nanofluids had diverse shapes after arrangement, as appeared in the TEM picture (Figs. 1, 2, 3).

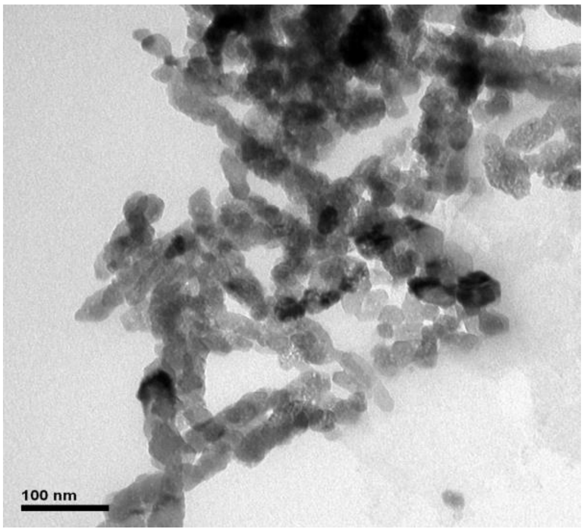

Figure 1. TEM of Silver nano particle

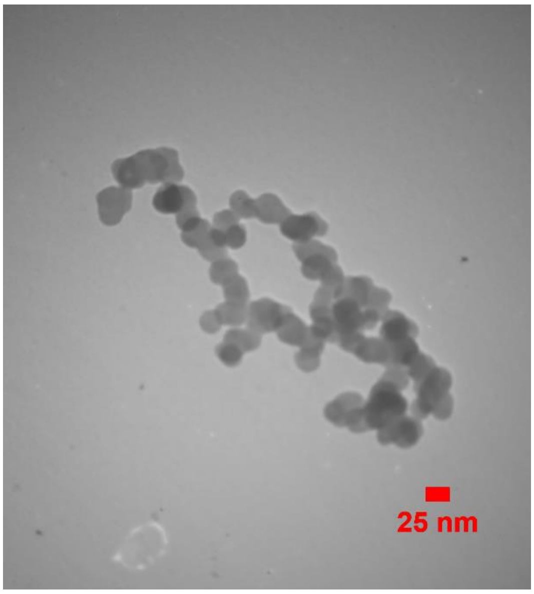

Figure 2. SEM of Silver nano particle

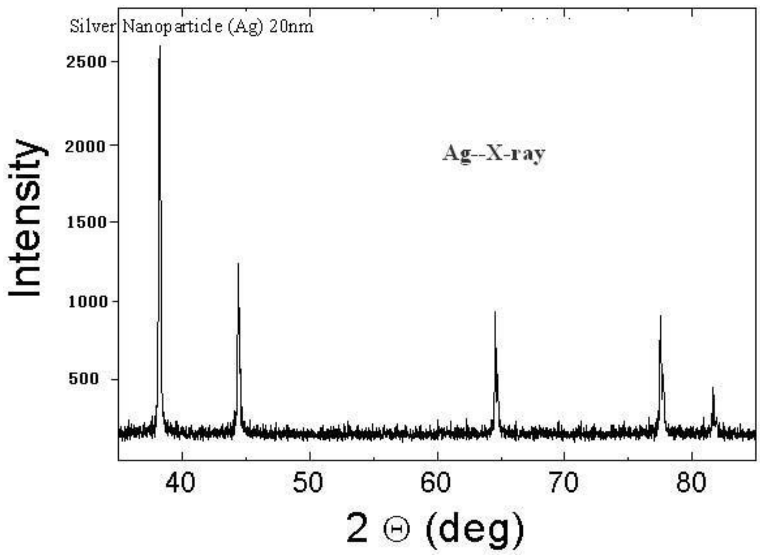

Figure 3. XRD of Silver nano particle

V. EXPERIMENTS

All the experiments were performed by modern equipment at the "Chemistry and Chemical Engineering Research Center of Iran" and "Iran's Research Center of Petroleum Industry"

5.1 Make the suspensions:

Nanofluids with the particle weight volume of 0.5%, 1% and 2% were made by dispersing a specified amount of Ag nanopowder in base oil using an sonic bath (Elma Company, Germany), generating ultrasonic at 37 kHz frequency. (Fig. 4).

Figure 4. Bath ultrasonic

This device was utilized to break extensive agglomerates of nanoparticles in the liquid and make stable suspension. added substance not included for late suspension which they may have some impact on the nanofluid peroperties. It was seen with unarmed eyes that the nanofluids were consistently scattered for 45 minutes and that practically following multi month we came to finished sedimentation. It ought to be noticed that to quantify all properties, ultrasonic was utilized too to build precision of information (Figs. 5 and 6).

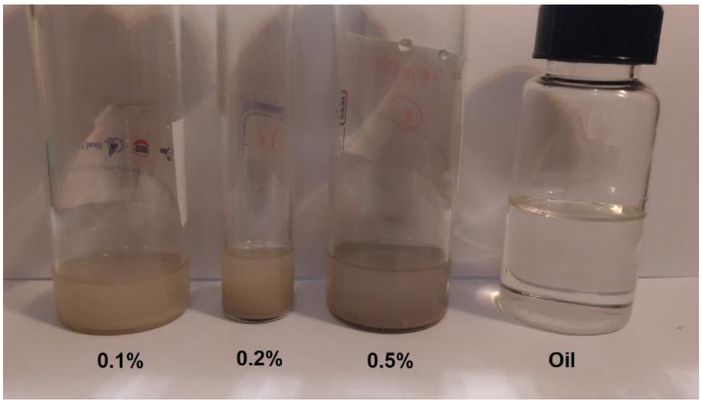

Figure 5. Samples after 1 month

Figure 6. Complete sample after 72 past

5.2 Measurement of thermal conductivity

Thermal conductivity of fluids is measured as their ability to conduct heat. It consists of a handheld microcontroller and sensor needles. The KD2 sensor needle contains both a heating element and a thermistor. The controller module contains a battery, a 16-bit microcontroller/AD converter,and power control circuitry.

For this purpose, we used KD2- pro equipment which is completely a portable field and laboratory apparatus for analyzing the thermal properties which uses the transient hot wire system for measuring thermal conductivity. Thermal conductivity of nanofluid measured in 0.1, 0.2, 0.5 wt% concentration at the various temperatures were measured. (Fig. 7).

Figure 7. KD2 Pro

5.3 Measurement of viscosity and density

In order to measure the density and viscosity properties , SVM3000 (Austria) was utilized, estimating the dynamic viscosity and density of oils and fuels as indicated by ASTM D7042. From this result, the viscometer consequently ascertains the kinematic consistency and conveys estimation results which are comparable to ISO 3104 or ASTM D445. The Stabinger estimating standard with Peltier indoor regulator empowers an especially wide consistency and temperature go with a solitary framework. SVM 3000 is snappy, smaller and vitality sparing, and adaptable being used, with just little measures of test and solvents required (Fig. 8.)

Figure 8. Anton Paar Viscometer and Density meter

Following is the procedure adopted to carry out the experiments with BSE170 bitzer oil-Ag as the nanofluid:

1. The weight measurement of Ag nanoparticles was performed to calculate volume fraction.
2. Ag oil was sonicated for 45 minutes at 37 Hz and checked for all nanoparticles.
3. Thermal conductivity was measured at the mentioned temperature by taking the nanofluid in the test needle KS1 of KD2 pro in it properly.

4. Measurement of viscosity and density was performed with sample in device (SVM3000 Austria) at the temperature between -60°C to 135°C.

VI. Results and Discussions

6.1 Variation of density with concentration

As measured data presented on the graph, the same as viscosity all parameters decrease on variety of temperature and concentration. Also density decrease with the increase in concentration of nanoparticles. Higher the concentration of nanoparticles, higher is the density of the nanofluid at a particular temperature. Almost there is a regularly decrease in the density of the nanofluid from 0.1 to 0.5% conc. 40-70`c., Highest density occurred on 0.5% conc. (Figure 9).

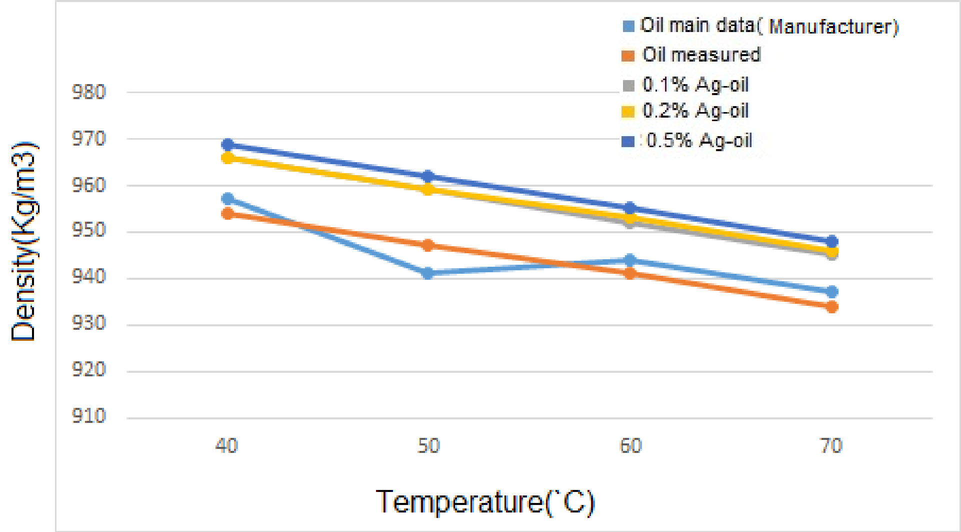

Figure 9. Density vs Temperature

6.2 Variation of viscosity with concentration

From the experimental data plotted on the graph, as long as expected the viscosity almost decrease on variety of in temperature and concentration. Viscosity also decrease with the increase in concentration of nanoparticles. While change the concentration, the higher is viscosity is at the higher specific particular temperature. Almost there is a regularly decrease in the viscosity of the nanofluid from 0.1 to 0.5% conc. of nanoparticles, however on all properties we had minor increase at 60 to 70 `c. (Figure 10).

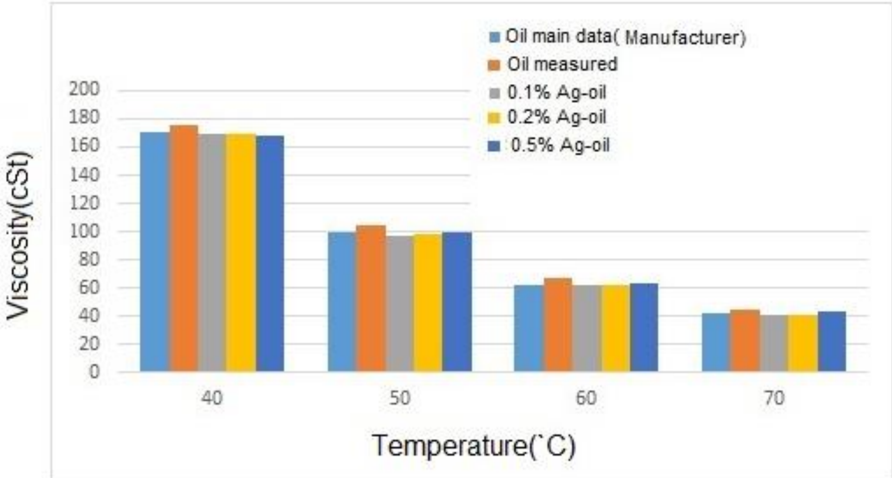

Figure 10. Viscosity vs Temperature

Recently, viscosity of nanofluids is considered as one of the important parameter in heat and fluid flow problems. With regard to the viscosity of nanofluids, most of researchers worked to show an enhancement in viscosity with concentrations. However, the viscosity will decreases with the increase of temperature. R. Kamatchi, [8], . H. Ganapathy. , [9]. On the other hand, a negligible change in viscosity between base fluid and nanofluid is observed by Kwark et al. [10].

6.3 Variation of thermal conductivity with concentration of nanoparticles

The nanofluid thermal conductivity increase with the increase in temperature at an exceptional convergence of the nanoparticles. At a unique temperature, the thermal conductivity nearly increase with increased in volume of nanoparticle. At 0.2% of focus, when nanoparticles are blended with oil, increase in thermal conductivity is too small. Anyway the warm conductivity of oil and nanofluid at 0.5% fixation is nearly in most elevated amount (70'c).
Besides, at 0.1% on 50-60 'c is higher than of 0.2% on same temperature. (Figure 11).
Prepared Al2O3–Cu hybrid nano fluids (90 wt% of Al2O3 and 10 wt% of CuO) and presented thermal conductivity increased of 12.11% at 2.0 vol%. Madhesh et al. [11].

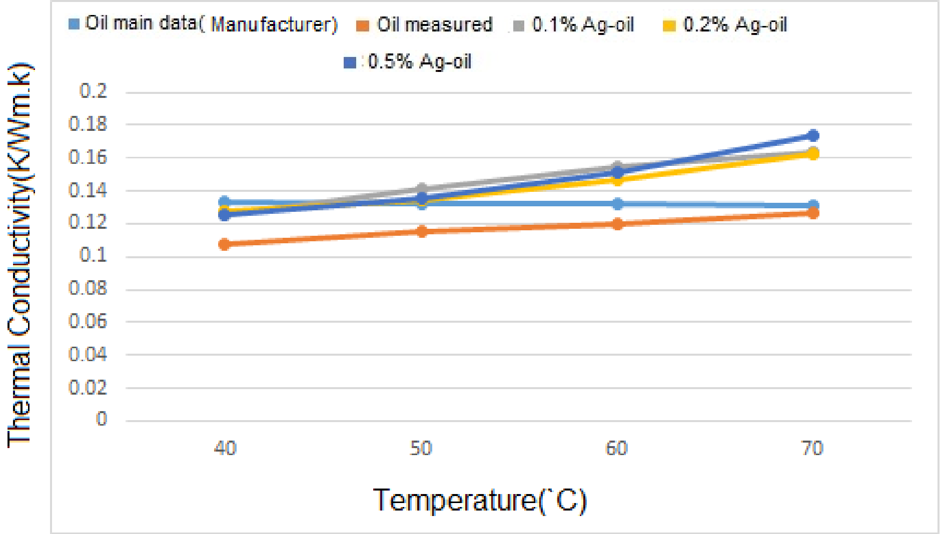

Figure 11. Thermal Conductivity vs Temperature

VII. CONCLUSION

In the present study, Thermophysical characteristics of the Ag–base refrigeration oil BSE170 based on best measuring devises are investigated.

1. The best conditions are when we consider 0.5% of nanoparticle, and increase all properties regularly.
2. The viscosity not being changed well against the particles concentrations, and there is no significant differences against particle concentrations at different temperatures as well.

In the future study, a wide range of study shall be performed on the different nanoparticles such as hybrid models based same oil or different oils on same applications to reach to best results and also looking for stability of nanofluids aggressively.

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REFERENCES

[1] S. Lee, S.U.S Choi., S. Li, J.A Eastman, Measuring thermal conductivity of fluids containing oxide nanoparticles, Journal of Heat Transfer 121 (1999) 280–289.

[2] W.Y. Lai, B. Duculescu, P.E. Phelan, R.S. Prasher, Convective heat transfer with nanofluids in a single 1.02-mm tube, Proceedings of ASME International Mechanical Engineering Congress and Exposition (IMECE) (2006) 65-76..

[3] H.Xie, W, Yu,Y, Li,Thermal performane enhancement in nanofluids containing diamond nanoparticles, K.Phys.D:Appl.Phys.42(2009)1-5.

[4] Subramaniyan, A. L., S. Lakshmi Priya, and R. Ilangovan. "Energy harvesting through optical properties of TiO2 and C-TiO2 nanofluid for direct absorption solar collectors. " International Journal of Renewable Energy Research, vol. 5, pp. 542-547, 2015.

[5] R. Kamatchi and S. Venkatachalapathy, "Parametric study of pool boiling heat transfer with nanofluids for the enhancement of critical heat flux: A review," International Journal of Thermal Sciences, vol. 87, pp. 228–240, Jan. 2015.

[6] S.M. Kwark, Ratan Kumar, Gilberto Moreno, Jaisuk Yoo, Seung M. You, "Pool boiling characteristics of lowconcentration nanofluids," International Journal of Heat and Mass Transfer, vol. 53 (5-6), pp. 972-981, Feb.2010.

[7] Lee SS, Choi SUS, Li S, Eastman JA. Measuring thermal conductivity of fluids containing oxide nanoparticles. J Heat Transfer 1999;121:280–9. doi:10.1115/1.2825978.

[8] R. Kamatchi, S. Venkatachalapathy, and B. Abhinaya Srinivas, "Synthesis, stability, transport properties, and surface wettability of reduced graphene oxide/water nanofluids, " International Journal of Thermal Sciences,

[9] H. Ganapathy and V. Sajith, "Semi analytical model for pool boiling of nanofluids," International Journal of Heat and Mass Transfer, vol. 57 (1), pp. 32-47, Jan.2013.

[10] S.M. Kwark, Ratan Kumar, Gilberto Moreno, Jaisuk Yoo, Seung M. You, "Pool boiling characteristics of low concentration nanofluids," International Journal of Heat and Mass Transfer, vol. 53 (5-6), pp. 972-981, Feb.2010.

[11] D. Madhesh, R. Parameshwaran, S. Kalaiselvam, Experimental investigation on convective heat transfer and rheological characteristics of Cu–TiO2 hybrid nano fluids, Exp.Therm. Fluid Sci. 52(2014) 104–115.

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